Conceptualizing Academic Entrepreneurship Ecosystems: A Review, Analysis and Extension of the Literature

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Abstract

Policy-related discussions increasingly view universities as so-called "engines of economic growth." Recognizing that the economic impact of universities is dependent, at least in part, on the success of university-affiliated entrepreneurial ventures, this paper reviews the extant literature to understand how academic entrepreneurship is conceptualized and the extent to which it adopts an ecosystem approach. We find that scholars have largely focused on individual ecosystem elements and characteristics, eschewing strategic and systemic conceptualizations of entrepreneurship ecosystems. As a result, we argue that the ecosystem perspective has not been fully leveraged to influence policy decisions. We conclude by offering several concrete recommendations on future research directions that, if pursued, would further enhance our understanding of the economic impact of universities.

Keywords: Academic Entrepreneurship; Ecosystems; Technology Transfer; Entrepreneurship Policy; Economic Development

JEL codes: L31, O31, O32, O34, O38

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1. Introduction

Academic entrepreneurship—the establishment of new spinoff companies by faculty, postdocs, students, or affiliated personnel based on university technology—is a critical vehicle for economic and social development (Rothaermel, Agung, and Jiang, 2007; Shane, 2004; Wright, Clarysse, Mustar, and Lockett, 2007). While a considerable body of literature investigates individual and firm-level characteristics associated with the success of university spinoffs, recent work emphasizes the importance of context to entrepreneurial innovation writ large (Autio et al., 2014). Specifically, Autio and colleagues (2014) focus on the potential of ecosystems, among other perspectives, to simultaneously provide both a more nuanced and a more complex understanding of entrepreneurial performance.

Scholars have, of course, long employed ecosystem perspectives to understand industrial dynamics (Moore, 1993). Although early conceptualizations emerged within the management (e.g., Iansti and Levien, 2004) and economic geography (Bahrami and Evans, 2000; Kenney and von Burg, 1999; Saxenian 1994) literatures, ecosystem perspectives have been recently applied within the context of academic entrepreneurship to, for example, examine the structure and effectiveness of support programs (e.g., Clarysse et al., 2014; Swamidass, 2013).

Ecosystems can vary by technology, network intensity and organizational variety. However, ecosystem conceptualizations generally focus on the role of networks and their ability to provide firms with resources and information to navigate a constantly changing competitive environment (Adner and Kapoor, 2010; Iansti and Levien, 2004; Moore, 1993; Zahra and Nambisan, 2012). Similarly, within the context of academic entrepreneurship, Hayter (2016b) posits that the efficacy of academic entrepreneurship ecosystems depends on the interconnectivity of constituent elements and their collective ability to provide information and resources important for firm success (Leyden et al., 2014; Powell et al., 2009; Whittington et al., 2009).

Although the term ecosystem has only recently been used within the context of academic entrepreneurship, earlier reviews do anticipate the emergence of ecosystem perspectives, focusing on the role of individual and inter-organizational networks. O'Shea et al. (2004, p. 23) write, for example, "Past models and research of spin-offs has underestimated the role that the social setting of the institution plays in the spin-off process. This is despite evidence … that spin-off rates can only be understood within the context of the social environment." Similarly, Rothaermel et al. (2007, p. 740) posit that future research "…can clearly benefit from a more holistic systems perspective across different levels of analysis, rather than its current focus on distinct subsystems, which is a reflection of its fragmented and embryonic state." Unfortunately, we lack a systematic review of the academic entrepreneurship literature that reflects emergent network-centric conceptualizations. Most notably, existing work fails to account holistically for the many influences on academic entrepreneurship and—perhaps most importantly, given emerging conceptualizations of ecosystems—their interconnectivity, thus providing an incomplete view of this critical phenomenon.

The goal of this article is to address this gap by inductively reviewing the extant literature since the year 2000 to understand to what extent it illuminates academic entrepreneurship ecosystem elements and their interconnectivity. The remainder of the paper is structured as follows. Section 2 explains our methodological approach. The third section provides an overview of publication patterns. The fourth and fifth sections offer analyses of the independent and dependent variables identified in prior work, accordingly. Section 6 considers these different variables in tandem through a network analysis of the prevalence and relationship between themes. Finally, we offer a synthesis of our findings and discusses implications for management practice and theory and recommends a future research agenda.

2. Methodology and Data

2.1. Research Approach

This paper employs a grounded-theory systematic approach (Petticrew, 2005; Wolfswinkel et al., 2013) to review the extant empirical literature. Although the general purpose of a systematic literature review is to establish the current state of knowledge in a field (Tranfield, Denver and Smart, 2003), the grounded theory method relies on inductivity, emphasizing thorough and relevant analyses resulting in insights otherwise overlooked. Relevant to conceptualizations of academic entrepreneurship ecosystems, a grounded theory approach focuses on interrelationships and dependencies within and beyond a body of literature (Wolfswinkel et al., 2013).

We implemented the following procedures in our review. First, we selected all journals included in the *Financial Times* May 2016 ranking of the top 50 research journals (FT50), supplemented by the *Journal of Technology Transfer*, *Technovation*, and *Small Business Economics* – journals with significant representation in prior relevant literature reviews on academic entrepreneurship (e.g. Rothaermel et al., 2007). The FT50 journals were selected in an

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effort to understand the extent to which top management journals focus on academic entrepreneurship, while the primary-area journals were selected for their depth of coverage.

Using a series of previously-identified keywords (Appendix A), we searched for articles published in these journals between 2000 and January 2017 (including articles available in pre-print form). This procedure yielded 253 results. After filtering the list to ensure that articles were empirical and focused on ways to improve academic entrepreneurship and/or its impact, we identified 209 publications for analysis.

We then read and synthesized each of these articles, compiling the information in tabular form: author, affiliation, country of affiliation, countries of interest, definition of academic entrepreneurship, variables, data used, and findings. Once we completed the synthesis, we inductively coded the definitions of academic entrepreneurship and study variables following the process recommended by Saldana (2012) and Wolfswinkel et al. (2013), including iterative open, axial, and selective coding.[2] Coding steps were undertaken iteratively, with researchers going back-and-forth between publications and emergent themes and subthemes.

Finally, to further assess the relationships between article themes, we performed a network analysis of the subthemes we identified. Thus, we began with an adjacency matrix consisting of articles on one dimension and subthemes on the other. We then transformed this two-mode matrix into a one-mode matrix with subthemes on both axes and cell values indicating the degree of overlap between subcategories. For visualization, we loaded this matrix into SocNetV, an open-source network analysis package. We employed the Kamada-Kawai algorithm for initial layout and then adjusted the layout as described in Section 6 of the findings.

3. Findings: Description of Articles

We identified articles matching our criteria in 11 of the 53 journals reviewed. Illustrated in Figure 1, 38-percent (80) of the articles were published in *Journal of Technology Transfer*, followed by *Research Policy* (57), which accounted for 27-percent. While these two journals accounted for about two-thirds of articles reviewed, the remaining articles were split among nine other journals. An initial surprising finding, therefore, is that the vast majority of FT50 journals –

[2] According to Wolfswinkel et al. (2013), the purpose of open coding is to identify, label or re-label, and build insights—categories—based on inductions from articles included in the review. The purpose of axial coding is to analyze and understand the relationship among subcategories within a respective category. Selective coding is the process of identifying and developing relationships between the main categories.

the top outlets in the field of management – have not published work in academic entrepreneurship since 2000, despite broad overall increases in the phenomenon and related articles (see Figure 2 below). Observing a similar pattern, Rothaermel et al. (2007) suggest that the focus of top journals on theory as the key publication criteria, rather than novel or important empirical contexts, may explain this pattern. Our results show that the situation has not changed in the decade since Rothaermel and colleagues' observation.

Figure 2 illustrates the number of articles published each year. Although there are several substantial year-to-year dips, the figure illustrates that an average of 0.85 additional articles are published each year. Because our list of journals is consistent over this time period and because these journals had relatively consistent page counts, on average, this finding indicates that a growing proportion of scholarship in these journals is focused on academic entrepreneurship.

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Figure 3 illustrates the distribution of publications by author. There were 353 unique authors represented by publications in our review. Most individuals authored or coauthored one (276 authors or 78-percent of the total) or two (47 authors or 13-percent of the total) publications. Thirty authors (9-percent) contributed to three or more publications. Mike Wright is an author or co-author for nearly 14-percent of articles reviewed, followed by Andy Lockett with 5-percent (see Figure 4). Of the 30 authors in Figure 4, 83-percent are in business schools, with the remainder stemming from programs such as public policy, economics and education. This finding reflects, in part, our selection of journals. Yet it also suggests that work on academic entrepreneurship is a focus of business-school-based scholars, especially. The skewed nature of authorship as well as the fact that two journals account for a high proportion of articles suggests that academic entrepreneurship remains a niche topic within the fields of entrepreneurship and management, despite the significant and increasing public attention to this phenomenon.

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Turning to author affiliation, represented in Figure 5, we see that Imperial College leads the list with 12 authors affiliated with publications in the review, followed by Nottingham

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University (9) and University of Bologna (8).[3] Notably, these are all European universities. One line of inquiry might pursue whether universities that are more innovative also produce the greatest amount of academic entrepreneurship research. For instance, Imperial College was ranked second in the Reuters Top 100 European Most Innovative Universities 2016 ranking.[4] Yet the Massachusetts Institute of Technology and Stanford University in the US, which are widely recognized as perhaps the most entrepreneurial universities in the world, rank only fifth and eleventh respectively. It is worth noting, too, that the top ten universities on our list all have a department, institute or program dedicated exclusively to innovation or entrepreneurship.

Figure 6 illustrates the country affiliation of each author.[5] Thirty-three percent of authors have US affiliations, followed by the UK, with 13-percent. Of the 15 countries that had at least two different affiliations, only four are outside of Europe; only Singapore and Israel represent Asia; and no institutions in Latin America, Africa, or Australia had multiple authors represented.

Finally, we examine which countries are the focus of academic entrepreneurship research. Illustrated in Figure 7, we find that research focused on the U.S. and U.K. account for 28 percent (79 representations) and 12 percent (35 representations) of the 287 country representations among publications within our review, respectively.[6] Moreover, of the 43 countries represented in the review, 77-percent are European countries. Thus, a relative lack of representation from Asia, Africa, the Middle East and South America characterizes both authors and empirical contexts in this literature, suggesting that current conclusions may be culturally specific.

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4. Findings: Independent Variables

Turning our attention to the factors that articles consider, Table 1 lists the eight categories of independent variables that emerged from our analysis: (1) characteristics of academic entrepreneurs, (2) human capital, (3) social networks, (4) entrepreneurial environment, (5)

[3] Affiliations were only counted once per author per university, preventing authors who appear multiple times under the same affiliation to disproportionately skew the distribution.
[4] See http://www.reuters.com/most-innovative-universities-europe
[5] Author affiliations that appeared multiple times under one same author were again counted only once, thus N in Figure 5 is 193 rather than 353.
[6] Note that 34 publications study university entrepreneurship in more than one country.

financial resources, (6) scientific, technical, and product characteristics, (7) academic entrepreneurship programs, and (8) university management and policies. The sections below discuss these independent variables and associated themes and subthemes.

<Place Table 1 About Here>

4.1. Characteristics of Academic Entrepreneurs

4.1.1. Individual Characteristics

Academic entrepreneurs make the decision to commercialize their technology individually or within the context of a team; research shows that myriad characteristics affects their ability to establish and grow a university spinoff company. First, basic demographic characteristics such as age, gender, race, family background, and citizenship are important. For example, family background, including having an entrepreneurial parent (Bergmann et al., 2016), entrepreneurial family member (Criaco et al., 2014), or history of entrepreneurship in their family, is predictive of engagement in academic entrepreneurship.

A number of studies focus on age, with most studies showing that academic entrepreneurship increases alongside age (e.g., Aldridge and Audretsch, 2011; Ambos et al., 2008; Bergmann et al., 2016; Grimm and Jaenicke, 2012; Haeussler and Colyvas, 2011; Muller, 2010; Oehler et al., 2015), which is related to academic rank (Clarysse, Tartari and Salter, 2011 RP) and seniority (Rasmussen et al., 2014). In other words, with age and academic experience, university researchers likely have the flexibility, contacts, and knowledge to participate in entrepreneurial activities (Haeussler and Colyvas, 2011; Huyghe et al., 2016b). Notable exceptions include Bercovitz and Feldman (2008), who find that faculty not involved in entrepreneurial activities early in their career are less likely to later embrace entrepreneurship, and Karlsson and Wigren (2012), who find that older university personnel are less likely to establish a company.

Hsu et al. (2007) also find that the average age for establishing a company is decreasing over time, though their focus for this finding is white males who hold U.S. citizenship – the group they determine most likely to be involved in academic entrepreneurship. Other studies, too, find that academic entrepreneurship is nearly always a male-centric enterprise (Aldridge and Audretsch, 2011, Bergmann et al., 2016; Karlsson and Wigren, 2012, Shane et al., 2015). Abreu and Grindvich (2013), Clarysse et al. (2011), and Haeussler and Colyvas (2011) similarly find that female gender correlates negatively with entrepreneurial behavior. In terms of nationality, however, the number of individuals from other countries, especially Latin America, who participate in entrepreneurial activities is increasing. Similarly, having a Chinese name is a predictive factor for attracting academic support from TTOs (Shane et al., 2015).

Finally, the eminence or prestige of faculty and the quality of their research is associated with entrepreneurship and improved entrepreneurial performance (DiGregorio and Shane, 2003; O'Shea et al., 2005; Powers and McDougall, 2005b). Similarly, the involvement of so-called “star scientists” in entrepreneurial activities is associated with improved product and employment outcomes (Zucker et al., 2002) and the likelihood that a spinoff with undertake an IPO (Fuller and Rothaermel (2012). Further, the prestige of the department (Perkmann et al., 2011) and university (Sine et al., 2003) in which an individual scientist is embedded is predictive of engagement in academic entrepreneurship.

