KNOWLEDGE SOURCES OF ENTREPRENEURSHIP: FIRM FORMATION BY ACADEMIC, USER & EMPLOYEE INNOVATORS*

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Abstract

Innovative new ventures are at the heart of economic development, particularly when these startups are created by employee, academic, and user innovators. We synthesize across literature streams examining each phenomena to document distinctions between firms originating from different "knowledge contexts." We then integrate the knowledge context into Teece's (1986) theoretical framework identifying factors that impact a firm's ability to profit from innovation. Doing so allows us to develop stylized facts and predictive propositions pertaining to differences in the innovative contributions, roles played in shaping industrial dynamics and evolution, and performance outcomes for startups stemming from the three entrepreneurial origins. These propositions provide unique insights into the causes of patterns of industry evolution, contribute to theory in the areas of entrepreneurship and industry evolution, and yield important policy and managerial implications.

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Across economics, sociology, psychology, policy, and management, differential knowledge resources has been identified as a central factor that gives rise to and shapes innovative new ventures. This focus dates back to Schumpeter (1934) and Hayek (1945), who suggested that information asymmetries arising from differences in knowledge are at the heart of why some individuals identify and exploit entrepreneurial opportunities before others (Kirzner, 1997). "Knowledge corridors" allow some aspiring entrepreneurs to create innovations, as well as to amass the necessary resources and complementary assets required to transform innovative ideas into viable commercial products and services through the formation of firms (Venkataraman, (1997).

Consistent with this notion, significant scholarly attention has recently been devoted to understanding three sources of innovative new ventures: employee entrepreneurship, academic entrepreneurship, and user entrepreneurship. Each of these bodies of work has developed independently, but they share a common underpinning: each focuses on a "knowledge context" in which an individual develops informational advantages that serve as the basis for the creation of a new firm. Production in existing firms is the knowledge context for employee entrepreneurship, where individuals employed by existing organizations in the focal industry venture out to capitalize on knowledge gained through employment (Agarwal et al., 2004; Klepper, 2001; Phillips, 2002). Research in academic institutions serves as the knowledge context for academic entrepreneurship, when firms are founded by scientists who innovate in the context of universities, national labs, or institutions that undertake basic research (Audretsch and Feldman, 1996; Feldman et al., 2005; Lockett et al., 2005; Mowery, 2005; Zucker et al., 1998). Finally, user entrepreneurship is the founding of firms by individuals who innovate in the knowledge context of using the focal product or service (Baldwin et al., 2006; Shah, 2005; Shah and Tripsas, 2007). These three knowledge contexts reflect the institutional backdrops that appear to seed the majority of innovations. Taken together, these three contexts span the focal industry and also upstream "science push" and downstream "demand pull" knowledge sources (Dosi, 1988; Nelson, 1959; Scherer, 1982).

Comparing and contrasting new ventures originating from different contexts permits us to expose the systematic differences between these firms along numerous strategic dimensions, thereby illustrating that the knowledge context from which a firm originates does indeed matter. Our objectives in this paper are two-fold. First, we provide a review and synthesis of extant literature on employee, academic, and user entrepreneurship to identify systematic patterns pertaining to the characteristics of the innovative knowledge exploited, access to complementary assets, intellectual property protection, entry timing, performance outcomes; and relationships with established firms. Second, we integrate the knowledge context into Teece's (1986) framework for profiting from innovation. We build and present theoretical arguments that serve to explain and extend empirically observed patterns, as well as highlight the differential contributions of firms from each of the three knowledge contexts to innovation and to industrial development and evolution.

Our primary contributions are to the innovation and industry evolution literatures. By adding the *knowledge context* as a fourth factor in the Teece framework, we deepen predictive insights regarding which firms will profit from innovation and the factors that will enable them to do so. Our refinement of Teece's framework also theorizes that the strength and importance of appropriability regimes increase as industries evolve, by drawing on empirical support from existing studies. By combining the novel insights that (a) the knowledge context shapes an innovative new venture's capabilities and (b) appropriability regimes tend to increase in strength over the industry life cycle with established wisdom that the importance of complementary assets increases over the industry life cycle, we provide explanations for several patterns in industry evolution.

