

S Y M P O S I U M

BEHIND THE SCENES: INTERMEDIARY ORGANIZATIONS THAT FACILITATE SCIENCE COMMERCIALIZATION THROUGH ENTREPRENEURSHIP

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When they lack resources to commercialize science, entrepreneurs rely on intermediary organizations often within their local ecosystems. This paper seeks to improve our understanding of how intermediaries operate to advance the commercialization of science by providing a set of specialized services. We review five intermediaries commonly mentioned in the ecosystem literature: university technology transfer and licensing offices; physical space (incubators, accelerators, and co-working spaces); professional services providers; networking, connecting, and assisting organizations; and finance providers (including venture capital, angel investors, public financing, and crowdfunding). Specifically, we explore how these various intermediaries function and provide complementary and related services in support of scientific commercialization through entrepreneurship. After defining intermediation, we review the literature on each organization type, providing a definition and considering the contribution of the intermediary and the related policy implications. Each section concludes with suggestions for additional research.

A successful theater performance requires a large support cast working behind the scenes, without which the show would not go on. Just as the audience focuses its attention on the dramatic action happening on stage, the commercialization of science tends to orient its gaze toward the innovative technology and its enabling star, the entrepreneur. But as with theater, diverse entities work behind the scenes to support the necessary processes of founding, managing, and scaling a new scientific venture. In the commercialization of science, the least visible players are intermediary organizations—entities that operate in the void between the scientific discovery and the ultimate realization of value from commercialization, providing specialized services and access to equipment and resources beyond the reach of many start-up firms. Although these support organizations have

a long history of helping disseminate information important to technology dissemination, they are often treated as tangential to the study of science-based entrepreneurship (Howells, 2006). Yet varying access to these background supports can have a profound effect on entrepreneurial performance, as well as helping to sustain innovative activities within a regional economy (Cooke, Uranga, & Etzebarria, 1997).

Academic interest in entrepreneurial ecosystems creates an opportunity to shine the spotlight on these *behind-the-scenes* organizations. By definition, ecosystems are “a set of interconnected entrepreneurial actors, institutions, entrepreneurial organizations and entrepreneurial processes which formally and informally coalesce to connect, mediate and govern the performance within the entrepreneurial environment” (Mason & Brown, 2014, p. 5). Thus, the nascent ecosystem literature makes room for a variety of innovation-supporting intermediaries, including nonprofit, private, and

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public organizations as well as universities, incubators, entrepreneurial support organizations, professional service providers, and venture capitalists (Auerswald, 2015; Bell-Masterson & Stangler, 2015; Isenberg, 2011; Mack & Mayer, 2015; Mason & Brown, 2014; Stam, 2015). The ecosystem model also suggests an organic and fluid relationship between intermediaries that coevolve in a region. While each type of intermediary offers the potential to bring unique—yet complementary—services and supports to a regional ecosystem, there is also the potential for multiple intermediaries to coordinate, and even duplicate, efforts to address persistent innovation challenges or gaps. Thus, to fully appreciate the synergistic effects of this relational dynamic, we first need to recognize the contribution each intermediary makes to this science commercialization ecosystem.

The objective of this paper is to improve our understanding of intermediaries in the commercialization of science. We limit our review to five intermediaries commonly mentioned in the ecosystem literature: university technology transfer and licensing offices; physical space (incubators, accelerators, and co-working spaces); professional services providers; networking, connecting, and assisting organizations; and finance providers (including venture capital, angel investors, public financing, and crowdfunding). Specifically, we explore how intermediaries operate in the context of scientific entrepreneurship by providing a set of specialized services to advance the commercialization of science. What unites these various intermediaries is their function and provision of both complementary and related services in support of scientific commercialization through entrepreneurship. After a brief framing of intermediation, we review the literature on each organization type in turn, providing a definition and considering the contribution of the intermediary and the related policy implications. Each section concludes with suggestions for additional research.

INTERMEDIARIES INSIDE AND OUT

Consideration of intermediaries adds a new theoretical dimension to studies on the commercialization of science. The Bush (1945) linear model argued that commercialization could be left entirely to the private sector if government supported upstream research (Hart, 1998). Stokes (1997), however, questioned this division of labor, arguing that interactions between public- and private-sector actors are often essential for bringing scientific discoveries

to market. Adding to the discussion, Branscomb and Auerswald (2002) used the colorful metaphor “valley of death” to not only explain the frequent failure of science-based commercialization, but also to recognize the need for intervention to bridge these noted gaps.

As this suggests, the ability to commercialize science depends on complex, dynamic, and adaptive responses and relationships among private, quasi-public, and public-sector organizations. The concept of systems of innovation has been used to capture the relational dimensions and characteristics of environments that support knowledge creation and enhance innovation (Edquist, 1997). Systems of innovation are most succinctly defined as “the set of institutions whose interactions determine the innovative performance. . . of national firms” (Nelson & Rosenberg, 1993, pp. 4–5). Yet the innovation system approach often assumes homogeneity within a single country, when significant regional differences within countries suggest that innovation is more often a subnational phenomenon.

Recent work by several European scholars has attempted to expand the triple helix model to include intermediaries that operate between universities, industry, and government in several European contexts (Fernández-Esquinas, Merchán-Hernández, & Valmaseda-Andía, 2016; Suvinen, Konttinen, & Nieminen, 2010; Todeva, 2013). While this work attempts to make the role of intermediaries more central, and uncovers the specific challenges of intermediation among the tripartite partners with differing goals, the theory is limited by its singular focus on university–industry–government links.

In contrast, the ecosystem concept, which originated with practitioners in the mid-1990s (Autio & Thomas, 2014), recognizes the micro-geography of innovation and thus captures the diverse mix of locally embedded support organizations that contribute to innovation. The modern concept of an innovation ecosystem is rooted in the earlier literature on systems of innovation and builds on endogenous growth theory (Romer, 1990). New growth theory, for example, puts knowledge creation at the center of models of economic growth, while resonating with observations of the dynamic intraregional social relations described as part of late 19th-century Marshallian industrial districts. Increased interest in capturing the subnational geography of innovation suggests an opportunity to look closely at the intermediary organizations that contribute to the vital health of a regional innovation ecosystem.

It has long been recognized that innovative firms must be able to access, acquire, assimilate, and

exploit external knowledge to develop and sustain competitive advantage (Cohen & Levinthal, 1990; Zahra & George, 2002). Yet firms, especially small entrepreneurial firms, rarely innovate in isolation. Networking with other firms often aids in the transmission of tacit and highly complex knowledge across firm boundaries, where vertical integration is inefficient and knowledge cannot be easily priced (Powell, 1990). Equally important, however, is access to other mediating agents and intermediary organizations that act as boundary spanners to help facilitate network formation among firms while also extending essential resources, services, and guidance in support of innovation and the transfer of tacit and explicit knowledge (Howells, 2006; Wright, Clarysse, Lockett, & Knockaert, 2008).