4.1.2. Motivations and Self-Efficacy

A critical factor in entrepreneurial activities is the motivations of individual university scientists, postdoctoral fellows, and students themselves. Otherwise known as entrepreneurial motivation (Oehler et al., 2015; O’Shea et al. et al., 2008), entrepreneurial orientation (Diánez-González and Camelo-Ordaz, 2016; Kalar and Antoncic, 2015; Walter et al., 2006; Walter et al., 2016), entrepreneurial passion (Huyghe, Knockaert, and Obschonka, 2016a), or the desire to explore commercial opportunities (Toole and Czarnitzki, 2009), research shows that motivations determine the extent to which university scientists participate in entrepreneurial activities, including spinoff establishment (e.g. O’Shea et al., 2008), patenting (e.g. Walter et al., 2006) and commercialization activities writ large (e.g. Renault, 2006). Hayter (2011) and Lowe and Ziedonis (2006) also examine post-establishment entrepreneurial motivations related to spinoff growth; Schillo (2016) examines firm-level ambitions and strategies.

D’Este and Perkmann (2011) find that university scientists who patent and establish spinoff companies are driven by commercialization motivations, a theme resonating among other scholars. Owen-Smith et al. (2001), for example find that scientists patent for so-called personal benefits, while Rizzo (2015) finds that PhDs found companies out of financial necessity. While Hayter (2011; 2015) and Lam (2011) similarly find that financial gain is an important motivation, they also find that academic entrepreneurs are motivated by many other personal and professional reasons. Hayter (2011; 2015) finds, for example, that faculty seek to develop their respective

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technologies that may or may not include plans for commercialization; Kolb and Wagner (2015) find that faculty may be "overly-motivated" by scientific and technical issues.

Studies also find that university scientists are usually motivated by academic rationales, at times conflicting with commercial- and growth-minded motivations (Huyghe et al., 2016a; Toole and Czarnitzki, 2009). Specifically, scientists often view academic entrepreneurship—along with joint research with industry and consulting (D'Este and Perkmann, 2011)—as a way to obtain financial resources in support of their research agenda and in advancement of their academic career (Fini et al., 2009; Hayter, 2011; 2015; Lam, 2011; O'Gorman et al., 2008; Owen-Smith et al., 2001). Further, faculty sometimes see their spinoff companies as a way to provide jobs to students, just as PhD students see it as a way to provide jobs to themselves (Hayter, 2011; Rizzo, 2015).

While conceptually different from professional and entrepreneurial motivations, identity and self-efficacy among individual academic entrepreneurs are also important considerations for academic entrepreneurship. Self-efficacy is one's perception of their own ability to successfully undertake entrepreneurship (Huyghe et al., 2016a), also known as self-perceptions of entrepreneurial capability (Guerrero and Urbano, 2014). Self-efficacy and motivations may both be related to identity; Jain et al. (2009) find that most academic entrepreneurs see themselves first as scientists and, second, entrepreneurs.

4.2. Human Capital

4.2.1. Academic Entrepreneurs

Human capital refers to the general knowledge of individuals obtained through formal education and experience. Following traditional human capital views, scholars find that technical education levels (Astebro et al., 2012; Hsu et al., 2007; Sideri and Panagopoulos, 2016) and research excellence are predictive of entrepreneurial activity. Research excellence may be associated with star scientists (Fuller and Rotheraermel, 2012; Zucker et al., 2002) or research groups (Rasmussen and Wright, 2015). According to Bercovitz and Feldman, (2008), where the university scientist was trained matters, too; scientists trained at a university with high levels of entrepreneurial activity are more likely to become academic entrepreneurs.

Researchers also have linked publishing, a proxy for the role of human capital in the production of new knowledge, to positive entrepreneurial outcomes (Haeussler and Colyvas, 2011; Horta et al., 2015; Karlsson and Wigren, 2012; Mindruta, 2012; Van Looy et al., 2011) – especially

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co-publication with industry researchers (Aldridge and Audretsch, 2011). The experiential basis of human capital – non-academic experience (Grimm and Jaenicke, 2012) and engagement (Tartari et al., 2014), especially experience working with industry – is generally predictive of entrepreneurial activity among university scientists (e.g., Aldridge and Audretsch, 2011; Criaco et al., 2014; Knockaert et al., 2010b; Lavie and Drori, 2012; Rasmussen et al., 2014; Shane et al. 2015; Todorovic et al., 2011; Wennberg et al., 2011; Wright et al., 2004). Industry relationships include pre-founding links with industry (Swamidass et al., 2009), total hours spent working with industry (Agrawal, 2006), industry consulting (D'Este and Perkmann, 2011; Gassol, 2007) and department-level industry connections (Rasmussen et al., 2014). Consulting with government agencies can also be important (Perkmann et al., 2011).

Entrepreneurial experience, including patenting (D'Este et al., 2012; Niosi, 2006; Kolympiris and Klein, 2017), product development (Karlsson and Wigren, 2012), and prior spinoff invovlement (Abreu and Grindvich, 2013; Algieri et al., 2013; Clarysse, Tartari and Salter, 2011; Karlsson and Wigren, 2012; Muscio et al., 2016; Rasmussen et al., 2011; Scholten et al., 2015), is also predictive of future entrepreneurship activity. The logic is that these experiences allow university scientists to develop the ability to recognize market opportunities and increase their level of entrepreneurial knowledge (Clarysse, Tartari and Salter, 2011; Davey et al., 2015; Oehler et al., 2015). Further, human capital oriented toward exploring commercial opportunities, as opposed to human capital oriented toward science, significantly improves the performance of spinoff firms (Toole and Czarnitzki, 2009).

While research shows that the involvement of founding academic entrepreneurs is critical to academic entrepreneurship success, the tradeoff is that founding scientists tend to maintain their academic identity and inhibit spinoff development (Clarysse and Moray, 2004; Franklin et al., 2001; Friedman and Silberman, 2003; Hayter, 2011; Johansson et al., 2005; Markman et al., 2005a). Scholars thus posit that spinoff development is dependent upon the presence of a professional manager or "surrogate entrepreneur" (Bray and Lee, 2000; Carayannis et al., 2016; Clarysse and Moray, 2004; Franklin et al., 2001; Lockett et al., 2003; Lundqvist, 2014; Vanaelst et al., 2006; Vohora et al., 2004; Wurmseher, 2017) who provides leadership, experience, and connections to funders. Yet while the presence of a surrogate entrepreneur is a critical developmental milestone (e.g. Vohora et al., 2004), these individuals might not possess the

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capability to understand the technology associated with a spinoff or the credibility and influence required to work with university scientists (Franklin et al., 2001; Knockaert et al., 2010a).

While most scholarship has focused on the role of faculty as academic entrepreneurs, a modest literature also focuses on the role of students and postdocs (Boh et al., 2016; Rasmussen and Wright, 2015; Pirnay et al., 2003). The focus on students-as-entrepreneurs flowed from the emergence of entrepreneurship education programs within universities (Rasmussen and Sorheim, 2006; Souitaris et al., 2007). More recent research, however, examines the role of PhDs and postdoc entrepreneurs in the establishment of new spinoff companies, as well as challenges to their success (Hayter et al., 2017).

4.2.2. Founding Teams

Scholars assume that non-academic members of founding spinoff teams are critical to entrepreneurship activities under the assumption that the limited commercial experience of founding university scientists eventually constrains spinoff development (Bathelt et al., 2010; Dianez-Gonzalez and Camelo-Ordaz, 2016; Ensley and Hmieleski, 2005; Rasmussen et al., 2011; Visintin and Pittino, 2014). Other team-related factors include the number and technical experience of inventors (Knockaert et al., 2010a), clarity of team-member roles (Clarysse and Moray, 2004; Grandi and Grimaldi, 2003), and levels of trust and familiarity among team members (Grandi and Grimaldi, 2005; Knockaert et al., 2010a). Spinoff teams also must evolve over time to include individuals with relevant business and commercialization experience (Vanaelst et al. 2006; van Geenhuizen and Soetanto, 2009). Similarly, Bjornali and Gulbrandsen (2010) and Aldridge and Audretsch (2011) focus the role of spinoff boards, especially the evolution from academic representation to one that enables connections to financial resources, entrepreneurial advice, and other resources important to spinoff performance.

4.3. Social Networks

4.3.1. Individual Social Networks

Given the limited commercial experience of university faculty, networks with outside contacts are crucial to motivate entrepreneurial activities as well as their success (e.g., Agarwal and Shah, 2014; Druilhe and Garnsey, 2004; Fini et al., 2011; Grandi and Grimaldi, 2003; 2005; Guerrero et al., 2014; Heblich and Slavtchev, 2014; Hunter et al., 2011; Jefferson et al., 2016;

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Lockett et al., 2003; Nicolaou and Birley, 2003a; 2003b; Nilsson et al., 2010; O'Gorman et al., 2008; Scholten et al., 2015; Soetanto and van Geenhuizen 2015; Vohora et al., 2004). Specifically, social networks are important sources of informal advice and mentoring (Abreu and Grindvich, 2013; Boh et al., 2016; Muller, 2010), technical and managerial expertise (Huyghe et al., 2014), and early stage funding, such as venture capital (Huyghe et al., 2014; Shane and Stuart, 2002). Thus, university spinoffs with structural holes (missing connections to important contacts) or homophilous networks (networks dominated by other academics) are constrained in their ability to evolve (Johansson et al., 2005; Mosey and Wright, 2007; Wright et al., 2004).

4.3.2. Organizational Networks and Entrepreneurship Support

Given the importance of networks, the efficacy of universities' efforts to support entrepreneurship depends on the diversity and quality of their organizational networks. Rasmussen and Borsch (2010) and Rasmussen et al. (2011), for example, emphasize the role of organizational intermediaries and their role in connecting (or not) academic entrepreneurs to contacts with valuable resources. Unfortunately, research shows that the networks of TTOs—often a critical point of exposure to commercial resources (Clarysse, Wright and Van de Velde, 2011; Comacchio et al., 2011)—are generally limited (Clarysse et al., 2014; Perez and Sanchez, 2003). Networks associated with university incubators (Cooper et al., 2012; Peters et al., 2004), science parks (Zou, 2014), alumni networking events (Levie, 2014), engineering research centers (Boardman and Corley, 2008) and PoCCs (Gulbranson and Audretsch, 2008; Maia and Claro, 2013) also play an enabling (or constraining) role for academic entrepreneurs and their spinoffs.

4.4. Entrepreneurial Environment

4.4.1. Culture

Research shows that culture—otherwise termed subjective entrepreneurial norms (Guerrero and Urbano, 2014)—is critical for academic entrepreneurship and is manifest at the departmental (Ambos et al., 2008; Bercovitz and Feldman, 2008; Clarysse et al., 2011; Kalar and Antoncic, 2015; Kenney and Goe, 2004; Jong, 2008; O'Shea et al., 2008; Rasmussen et al., 2014), university (Colyvas, 2007; Clarysse et al., 2011; Owen-Smith et al., 2001), regional (Clarysse et al., 2014), and national levels (Carayannis et al., 2016; Davey et al., 2016; Gassol, 2007; Jefferson et al., 2016).

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University-centric views also include the culture of associated sub-units such as medical schools (Bercovitz and Feldman, 2008); specialized research centers (Nelson, 2014), including engineering research centers (Boardman and Corley, 2008; Feller et al., 2002; Hunter et al., 2011); and science parks (Zou, 2014). Studies also focus on the cultural context related to student entrepreneurship (Bergmann et al., 2016) as well as scenarios whereby university culture presents a barrier to business engagement (Siegel et al., 2003).

The basis of an entrepreneurial culture is academic peers, both at the university and within an entrepreneur's academic discipline (Bercovitz and Feldman, 2008). Specifically, peers potentially increase (or constrain) the propensity of their colleagues to engage with industry (Tartari et al., 2014), patent (Haeussler and Colyvas, 2011; Owen-Smith et al. (2001) and establish spinoff companies (Bergmann et al., 2016; Hayter, 2011). Further, entrepreneurial activity generally reinforces culture as successful academic entrepreneurs become role models for their departments, universities, and regions (Steffensen et al., 2000).

4.4.2. Locational Factors

A symbiotic relationship potentially exists between entrepreneurial universities and the regions in which they are embedded. Policymakers have focused on increasing the regional economic impact of universities through students' "externships" (Bramwell and Wolfe, 2008), industrial engagement by faculty and students (Tartari et al., 2014), spinoff company establishment (Steffensen et al., 2000), and "non-traditional" university policy and outreach services (Breznitz and Feldman, 2012).

Scholars have similarly focused on the impact of regions on academic entrepreneurship; high tech regions, especially those in which other spinoffs have been established (Zhang, 2009), often provide valuable resources and networks critical to academic entrepreneurship (Alegieri et al., 2013; Degroof and Roberts, 2004; Friedman and Silberman, 2003; Heblich and Slavtchev, 2014; Shah and Pahnke, 2014; Sternberg, 2014), especially venture capital (Powers and McDougall, 2005b; Samilla and Sorenson, 2010) and connections to relevant industries (Casper, 2013; Nilsson et al., 2010). Regional environments influence university entrepreneurship strategies (McAdam et al., 2016; Powers and McDougall, 2005a) and how universities organize and manage their TTOs (Brescia et al., 2016). Further, entrepreneurial regions may influence

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academic entrepreneurs to bypass their TTOs and patent their invention on their own or with assistance from a company in the region (Gianodis et al., 2016).

Regional entrepreneurial services and facilities beyond those provided by universities – such as science parks (Link and Scott, 2005; Zou, 2014), incubators, service providers (Rasmussen et al., 2006), and other forms of entrepreneurial support (O'Shea et al. 2008; Powers and McDougall, 2005a) – can be helpful to early-stage spinoffs.

Other scholars have focused on the explanatory importance of regional economic characteristics such as consumer confidence and unemployment (Horta et al., 2015), regional prosperity (Bergman et al., 2015), and R&D expenditures (Fini et al., 2009; Van Looy et al., 2011).

4.5. Financial Resources

4.5.1. R&D Funding

The basis for university spinoff technologies is R&D support. Thus, scholars attribute entrepreneurship activity, including number of spinoffs and IP outputs, to total university R&D expenditures (Algieri et al., 2013; Davey et al., 2016; Link and Scott, 2005; Markman et al., 2004; Meoli and Vismara, 2016; O’Shea et al., 2005). Interestingly, entrepreneurial activity not only allows universities to potentially generate revenue from licensing, but also enables universities to increase their reputation and thus obtain higher levels of R&D funding (Pitsakis et al., 2015).