We also contribute to the entrepreneurship literature through the systematic comparison of new ventures originating across the three distinct knowledge contexts. Entrepreneurial innovation occurs when startup firms introduce innovations into the commercial marketplace, becoming important sources of technological and industrial progress (Baumol, 2002; Scherer, 1980). We focus on a "first principles" approach to entrepreneurial innovation: we highlight the underlying seedbeds—i.e. the knowledge contexts—from which innovative new ventures arise, distinguish among the contributions of each type of innovative new venture, and identify the manner in which various factors differentially shape each type of entrepreneurial entry and their post entry activities. By integrating insights across literature streams that have largely developed in isolation to each other, our theoretical framework provides a parsimonious rationale for how the knowledge context shapes formation and modes of value capture by new ventures, and how and when each type of entrepreneurial venture is likely to contribute to an industry's growth and evolution. In doing so, we show how heterogeneity in entrepreneurial innovations arise and provide policy-makers, practitioners, and investors with a nuanced basis from which to make decisions regarding how to promote entrepreneurial innovation.

THE KNOWLEDGE CONTEXT & ENTREPRENEURSHIP

Scholarship in entrepreneurship, innovation and strategy has made significant strides recently in examining how the macro knowledge context relates to the micro-underpinnings of new firm formation and performance. Since start-ups benefit from the pre-entry experience and knowledge embodied in their founders, independent literature streams have examined how individuals gain knowledge related to the production and marketing of the focal products and services (employee entrepreneurship), in the process of scientific discovery in academic institutions (academic entrepreneurship), and in the use of these products and services (user entrepreneurship). We synthesize across these literature streams by formally defining them, discussing the industries and sampling frames used as an empirical context, and reporting on the known prevalence of each type of entrepreneurship. We then document patterns along the following dimensions: the type of knowledge and innovation exploited through firm formation; the relevance of the three factors highlighted by Teece (1986)—complementary assets, appropriability regimes and industry life cycle[1]; new ventures' relationship with established firms; and finally, their performance subsequent to entry.

[1] Teece's (1986) framework identified complementary assets, appropriability regimes, and industry life cycle stages as critical factors that influence a firm's ability to profit from innovation. Complementary assets required for the development, manufacture or distribution of an innovative product or service may consist of physical capital, brand equity, organizational knowledge, and tacit human capital of other employees. Appropriability regimes are "environmental factors, excluding firm and market structure, that govern an innovator's ability to capture the profits generated by an innovation," which depend on the technology and the efficacy of property rights protection offered through legal mechanisms. Finally, while Teece distinguished between pre and post dominant design based on Abernathy and Utterback's (1978), scholars have differentiated between early, growth and mature periods of the industry life cycle due to transformations in the underlying market structure (Agarwal et al., 2002; Gort and Klepper, 1982).

We impose the following boundary conditions on our review. First, we note that the three knowledge contexts are neither mutually exclusive nor exhaustive. For example, industrial scientists may work on basic research in corporate labs, such as Xerox PARC or Bell Labs, where industry and academic science norms comingle (Chesbrough and Rosenbloom, 2002; Holbrook et al., 2000). Also, individual entrepreneurs may possess varied career histories that provide them with knowledge from multiple contexts (Mosey and Wright, 2007; Wennberg et al., 2011). For example, employees of firms may be user innovators, resulting in a hybrid of user and employee entrepreneurship (Fontana and Malerba, 2010; Shah et al., 2012). Further, firms may be formed by entrepreneurial teams composed of members from various knowledge contexts: whether this leads to "super" firms endowed with a great array of knowledge and/or firms plagued by conflict is an empirical question that has yet to be investigated.[2] For simplicity, we limit our examination to the three "pure" entrepreneurial contexts, but note exceptions as they arise. Also, while not exhaustive, the three knowledge contexts span the focal industry, as well as upstream "science push" and downstream "demand pull" knowledge sources (Dosi, 1988; Nelson, 1959; Scherer, 1982). That said, other important knowledge contexts include industries that are otherwise related to the focal industry context, including complementary or supplier products and services. We do not discuss these contexts, given lack of systematic literature streams on these origins.

Second, we limit attention to *entrepreneurial firm formation,* and not the broader literature on academic, employee and user *innovation.* We assume that the innovation being commercialized has already been developed, and focus on situations where the calculus across alternative options (licensing technology, free dissemination, etc.) has resulted in firm formation, to provide products or services for the end consumer or other firms in the ecosystem. Finally, we employ an inductive approach, focusing on identifying empirical patterns prior to creating a theoretical framework. According, our review focuses only on papers that have an empirical context and findings.[3]

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[2] For example, Franklin, Wright & Lockett (2001) show that when university policies permit use of "surrogate" entrepreneurs in launching academic founded firms, there are more venture launches.