Intermediaries are especially important for science-based entrepreneurial firms, given high barriers to commercializing scientific knowledge. At a general level, intermediary organizations support innovation by directly engaging with individual establishments through the provision of services and access to resources that can enhance business development or expedite technology commercialization. More specifically, intermediaries work with science-based entrepreneurs to overcome information and resource asymmetries by providing specialized information about intellectual property protection, the navigation of clinical trials in the life sciences, and the negotiation of technical standards for firms innovating in information, Internet, and equipment technologies. Some intermediaries offer specialized services that help entrepreneurs refine their ideas and business plans, reducing the transaction costs of engaging in commercialization activity. McEvily and Zaheer (1999) found that the development of new capabilities is stronger in firms with ties to regional intermediaries. Intermediaries can also help firms resolve financial constraints either directly, through subsidies, or indirectly, by making introductions to other sources of finance.

Intermediaries also play an essential coordinating role, forging networks and partnerships across the science-based business community and introducing nascent entrepreneurs to more established and influential business leaders, mentors, or partners. In this regard, intermediaries do not just address innovation gaps at the individual firm level; they also contribute to agglomeration economies by shaping and reshaping relational dynamics within and across the regional economy, by creating an industry commons (Berger, 2013). Intermediaries diffuse knowledge

across firms and supply chains, thus providing a mechanism to give greater material substance to the concept of knowledge spillovers.

While Marshall (1890) noted that the “secrets of the industry are in the air,” these intermediate support organizations provide channels for air circulation, a concept supported by recent research. Corredoira and McDermott (2014), for example, supported these findings, suggesting that intermediaries play an invaluable role in filling structural holes that separate firms, allowing for the fluid movement of knowledge. Their geographic concentration can also contribute to greater regional specialization, thereby helping to motivate new product and firm development (Feldman & Kogler, 2010).

Yet despite these advantages, it is important to consider the possibility of negative externalities from the networking role of intermediaries. For example, Pahnke, McDonald, Wang, and Hallen (2015) found evidence of competitive information leakage across shared intermediaries. Specifically, when firms are indirectly linked because they share the same intermediary (e.g., a venture capital firm), information may accidentally be leaked to a competitor and hinder—rather than support—innovation. This suggests that there are important qualitative differences in the ways that intermediaries operate.

Innovation is clearly a high-risk undertaking, not simply for entrepreneurial firms that seek to transform novel ideas into society-enhancing solutions and marketable products, but also for the regions in which these innovative firms are embedded. In this regard, it is important to also recognize an additional, yet often obscured, contribution of regional intermediaries. An intermediary can reach well beyond the business community to support and sustain regional innovation and science commercialization through their ongoing interaction with other intermediaries. This is the essential idea behind innovation systems or ecosystems: The whole is greater than the sum of the parts.

Intermediaries have been known to join forces to shape and inform policy action and regional strategy, even engaging in forms of collective action to amass political support to advance policy goals and capacity building (Feldman & Lowe, 2017). But equally, intermediaries align efforts to shape the types of scientific discoveries that get commercialized by local entrepreneurs, and in ways that often reflect the unique social, environmental, or technological challenges facing residents in their region (Owen-Smith & Powell, 2006). In this respect, intermediaries are not only well positioned to address some of the emergent gaps in U.S. federal

science policy, but they also provide a resource for guiding policy in support of science commercialization and regional economic development.

METHODOLOGY

With this potential contribution in mind, we examined the ecosystem literature. Admittedly, the ecosystem concept encompasses a variety of cultural, social, and symbolic conditions that augment the contribution of more formal support institutions (Stam, 2015). Still, as Spigel (2015) noted, formal institutions within an ecosystem are tangible entities that are most easily influenced by policy. We focused on five tangible, physical entities most commonly featured in ecosystem analysis: university technology licensing offices; professional service firms; workspace providers, including incubators, accelerators, and co-working spaces; organizations that provide networking and programmatic assistance; and financing entities, including venture capital, angel investment, public funding, and crowdsourcing. Table 1 defines each intermediary and provides examples of their roles in scientific entrepreneurship.

For each of these categories, we conducted an extensive literature search using a variety of keywords outlined in Appendix A. This produced a large cross-section of the literature. Scholarly journal articles were found through online searches of bibliographic databases such as Web of Science, Google Scholar, and ProQuest Summon. In an effort to reduce bias in the results of searches, we specifically included highly cited as well as more recent articles. We also included articles from a range of journal rankings and disciplinary fields. Papers were included based on whether they contributed to the state of knowledge on intermediation or a specific intermediary organization.

UNIVERSITY TECHNOLOGY TRANSFER AND LICENSING OFFICES

The commercialization of academic science typically begins with university technology transfer or licensing offices (TTOs) that work with businesses to license a university-created technology (Spigel, 2015; Stam, 2015). In the United States, the Bayh-Dole Act of 1980 formalized a process for the licensing of university inventions that resulted from government-funded research, although there was a historical precedent for university ownership (Mowery Nelson, Sampat, & Ziedonis, 2004). Other

countries have adopted policies similar to the U.S. system of university ownership or, alternatively, assert professors' privilege so that the individual inventor retains ownership (Cunningham & Link, 2016; Huyghe, Knockaert, Piva, & Wright, 2016). Many review articles consider the role of universities in the economy and highlight their role in ecosystems (D'Este & Patel, 2007; Etzkowitz, Webster, Gebhardt, & Terra, 2000; Rothaermel, Agung, & Jiang, 2007). Our focus, however, is limited to the specific role of TTOs as intermediary organizations that assist in the commercialization of science. It is worth noting that ideas with scientific value can also originate from government labs and from private firms, although there is less research on their commercialization efforts. For private firms, internal offices and legal counsel (rather than intermediaries) manage the licensing relationship (Kline, 2003; Maine, 2008).

TTOs participate in markets for technology, defined as "transactions for the use, diffusion and creation of technology (or intellectual property)" (Arora, Fosfuri, & Gambardella, 2001, p. 423). While firms of all sizes license technology, academic startups feature most prominently in scholarly work as they are seen to offer the possibility of greatest impact. Yet university technology transfer is characterized by highly skewed distributions, with the majority of offices failing to break even while other TTOs have big hits and enjoy strong revenue flows (Feller & Feldman, 2010).

Siegel and Wright (2015a) argued that TTOs overcome three main challenges: (1) they provide faculty incentives to disclose inventions and engage in the commercialization process, (2) they maintain researcher involvement in the development process, and (3) they provide information about the value of technology. Of course, faculty can bypass the formal TTO process by patenting directly with industry (Siegel, Waldman, Atwater, & Link, 2004). While some critics complain that licensing may diminish the traditional strength of informal university knowledge spillovers, Thursby and Thursby (2002) provided evidence that this is not the case. In a study of TTOs in the United Kingdom, Belgium, Germany, and Sweden, however, Wright and colleagues (2008) found that TTOs are better at intermediating the transfer of explicit rather than tacit knowledge.