Federal R&D funding constitutes the bulk of this funding. Specific funding agencies, such as the (U.S.) Department of Defense and National Science Foundation, have a higher likelihood of leading to entrepreneurial behavior (Samilla and Sorenson, 2010). Defense-related funding, however, may also come with security-related constraints on its dissemination, thus limiting its economic impact (Plummer and Gilbert, 2015).

Non-government R&D funding, especially from industry, is especially important; not only does industrial R&D support lead to increasing levels of entrepreneurial activity among universities (Powers and McDougall, 2005b; O’Shea et al., 2005), it also provides researchers with valuable opportunities to interact with company researchers and gain commercial experience (Karlsson and Wigren, 2012; O’Shea et al., 2008; Renault, 2006). Further, Feldman et al. (2002) find that industry funding is associated with higher levels of equity involvement among universities. Wu (2010), however, warns that there may be a tradeoff between increasing levels of industry support and the number of spinoffs generated from a university.

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Philanthropic foundations are also playing an increasingly important role in funding R&D in an attempt to find novel solutions to, for example, chronic disease, though concern exists about lower overhead rates and potential "over-involvement" associated with foundations (Feldman and Graddy-Reed, 2014).

4.5.2. Early-stage Venture Funding

While early-stage public and university funding programs are discussed below, scholars have long investigated the role of early-stage venture funding in university spinoff success (Alegieri et al., 2013; Degroof and Roberts, 2004; Druilhe and Garnsey, 2004; Huyghe et al., 2014; Rasmussen et al., 2006; 2008). Scholars have primarily focused on the importance of venture capital (VC) and its role in entrepreneurial development (Fini et al., 2009; Bray and Lee, 2000; O'Shea et al., 2008; Zucker et al., 2002), such as achieving an IPO (Shane and Stuart, 2002). As mentioned, the availability of VC within regions where spinoffs are located is important to their success (Powers and McDougall, 2005b; Samilla and Sorenson, 2010). Venture capitalists complement financial resources by also providing academic entrepreneurs with credibility (Fernández-Alles and Camelo-Ordaz, 2015), technical and managerial advice (Hayter, 2016a; Knockaert et al., 2010a), and connections with industry (Vohora et al., 2004).

4.6. Scientific, Technical, and Product Characteristics

4.6.1. Research Discipline

Similar to the role of research *funding* discussed above, research *focus* is likely just as important to entrepreneurship outcomes. IP outputs (patents) are closely associated with the life sciences (Fini et al., 2010; Kenney and Patton, 2011) and biotechnology (Kolympiris and Klein, 2017), though other scholars include the physical sciences (Owen-Smith et al., 2001). While the life sciences and biotechnology are also associated the establishment of spinoffs (Abreu and Grindvich, 2013; Fini et al., 2009; Kalar and Antoncic, 2015; Zhang, 2009), other relevant disciplines include physics, engineering, information and communication technologies (Abreu and Grindvich, 2013; Haeussler and Colyvas, 2011; Hsu et al., 2007; Knockaert et al., 2010b; Nelson, 2014). Although Karlsson and Wigren (2012) associate law and social sciences, too, with entrepreneurial behavior, Kalar and Antoncic (2015) do not.

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4.6.2. Technology

Scholars contend that technologies underlying commercial behavior are an important consideration for academic entrepreneurship. The nature of knowledge, codified and tacit, underlies a technology (Pirnay et al., 2003). University technology-transfer operations generally favor codified knowledge because it may be easily patented and licensed by large companies, thus generating revenue (Meyer, 2006). However, patent-centric views overlook the value of tacit knowledge, which is critical to spinoff companies (Karnani, 2012; Wood, 2009). Technology maturity is a related consideration with well-developed technology sometimes better suited for licensing (Agrawal, 2006), while the scope and pioneering nature of a technology is associated with its commercialization (Nerkar and Shane, 2003). In contrast, Colyvas et al. (2002) posit that patents are important for embryonic technologies.

Finally, Lowe and Ziedonis (2006) find that spinoffs hold onto unsuccessful technologies longer than other types of firms. Thus, spinoffs have a better chance of success when they develop a broader scope of technologies and focus on commercialization as opposed to advancing a specific technology (Clarysse et al., 2011; D'Este et al., 2012).

4.7. Academic Entrepreneurship Support Programs

4.7.1. Technology Transfer Offices

Technology Transfer Offices (TTOs) have received substantial attention in the literature, with most scholars considering their presence to be a critical element of an academic entrepreneurship ecosystem (Fini et al. 2011; Degroof and Roberts, 2004; Hsu et al., 2007; Jacob et al., 2003; Jefferson et al., 2016; O'Gorman et al., 2008). TTOs provide management support to early spinoff teams (Fernández-Alles and Camelo-Ordaz, 2015) as well as financial support, technical expertise, and connections to other researchers and companies (Huyghe et al., 2014).

However, scholars have raised doubts about the ability to TTOs to provide entrepreneurial assistance beyond initial spinoff establishment (Hayter 2016b; Mosey and Wright, 2007; Rasmussen and Wright, 2015). One concern is that TTOs' IP protection mission prioritizes revenue generation over entrepreneurial activity (Fini et al., 2009; 2016; Markman et al., 2004; Swamidass et al., 2009), industry engagement (Perkmann et al., 2013) and relationship-building between universities and industry (Clarysse et al., 2014). Interactions with TTOs also constitute a

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significant investment in time, detracting from other important scientific and commercial activities (Owen-Smith et al., 2001).

The effectiveness of TTOs in academic entrepreneurship is also impacted by the TTO's access to resources (O'Shea et al., 2005; O'Shea et al., 2008), its size (number of employees) (Algieri et al., 2013; Horta et al., 2015; Kolympiris and Klein, 2017; Markman et al., 2005a), its age (Kolympiris and Klein, 2017; Powers and McDougall, 2005b), its hiring and compensation practices (Markman et al., 2004; Siegel et al., 2003; Swamidass et al., 2009), as well as its equity involvement in spinoffs (Feldman et al., 2002). Further, TTO legitimacy (O'Kane et al., 2015); management and business development capabilities (Bercovitz et al., 2001; Lockett and Wright, 2005); resources spent on IP protection (Lockett and Wright, 2005), for-profit structure (Markman et al., 2005b); ability to connect to bridge important social networks (Clarysse, Wright and Van de Velde, 2011; Comacchio et al., 2011; Markman et al., 2005a); and awareness levels among faculty of its existence (Huyghe et al., 2016b - SBE) are also determinant. TTO efficacy is also seen as a function of its organizational form (Brescia et al., 2016), especially the degree to which it is decentralized (Carayannis et al., 2016). Due to frustration, perceived TTO ineffectiveness, the discipline of their technology, or illicit behavior, faculty may choose to bypass their TTO (Fini et al., 2010; Gianodis et al., 2016).

4.7.2. University Entrepreneurship Programs

Beyond TTOs, a diverse literature explores the role and, at times, the efficacy of various university entrepreneurship support programs and infrastructures (Ndonzuau et al., 2001; Powers and McDougall, 2005a). These elements include incubators (e.g., Barbero et al., 2014; Boh et al., 2016; Cooper et al., 2012; Kolympiris and Klein, 2017; Lundqvist, 2014; McAdam et al., 2008; 2016; Mustar and Wright, 2010; Peters et al., 2004; Rothaermel and Thursby, 2005) and science parks (Link and Scott, 2005; Wright et al., 2007; Zou, 2014)—or both (Fernández-Alles and Camelo-Ordaz, 2015; Phan et al., 2005; Salvador, 2011). These studies focus on the role these elements play in providing physical space, technical and financial resources, access to important networks, and coaching to academic entrepreneurs. [V]an Geenhuizen and Soetanto (2009) contend, however, that physical space (the focus of many incubator and science park initiatives) does not generally seem to be a problem for successful spinoffs and is thus of marginal value relative to, for example, assistance in putting together effective entrepreneurial teams. Further,

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these studies collectively show that science parks and incubators produce mixed results. Thus, their role in academic entrepreneurship is likely dependent on myriad contextual factors.

University seed funds are also recognized as a critical entrepreneurship ecosystem element (Algieri et al., 2013; Degroof and Roberts, 2004; Guerrero et al., 2014; Jacob et al., 2003; Jefferson et al., 2016; Mustar and Wright, 2010; O'Shea et al., 2005; Rasmussen et al., 2006; 2008; Swamidass, 2013). Wright et al. (2006) posit that these funds are needed because venture capitalists do not invest in early stage companies. Moreover, the funds provide an important signal to outside investors; they support intangible goals of the university (e.g. building an entrepreneurial culture); and they help strengthen networks with regional stakeholders (Gubitta et al., 2015; Munari et al., 2015). Munari et al. (2015), however, find that spinoffs receiving university seed funds have a lower likelihood of IPO. Croce et al. (2014) find that university funds in the U.S. seem to be outperforming those in Europe, perhaps due to their disciplinary and later-stage spinoff focus.

Entrepreneurship education, either as part of a degree program or extra-curricular offering, can provide students and faculty knowledge important to encourage and support entrepreneurial endeavors (Bergmann et al., 2016; Boh et al., 2016; Carayannis et al., 2016; Criaco et al., 2014; Guerrero et al., 2014; Jacob et al., 2003; Jefferson et al., 2016; Levie, 2014; Oehler et al., 2015; Rasmussen, 2008; Souitaris et al., 2007; Swamidass, 2013). However, Astebro (2012) contends that science and engineering education among students is far more important to their long-term entrepreneurial contributions compared to the growing emphasis on entrepreneurship classes.

Rasmussen et al. (2006) contends that entrepreneurship education should fit within an overall commercialization strategy of a university, and be conceptualized as a suite of educational offerings, programs, and policies that will enable students to undertake entrepreneurial activity. Entrepreneurship education can be incorporated into ongoing entrepreneurship support efforts, such as the NSF iCorps program (Huang-Saad et al., 2016), as well as proof-of-concept centers (Maia and Claro, 2013), just as MBA students can support academic entrepreneurship by training them in IP negotiation (with the TTO), market analysis, technology evaluation, and technology feasibility analysis (Nelson and Monsen, 2014; Phan, 2014).

Proof-of-concept centers (PoCCs) have emerged as a promising academic entrepreneurship support mechanism that combines entrepreneurship education, mentoring, networking, and technology development services, often in combination with modest levels of funding to support

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entrepreneurial activities (Bradley et al., 2013; Gulbranson and Audretsch, 2008; Maia and Claro, 2013; Munari et al., 2016). While the efficacy of these programs has not been evaluated, Hayter and Link (2015) find that universities with PoCCs tend to produce higher number of spinoffs.

Industry research centers—such as the (U.S.) NSF-sponsored Engineering Research Centers (ERCs)—not only encourage faculty to work with industry, but also promote collaboration within and among universities (Boardman and Corley, 2008; Feller et al. 2002). Youtie and Shapira (2008) industry research centers at Georgia Tech which, with federal and state support, focus on promoting innovation within traditional and advanced industries.

Recent research focuses on the emergence of university business plan competitions (Boh et al., 2016; Hsu et al., 2007; Jefferson et al., 2016), such as the MIT 100k challenge (Swamidass, 2013). These competitions encourage students and faculty to think in terms of market demand and the steps that their business must take to respond. Scholars have similarly focused on the importance of business plan assistance services (Rasmussen et al., 2006), management services (Bray and Lee, 2000), marketing services (Colyvas et al., 2002; Soetanto and Jack, 2016), networking support (Soetanto and Jack, 2016), student entrepreneurship support organizations (Rasmussen et al., 2006), the provision of "consumables" (Rasmussen et al., 2014), and shared laboratory space and research services for spinoffs and other industrial partners (Gassol, 2007).

Finally, hackathons offer students an opportunity to focus on quickly developing applications, such as phone apps, that provide the basis for entrepreneurship activity (Shah and Pahnke, 2014). Technology competitions similarly bring diverse groups to address a specific technological need and attract public attention (Eesley et al., 2016; Mustar and Wright, 2010).

4.8. National Programs and Policies

Limited attention has been placed on the role of national programs and policies and their role critical role supporting academic entrepreneurship. What research exists focuses on the emergence of national intellectual policy frameworks (Fini et al., 2011; Muscio et al., 2016), such as the Bayh-Dole Act in the U.S. and its impact on the scientific and entrepreneurial behavior of universities (Mowery et al., 2001). Other countries, such as France, have introduced national legislation that authorize university employees—whose commercial activities were once limited—to establish spinoff companies (Mustar and Wright, 2010).

Other research has focused on national entrepreneurship support programs, such as Germany's EXIST program (Ayoub et al., 2016), Canada's industrial assistance grant program (Niosi, 2006), and the U.S. iCorps program (Huang-Saad et al., 2016), and their role in academic entrepreneurship. Scholars have also used data from national programs, such as the (U.S.) SBIR program to understand academic entrepreneurship and entrepreneurship writ large (e.g. Toole and Czarnitzki, 2009; Siegel and Wessner, 2010). Mustar and Wright (2010) examine government attempts to establish seed capital funds and innovation agencies within the U.K. and France. Similarly, national government funding has been used to support some of the aforementioned university-level programs, including science parks (Zou, 2014), entrepreneurship education (Rasmussen and Sorheim, 2006), innovation awards (Eesley et al., 2016), and engineering research centers (Boardman and Corley, 2008).

Scholars recommend that entrepreneurship support programs be supplemented by tax benefits to assist spinoff firms (Henrekson and Rosenberg, 2011; Patzelt and Shepherd, 2009). Further, regulation and excessive bureaucracy can stifle entrepreneurship (Henrekson and Rosenberg, 2011; Zou, 2014). Thus, national regulation reform initiatives are complementary to entrepreneurship efforts (Goldfarb and Henrekson, 2003; Klofsten, 2000).

4.9 University Management and Policy

4.9.1. University Management

Although scholars have examined the impact on academic entrepreneurship of university characteristics such as size (Horta et al., 2015; Van Looy et al., 2011) and the presence of a medical school (Feldman et al., 2002), far more attention has been given to management practices and policies. Scholars emphasize the foundational role of a clear entrepreneurship-focused university mission (Davey et al., 2016; Friedman and Silberman, 2003; Guerrero and Urbano, 2014; Jefferson et al. 2016; Levie, 2014; Nilsson et al., 2010; O'Shea et al. et al., 2008); Breznitz and Feldman (2012) favor defining the university economic development mission broadly to include myriad services including real estate development and policy advice.