[3] We used the following process to identify relevant work: First, we selected leading papers based on citations in Google Scholar. Our search terms included the breadth represented in each stream (e.g. in employee entrepreneurship, we

Employee Entrepreneurship

Empirical Context and Sampling Frame Used in Studies: Employee entrepreneurship is defined as new venture creation when employees of existing firms found a firm in the same industry (Agarwal et al., 2004; Klepper, 2002). Dominant labels of these new ventures include "intra-industry spin-offs" (Klepper, 2002), or "spin-outs" (Agarwal et al., 2004), and the attention is focused on contexts where both the "parent" firm and the spawn operate in the same industry. Table 1 summarizes across the key empirical studies on employee entrepreneurship. The studies cover both professional services and high-technology manufacturing, and represent long histories, some dating back into the nineteenth century. Garvin (1983), seemingly first to document the phenomena, compiled impressive anecdotal evidence spanning several industries. Brittain and Freeman (1986) and Mitton (1990) followed, with a research design that now characteristics scholarly work that has exploded in the area: comprehensive and longitudinal single industry studies that track genealogical relationships between firms due to the employee-founders. The benefits of employing such a sampling frame include the ability to measure the incidence of employee entrepreneurship and track their relative performance. A cost of the sampling frame, however, is that single industry context studies do not facilitate inter-industry comparisons of factors that impact the formation and performance of the new ventures. Further, the generalizability of the studies are limited to a synthesis of the results, an issue we attempt to address in this study, rather than a formal and empirical examination of the boundary conditions under which the phenomena is prevalent.

Type of Knowledge or Innovation Utilized in Firm Formation: Their knowledge context provides the founders with critical technology, operations and market knowledge. Technical knowledge capitalized by employee founded firms includes codified information in the form of products, patents, or firm routines. Agarwal et al. (2004) provide quantitative evidence regarding the inheritance of technological capabilities in the disk drive industry, and Klepper and Sleeper (2005)

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searched on this term, and terms such as *spinouts, spawns*, and *intra-industry spinoffs*). We then conducted forward and backward citation searches, and appended to the literature review based on our own expertise and knowledge of relevant work. While we do not claim to have reviewed *every* paper in each literature stream, our methodology captures the most cited research, and works they draw upon and generate.

document the leveraging of parent firm technology (patents and products) in the laser industry. Tacit technical know-how is also identified as a critical resource (Clarysse, Wright, et al., 2011), whether in high technology contexts such as automobiles, biotechnology, and semiconductors, or in knowledge intensive service industries, such as fashion design and legal services. Often, as in medical devices (Chatterji, 2009), the tacit knowledge may include operational knowledge for navigating regulatory processes and clinical trials.

Market and business knowledge are also exploited by employee founded firms. Moore and Davis (2004) note that the managerial skills learned by technical personnel employed at Fairchild Semiconductor was critical in their subsequent decisions to venture out and found firms that contributed to the vibrancy of Silicon Valley. Agarwal et al. (2004) and Franco and Filson (2006) systematically link employee founded firms' ability to pioneer new product markets within the disk drive industries to their parent's market pioneering capabilities. These "entrepreneurial capabilities" are also highlighted by Ellis et al. (2008) in the information technology and communications industry. Importantly, in knowledge intensive service industries, industry specific knowledge residing in human capital is of critical importance, as documented by studies of the legal services (Campbell et al., 2012; Carnahan et al., 2012; Phillips, 2002) and winery industries (Simons and Roberts, 2008). In part, this is also due to access to important resources through social networks (Sorenson and Audia, 2000; Stuart and Sorenson, 2003a; Stuart and Sorenson, 2003b).

As seen in Table 1, almost all studies note the prevalence of both product and process innovation. This is understandable, since employee-founders are armed not only with technical and market know-how that enable product innovation, but also operational knowledge in the focal industry context, which enables process innovations targeted towards efficiencies in production.

Dimensions of the Teece Framework—Complementary Assets, Appropriability Regimes and the Industry Life Cycle: Various complementary assets have been identified in the studies of employee entrepreneurship. Table 1 shows that employee founded firms leverage physical and organizational knowledge (e.g. routines) as complementary capabilities (Brittain and Freeman, 1986; Ganco, 2013; Garvin, 1983; Klepper, 2002; Klepper and Sleeper, 2005). Further, Klepper and Sleeper (2005) note that knowledge becomes increasingly embedded in physical rather than human capital in the laser industry context over time. Other studies highlight the ability of employee founded firms to access both upstream scientific knowledge and downstream distribution and market channels (Chatterji, 2009; Mitton, 1990; Stuart and Sorenson, 2003a; Stuart and Sorenson, 2003b). In knowledge intensive professional service industries, employee founded firms benefit from the ability to transfer and recreate complementary human capital and organizational routines (Campbell et al., 2012; Carnahan et al., 2012; Dahl and Reichstein, 2007; Wennberg, 2009). Still others highlight complementary assets that stem from geographical proximity: Sorenson and Audia (2000) document high and stable geographical clustering in the US footwear industry that relate to supply of resources, and Klepper (2002) and Buenstorf and Klepper (2009) also highlight location preferences of employee entrepreneurs in the automobile and tires industries. Geographical proximity provides social networks and access to venture financing, two complementary assets emphasized in studies related to biotechnology and semiconductors (Mitton, 1990; Moore and Davis, 2004; Stuart and Sorenson, 2003a; Stuart and Sorenson, 2003b).