The organization of the TTO and the level of resources committed by the university are important to the capacity to commercialize technology (Bercovitz, Feldman, Feller, & Burton, 2001; Siegel, Waldman, & Link, 2003). Thursby and Kemp (2002) found that private universities tend to be more efficient in

TABLE 1
Intermediary Definitions and Roles in Scientific Entrepreneurship

Intermediary type	Definition	Primary roles in scientific entrepreneurship
University intermediaries		
University technology transfer/ licensing offices	University offices that manage intellectual property of university-created technologies	Provide incentives for invention disclosure Engage faculty in development process Work with businesses to license technology
Physical space intermediaries		
Incubators	Physical space for early-stage firm formation and idea development	Offer affordable space Provide support services Generate revenue for incumbent firms
Accelerators	Physical space, complemented with resources and financial investment	Offer intensive programming Accelerate milestones Invest in exchange for equity
Co-working spaces	Physical space that promotes proximity and interaction	Provide flexible, less structured programming Offer space for social interaction Facilitate networking and peer mentoring
Service intermediaries		
Professional service firms	Third-party firms—including law, accounting, and real estate firms—that provide resources and connections	Reduce transaction costs Advise on IP and business formation strategy Act as dealmakers
Other assisting organizations	Public, quasi-public, and nonprofit groups that provide networking, specialized services, and programs	Facilitate networking and mentoring Influence policy through agenda setting
Financial intermediaries		
Venture capital firms	Investment firms that raise funds from individuals and institutions to support new ventures with high growth potential	Provide multistage, benchmarked financing Motivated to increase firm performance
Angel investors	Individual investors or investment clubs that provide early-stage financing in support of new ventures	Provide early-stage funding Act as a source of patient capital Offer business advice and mentoring
Public funding programs	Public and quasi-public programs that provide financial assistance in the form of grants or loans to new ventures	Offer a long-term source of support Act as a non-dilutive source of funding Signal quality for private financing mechanisms
Crowdfunding platforms	Method of securing large numbers of small investments	Recession proof Enable inventors to gain immediate product feedback Support idea sharing

licensing than public universities, while universities with a medical school are less efficient in licensing. O'Shea, Allen, Chevalier, and Roche (2005) found that the number of start-ups a university is able to generate is related to past university TTO success, faculty quality, the size and source of research funding, and the amount of resources devoted to TTO staff. Markman, Phan, Balkin, and Gianiodis (2005) found a positive relationship between the speed with which the TTO processes new invention reports and the creation of start-ups. Importantly, based on the case of Belgium's K.U. Leuven TTO, Debackere and Veugelers (2005) argued that well-managed and -structured TTOs reduce information asymmetries

between industry and university, fostering industry-university linkages that are lacking in the European context and cause the "European paradox" of high levels of scientific expertise with low contributions to industry. This idea is reflected in findings by Huyghe and colleagues (2016) showing that more than half of surveyed pre- and postdoctoral researchers at 24 European universities were completely unaware of their university's tech transfer operations.

TTOs use various mechanisms to improve the commercialization of academic science, including equity and uniform start-up licenses, educational support programs, and incubators. Universities started using equity in lieu of licensing fees to

encourage new firm formation (Feldman, Feller, Bercovitz, & Burton, 2002). Di Gregorio and Shane (2003) found that TTO policies, rather than capital market constraints, affect the number of new ventures created: More start-ups are formed when TTOs make equity investments. Many types of licensing agreements are used by TTOs, with new express licenses recently becoming popular (Rector & Thursby, 2016).

The commercialization of academic science now involves more stakeholders, especially at the regional level. Furthermore, the methods of commercialization have expanded—for example, accelerators and business plan competitions (Siegel & Wright, 2015b). If the local TTO is not effectively engaged, other intermediaries are likely to gain importance in the ecosystem. If TTOs serve an important purpose, then faculty members who commercialize on their own (either through professor privilege or by circumventing the process) should find a substitute intermediary. And even when the university TTO is well resourced and has a strong history, other intermediaries may assist with commercialization activity.

PHYSICAL SPACE: INCUBATORS, ACCELERATORS, AND CO-WORKING SPACES

The commercialization of science requires physical workspace, laboratory space, clean rooms, and advanced equipment. Incubators, accelerators, and co-working spaces provide entrepreneurs access to physical facilities at below-market rates, and with preferential terms. Moreover, the collocation of physical facilities allows for the circulation of ideas. Incubators, accelerators, and co-working spaces may be affiliated with universities or operate as public, for-profit, or nonprofit entities. Mian, Lamine, and Fayolle (2016) called for the development of a field of study called technology business incubation (TBI) to further define these intermediaries' contributions. Perhaps what is most interesting is that while incubators have been in existence for more than half a century, accelerators are a much newer phenomenon, and new organizational forms (such as co-working spaces) are proliferating. In general, the trend is for physical space providers to add services that aid commercialization, reflecting the political and social context surrounding these organizations (Phan, Siegel, & Wright, 2005).

Incubators

Incubators, as the name implies, attempt to support early-stage firms to a point where they hatch, or become viable entities. The expectation is that

successfully incubated firms can exit in a strategic business position (Aernoudt, 2004). Though first appearing in the 1950s, incubators began to grow in number in the United States during the 1980s for reasons including the passage of Bayh-Dole, expansion of IP rights in the U.S., and newfound profits from biotechnology commercialization—all factors driven by the potential for commercializing science (Hackett & Dilts, 2004). The rise of European science parks occurred largely as a result of triple helix partnerships designed to replicate U.S. successes (Colombo & Delmastro, 2002).

Categorizing the organizational forms and management practices of incubators has been a vexing problem, which is one reason there is little conclusive empirical research. Bruneel, Ratinho, Clarysse, and Green (2012) presented an evolutionary process that characterizes generations of incubators, with each augmenting the value proposition. First-generation incubators focused only on offering affordable space, while second-generation incubators added knowledge-based business support services. Third-generation incubators began to add networking support and serve earlier stage companies, focusing more on selection and quicker tenant turnover in an effort to make profits. While the earliest incubators were publicly financed, for-profit and corporate incubators emerged, with incumbent companies offering incubation as a means to generate new sources of revenue (Becker & Gassmann, 2006).