Scholars also have focused on the positive role or inadequacy of university administration (Meoli and Vismara, 2016; Rasmussen and Wright, 2015). For example, university administrators generally focus on top-down academic entrepreneurship initiatives; yet decentralized, integrative initiatives are not only more effective, but also more closely aligned with the decentralized nature of science (Carayannis et al., 2016; Debackere and Veugelers, 2005; Hayter, 2016b; Henrekson and Rosenberg, 2011; Philpott et al., 2011; Rasmussen and Borch, 2010; Todorovic et al., 2011). Similarly, Colyvas et al. (2007) recommend that universities focus on the co-evolution of systems to fit both academic and commercial goals. Carayannis et al. (2016) recommend that universities focus on integrated ecosystem approaches which might include funding and other incentives for different units to work together (Debackere and Veugelers, 2005; Jefferson et al., 2016). Such actions might provide a university-wide entrepreneurship focus and might, for example, better align the efforts of business schools in support of academic entrepreneurship (Wright et al., 2009).

4.9.2 Incentives and Policy

Given that many universities have adopted economic development missions, scholars have taken an interest in incentives and policies that encourage and support academic entrepreneurship (Degroof and Roberts, 2004; Wright et al., 2009). Research shows that incentives increase university-level licensing and revenue (Siegel et al., 2003) and spinoff activity (Muscio et al., 2016), though Markman et al. (2004) show incentives discourage commercial behavior. Walter et al. (2013) posit that university incentives are needed to encourage technology disclosure and patenting, while Rasmussen et al. (2006; 2008) posit that departmental incentives are critical – though faculty may respond differently to different incentives (Colyvas et al., 2007).

University IP policies have been of particular interest to scholars. While Baldini et al. (2006) shows that the adoption of university patent regulations can spur industrial engagement, Karnani (2012) posits that universities overvalue patents. University IP policies that prioritize patenting may reduce scientific collaboration (Feller et al., 2002), the knowledge available for future research (Mowery et al., 2001), and publishing (Walter et al., 2013). Colyvas et al. (2002) contend that patents are not valuable for well-developed technologies except for revenue generation for the university. At worst, patent-centric IP policies are often not linked with the entrepreneurial goals and support mechanisms of a university (Markman et al., 2005b) and may hinder entrepreneurial outcomes (Fini et al., 2016).

Conversely, university policies favoring equity approaches to IP are generally supportive of academic entrepreneurship (Bray and Lee, 2000; DiGregorio and Shane, 2003; Lockett et al., 2003; Markman et al., 2005b; Rasmussen et al., 2006; Rasmussen, 2008), though Shane (2002) finds—in the case of spinoffs—that licensing back to an inventor reduces the likelihood of commercialization.

Payout to the inventor (Friedman and Silberman, 2003) and other revenue-sharing agreements stimulate entrepreneurial behavior (Renault, 2006), though DiGregorio and Shane (2003) find that keeping the revenue share low increases propensity of inventors to establish a company. Further, Bramwell and Wolfe (2008) posit that the inventor-ownership policies at University of Waterloo (Canada) are an important aspect of its entrepreneurial impact; Kenney and Patton (2011) find that Waterloo has spun off far more companies with far less R&D spending compared to other prominent universities in the U.S., and they attribute this fact to the university's IP ownership policy.

Beyond IP policies, scholars also have examined conflict of interest policies. Jefferson et al. (2016), Meoli and Vismara (2016) and Rasmussen and Borch (2010) find that conflict-of-interest policies are important for encouraging entrepreneurial activity, while Renault (2006) and Nelson (2014) find that conflict of interest can diminish entrepreneurial behavior by adding to administrative red tape or prohibiting certain roles.

5. Findings: Dependent Variables

Table 2 presents dependent variables from reviewed publications grouped by academic entrepreneurship themes, sub-themes, and the number of corresponding articles. Three dependent variable themes are emergent: (1) spinoffs, (2) university role, and (3) IP outputs. The sections below review the literature affiliated with each of these categories, highlighting the main themes.

<Place Table 2 About Here>

5.1 University Spinoffs

A majority of articles in our review (135) frame academic or university entrepreneurship in terms of establishment and outcomes of spinoff companies. Traditional definitions of spinoffs have focused on the role of faculty establishing a company based on a technology licensing agreement with their home university (e.g. Shane, 2004). However, scholars have broadened their definition of university spinoff to include companies that do not necessarily have a formal licensing agreement with a university (e.g. Fini, Lacetera & Shane, 2010), as well as the establishment of spinoffs by individuals other than faculty, including postdocs and graduate students (e.g. Hayter et al., 2017). The following section describes the dependent variables used in reviewed publications categorized by subtheme.

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5.1.1 Startup Decision

Several studies focus on the decision to establish a spinoff. These studies typically focus on individual-level factors, the most common of which are entrepreneurial motivations (O'Gorman, Byme & Pandya, 2008; Rizzo, 2015), post-establishment growth ambitions (Hayter 2011; 2015), start-up intentions (Guerrero & Urbano, 2014; Huyghe, Knockaert, & Obschonka, 2016), entrepreneurial propensity (Aldridge & Audretsch, 2011), determinants of new venture formation (Fini, Fu, Mathisen, Rasmussen & Wright, 2016; Karlsson & Wigren, 2012), and role identity as a precursor to entrepreneurial behavior (Jain, George & Maltarich, 2009).

While Davey et al. (2016) examines individual-level determinants of academic entrepreneurship within different national contexts, Dianez-Gonzalez and Camelo-Ordaz (2016) proxy the entrepreneurial orientation of individual spinoff companies based on the proportion of the founding team comprised by non-academics.

Although most studies focus on university faculty, Oehler, Höfer and Schalkowski (2015) investigate entrepreneurial understanding among university students under the assumption that knowledge predicts entrepreneurial action. Bergmann, Hundt & Sternberg (2016) similarly investigate factors that motivate students to become entrepreneurs. Hsu, Roberts & Eesley (2007) examine startup intentions among university alumni. Muller (2010) investigates the speed of establishing a spinoff firm among students, graduates, and researchers after leaving academia.

Other studies examine university-level factors that shape the decision to establish a spinoff. Kenney and Goe (2004), for example, examine the role of university departments in encouraging academic entrepreneurship, just as Kalar and Antoncic (2015) examine the entrepreneurial orientation of individual departments. Markman et al. (2005) and Shane et al. (2015) investigate factors that shape when a TTO encourages faculty to start a company versus license their technology to an existing company. Huyghe et al. (2014) similarly examine the role of TTOs during the early phases spinoff company establishment.

5.1.2 Counts of Spinoffs

Other studies focus not on the decision to spinoff a company, but rather on tracking actual spinoffs. Several publications focus on the number of spinoff companies established by universities. The oldest of these publications (DiGregorio & Shane, 2003; O'Shea, 2005) use data

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from the Association of University Technology Managers (AUTM) to examine university-level factors that help explain spinoff establishment. Similarly, Hayter and Link (2015) use AUTM data to explain spinoff differences among universities with proof-of-concept centers and those without. Kenney and Patton (2011) use hand-collected spinoff data from six universities (five from the U.S. and one from Canada), while Link and Scott (2005) employ a survey of U.S. science parks to explain how many affiliated organizations are spinoff companies. Kolb and Wagner (2015) investigate spinoff propensities among those employed at a university compared to those who are not.

Several studies focuses on spinoff establishment examine the Italian context, specifically (Algieri et al., 2013; Fini et al., 2011; Horta et al., 2016; Meoli and Vismara, 2016; Muscio et al., 2016). Still other articles use a combination of number of spinoffs and number of IP outputs (Ambos et al., 2008; Friedman and Silberman, 2003; Grimm and Jaenicke, 2012, Guerrero, Urbano, Cunningham and Organ, 2014; Markman et al., 2004; McAdam et al., 2016; Powers and McDougall, 2005a; Samilla and Sorenson, 2010) to assess academic entrepreneurship.

5.1.3 Intermediate Spinoff Outcomes

Instead of focusing on the establishment of spinoffs, other scholars focus on various milestones in the development of a spinoff company – what we term "intermediate outcomes." Our review identified four categories of intermediate spinoff outcomes, including founding teams, funding, business ideas and knowledge, and social networks.

The composition and dynamism of founding teams is of critical importance, from early formation to organization sustainability. For example, Wurmseher (2017) conceptualizes three different roles of faculty founders and the relationships of these roles to future spinoff success. Franklin et al. (2001) focus on the importance of surrogate entrepreneurs, professional, non-academic managers, relative to faculty founders, while Bjornali and Gulbrandsen (2010) focus on the composition of the spinoff board of directors and the importance of their networks for obtaining resources and technical resources for the spinoff. Finally, Grandi and Grimaldi (2003) focus on the developmental dynamics of a founding team.

Other studies focus on financial resources as development milestones. Soetanto and van Geenhuizen (2015) use early-stage funding from all sources, while Fini et al. (2016), Lockett and Wright (2005), Knockaert et al. (2010b), and Wright et al. (2006) and focus on venture capital as an important proxy of spinoff success. Gubitta et al. (2015) focus on university gap funding, suggesting that it serves as an important signal to outside investors. Bercovitz et al. (2001) focus on sponsored research, while Toole and Czarnitski (2009) examine the US Small Business Innovation Research (SBIR) awards.

Grandi and Gramaldi (2005) were among the first scholars to examine the role of business ideas as an intermediate outcome. Similarly, Karnani (2012) creates a typology of business knowledge as an intermediate outcome while Walter, Schmidt and Walter (2016) use patenting propensity to proxy for knowledge creation. (Note that we separate this perspective from articles that focus on IP outputs for their own sake.)

Finally, six articles in our review use social networks as an intermediate outcome for spinoff development. Steffensen, Rogers and Speakman (2000), for example, examine networks between spinoffs and their respective home university in terms of conflict and entrepreneurial support. Nicolaou and Birley (2003a) create a categorization of social networks among spinoff founders while Mosey and Wright (2007) examine challenges within networks related to spinoff development among academic entrepreneurs. Cooper, Hamel and Connaughton (2012) use networking within the context of an incubator as a proxy for spinoff development. Nicolaou and Birley (2003b) and Perez and Sanchez (2003) examine the evolution of spinoff social networks, the latter focusing on the transformation of networks from those focused on academic contacts to those focused on existing and potential customers.

5.1.4 Spinoff Outcomes

Fifty-three articles focused on spinoffs examine longer-term outcomes. Our analysis divided spinoff outcomes into three types of dependent variables: survival, development, and performance outcomes. Only a handful of studies in our review examine spinoff survival (Criaco et al., 2014; Schillo, 2016; Zhang, 2009). More commonly, articles use various measures of development, especially developmental frameworks, to proxy spinoff outcomes (Degroof and Roberts, 2004; Johansson, Jacob and Hellström, 2005; Ndonzuau et al., 2002; Pirnay et al., 2003; Rasmussen and Borch, 2010; Salvador, 2011; van Geenhuizen and Soetanto, 2009). McAdam and McAdam (2008), for example, construct what they term a lifecycle model that includes various stages of entrepreneurial growth. Clarysse and Moray (2004) construct a developmental model that includes spinoff establishment, including project, pre-startup, start-up, and post-start-up

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phases. Argawal and Shah (2014) incorporate spinoff survival into their developmental framework while Fuller and Rothaermel (2012) include firm failure, along with acquisition and initial public offering (IPO) outcomes. Uniquely, Rasmussen and Wright (2015) base their developmental framework on entrepreneurial competencies, including opportunity development, championing, and resource acquisition.

At least four studies (Hayter, 2016a; Hayter, 2016b; Rasmussen et al., 2011; Rasmussen et al., 2014) utilize the developmental model constructed by Vohora, Wright and Lockett (2004) and Wright, Vohora and Lockett (2004), which includes four developmental stages: opportunity recognition, entrepreneurial commitment, credibility, and sustainability. Boh, De-Haan and Strom (2016) associate developmental paths with specific types of founding teams; Vanaelst, Clarysse, Wright, Lockett, Moray and S'Jegers (2006) approximate development by examining differences among founding teams during pre- and post-spinoff phases.

Peters, Rice and Sundararajan (2004) use incubator graduation as a proxy for spinoff development and to understand the effectiveness of incubator support. Patzelt and Shepherd (2009) compare perceptions of the efficacy of national academic entrepreneurship support programs among academic entrepreneurs with the development of their spinoff.

Sixteen studies use performance outcomes to proxy spinoff success. Spinoff revenue is a common measure in this category, typically used in combination with sales growth (Lundqvist, 2014), employment growth (Clarysse et al., 2011; Niosi, 2006; Visintin and Pittino, 2014), employment growth and survival (Wennberg and Wiklund, 2011), employment and profit (Sternberg, 2014), or profit and market share (Soetanto and Jack, 2016). Scholten et al. (2015) and Wright et al. (2007) focus on spinoff employment growth, Niosi (2006) focuses on sales and employment growth, and Ensley and Hmieleski (2005) focus on sales growth and net cash flow among spinoffs in comparison to other types of entrepreneurial firms.

Aside from Shane and Stuart (2002), who use IPO as their proxy, the remaining publications use amalgams of dependent variables to represent spinoff outcomes. Ayoub, Gottschalk and Müller (2016) likely employ the most elaborate combination of dependent variables, including initial number of employees, average number of employees, relative employment growth since start-up, annual profit/deficit, relative annual profit growth, total assets, return on equity and on total capital employed, debt ratio, leverage, and credit rating, and likelihood of closure. Walter, Auer and Ritter (2006) use sales growth, sales per employee, profit, survival, and customer relationship quality, while Lowe and Ziedonis (2006) use the likelihood of achieving commercial sales, likelihood of terminating a development effort, and university licensing revenues generated by invention developed by a spinoff. Bathelt, Kogler and Munro (2010) examine the extent to which faculty and/or students are involved in the spinoff team, the IP relationships with a university as well as formal research agreements with the university. Finally, Siegel and Wessner (2010) also use sales and number of employees as well as copyright filings, trademarks, patents, and licensing agreements.

5.2 University Activity

Fifty-eight articles have dependent variables related to university programs and behaviors. We categorized these articles into four subthemes, including support programs and policies, university impact, impact on traditional academic outputs, and industry engagement.