Employee founded firms are prevalent regardless of whether industries are characterized by strong or weak appropriability regimes. Employee entrepreneurship has been documented in several industry contexts—medical, biotechnology and semiconductors in particular—with strong appropriability regimes built on patents and trade secrets (Chatterji, 2009; Ganco, 2013; Stuart and Sorenson, 2003a; Stuart and Sorenson, 2003b). Strong appropriability regimes seem to both foster and deter employee entrepreneurship. On the one hand, studies have highlighted high rates of employee entrepreneurship by founders possessing intellectual property rights in the form of patents (Ganco, 2013; Hall and Ziedonis, 2001; Kim and Marschke, 2005; Klepper and Sleeper, 2005). On the other hand, scholars have also noted the strategic use of patent thickets by established firms to stave competition (Ziedonis, 2004), and aggressive IP litigation to reduce knowledge spillovers through employee mobility and entrepreneurship (Agarwal et al., 2009; Ganco et al., 2013; Klepper and Sleeper, 2005). A number of studies of employee entrepreneurship have also been conducted in weak appropriability regimes, including consulting, legal services, fashion design, and wineries

(Campbell et al., 2012; Carnahan et al., 2012; Garvin, 1983; Phillips, 2002; Simons and Roberts, 2008; Wenting, 2008). Almost all of these studies document knowledge transfers and spillovers to the new ventures (Agarwal et al., 2013; Campbell et al., 2012). For example, studies of legal services, a context notorious for weak appropriability since even non-compete contracts are not applicable, document both high rates of employee entrepreneurship and adverse effects on parent performance (Campbell et al., 2012; Phillips, 2002). Other studies, on wineries, for instance, document transfer of tacit local and non-local knowledge across organizations through employee entrepreneurship (Simons and Roberts, 2008). Thus, in weak appropriability regimes, employee founded firms seem to suffer less from a deterrent effect, and capitalize on tacit knowledge and industry specific information gained through employment.

The sampling frame used in employee entrepreneurship studies is particularly amenable to studying the effect of industry evolution on new firm formation. Almost all studies reported in Table 1 find employee founded firms to be most prevalent in the growth and mature stages. In part, this may be tautological—as the number of firms in the industry increases, so does the population of employees that are at risk of spinning out. However, the incidence of employee entrepreneurship is not a mere mathematical artifact. Increases in industry specific knowledge, and shifting focus on operational knowledge and process innovation over time (Abernathy and Utterback, 1978; Gort and Klepper, 1982) would foster higher rates of employee entrepreneurship in the growth and mature stages of the industries. In addition, it is not the number of potential parent firms per se, but the quality of those firms that determines the propensity of employees to found firms: evidence from automobiles, disk drives, lasers, semiconductors and tires, show that abundant under-utilized knowledge among high performing firms results in greater rates of employee entrepreneurship (Agarwal et al., 2004; Buenstorf and Klepper, 2009; Klepper, 2002; Moore and Davis, 2004).

Firm Formation & Relationship with Established Firms in the Industry: Studies of employee entrepreneurship find that the fraction of employee founded firms in an industry range from approximately 25% of start-up activity in industries such as automobiles and disk drives (Agarwal et al., 2004; Klepper, 2002) to a staggering 80% and above in industries such as information technology and communications, and tires (Buenstorf and Klepper, 2009; Ellis et al., 2008).[4]

Employee founded firms often compete with and sometimes complement, but rarely cooperate with established firms; this distinction may be based on the motives of employee entrepreneurs. Most studies reviewed in Table 1 document a competitive relationship with the established parent. Regardless of whether employee departures are motivated by strategic disagreements (Klepper, 2002, 2007), underexploited knowledge (Agarwal et al., 2004), or learning through apprenticeship (Franco and Filson, 2006), employee founded firms imitate core capabilities and strategies from their parents and compete in the same industry segments and submarkets. As a result, studies consistently find that employee entrepreneurship negatively impacts parent performance, perhaps even resulting in parent firm exit (Campbell et al., 2012; Franco and Filson, 2006; McKendrick et al., 2009; Moore and Davis, 2004; Phillips, 2002).