Incubators can also be categorized according to their objectives: Mixed-type incubators serve all technologies and types of firms, while economic-development incubators aim to leverage local activities to create employment opportunities (Aernoudt, 2004). Those in a third category, technology incubators, typically focus on specific sectors (often aligned with cluster development strategies) and offer access to shared specialized resources, such as testing facilities or chemical formularies, that are especially important for the commercialization of science. In a study of 13 specialized and 13 diversified German business incubators, Schwartz and Hornyk (2010) found that a firm's industry rather than incubator specialization better explains the likelihood of firm linkages to academic institutions, and found no difference in internal network patterns between incubator types. This heterogeneity of mission, organizational form, and practice complicates impact assessments (Berger & Norman, 2008; Di Gregorio & Shane, 2003; Hackett & Dilts, 2004, 2008; Mian, 1996, 1997; Mian et al., 2016; Theodorakopoulos, Kakabadse, & McGowan, 2014).

Not surprisingly, the effectiveness of incubator participation on the commercialization outcomes of individual firms also varies. Schwartz (2013) found that incubated firms do not have a statistically significantly higher chance of survival than non-incubated firms. In contrast, Lewis, Harper-Anderson, and Molnar (2011) used discriminant analysis and found that business incubation positively affects firm outcomes. Incubator quality is more predictive of outcomes than incubator size, age, or regional capacity for entrepreneurship. They also found that most top-performing incubators tend to be non-profit, have government support, have larger budgets, and exhibit similar management practices (Lewis et al., 2011). Furthermore, incubator success is correlated with having incubator graduates and technology transfer specialists on the incubator's board.

In interesting new research analyzing the roles of business incubators in emerging markets, Dutt and colleagues (2016) found that these incubators may operate as "open system intermediaries" to support market development as well as to support individual business development. These contrast to "closed system intermediaries," as open system intermediaries "seek to create benefits for parties beyond a well-identified set of participating actors" (p. 819). More research on intermediaries in these emerging economies is warranted.

The number of incubators is ever increasing, suggesting an opportunity for evidence-based research to guide operations. Contradictory results may reflect the wide range of services offered by incubators, from subsidized real estate to intensively managed, supportive environments. This suggests the possibility of developing a matrix of incubator characteristics matched against the local characteristics of entrepreneurs and the existence of other support organizations in the region.

Accelerators

Although accelerators have been described as a "new generation incubator model" (Pauwels, Clarysse, Wright, & van Hove, 2015, p. 13), they differ from incubators on a number of variables, including duration, business model, selection, and mentorship, among others (Cohen, 2013). Firms are typically provided with a small investment in return for an equity share. Selection into accelerators is highly competitive, which sends a quality signal to outside investors (Kim & Wagman, 2014). Accelerators make extensive use of seminars for education

about entrepreneurship. Furthermore, mentorship is intense in accelerators, and a multitude of relationships can exist between the accelerator and the start-up, including direct investment, help with finding additional investment, and partnering in pilot production and distribution (Kohler, 2016). Accelerators also stress finding the value proposition for the customer, which can be especially beneficial for scientists-turned-entrepreneurs who tend to focus on the scientific aspects of their firms. Moreover, many accelerators focus on ideas, projects, or ventures before the formation of a company. After an intense three- to six-month program, entrepreneurs have gained information about the viability of their project—the science may be strong, but if a market does not yet exist then it is not a good opportunity.

Accelerator funders are more like venture capitalists in that they invest in a group of firms, while expecting to receive large returns on only a few ventures. Therefore, they will accept earlier investments overall, which is important for commercializing science. Hallen, Bingham, and Cohen (2014) studied the impact of accelerators based on the time it takes ventures to reach certain milestones, such as the first round of VC. They found mixed results using a Cox proportional hazard model on a matched set comparison of accelerated and non-accelerated ventures. They found no difference between accelerated and non-accelerated firms, but firms in some specific accelerators did realize a faster time to milestones than those in other accelerators. Hallen and colleagues (2014) argued that these results are indicative of the difficulties in the acceleration process. Empirical work is needed to shed further light on acceleration processes and outcomes, as data on accelerators becomes more widely available.

Recent studies have found that accelerators do have an effect on early firm outcomes. Winston-Smith and Hannigan (2015) used hazard analysis to compare start-up exits and follow-on funding outcomes between accelerated and angel-funded firms. With data from two top accelerators and 19 top angel funders, they found that accelerated ventures are more likely to exit by acquisition, and at an earlier date, than angel-funded firms. Accelerated firms are also more likely to receive a first round of VC funding earlier than angel-funded firms, and this earlier date is around the time of the accelerator's "demo day." Winston-Smith and Hannigan (2015) argued that these findings are the result of differences between the processes of angel and accelerator investing, and the ways in which angels and accelerator managers

realize returns. The fact that accelerator operators invest in cohorts and spend more time nurturing and mentoring the firms could be such an explanation.

The presence of an accelerator may signal a strong or growing entrepreneurial ecosystem. Fehder and Hochberg (2014) used difference-in-differences analysis to analyze the impact of accelerators on entrepreneurial ecosystems. They found that start-ups located in MSAs with an accelerator receive more financing whether or not they participated in the accelerator, and argued that this indicates that accelerators have an impact on ecosystem strength. The role of accelerators in ecosystems and compared to other workspace provision models, however, would benefit from greater theoretical and empirical development.

Co-working Spaces

Co-working spaces—low-rent alternative workspaces intended to offer a fun and informal atmosphere—are another new phenomenon in the workspace intermediary field. Co-working spaces are distinguished from earlier shared office facilities by their emphasis on social interactions, aesthetic design, and management by cashed-out entrepreneurs and potential investors (Waters-Lynch, Potts, Butcher, Dodson, & Hurley, 2016). They are found in hotspots of activity and range from small operations to national organizations (such as WeWorks) to large firms (such as Microsoft and Google). Incubators and accelerators have evolved to offer co-working spaces, but Moriset (2014) questioned their future, arguing that the spaces neither create much profit for operators nor add much value to occupants.

There are three types of co-working space users: freelancers, microbusinesses, and people working for themselves or for companies external to the space (Parrino, 2015). Knowledge exchange through collaborative relationships occurs only when the co-working organization encourages such collaboration—collocation alone does not foster collaborative relationships. Data from an online co-working magazine, *Deskmag*, indicates that entrepreneurs are present and active users of co-working spaces; approximately 20% of co-workers are entrepreneurs who employ other workers (Foertsch, 2011).

Research on the contribution of co-working spaces to science entrepreneurship is limited thus far. A case analysis in South Wales found that co-working spaces support entrepreneurs and entrepreneurial activities through networking, peer mentoring, and easier access to forms of capital, among other things,

but this study has limited generalizability (Fuzi, Clifton, & Loudon, 2015). Waters-Lynch and colleagues (2016) argued that Schumpeterian economic theory is a useful theoretical lens through which co-working may be studied to understand how it contributes to innovation. For scientists working on an idea, a third place to go to meet with like-minded people may be an important first step. Future empirical work will be important for this field.