5.2.1 Support Programs and Policies

Twenty-five articles investigate, often through descriptive analysis, factors that shape the establishment of university-based programs and policies in support of academic entrepreneurship. For example, Bradley et al. (2013a), Brescia, Colombo and Landoni (2016), Comacchio, Bonesso and Pizzi (2012), and Huyghe et al. (2016) examine the role of TTOs in supporting entrepreneurial universities, while O'Kane et al. (2015) examine factors that affect the legitimacy of TTOs and thus their efficacy.

Studies also focus on the establishment and role of incubators (Barbero et al., 2014; Rothaermel and Thursby, 2005), science parks (Phan et al., 2005; Zou, 2014), engineering research centers (Feller, Ailes and Roessner, 2002), and proof-of-concept centers (Bradley et al., 2013b; Gulbranson and Audretsch, 2008; Maia and Claro, 2013; Munari, Rasmussen, Toschi and Villani, 2016). Other studies focus on university seed funds (Croce, Grilli and Murtinu, 2014; Munari et al., 2015) or on the adoption of IP policies (Baldini et al., 2006). Scholars also have focused on entrepreneurship education programs (Souitaris, Zerbinati and Al-Laham, 2007), both in collaboration with business schools (Phan, 2014) or in failing to spur collaboration with business schools (Wright et al., 2009). The recent establishment of the (U.S.) iCorps program, which is designed to enable the formation and development of commercialization-minded startup teams (Huang-Saad et al., 2016), has spurred additional research on entrepreneurship education.

Finally, several studies have offered case studies of single institutions, including Waterloo University (Bramwell & Wolfe, 2008), Chalmers University (Jacob, Lundqvist and Hellsmark, 2003), Universidad de Simon Bolivar (Gassol, 2007), Strathclyde University (Levie, 2014), the University of British Columbia (Rasmussen, 2008), Stanford University (Shah and Pahnke, 2014), and Georgia Tech (Youtie and Shapira, 2008). Other authors have compared the emergence of multi-level academic entrepreneurship initiatives *among* universities in the U.S. (Swamidass, 2013), multiple European countries (Rasmussen, Moen and Gulbrandsen, 2006), and China (Eesley, Li and Yang, 2016). Almost all of these studies focus on multiple support programs and policies, and the ways in which they work in tandem at a given university.

5.2.2 Overall University Impact

Scholars have used a variety of approaches to examine the overall entrepreneurial impact of research universities that differ from the aforementioned discussions relating to number of spinoffs and, separately, patents. Bray and Lee (2000), for example, use commercialization revenues as a gauge of entrepreneurial impact while Todorovic, McNaughton and Guild (2011) examine factors that predict university entrepreneurial impact. Lockett, Wright and Franklin (2003) investigate factors that contribute to the impact of so-called V10 universities, research institutions that have produced the highest number of spinoffs that have received external (non-university) funding in the UK.

Philpott et al. (2011) investigate university-level factors associated with the 'entrepreneurial ideal', which they define as the recognition of a wide range of entrepreneurial activities beyond patenting and spinoff company establishment. Breznitz and Feldman (2012) similarly examine other university mechanisms for economic and social impact beyond patenting, licensing, and spinoff companies. Feldman and Graddy-Reed (2014) examine the growing role of philanthropic foundations in support of the research and development goals universities.

Although Plummer and Gilbert (2015) is the only paper in our review that examines the (U.S.) county-level impact of entrepreneurial universities, a handful of publications examine institutional and nation-level contextual issues that affect the entrepreneurial impact of universities. Three of these studies focus on the Swedish context (Goldfarb and Henrekson, 2003), including comparisons with the United States (Henrekson and Rosenberg, 2011) and Ireland (Klofsten, 2000). Mustar and Wright (2010) examine national-level policies in the U.K. and

France, while Jefferson et al. (2016) compare university and national policies in the U.S., Chile, and Argentina. Wu (2010) examines university impact within the context of Chinese national policies.

5.2.3 Impact of Academic Entrepreneurship on Traditional Academic Outputs

Eight articles in our review examine the impact of entrepreneurship on traditional academic outputs of the university. Lowe and Gonzalez-Brambila (2007) examine the publication rate among academic entrepreneurs after spinoff establishment, finding that publication productivity does not diminish. Walsh and Huang (2014) also examine the impact of academic patenting on publication productivity among U.S. and Japanese scientists, finding that scientists are more secretive after they patent. Barbieri, Rubini, Pollio and Micozzi (2016) examine the propensity among faculty to co-publish and co-patent with industry scientists after establishing a company, finding that scientists publish less but patent the same after firm founding. Pitsakis, Souitaris and Nicolaou (2015) examine the impact of spinoff company establishment on total sponsored research funding. Finally, Nelson (2016) finds that the effect and approach pursued depend on both timing and scientific field.

5.2.4 Industry Engagement

Several studies focus on industry engagement among faculty, students, and program staff. Corley and Boardman (2008), for example, examine the collaborative behavior of individuals affiliated with university research centers, defining collaboration as working with individuals of different backgrounds and organizations; Debackere and Veugelers (2005) examine managerial impact on industry-science links, especially through the TTO. Jong (2008) examines sees industry engagement as a harbinger for departmental evolution toward a more entrepreneurial mindset.

While Perkmann, King and Pavelin (2011) and Tartari, Perkmann and Salter (2014) examine determinants of industry engagement, Perkman et al. (2013) review the literature focused on engagement outside the university broadly defined. Similarly, Mindruta (2012) focuses on factors that predict faculty collaboration with small firms, especially in terms of publication and patenting.

Haeussler and Colyvas (2011) investigate the determinants of what they term commercial engagement, which they define as consulting, patenting, and establishing a company. Van Looy, Landoni, Callaert, van Pottelsberghe, Sapsalis and Debackere (2011) also include total contract research receipts; D'Este and Perkmann (2011) includes consulting, contract research, and joint research activities.

5.3 University IP Outputs

Our search yielded 46 articles that defined academic or university entrepreneurship within the context of IP outputs. Thus, these articles share similarity with some themes above, such as intermediary outputs or university impact, yet place primary emphasis on IP itself.

5.3.1 IP Output Activity

Similar to studies that use number of spinoffs to proxy entrepreneurial activity, nineteen publications use the number of university IP outputs as a measure of entrepreneurial behavior. Bercovitz and Feldman (2008) and Colyvas (2007), for example, use invention disclosures, while Hunter, Perry and Currall (2011) use disclosures and patenting. Carayannis, Cherepovitsyn and Ilinova (2016) similarly use patenting and licensing, while Sine, Shane and Di Gregorio (2003) use number of licensing agreements. Markman et al. (2005) examine factors that predict the speed of patenting, licensing, and spinoff formation.

5.3.2 IP Rationales

Fourteen articles examine the factors that shape invention disclosures and patents. Thus, these articles place emphasis on what drives disclosure and patenting decisions rather than on the *count* of disclosures and patents. Owen-Smith and Powell (2001), for example, focus on patent rationales, including costs and benefits. Gianiodis, Markman and Panagopoulos (2016) examine the tendency for university scientists to generate patents but not assign them to their home university, so-called "out the back door" behavior.

5.3.3 IP Output Outcomes

Eleven articles measure the outcomes of IP outputs in various ways, including the first sale and revenue associated with a specific university technology (Nerkar and Shane, 2007) as well as well as the likelihood of commercialization (sales) success (Agrawal, 2006). Siegel, Waldman and Link (2003) use number of technology licenses combined with licensing revenue, while

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Swamidass and Vulasa (2009) focus on licensing revenue. Shane (2002) similarly focuses on patenting, licensing, and licensing revenue. Kolympiris and Klein (2017) examine not only patent-linked revenue, but also patent citations.

5.3.4 IP Output Utilization

Finally, four articles examine the utilization of IP. Colyvas et al. (2002), for example, explore how university technologies get into practice, especially through patent and copyright licenses. Meyer (2006) investigates how patents are utilized, while Knockaert et al. (2010a) seek to understand the extent to which knowledge created in universities is transferred to a firm.

6. Analysis: Ecosystem Elements and Their Connectivity

Ecosystems, by definition, include a variety of different elements working in harmony. Accordingly, our next analyses consider how many different elements are present in the articles that we review and how these elements are connected. Beginning with the independent variable (IV) subthemes, Figure 8 illustrates how many subthemes appear in the various articles. Most commonly, an article considers just one subtheme and on average, an article considers 2.2 IV subthemes. Fully 87-percent of articles consider three or fewer IV subthemes. This finding provides an initial indication that articles, by and large, are not considering the full array of factors that shape academic entrepreneurship.

<Place Figure 8 About Here>

Next, we analyze the relationship between subthemes through network images. Network conceptualizations – the consideration of the structure that connects a multitude of individual elements – lie at the heart of an ecosystem perspective. In the network images that follow, each "node" is a subtheme and the size of the node corresponds to the number of articles that include that subtheme. Two subthemes are connected with a line if a given article considers both subthemes. Thicker lines indicate a greater number of articles that include a given combination. (To facilitate a cleaner display, the figures do not depict connections of two or fewer instances.)

<Place Figure 9 About Here>

As Figure 9 illustrates, “Human capital: entrepreneur”, “TTOs,” and “Entrepreneur support programs” are both the most common subthemes and the most connected ones, with 14, 11, and 10 ties respectively. By contrast, “Technology” (pictured in the lower-right) is never considered alongside other subthemes. Similarly, “National Programs and Policies” and “Organizational Networks” are rarely considered alongside other subthemes. “Human Capital: Team” and “Individual Characteristics” have two connections each and “Motivation and Self Efficacy” and “Research Discipline” have three connections each. All of these cases suggest as-yet-untapped opportunities to consider these independent variable subthemes alongside other subthemes. For example, future research might fruitfully explore how organizational networks interact with individual characteristics and/or locational factors to shape outcomes of interest. Similarly, future research might consider how national programs and policies interact with technology. In other words, each unconnected node represents a research opportunity that nudges closer to an ecosystem perspective.

Turning to the dependent variable (DV) subthemes, Figure 10 illustrates that the vast majority of articles consider just one subtheme. On average, an article considers 1.2 DV subthemes and only two-percent of articles consider DVs across three subthemes. (Recall that we identified 13 total DV subthemes.) This finding provides further evidence that articles are focusing on specific factors of interest, following a typical empirical approach of picking a single DV (or a set of closely-related DVs that fall under the same subtheme) and a somewhat larger set of IVs, and then analyzing and reporting results accordingly. As argued above, this approach provides specific insights but does not reflect an ecosystem conceptualization of the phenomenon.

Indeed, only a handful articles have attempted to provide a conceptual foundation for multi-program and multi-level university-centric approaches. O’Shea, Chugh and Allen (2008), for example, take a multi-resource, multi-program, and multi-level approach to conceptualizing the role of universities (and regions) in academic entrepreneurship. Similarly, Clarysse et al. (2014) conceptualize business ecosystems and knowledge ecosystems, defining knowledge ecosystems as public research institutions, including research universities, as well as TTOs and regional public venture capital funds intended to link to the two ecosystem types. Yet such articles are the clear exceptions in the literature.

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These patterns become even more apparent when viewed from a network perspective. As Figure 11 illustrates, "Spinoff outcomes," "Startup decisions," "Intermediate outcomes," and "Number established" are the most common dependent-variable subthemes. The most *connected* subtheme, by contrast, is "IP Activity – Number," with links to four other subthemes. By contrast, "Economic and innovation impact" and "IP utilization" are never considered alongside other subthemes. Similarly, studies that focus on "Industry engagement" and "Support programs and policies" only consider these outcomes in relation to one other subtheme ("Intermediate outcomes" and "Startup decisions," respectively). In general, the network depicted in Figure 11 is sparse, meaning that most subthemes are not connected to one another and, by extension, most articles do not consider multiple subthemes simultaneously.

As with the IV subthemes, drawing a "line" between unconnected subthemes can thus suggest several future research opportunities. For example, future work might consider startup decisions and spinoff outcomes simultaneously. Similarly, studies could consider industry engagement alongside support programs and policies, or alongside impact on traditional academic outputs.

<Place Figure 11 About Here>

Finally, we consider which IVs are tied to which DVs across the full set of studies. Figure 12 illustrates these connections, with IVs on the left-hand side of the figure and DVs on the right-hand side. Not surprisingly, the most common IV subthemes ("Human capital: entrepreneur" and "Entrepreneur support programs") are linked to the widest array of DV subthemes, while the most common DV subthemes ("Spinoff outcomes" and "Startup decisions") are linked to the widest array of IV subthemes. The more provocative aspect of this illustration concerns the missing linkages. The average IV subtheme connects to 8.8 DV subthemes (out of a possible 13). Yet the variance is wide, ranging from 4 ("Human capital: team") to 13 ("Human capital: entrepreneur"). As before, missing links are suggestive of future research opportunities. For example, although prior work connects "Human capital: team" to startup decisions, spinoff outcomes, intermediate outcomes, and IP utilization, we have no work that explicitly connects this construct to economic and innovation impact, industry engagement, or support programs and policies (as DV subthemes).

Examining the picture from the perspective of DV subthemes, the average DV subtheme connects to 11.5 IV subthemes (out of a possible 17). Again, the variance is wide, ranging from 5

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("IP utilization") to 16 ("Spinoff outcomes"). Here, future work might connect DV subthemes of interest, such as IP utilization, to a wider range of IVs and IV subthemes in order to provide a more comprehensive understanding of what is driving these DVs. Similarly, future work might connect national programs and policies not only to startup decisions and spinoff outcomes, where the literature has focused, but also to outcomes such as industry engagement.

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7. Discussion

A recent study discussed in *Science* (Mervis, 2016) tied a decreasing number of academic spinoffs in Norway to a policy change that shifted a portion of associated revenues from the academic-inventor to his or her institution. Reacting to the study, Lita Nelsen, the long-time head of MIT's Technology Licensing Office, commented: "I would guess that something else is in play besides the fraction of royalties that inventors receive" (Mervis, 2016, p. 396). In other words, Nelsen suggests that challenging or controversial results demand consideration of a wide range of possible influences and relationships. Our analysis supports this message, encouraging scholars to consider the wide array of characteristics and elements tied to academic entrepreneurship from an ecosystem perspective. Specifically, our review finds that most research focuses on individual, university, and firm-level outcomes and their relationship to specific characteristics. Yet researchers have yet to make "vertical connections" between micro-level phenomena to macro-level outcomes, not to mention frame these connections in terms of complex interactions.