When under-utilized knowledge is the impetus, employee founded firms are more likely to enter niche or new market segments, or build on technological advances left unexploited by the parent firm (Agarwal et al., 2004; Klepper and Sleeper, 2005). In some instances, the new market segments transitioned from low market overlap to greater competition (Christensen, 1997; Franco and Filson, 2006); while in others, the firms co-existed in non-overlapping market segments for the entire observed time period (Klepper and Sleeper, 2005).

Instances of collaboration between employee founded firms and established firms are not often observed, although a few exceptions—often involving technology licensing and venture financing—have been documented (Garvin, 1983; Klepper and Sleeper, 2005). Agarwal, Audretsch and Sarkar (2007) provide anecdotal evidence regarding the process of creative *construction*, whereby employee founded and parent firms occupy complementary or vertical positions in an ecosystem that enable spill-ins from the employee founded firm to the parent.

[4] The statistics are computed with the denominator being all new ventures (but not all entrants) in the industry, and thus excludes diversifying firms (existing firms in other industries that enter into the focal industry) from the computation.

Performance: Survival is the key performance metric, and most studies find that employee founded firms outperform all other entrants (See Table 1). Given the importance of knowledge inheritance from parent to employee founded firms, studies unsurprisingly find that parent firms with superior technological or market know-how generate more progeny, who subsequently enjoy higher survival rates (Agarwal et al., 2004; Brittain and Freeman, 1986; Klepper, 2002; Klepper and Sleeper, 2005).

A few studies do examine performance measures other than survival. In disk drives, Agarwal et al. (2004) find that employee founded firms inherit superior technological and market pioneering capabilities from their parents. In footwear, Sorenson and Audia (2000) find that the growth of employee founded firms is negatively related to geographical concentration of the region. In medical devices, Chatterji (2009) finds that employee founded firms perform better than other entrants in terms of venture financing and valuation. Simons and Roberts (2008) examine performance consequences in terms of size and quality of products, and find evidence consistent with findings on survival that founders with better experience are advantaged.

Summary of Employee Entrepreneurship: The extensive literature in employee entrepreneurship that has blossomed in the last thirty years shows remarkable consistency in the empirical evidence gathered across an impressive array of industries. Collectively, these studies show that a significant fraction of new firms formed in an industry are likely to be employee founded firms that build on technical and marketing know-how from their parents (both tacit and codified) to introduce product and process innovations. These patterns are consistently observed regardless of the type of complementary assets required in the industry and the strength of the appropriability regime in the industry. Employee founded firms tend to enter in the growth and mature periods of the industry life cycle, and are more likely to compete directly rather than collaborate with the established firms. This competition does not necessarily bode badly for employee founded firms, who often exert competitive pressures on their parents and generally outperform other firms that enter in the industry.

Academic Entrepreneurship

Empirical Context and Sampling Frame Used in Studies: Academic entrepreneurship (also referred to as university spinoffs or academic spinouts) is defined as new venture formation by faculty, staff or students who innovate in an academic or non-profit research context, and subsequently found a firm that directly exploits this knowledge (Shane, 2004). Although technology transfer and university-firm relationships date back to the creation of land-grant universities and the Morrill Act of 1862, academic norms were strongly against both ownership and commercialization of technologies created for most of the post industrial revolution era (Nelson, 1959; Stokes, 1997). As a result, academic entrepreneurship was neither a pervasive phenomenon, nor a subject of scholarly attention. Mitton (1990), perhaps the first scholarly study on the subject, conducted an in-depth, study of the biotechnology industry in San Diego and found that three research institutions accounted for 54% of new ventures established between 1971 and 1989. Scholarly attention to academic entrepreneurship blossomed after the mid-1990s. This coincided with a fundamental shift in legislative attitudes in both the US and the UK towards intellectual property rights from an anti-competitive, antitrust lens to more innovator friendly regimes.[5]

Most academic entrepreneurship studies utilize a sampling frame that concentrates on one or a small number of universities, and examine academic entrepreneurship in the context of available technology transfer opportunities from the source. Scholars have examined academic entrepreneurship from MIT (Shane, 2004), University of California system (Lowe, 2002; Lowe and Ziedonis, 2006), major east and west coast research universities (Hsu and Bernstein, 1997), and universities in the United Kingdom (Lockett and Wright, 2005; Vohora et al., 2004). The benefit of employing this sampling frame is that it enables an understanding of the types of university science that lend themselves to entrepreneurial firm formation, and measurement of new venture creation across disciplines and fields. Consistent with Pasteur's quadrant (Stokes, 1997), academic entrepreneurship is more prevalent in disciplines which emphasize both basic and applied research. Based on Table 2, the highest incidence of science based new ventures is in biological and life sciences (Audretsch and Stephan, 1996; Lowe, 2002; Mitton, 1990; Shane, 2004; Stuart and Ding,