PROFESSIONAL SERVICE FIRMS

Professional service firms (PSFs) aid in the commercialization of science by vetting proposals for new companies and connecting founders to a wider pool of resources, networks, and entrepreneurial support. These service professionals have access to specialized knowledge, are usually embedded in an existing entrepreneurial community, and can serve as network bridges for new entrepreneurs, thus helping reduce transaction and search costs (Zhang & Li, 2010). Extending the entrepreneurial ecosystem concept, Stam (2015) considered PSFs to be vital “feeders” into that system. Hayter (2016) found that service providers are especially important to academic entrepreneurs as they provide information related to law and accounting, as well as services such as product testing that might not be accessible to them through their established academic networks.

Professional service firms have not been studied widely in the management literature (Empson, Muzio, Broschak, & Hinings, 2015). This reflects difficulty in identifying which ancillary firms qualify as technology intermediaries. Von Nordenflycht (2010) presented a taxonomy based on three defining features: knowledge intensity, low capital intensity, and high degree of professionalization. Knowledge intensity—high degree of knowledge specialization—is the most important defining feature. The higher the degree of knowledge specialization, the more important the service is to the entrepreneur.

The majority of studies focus on law firms. Gilson's (1984) seminal work found that Silicon Valley attorneys act as *transaction cost engineers*, reducing costs of engaging in commercialization. In a study of prospective entrepreneurs, Shane (2001) found that local attorneys provide initial advice on patent protections and scope, affecting the decision to start a company. Accountants and investment bankers provide a similar function in reducing the impact of information market failures on start-ups (Gilson, 1984). Suchman and Cahill (1996) found

that Silicon Valley business attorneys further define local business norms and integrate norms into the legal and business community. Suchman (2000) found that Silicon Valley attorneys function as business counselors, dealmakers, gatekeepers, proselytizers, and matchmakers. As dealmakers, lawyers link start-ups to other firms, such as VC. As gatekeepers, they selectively connect start-ups to other members of their networks. As proselytizers, they use their influence to educate start-ups on business norms, further solidifying those norms. As matchmakers, attorneys sort and match clients and resources. These roles shape the broader community. Cable (2014) argued that this model of *start-up lawyering* has grown with the proliferation of entrepreneurship as an economic development strategy. Originating in Silicon Valley, the practice has several distinctive features as attorneys set contract standards and defer initial payments in lieu of equity, believing that greater return will follow.

In an investigation of the spatial patterns of semiconductor firms that had recently had an initial public offering, Patton and Kenney (2005) found that legal counsel used by entrepreneurs is always proximate to start-up activity, followed by investment bankers, venture capital, and finally independent directors. While locational patterns differ across industries, a subsequent paper using the same data found that attorney start-up services remain highly local (Kenney & Patton, 2005).

Gompers and Lerner (2010) argued that real estate brokers and managers familiar with equity investing also reduce transaction costs of obtaining finance. Accountants and investment bankers provide a similar function, reducing the impact of market failures on start-ups (Gilson, 1984). Zhang and Li (2010) analyzed the impact of start-up network ties to PSFs on production innovation in a study of 202 firms in a Chinese technology cluster. They found that new ventures' networks with technology service firms, law firms, and accounting firms have a positive impact on firm product innovation.

The sparse and disconnected nature of the literature outlined here shows ample room for continued research on the role of PSFs as intermediaries in the entrepreneurship and technology commercialization process. The literature lacks a theoretically constructed conceptualization of the impact of attorneys, accountants, insurance agents, and other service providers on technology commercialization. Additional analysis at a regional scale will be most useful as previous studies show service providers mostly operate at a local level. Finally, an important yet unanswered question raised by Friedman,

Gordon, Pirie, and Whatley (1989) is whether Silicon Valley attorneys help the high-technology industry grow, or whether—conversely—the high-technology industry led to growth in the local legal sector. Perhaps it is less a case of determining directionality and more a future research opportunity for studying positive feedback and mutual reinforcement.

NETWORKING, CONNECTING, AND ASSISTING ORGANIZATIONS

Public, quasi-public, and nonprofit programs frequently step in to support scientific entrepreneurship. These public service organizations have limited expectation for direct financial gain, but rather a greater focus on the public outcomes of economic growth through the promotion of start-ups. They serve networking support roles for entrepreneurs, coordinating local organizations and programs by bringing together public and private entities, and serve agenda-setting roles for policy and practice. Motivated to serve a public purpose, these organizations exist to address network failures (Schrank & Whitford, 2009).

One example of such an organization is the North Carolina Biotechnology Center (herein, “the Biotech Center”), established by the North Carolina legislature in 1981 as a nonprofit 501(c)(3), with the majority of its budget derived from annual state appropriations (Feldman & Lowe, 2011). As a quasi-public nonprofit, the Biotech Center has the option to secure additional funding, including federal research grants. This nonprofit structure has enabled the Biotech Center to position itself as less partisan, and thus retain state support even during changing political environments (Lowe & Feldman, 2015). Another example of a successful quasi-public coordinating and networking program is San Diego CONNECT. This intermediary was founded in 1985 as a bottom-up effort of entrepreneurs, supported by economic development officials, to connect industry to academia and advance local entrepreneurship and the commercialization of academic science (Kim & Jeong, 2014; Walcott, 2002). Disconnecting from the university may have allowed CONNECT to reach a broader base of entrepreneurs to assist.

Not-for-profit organizations with more limited government involvement also offer a portfolio of topical programs to respond to local needs and contribute to the commercialization of science through entrepreneurship. One example is the nonprofit Council for Entrepreneurial Development (CED), one of the nation's first membership organizations

dedicated to supporting new firms by providing networking assistance, mentorship, entrepreneurial education and training, and identification of capital sources. Research has found such organizations' efforts fruitful. Cumming and Fischer's study (2012) of the one-stop Innovation Synergy Center in Ontario found that publicly provided business advisory services positively affect entrepreneurial outcomes.

Both nonprofit and quasi-public programs can operate at multiple scales. Nonprofits such as SCORE and America's Small Business Development Centers (SBDCs) have a national reach and receive federal funding from the Small Business Administration (SBA), but they operate a decentralized network of local programs. SCORE offers entrepreneur training workshops and mentoring through more than 300 chapters. SBDCs form an entrepreneur and small business assistance network that offers training and mentoring through partnerships with universities and state economic development agencies. Chrisman, McMullan, and Hall (2005) found that the time entrepreneurs spent in "guided preparation" with an outside adviser at an SBDC before starting a company was associated with increased start-up performance, including better employment and sales outcomes. Still, the time spent had diminishing marginal returns. Yusuf (2010) argued that start-up assistance programs like these may not have an immediate effect, but often help support entrepreneurs' latent, rather than perceived, needs.

Local programs to support entrepreneurship also exist, and may be directed by a higher level of government. In their case study of a Midwest region, Feldman and Lanahan (2010) found that firms pursue state and local funding programs more often than federal programs. They also found that local innovation programs have difficulty coordinating activities and practices, and argue for the creation of bottom-up regional coordinating bodies.