On the basis of our analysis, researchers also would be well-advised to eschew research conceptualizations that rely upon the linear, patent-focused technology transfer context (see also Bradley et al., 2013) in favor of conceptualizing academic entrepreneurship as a process of co-evolution among myriad agents. Co-evolution is a critical tenet of systems and complexity-oriented theories (e.g. Byrne and Callaghan, 2013) and is likely at play within a multi-level systems context such as academic entrepreneurship, including within and among individual, organizational, and regional levels.

As an initial step, scholars can focus on meso-level academic entrepreneurship research as a precursor to multi-level ecosystem views. Certainly, scholars have mapped academic entrepreneurship resources within individual universities and the regions where they are located

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(e.g. Rasmussen, 2008; Youtie and Sharpira, 2008) and, more recently, compared entrepreneurship support programs among universities (e.g. Swamidass, 2013). However, these studies are typically descriptive in nature and do not examine the interaction of ecosystem characteristics, including programmatic interventions, as it relates to their efficacy. Hayter (2016b) examines the evolution of social networks among individual academic entrepreneurs using them as a vehicle to explain how different universities support entrepreneurship through various intermediaries. Future research might combine the two approaches—mapping and network interactions—to examine how academic entrepreneur think about and utilize services and, most importantly, how various characteristics co-evolve toward a specific outcome.

Finally, it is worth reemphasizing that a diversity of perspectives can only help to further these goals. Indeed, although the academic entrepreneurship literature has expanded steadily since 2000, most papers are published by a relatively small group of scholars from business schools located primarily in the U.S. and U.K. Most top-ranked management journals have overlooked academic entrepreneurship entirely, while papers in field-area journals such as *Research Policy* and *Journal of Technology Transfer* rarely focus on contexts beyond the U.S. and Europe. Scholars wishing to make an immediate contribution to the literature would do well to focus on international contexts, and especially on emergent trends and models in the developing world.

In short, excellent opportunities remain for scholars to contribute to the evolving academic entrepreneurship literature. The promise, of course, is that future scholarship will not only rest firmly "on the shoulders of giants," but it can also provide useful guidance to policymakers and, ultimately, shape outcomes to the benefit of universities, businesses, and society at large.

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Figures and Tables

Figure 1: Publication Journal Frequency (n = 209)

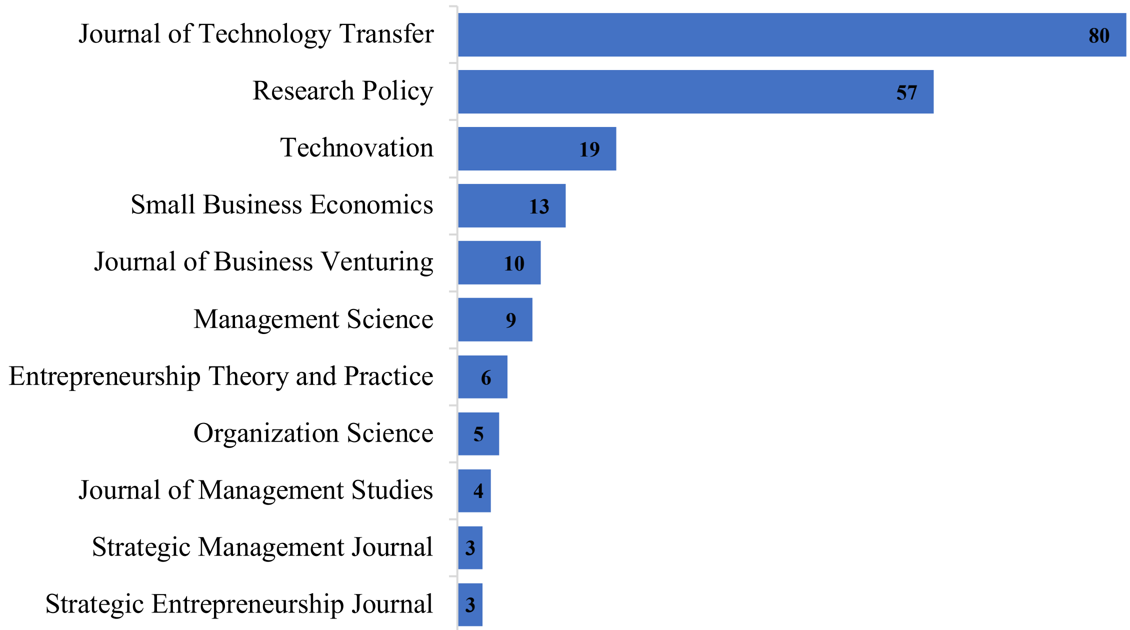

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Figure 2: Year of Publication Frequency (n = 209)

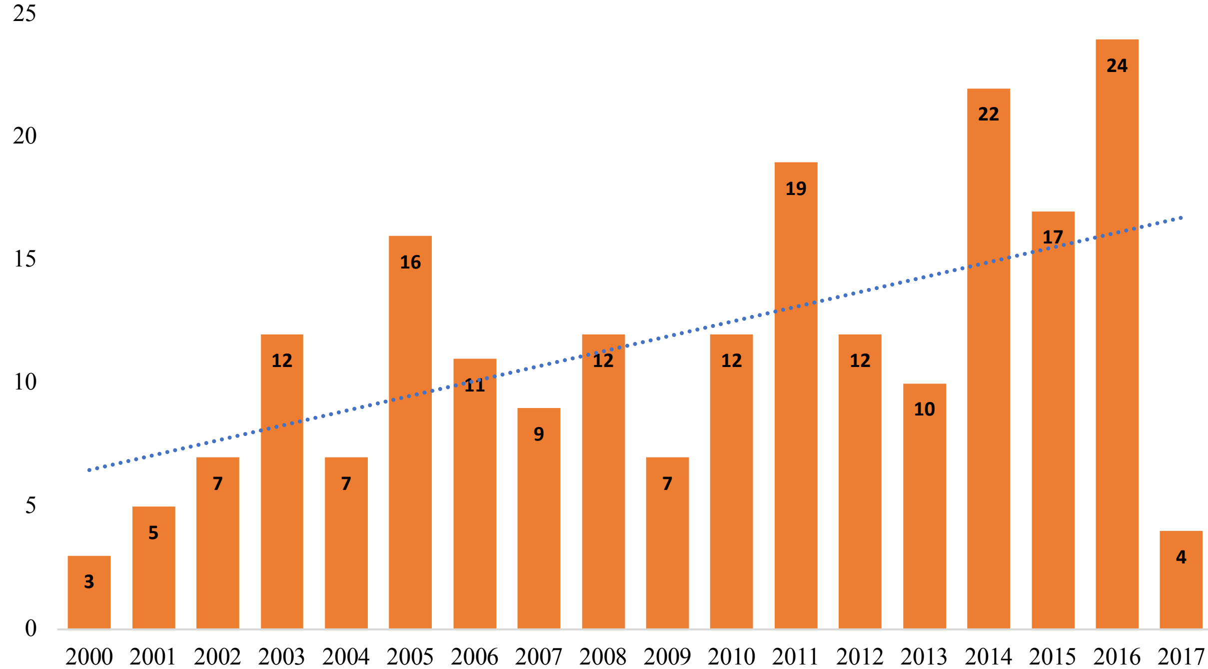

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Figure 3: Distribution of Authors by the Number of Publications Authored or Co-Authored (n = 353)

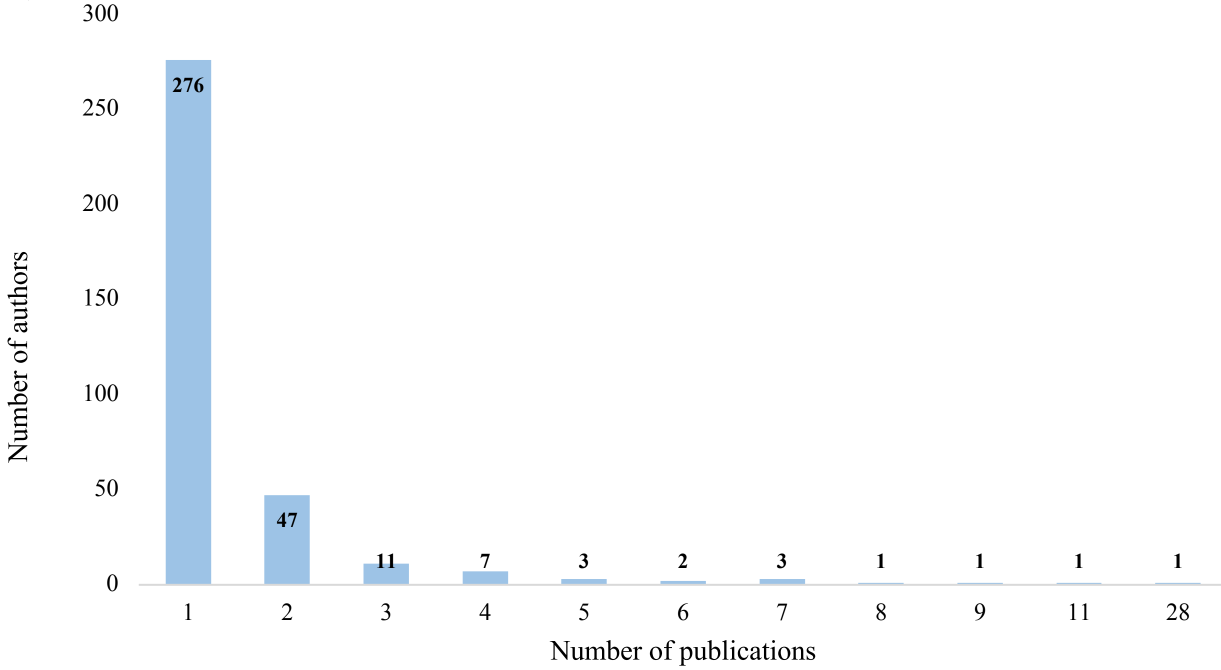

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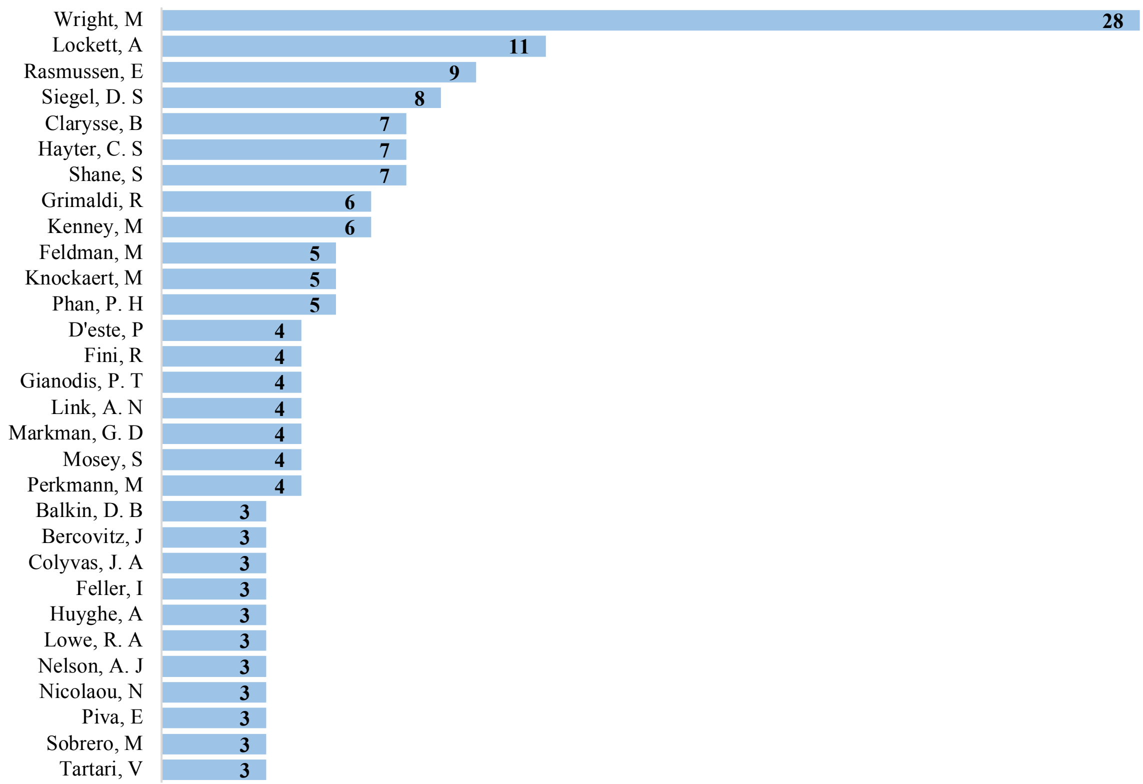
Figure 4: Authors that Authored or Co-Authored At Least Three Publications* (n = 353)