[5] In the US, the 1980s witnessed several policy reforms, including the Stevenson-Wydler Technology Innovation Act of 1980, the Bayh-Dohl Act of 1980, and the Federal Courts Improvement Act of 1982 (Jaffe, 2000; Lockett et al., 2005). In the UK, the passage of the 1977 Patents Act was followed by major changes in educational policy undertaken by the Thatcher administration in the 1980s, requiring universities to engage in technology transfer and develop stronger ties with industry as a co-requisite to receiving governmental support (Lockett et al., 2005; Lockett et al., 2012; Shane, 2004).

2006) and in computer and engineering sciences (Hsu and Bernstein, 1997; Kenney and Patton, 2011; Lockett and Wright, 2005; Scott, 2008; Shane, 2004; Vohora et al., 2004). A cost of using this sampling frame is that it does not permit precise estimations of the fraction of firms that stem from university science over the industry life cycle, or their relative performance.

Type of Knowledge or Innovation Utilized in Firm Formation: Academic entrepreneurship is based on technological advances in laboratory research and not surprisingly, Table 2 documents that technical knowledge is at the core of all academic founded firms. Possession of process/operational knowledge is conspicuously absent in discussions of academic entrepreneurship, as university scientists lack knowledge of the focal industry context outside of the research domain. Unless the scientists are also immersed in the use of the technologies (e.g. physician-scientists (MD-PhDs) conducting research *and* treating patients (Winston Smith and Shah, 2013), firms founded by academics are also not likely to possess market knowledge.[6] Further, the technologies represent product innovations, rather than process innovations. In particular, Shane (2004) notes that universities are more successful at creating novel product solutions, and less effective at creating efficient process technologies, given lack of expertise in product development and manufacturing.

A key characteristic of the knowledge utilized by academic founded firms, as documented in Table 2, is that most university innovations are in the embryonic ("proof of concept" or initial prototype) stages of technology development, regardless of whether they are intended for application in early or mature stage industries (Clarysse, Wright, et al., 2011). A key reason for firm formation is to incubate the technology for development and commercialization (Feldman et al., 2002; Jensen and Thursby, 2001; Katila and Shane, 2005; Lowe and Ziedonis, 2006; Nerkar and Shane, 2003). Jensen and Thursby (2001) report that only 12 percent of innovation disclosures in university technology transfer offices are ready for commercialization, and require continued development and attention to applications of the technology. Most academic founded firms are based on technologies that existing firms chose not to pursue, even though these firms had invested

[6] These startups are best characterized as hybrids between user and academic entrepreneurship, though pragmatically speaking, most studies of academic entrepreneurship include such startups within their samples.

in the research that led to these technologies (Nerkar and Shane, 2003), and thus require the creation of new ventures as vehicles for technology development (Lowe and Ziedonis, 2006).

As a result, the tacit knowledge possessed by scientists is a critical element of the knowledge embodied in academic founded firms. All the founders of search engine firms were researchers themselves (Scott, 2008). Tacit knowledge of scientists is important even in the presence of patents that codify knowledge (Bercovitz and Feldman, 2006; Stuart and Ding, 2006), which underscores the need for the scientists' continued involvement in the process of commercialization (Feldman et al., (2002). Star scientists, for example, embody the tacit and complex knowledge that complements the codified knowledge in patents, requiring their involvement in the new ventures as either founders, or scientific advisory board members (Zucker et al., 2002; Zucker et al., 1998).

Dimensions of the Teece Framework—Complementary Assets, Appropriability Regimes and the Industry Life Cycle: Complementary assets pose formidable barriers to academic founded firms, thus, firms founded by academics are less likely to occur in industries that require significant complementary assets in manufacturing and marketing (Katila and Shane, 2005; Shane, 2001; Shane, 2004). In addition to the type of knowledge being utilized, the lack of access to complementary assets has often been cited as a reason why academic entrepreneurship is more prevalent in industries such as biotechnology and software: these industries represent contexts where the innovations may stand alone, and do not require significant integration with other complementary technologies and assets (Shane, 2004). In addition to inter-industry variation, complementary assets have also been linked to variation in the rates of entrepreneurial activity across universities. Universities that provide scientists with important complementary resources in the form of pro-entrepreneurial structures (tech transfer offices, social networks and infrastructure), policies (licensing and rent appropriation; leaves of absence, etc.), and culture (academic attitudes towards commercialization, entrepreneurial role models) are more likely to have higher rates of entrepreneurship (Bercovitz and Feldman, 2008; Hsu and Bernstein, 1997; Kenney and Patton, 2011; Lockett and Wright, 2005; Shane, 2004; Stuart and Ding, 2006). Finally, scholars have highlighted complementary capabilities within the scientists themselves as critical to the success of academic founded firms: social networks (Stuart and Ding, 2006), prior board experience and industry collaborations, access to venture capital financing (Shane and Stuart, 2002), and ability to recruit other personnel who have market and operational knowledge (Vohora et al., 2004) are all important complementary capabilities for academic entrepreneurs.