As nonprofit and quasi-public structures and governing bodies continue to proliferate, there is a need for greater research on these organizations, their programs, and their impact. Multiple points of contact, however, make evaluations of single organizations more difficult. There is an opportunity for more empirical work on the interaction, sequencing, and coordination of various forms of public and quasi-public support.

FINANCE PROVIDERS

Finance organizations are especially important intermediaries for supporting the commercialization

of science through entrepreneurship. Without money, science- and technology-based companies simply cannot grow. Kerr and Nanda (2015) reviewed the literature on innovation finance and found that four features of the R&D process constrain finance. First, the innovation process is uncertain. Second, innovation's returns are highly skewed. Third, information asymmetries between entrepreneurs and investors favor entrepreneurs. Fourth, new innovation-focused ventures often rely on intangible assets that can easily be lost if employees leave; these expenses for science-based start-ups are higher than average due to the costs of labs and clean workspaces, highly skilled employees, insurance, consulting services, and the need to protect intellectual property. This list of expenses could easily be substantially increased, depending on the technology. Thus, a variety of entrepreneurial funding sources have emerged to help companies commercialize. These sources entail varying costs to the entrepreneur, and provide different degrees of value-added services. For example, both banks and VCs monitor investee firms, but VCs also offer value-adding services (Fraser, Bhaumik, & Wright, 2015).

Funding sources are typically characterized by ownership: public, nonprofit, and private. Funding organizations may be local or operate at a national level. Furthermore, universities take equity in academic start-ups in lieu of licensing fees, which provides legitimacy for the start-up and allows the university to share in any potential upside (Feldman et al., 2002). Entrepreneurs typically initially bootstrap their companies, obtaining funding from what is known as the three F's—friends, family, and fools. Other financial intermediaries screen start-ups, provide contractual agreements, and monitor investments on behalf of investors (Berger & Udell, 1998). We look at financial intermediation in terms of its impact on commercialization outcomes, rather than just in terms of financial outcomes for investors, and to investigate the nonpecuniary roles of financial intermediaries.

Venture Capital

Defined as "the professional asset management activity that invests funds raised from institutional investors, or wealthy individuals, into promising new ventures with a high growth potential" (Da Rin, Hellmann, & Puri, 2012, p. 573), VC firms operate as partnerships that raise money from institutional and individual investors. They may be corporate, bank-owned, or private- or government-sponsored.

Private-sponsored VC is less common in European countries than in the United States. In Asian countries, however, VCs do not have the same relationships with universities as in the United States: VCs often invest in earlier stages in Asia than in the United States (see Kenney, Han, & Tanaka, 2002, for a review of VC in Asia). VC funding is the most extensively studied form of entrepreneurial finance and is noted to have an aggressive management model that facilitates the commercialization of science. Samila and Sorenson (2010, p. 1358) argued that “venture capital supports the development of these [innovative] ideas and helps to train and encourage a community of entrepreneurs capable of bringing those ideas to market,” making clear the contribution of VC as a commercialization intermediary.

Venture capitalists use a multistage financing approach that provides funding in tranches. This allows VCs to stop funding if specific benchmarks are not met, or if it becomes apparent that the firm is not going to succeed (Kerr, Nanda, & Rhodes-Kropf, 2014). Public research funding and VC are complementary and result in more innovative activity, as measured by patents and start-ups, when a region has a greater amount of VC (Samila & Sorenson, 2010). The ability of VC investment to stimulate innovation also depends on characteristics of the VC firm (Kortum & Lerner, 2000). Hsu (2006) found that VC-funded firms are more likely to engage in cooperative commercialization strategies such as strategic alliances, and more likely to have an initial public offering than non-VC funded firms; these results were intensified when well-known VCs provided funding. Hsu (2004) found that start-ups will pay more in terms of equity for investments from VC firms with higher reputations. VC networks are useful to start-ups (Cable & Shane, 1997), yet Wright, Lockett, Clarysse, and Binks (2006) identified heterogeneity, as some VC have more social capital and involve themselves more deeply with the company.

Cumming and Dai (2010) found that VC investment decisions have a decidedly local focus. Over 50% of investments are made in firms located within 250 miles of the VC firm’s office. However, more reputable and well-networked VCs have a broader geographic reach. More local bias is present when VC is specialized in a technology industry and when investments are made in a greater number of rounds. Results show that local investments are more likely to have successful exits, which also has implications for how VCs add value to portfolio firms. Furthermore, the value-added effect of VC tends to vary depending on where the VC firm is

located. Pinch and Sunley (2009), for example, found VCs in the Southampton, U.K., cluster are less effective as knowledge transfer agents than VCs in leading high-tech clusters such as Silicon Valley.

Cumming and Dai (2011) investigated the relationship between VC fund size and successful firm exit—finding that fund size has a diminishing marginal return to start-ups. In a novel exploitation of exogenous variation in new airline routes, Bernstein, Giroud, and Townsend (2016) found that greater on-site involvement, particularly of the lead VC, increased innovation in firms along a number of dimensions; they interpreted these findings as indicating that monitoring by a VC is, in fact, a valuable asset for funded firms.

Wright and colleagues (2008, p. 1209) argued that “venture capitalists and angels with specialist technological skills may act as intermediaries that provide access to customers and suppliers.” These connections may be especially important for technology-based firms. Vanacker, Collewaert, and Paeleman (2013) investigated how VC adds value to start-ups compared to angel investors. They matched a sample of VC- and angel-backed firms to similar non-backed firms and used OLS regression to assess impact on performance measured by gross profits, finding that both funding sources moderate the relationship between slack resources and firm performance compared to non-backed companies. Angel investors are associated with better use of human resources, while VC investment was associated with better financial and human resource use. The results indicate that start-ups’ efficiency in operations, such as commercialization, may benefit more from VC than angel investment. Furthermore, the VC effect is correlated with the equity share: Greater VC ownership increases performance.

The literature has also considered how VCs make investment decisions. Nanda and Rhodes-Kropf (2013) found that hot markets make VC investors more willing to experiment by investing in more radical innovations. Bottazzi, Da Rin, and Hellmann (2016) found that trust levels affect VC decision making and are a complement to contingent control contracts. Specifically, higher trust predicts the likelihood of an investment being made, meaning that contracts are used not to overcome trust issues but when trust exists.

Further investigation into the characteristics of VC that allow them to best act as local intermediaries and affect commercialization would be useful. There is a need to consider the match between VC characteristics and firm characteristics and commercialization

potential. Also, there is currently little research that considers how VC interacts with other ecosystem intermediaries and members.