*A total of 323 authors have fewer than three publications

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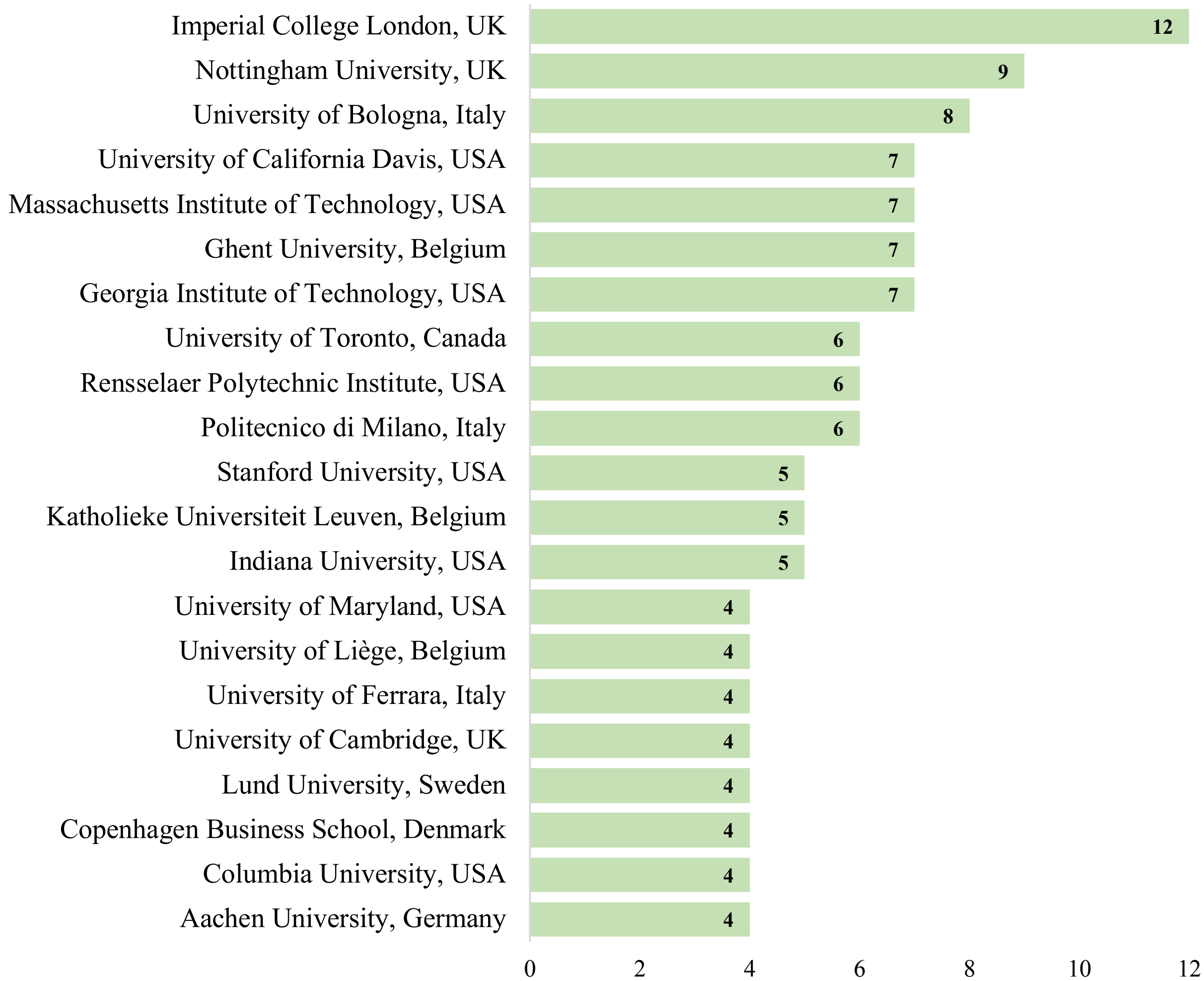
Figure 5: Author Affiliation at Time of Publication, Frequency* (n = 380)



*The review also included 23 institutions with three author affiliations each, 40 institutions with two affiliations, and 109 institutions with one affiliation each.

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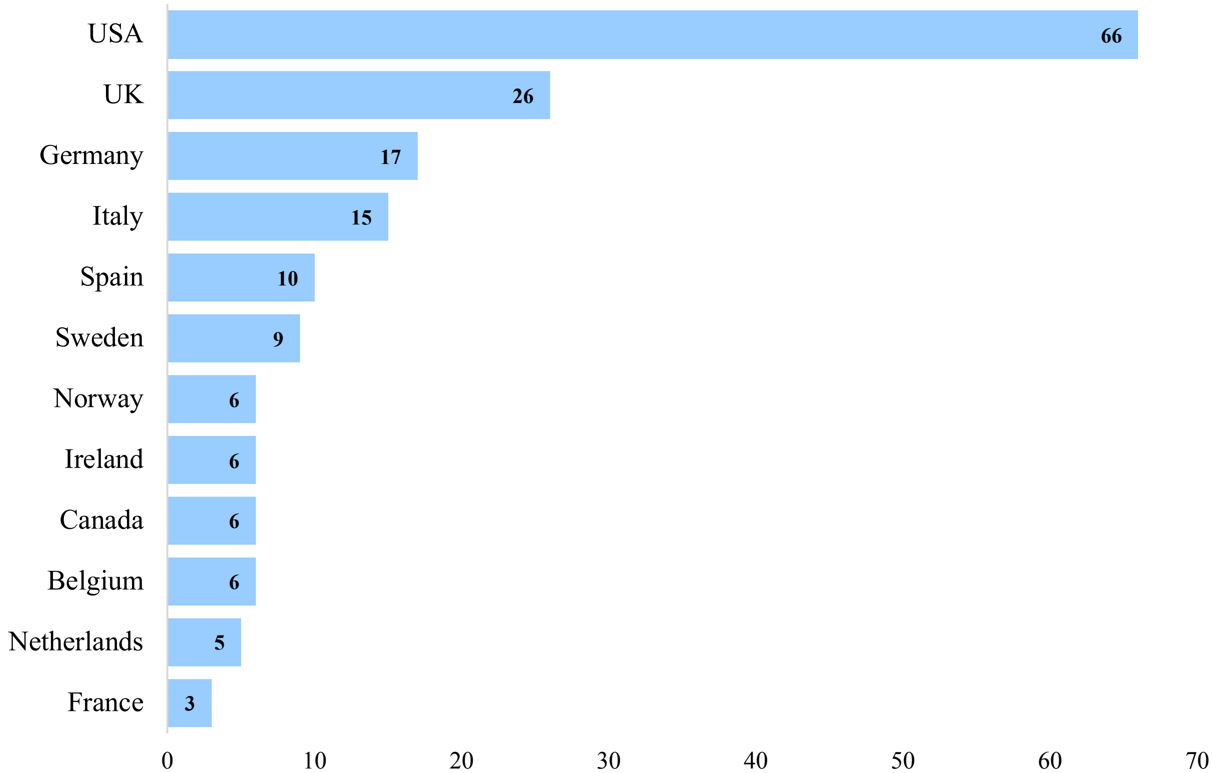
Figure 6: Country of Author Affiliation at Time of Publication Frequency* (n = 194)



*The following countries had 2 author affiliations: Israel, Singapore, Switzerland. The following countries had one author affiliation each: Australia, Austria, Chile, China, Cyprus, Denmark, Greece, Hong Kong, Mexico, New Zealand, Portugal, Russia, Slovenia

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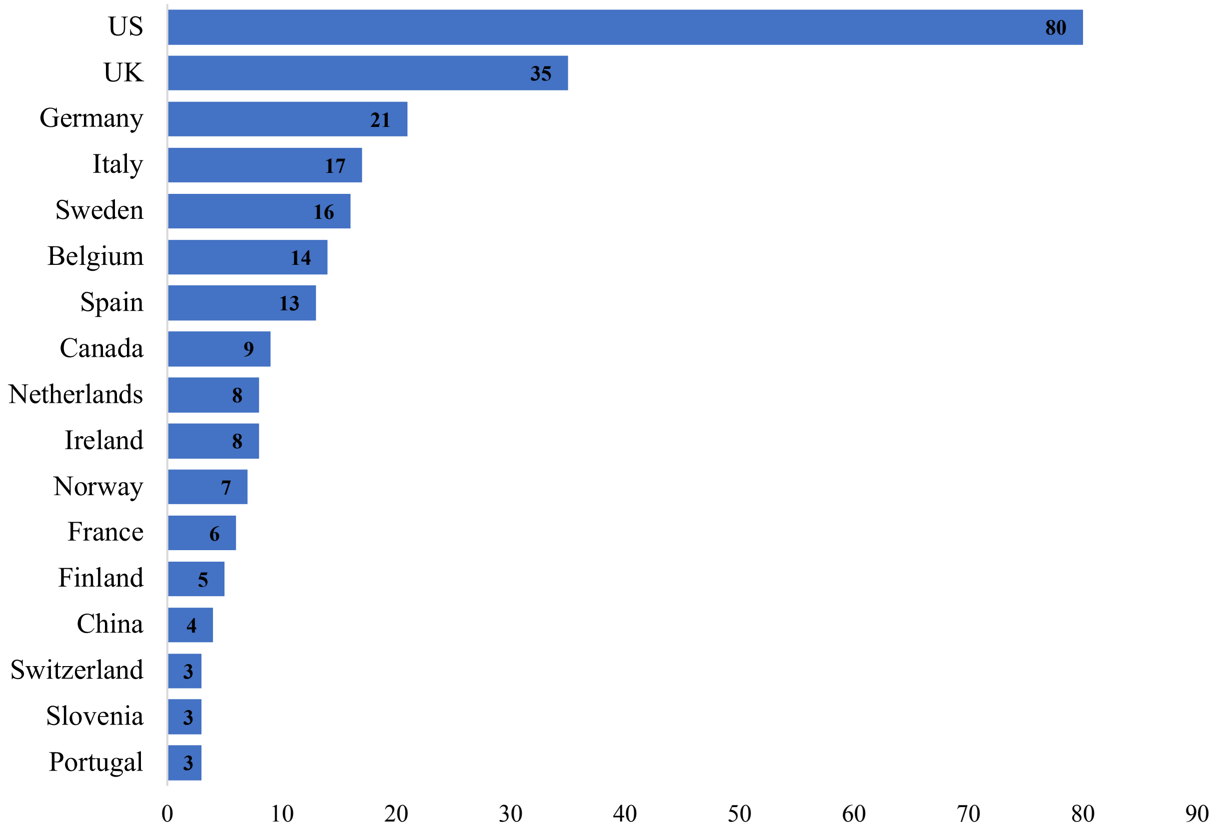
Figure 7: Country of Study of Publications in Review* (n = 286)



*Although some publications studied more than one country, each country was counted once. Publications that had no specific country of study or that did not specify the countries within the region studied are not included

The following countries were the subject of two articles included in the review: Austria, Croatia, Denmark, Georgia, Greece, Hungary, Luxembourg, Portugal. The following countries were the subject of one article included in the review: Albania, Argentina, Bulgaria, Chile, Czech Republic, Estonia, Iceland, Israel, Japan, Latvia, Lithuania, Malta, New Zealand, Romania, Russia, Slovakia, Turkey, Venezuela.

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Figure 8: Number of Independent-Variable Subthemes Addressed by Articles (n = 209)

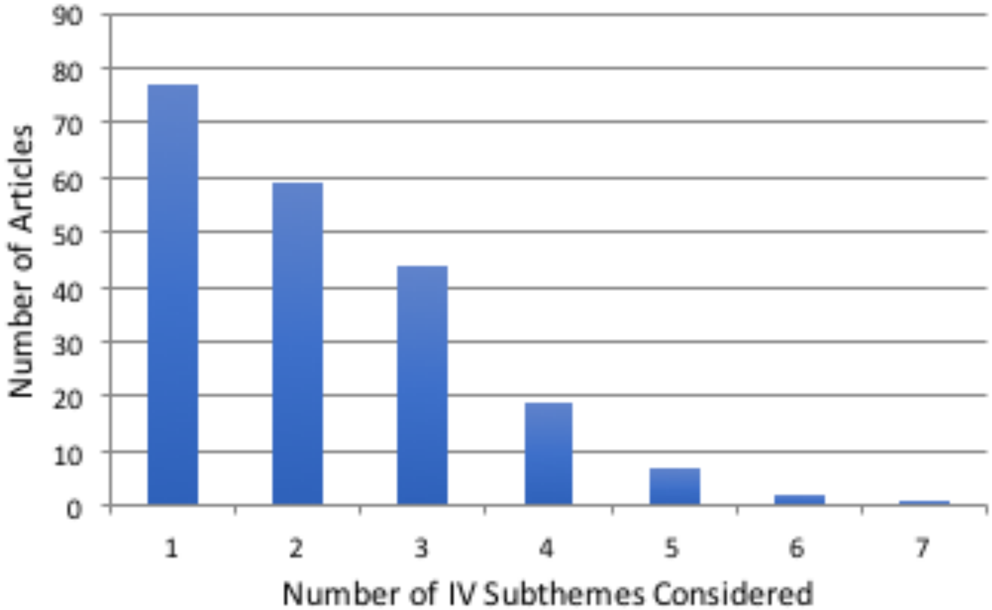

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Figure 9: Network of Independent-Variable Subthemes

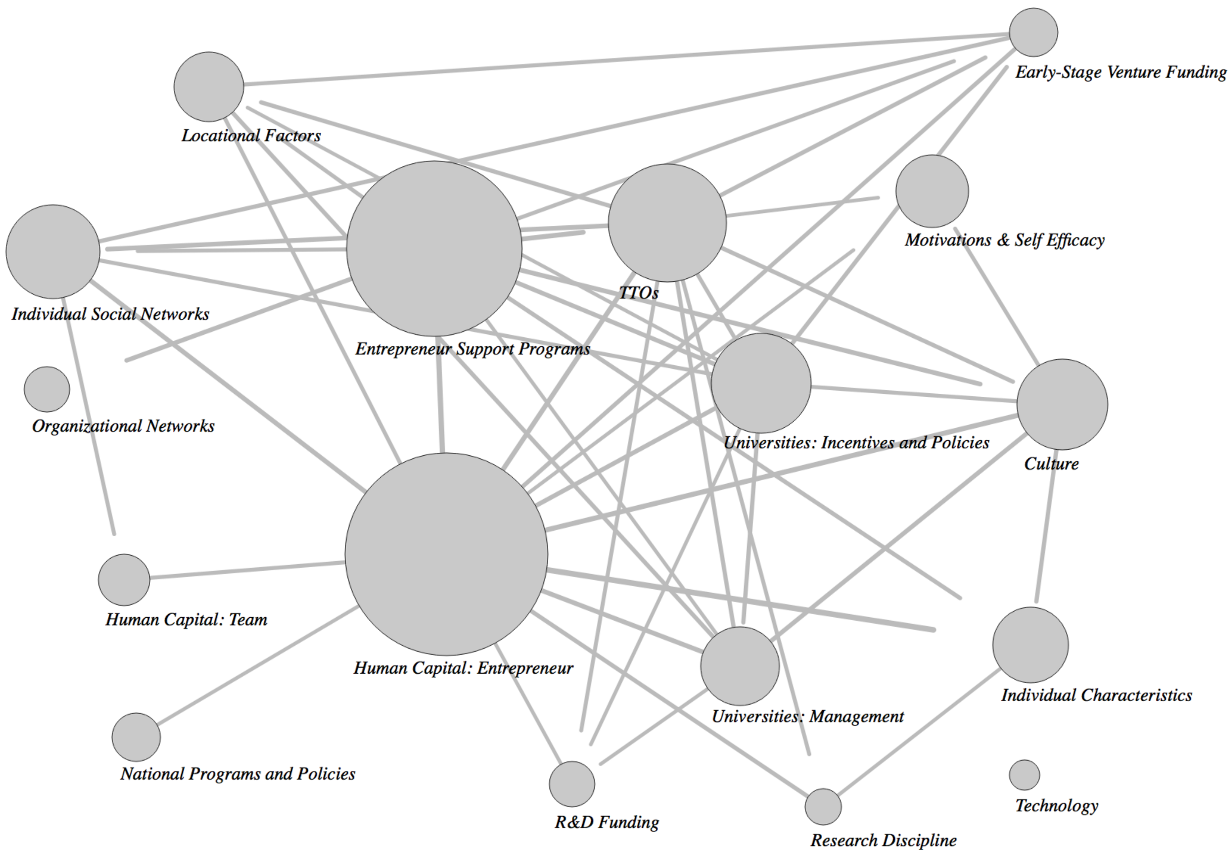

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Figure 10: Number of Dependent-Variable Subthemes Addressed by Articles (n = 209)