Not surprisingly, Table 2 documents that academic entrepreneurship requires strong appropriability regimes, flourishing in industries typically accorded higher patent protection. Indeed, most studies utilize university disclosures and patents for data access through technology transfer offices as their sampling methodology. The importance of intellectual property protection is not merely an artifact of the sampling frame; cross-sectional comparisons reveal higher rates of academic startups in industries with stronger patent protection (Hsu and Bernstein, 1997; Katila and Shane, 2005; Nerkar and Shane, 2003). Scientists with patents protecting their intellectual property are also more likely to venture out than their counterparts (Agarwal et al., 2010; Audretsch and Stephan, 1996; Lowe and Ziedonis, 2006; Mitton, 1990). In this context, broad scope patents that afford stronger intellectual protection are more conducive to scientists' willingness to venture out, because they provide necessary barriers to imitation during the time needed for the new ventures to create the marketing and manufacturing assets to exploit their technologies (Merges and Nelson, 1990). Further, Nerkar and Shane (2003) find evidence consistent with Ziedonis (2004) in terms of fragmentation; academic entrepreneurship is more likely when the industry is less concentrated and ownership of patent thickets by other firms do not pose barriers to entry.

Studies that utilize a longitudinal industry frame document higher incidence of academic entrepreneurship in the early industry stages (Mitton, 1990; Scott, 2008; Stuart and Sorenson, 2003a; Stuart and Sorenson, 2003b; Zucker et al., 1998). Scholars have noted that within biotechnology, the earliest firms were founded by academics, but as the industry evolved, employee entrepreneurship overtook academic entrepreneurship (Mitton, 1990; Scott, 2008; Stuart and Sorenson, 2003a; Stuart and Sorenson, 2003b; Zucker et al., 1998). Among studies employing a university sampling frame, Shane (2001) finds evidence consistent with the longitudinal studies: new firm formation by academics declines over the industry life cycle.

Firm Formation & Relationship with Established Firms in the Industry: The sampling frame used in most studies precludes the ability to assess the fraction of academic founded firms in an industry. Longitudinal studies of the biotechnology and search engine industries provide the only exceptions: over 50% of all new biotechnology ventures (Audretsch and Stephan, 1996; Mitton, 1990; Stuart et al., 2007; Zucker et al., 1998) and 57% of search engine firms stem from academia (Scott, 2008).

Academic founded firms are most likely to collaborate with established firms in the industry (Table 2). These new ventures occur, as noted above, when established firms choose to forgo licensing options with universities on embryonic stage technologies requiring additional incubation (Lowe and Ziedonis, 2006; Nerkar and Shane, 2003). Lowe and Ziedonis (2006) note that academic inventors who cannot transact with established firms in the markets for technology (Arora et al., 2001; Gans and Stern, 2003) are likely to form firms and realize value through collaboration with or acquisition by established firms. From the established firm's perspective, such alliances represent valuable "exploration options" (Rothaermel, 2001).

When academic technologies and innovations are past the "proof of concept" stage, academic entrepreneurship is more likely to occur in upstream markets, requiring collaborations with downstream firms for distribution and marketing channels (Rothaermel, 2001; Shane, 2004). Within the biomedical sciences, for instance, academic founded firms are more likely to collaborate with downstream pharmaceutical firms than sell directly to end consumers (Rothaermel, 2001; Stuart et al., 2007; Zucker et al., 2002). Collaboration with established firms is the dominant relationship observed across a cross-section of industries (Hsu and Bernstein, 1997; Vohora et al., 2004). For example, Vohora et al., (2004) find that 50 percent of academic founded firms in their samples had alliance relationships with an established firm in their focal industry context.

Remarkably, none of the studies of academic entrepreneurship document a competitive relationship with established firms. At best, a small number of studies show that academic founded firms may peacefully co-exist with established firms in the absence of formal or informal cooperative relationships, by occupying segments or niches in fragmented industries that are left vacant by established firms (Katila and Shane, 2005; Nerkar and Shane, 2003; Shane, 2001; Shane, 2004).