Angel Investors

Angel investors are individual investors who invest in smaller amounts and at an earlier, riskier stage of start-up development, which helps to provide proof of concept for scientific discoveries. The total amount of start-up financing provided by angels is greater than the amount provided by VC (Wessner, 2002). Angels are often experienced entrepreneurs with technology expertise, and they offer advice and mentoring for an indefinite amount of time (Cohen, 2013; Ibrahim, 2008). Beneficial for commercializing science, angels also have much longer time horizons than VC as they do not have to exit at some point on behalf of other investors, yet like VC they prefer to be located close to start-ups in which they invest (Berger & Udell, 1998; Sohl, 1999).

Research on angel investment is still developing, constrained by a lack of data. Sohl (1999, p. 106) described angel investment as a “relatively invisible” venture capital market segment. Ibrahim (2008) observed a lack of interest in this group from academics and media, even though this group has attributes, such as patience and eclectic interests, that make them good first investors in commercializing science. Ten years later this trend has reversed, but the difficulty of obtaining data from private angel investors makes empirical work challenging.

Studying this less visible group requires innovative techniques. Kerr and colleagues (2014) used data obtained directly from organized angel groups in a regression discontinuity design to study the effect of angels on firm outcomes. Defining a discontinuity threshold as a level of critical interest shown in a company by angels, the results suggest that start-ups funded by two successful angel groups had a higher probability of survival or successful exit and better employment outcomes than those rejected by the same groups. Bernstein, Korteweg, and Laws (2017) performed a randomized field experiment using the online AngelList investing platform to investigate how angel investors make investment decisions based on start-up characteristics. The manipulation of emails alerting investors to new investment opportunities introduced exogenous variation into the information provided to potential investors, allowing identification of angels’ interest level. Interestingly, angel investors were more influenced by founding team composition than firm sales and the

identities of other investors, reinforcing the idea that this class of investor may be important for commercializing science.

Public Funding

Public and quasi-public funding programs often extend financial support for commercializing science. Government has taken an active role in supporting science and innovation for over half a century, though direct public support for entrepreneurship is more recent. Public programs such as the U.S. Small Business Innovation Research (SBIR) program, which provides highly competitive grants to develop technology for federal agencies, have operated since the 1980s. Such programs operate outside the United States as well: Aernoudt (2005) used the case of a successful Belgian program to argue that public co-investment programs are an effective means to help angels spread risk.

A long literature evaluates the impact of the SBIR program (Lanahan, 2016; Lanahan & Feldman, 2015, 2017; Lerner 1999; Link & Scott, 2010; Qian & Haynes, 2014), yet consensus on the program’s impact is elusive. An SBIR-funded project faces a 50% probability of failing to produce a commercialized technology, though Link and Scott (2010) compellingly argued that this is an acceptable risk level for the federal government. Reinforcing this, Lerner (1999) found that firms with SBIR grants grew faster in sales and employment and were more likely to receive subsequent VC investment than a matched set of firms without SBIR grants; results were stronger in high-technology industries and in regions with a higher concentration of VC. Furthermore, SBIR funding has a positive impact on patenting levels in small and medium-size nanotechnology firms (Kay, Youtie, & Shapira, 2013).

While U.S. states create their own entrepreneurship programs, they also leverage and augment national programs. Forty-two states have SBIR service assistance programs, and 17 states have an SBIR matching grant (Lanahan & Feldman, 2015). Lanahan and Feldman (2017) provided evidence of the efficacy of such policies, finding that firms that receive an SBIR Phase I state match grant have a higher probability of receiving an SBIR Phase II grant, when awarded from the National Science Foundation.

Finance is also available in the form of public VC. Pergelova and Angulo-Ruiz (2015) analyzed the impact of U.S. government equity, loan, and guarantee programs for entrepreneurship, finding that guarantees

and equity have a positive impact on firms' competitive advantage and an indirect effect on profits. Public sources may offer less added value to start-ups engaging in commercialization than private sources, though. Pierrakis and Saridakis (2017) found that U.K. firms receiving only public VC apply for fewer patents than those obtaining only private VC, attributing this divergence to public fund managers' lack of expertise compared to private managers.

Indirect public efforts are also seen through attempts to stimulate investments from private sources. Lerner (2002) argued that government intervention, in the form of public VC, is justified when public investment can certify firm quality to other investors, and when technological spillover is possible. Several states have created investment programs, such as Connecticut Innovations, a quasi-public, state-funded venture capital fund founded in 1989 (Feldman & Kelley, 2002). Lerner (2002) warned, however, that public VC programs can be inefficient and difficult to design.

It is certainly true that many public financing programs are oriented toward capturing the benefits of science commercialization within their jurisdictions' boundaries. Moreover, different levels of governments, national and local, have the capacity to design their own programs and experiment with different requirements and stipulations, which makes program evaluation difficult. Future research should continue to investigate the role public funding sources play in stimulating innovation and commercialization.

Crowdfunding

Crowdfunding is the newest—and least understood—practice in entrepreneurial finance; it is defined as “the efforts by entrepreneurial individuals and groups—cultural, social, and for-profit—to fund their ventures by drawing on relatively small contributions from a relatively large number of individuals using the Internet, without standard financial intermediaries” (Mollick, 2014, p. 2). Crowdfunding emerged after the 2008 recession—when bank financing became less available—and has become more structured with time, though equity crowdfunding standards are slow to develop in many countries (Bruton, Khaul, Siegel, & Wright, 2015; Harrison, 2013). The 2012 JOBS Act legalized equity crowdfunding in the United States (Agrawal, Catalini, & Goldfarb, 2014).

Crowdfunding platforms allow individual or pooled investments in firms or projects, usually

called campaigns (Bruton et al., 2015). The use of web-based platforms offers an opportunity to describe the science underlying a project and to reach a larger set of potential investors than possible through the angel-funding model. Crowdfunding models also differ in how funders receive compensation. Donation models do not provide compensation for investors and usually benefit nonprofits or charities. Reward models offer gifts in return for investment. Pre-purchase models provide investors with the product in which they invested. In lending models, investors receive returns following typical borrow–lender relationships. Finally, equity models offer shares in profit, or ownership (Harrison, 2013).

Current crowdfunding research is dominated by descriptive and case-based studies. Lehner, Grabmann, and Ennsgraber (2015) uncovered broad, nonfinancial implications of crowdfunding using four campaign case studies, including crowdfunding's ability to serve as an alternative distribution channel where funders act as pre-market testers and help with problem identification, quickening commercialization time.

Several crowdfunding studies use data from Kickstarter, a prominent reward-based platform. Frydrych, Bock, Kinder, and Koeck (2014) found that certain signals affect how projects gain legitimacy, including founding team composition and the time it takes to achieve funding goals. Stanko and Henard (2016) studied innovation outcomes of successful Kickstarter campaigns and found that beyond funds generated, campaigns help creators with product feedback and idea sharing—both of which are important to commercialization. With surveys and data from more than 200 Kickstarter firms, they found that the amount of subsequent innovation by campaigners is related to campaign features, such as how open the campaign is to external ideas and how early in the development process the campaign began. These findings suggest that crowdfunding may provide an enhanced commercialization model.