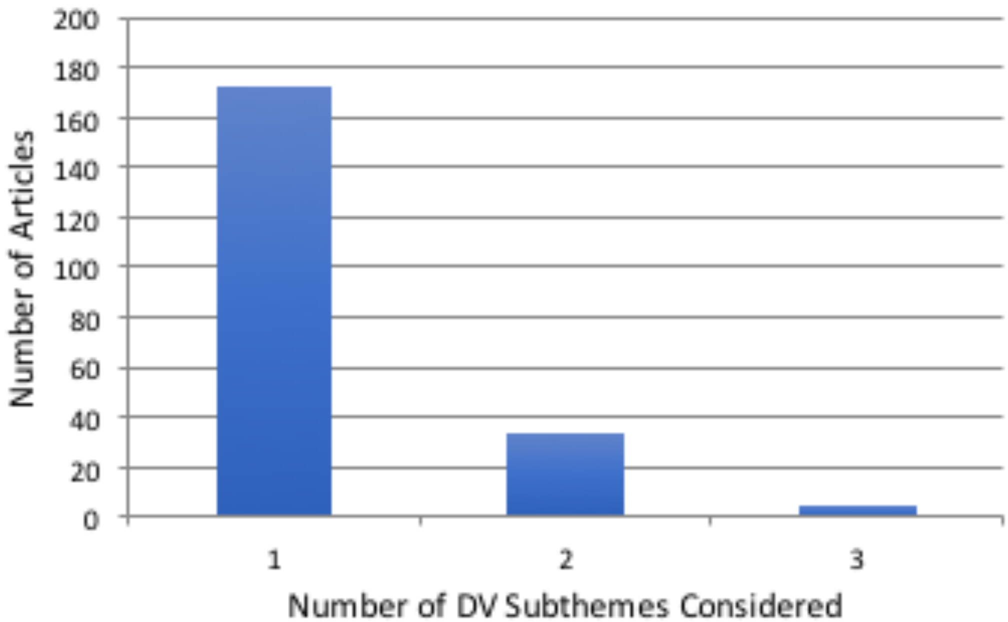

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Figure 11: Network of Dependent-Variable Subthemes

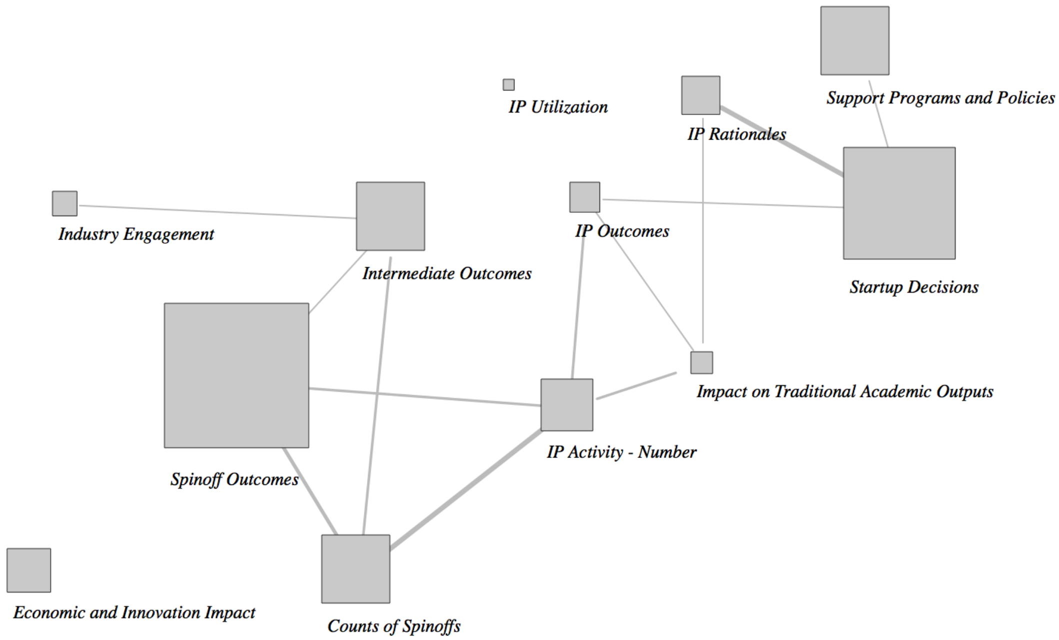

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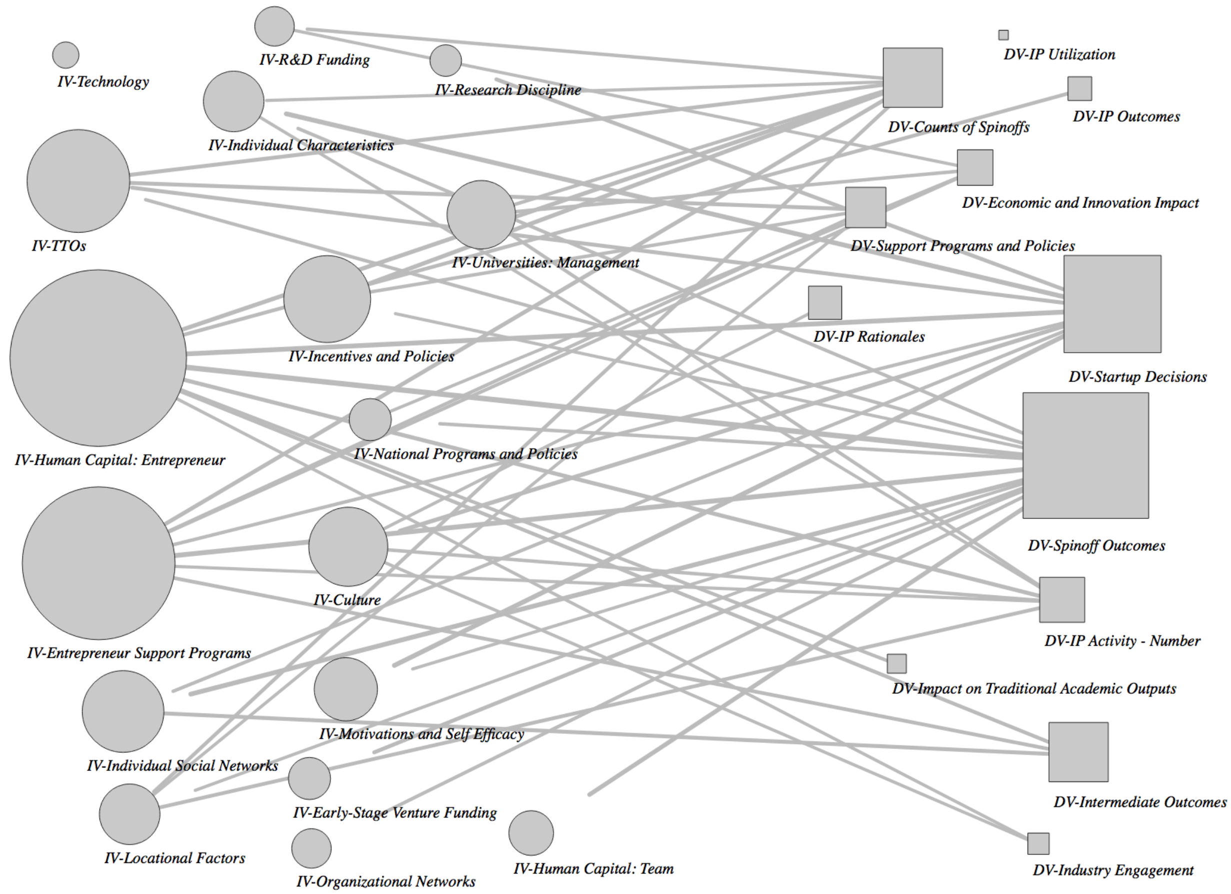
Figure 12: Network of Independent- and Dependent-Variable Subthemes



In this figure, ties between independent variables and ties between dependent variables are omitted, in order to more clearly show the connections between independent and dependent variables.

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Table 1: Academic Entrepreneurship Independent Variables and Associated Themes and Subthemes

Themes	Subthemes	Independent Variables	Number of Articles
Characteristics of Academic Entrepreneurs (47)	▪ Individual Characteristics	▪ Age ▪ Academic rank ▪ Capability ▪ Citizenship ▪ Eminence/prestige ▪ Family background ▪ Gender ▪ Market knowledge ▪ Race ▪ Self-identity	25
	▪ Motivations and Self Efficacy	▪ Academic motivations ▪ Entrepreneurial motivations ▪ Financial motivations ▪ Identity ▪ Scientific motivations ▪ Self-efficacy ▪ Technology development motivations	24
Human Capital (78)	▪ Academic Entrepreneurs	▪ Academic experience ▪ Education/academic experience ▪ Entrepreneurial experience ▪ Faculty role ▪ Industry experience ▪ Patenting experience ▪ Product development experience ▪ Publication experience ▪ Role of students and postdocs ▪ Surrogate/professional management	67
	▪ Founding Teams	▪ Board composition ▪ Spinoff team composition	17
Social Networks (43)	▪ Individual Social Networks	▪ Constrain ▪ Non-academic contacts ▪ Provide advice and mentoring ▪ Resource provision	31
	▪ Organizational Networks and Entrepreneurship Support	▪ Can enable (or constrain) entrepreneurship support programs	15
Entrepreneurial Environment (49)	▪ Culture	▪ Culture ▪ Entrepreneurs as role models ▪ National environment ▪ Peer support	30

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		▪ Regional environment	
	▪ Locational Factors	▪ Economic characteristics of region ▪ Industry presence ▪ University generates economic impact ▪ VC in region	23
Financial Resources (28)	▪ R&D Funding	▪ Total R&D funding ▪ Industry R&D funding	15
	▪ Early-stage Venture Funding	▪ VC ▪ Other sources	16
Scientific, Technical, and Product Characteristics (22)	▪ Research Discipline	▪ Biotechnology ▪ Engineering ▪ Information technology ▪ Life sciences ▪ Physics	12
	▪ Technology	▪ Broad technology scope ▪ Patenting and licensing versus spinoff	10
Academic Entrepreneurship Support Programs (99)	▪ Technology Transfer Offices	▪ Advice and support ▪ IP protection may detract from entrepreneurship ▪ Needs capabilities and resources ▪ Structure	39
	▪ University Entrepreneurship Programs	▪ Business plan competitions ▪ Early-stage seed funds ▪ Incubators ▪ Industry Research Centers ▪ Proof-of-Concept Centers ▪ Science parks	58
	▪ National Programs and Policies	▪ Entrepreneurship Support Programs ▪ IP Policy Frameworks ▪ Legislation ▪ Tax benefits and regulatory reform	16
University Management and Policies (50)	▪ Management	▪ Administration ▪ Decentralized, integrated initiatives ▪ University mission	26
	▪ Incentives and Policy	▪ Conflict of Interest ▪ Disclosure and IP-related incentives ▪ Equity policies ▪ IP ownership	33

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Table 2: Academic Entrepreneurship Dependent Variables, Themes and Subthemes

Themes	Subthemes	Dependent Variables	Number of Articles
Spinoffs (135)	▪ Startup Decision	▪ Individual, department, university and policy factors shaping startup decisions	41
	▪ Counts of Spinoffs	▪ Counts of spinoffs established	25
	▪ Intermediate Outcomes	▪ Founding team; team composition ▪ Funding ▪ Business ideas and knowledge ▪ Networks	25
	▪ Outcomes	▪ Survival ▪ Development stages ▪ Performance outcomes, such as revenues, profits, employment, growth, and IPO	53
University Activity (58)	▪ Support programs and policies	▪ TTOs ▪ Incubators ▪ Science parks ▪ Proof-of-concept centers ▪ Education programs ▪ IP policies	25
	▪ University impact	▪ Revenues ▪ Economic and social impact ▪ Descriptions of role on entrepreneurial activity	16
	▪ Impact on traditional academic outputs	▪ Publication ▪ Degree or amount of disclosure ▪ Sponsored research	8
	▪ Industry engagement	▪ Industry engagement and collaboration ▪ Departmental activity and change	9
IP Outputs (46)	▪ Activity	▪ Number of disclosures ▪ Number of patents ▪ Number of licenses	19
	▪ IP Rationales	▪ Motivations ▪ Out-the-back-door behavior	14
	▪ Outcomes	▪ Licensing revenue ▪ Likelihood of patenting success ▪ Citations	11
	▪ Utilization	▪ Degree to which knowledge is transferred ▪ Where patents are used	4

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Appendix A: Keyword Combinations Used in Literature Search

a. "university", "academi", or "facult"

b. "entrepreneurship", "commercialization", "technology development", "spinoff", "startup", or "spinout"

c. Other search terms

1. Ecosystem
2. Support
3. Assistance
4. Advising
5. Services
6. Technology transfer office
7. Proof of concept center
8. Accelerator
9. Incubator
10. Entrepreneurship education
11. Science park
12. Fund
13. Venture fund
14. Industry research center
15. Networking
16. Federal programs (e.g. Small Business Innovation Research Program and Engineering Research Centers *only* as they relate to the commercialization of university technologies or supporting university spinoffs)

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