The geography of crowdfunding investment is of interest because its online basis should theoretically eliminate geographic bias. Agrawal, Catalini, and Goldfarb (2011) found that geography does not play a role in investment decisions once campaigners' friends and family network is controlled for. Still, most campaigns are concentrated in geographic regions typically viewed as more entrepreneurial (Mollick, 2014), highlighting the need to consider crowdfunding as part of the regional innovation ecosystem.

Though some entrepreneurial finance providers have been studied extensively, there is a need to

understand the relationships and dependencies among finance sources. Learning how various sources affect the likelihood of receiving funding from different sources will provide important information to entrepreneurs seeking to commercialize scientific discoveries, and policy makers designing public finance programs. Better data are imperative to extending research on angel investing and crowdfunding.

CONCLUSION

In many ways, the journey from research funding to technology commercialization via an entrepreneurial firm conjures up the image of an old suitcase or steamer trunk papered with all the tags from the destinations on its journey. Every intermediary or support organization that has contact with a firm leaves a fading yet indelible mark. Studying each institutional category in detail allows researchers not only to identify important sources of divergence, but also to begin to explore the interdependencies and intersections of different programs. In this paper we reviewed five intermediaries commonly mentioned in the ecosystem literature: university technology transfer and licensing offices; physical space (incubators, accelerators, and co-working spaces); professional services providers; networking, connecting, and assisting organizations; and finance providers (including venture capital, angel investors, public financing, and crowdfunding).

As we note, university technology transfer and licensing offices have long been known to partner with incubators and support organizations within their regions. Reinforcing this, Fini, Grimaldi, Santoni, and Sobrero (2011) recognized that university supports for academic spin-offs can act to reinforce the contribution of other local support mechanisms.

Indeed, universities are on the front lines of technology intermediation. The ability of TTOs to accumulate stocks of human, network, and technological capital make them important players in ecosystems. However, not much is known about their actual potential for economic development and how policy-makers might exploit their resources for broader goals. While the TTO literature is expansive, there are gaps in our understanding of the effectiveness and relationships of TTOs to other intermediaries in the ecosystem.

Incubators, accelerators, and co-working spaces offer firms and entrepreneurs varying levels of support with one common feature: the provision of a laboratory and/or workspace. While incubators have been studied the most closely of all three types,

we need more knowledge about incubation processes and effectiveness. The research on accelerators and co-working spaces is much newer. Empirical and theoretical work is necessary to better understand how these organizations contribute to technology commercialization and start-up outcomes.

Another promising topic for future empirical research is professional services firms. Though these firms are not as glamorized as accelerators and VCs, for example, they provide critical services that contribute to successful commercialization. The law literature has extensively studied Silicon Valley attorneys, but without an empirical lens. Other service providers are mentioned in studies, but often fail to receive due attention. The innovation literature has studied PSFs in more depth than the management literature, but this trend is improving.

Additional research is needed to understand the function of institutional intermediaries, including networking, connecting, and assisting organizations. Quasi-public programs are well positioned here, often connecting firms to a broader range of private and public stakeholders compared to their counterparts in academia or corporate settings. Finance providers (including venture capital, angel investors, public financing, and crowdfunding) have received the most attention, with decades of research. Yet there is continual innovation, including emergent funding models such as crowdfunding as well as the evolution of earlier finance sources, making the area ripe for continued inquiry. While the VC literature is extensive, literature investigating the relationship between VC and other funding sources is less developed. The impact of crowdfunders and angels on innovation is still unclear. Though at first glance crowdfunding may appear to have fewer value-added services than angels and VC, recent studies illuminate a number of features, such as idea sharing and consumer feedback, that angels and VC may not provide.

Popular accounts of innovation in regional economies often presume that venture capital is the most essential institutional actor for supporting local entrepreneurship. But as Lerner (2009) noted in *The Boulevard of Broken Dreams*, the presence of VC is not sufficient to create an innovative local economy, and VC investment does not guarantee that entrepreneurial firms will be successful. As this comprehensive survey illustrates, there are many other institutional actors in the mix, each adding additional and complementary services and supports. In some cases, these intermediaries focus on a particular segment of the local entrepreneurial community—the

most focused of which are incubators, accelerators, and co-working spaces, which service only those firms that secure residency in their facilities. But others have a broader reach.

In our own research, we introduce the concept of entrepreneurial pathways to capture the different combinations and sequences of institutional supports that firms engaged with over time to grow their businesses and support innovation (Lowe & Feldman, 2017). More than a static inventory, the pathway concept places the firm within a well-mapped institutional surrounding. It allows us to study the exact navigational routes that firms use to traverse that regional institutional landscape, and thus offers a unique vantage point for exploring the contribution of multiple institutions in advancing science, innovation, and sustained entrepreneurial growth. As we begin to recognize this fuller institutional picture of a region, it also creates an opportunity to propose an alternative policy narrative—one less focused on evaluating and identifying the best institutional fit and fit, and channeling all resources there: one that instead considers the longer term entrepreneurial value of having institutional diversity, even redundancy, within a regional ecosystem.

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APPENDIX A

Literature search keyword combinations:

- (1) intermedia* AND (technology commercialization OR academic entrepreneurship) AND spin-off AND (local OR region)
 - (a) intermedia* AND spin-off AND (technology commercialization OR academic entrepreneurship)
- (2) ((intermedia* AND spin-off) OR (commercial* OR tech* transfer OR entrepreneur*)) AND university technology transfer/licensing office AND (local OR region)

- (a) intermedia* AND spin-off AND university technology transfer/licensing office
- (3) ((intermedia* AND spin-off) OR (commercial* OR tech* transfer OR entrepreneur*)) AND (KIBS OR professional service firm) AND (local OR region)
 - (a) intermedia* AND (entrepreneur* OR spin-off) AND (KIBS OR professional service firm)
- (4) ((intermedia* AND spin-off) OR (commercial* OR tech* transfer OR entrepreneur*)) AND (government support program OR non-profit support program) AND (local OR region)
 - (a) intermedia* AND (entrepreneur* OR spin-off) AND (government support program OR nonprofit support program)
- (5) ((intermedia* AND spin-off) OR (commercial* OR tech* transfer OR entrepreneur*)) AND (incubator OR accelerator OR co-working space) AND (local OR region)
 - (a) intermedia* AND spin-off AND (incubator OR accelerator OR co-working space)
- (6) ((intermedia* AND spin-off) OR (commercial* OR tech* transfer OR entrepreneur*)) AND (venture capital OR angel OR crowdfunding OR public funding OR government funding) AND (local OR region)
 - (a) intermedia* AND spin-off AND (venture capital OR angel OR crowdfunding OR public funding OR government funding)