Performance: A number of metrics have been used to gauge the performance of ventures founded by academics, including survival, the likelihood of initial public offerings (IPO), and acquisition. This is consistent with most entrepreneurship studies that cast these options as successful exit strategies, relative to termination and failure. While the sampling frame utilized in most academic entrepreneurship studies does not permit a direct examination of performance relative to other types of entrepreneurial startups, a few studies have noted performance differentials relative to averages across industries. In reviewing across articles, Shane (2004) notes that academic founded firms have higher survival rates relative to economy wide benchmarks, ranging from 68 percent overall to over 80 percent for firms originating from leading universities. However, it is difficult to ascertain the extent to which these high survival rates occur due to selection or sampling issues that arise because a disproportionate number of academic founded firms occur in high technology industries, or in the early and growth stages of industry evolution. The importance of these factors is evidenced by the fact that academic founded firms are less likely to survive in more concentrated industries (Nerkar and Shane, 2003). Particularly noteworthy in this context is the comprehensive study of *all* entrepreneurial startups in Sweden from 1994-2002 undertaken by Wennberg, Wiklund and Wright (2011). They explicitly compare academic and employee entrepreneurship, and find lower growth and survival rates for academic founded firms. Using a matching design, Ensley and Hmieleski (2005) find consistent evidence that academic founded firms have lower revenue growth and cash flow than equivalent non-academic start-ups.

In terms of IPOs and acquisitions as performance measures, studies of biotechnology firms show that academic founded firms have the same likelihood of going public as employee founded firms (Audretsch and Stephan, 1996; Stuart et al., 2007). Acquisitions represent an important *successful* exit strategy for academic founded firms. Almost all the new ventures in Lowe and Ziedonis (2006) were acquired by established firms, as were most of the European academic founded firms that went public in the sample studied by Bonardo et al., (2010), highlighting again the importance of complementary relationships among established firms and academic founded firms. Further, there is significant within-variation among academic founded firms—higher market value and likelihood of IPO is associated with the presence of star scientists (Zucker et al., 2002; Zucker et al., 1998).

Summary: Academic Entrepreneurship: Academic entrepreneurship has increased in prevalence due to critical changes in institutions and policy that favor university technology transfer, which is also reflected in the burgeoning literature on the phenomenon. Collectively, the studies show that academic entrepreneurship is concentrated in industry contexts that lend themselves to applications of basic research. Most academic founded firms introduce product innovations based on the technical knowledge of the founding scientists. Often, the technologies commercialized through new firm formation represent early stages in their development cycle and the startup environment permits subsequent development to take the technologies to market. Academic founded firms are more likely to occur in high appropriability regimes and in early stages of the industry life cycle, and given the need for complementary assets, often result in collaborative or complementary relationships with established firms. Thus, in addition to continuing operations and potentially going public, academic founded firms are also likely to pursue acquisition as a successful exit strategy.

User Entrepreneurship

Empirical Context and Sampling Frame Used in Studies: User entrepreneurship is defined as new venture creation by individuals based on innovations aimed initially towards satisfying their *own* needs for a new or improved product or service, and subsequently produced and sold to others (Shah and Tripsas, 2007). Based on *where* the need for innovation was encountered, user entrepreneurship is further classified as either professional user entrepreneurship (need encountered in the work place) or end user entrepreneurship (need encountered through personal use). The study of user entrepreneurship has just begun. While observed in the early automotive industry (Kline and Pinch, 1996) and the early personal computer industry (Freiberger and Swaine, 1999; Langlois and Robinson, 1992), the first study to explicitly study user entrepreneurship was only eight years ago: Shah (2005) compiled systematic data on key innovations in the windsurfing, skateboarding, and snowboarding industries to show that 60% of key innovations were created by users, and 71% of these users subsequently founded firms. Since then, scholars studying the phenomenon have used a variety of lenses, including innovation management (e.g., Baldwin et al., 2006; Haefliger et al., 2010; Shah and Tripsas, 2007), strategy (Tripsas, 2008; Winston Smith and Shah, 2013), and economics (Fontana et al., 2013; Langlois and Robinson, 1992).

There are few empirical studies on user entrepreneurship, and no research design has yet become the norm (see Table 3). Most are single industry studies: as a set, these studies span both consumer and industrial products, and vary in whether they use case based, historical, cross-sectional or longitudinal research design. The studies examine products developed relatively recently; this is more likely due to data needs rather than a statement about the emergence of user entrepreneurship as a phenomenon. Several qualitative studies focus on process issues pertaining to the dynamics of firm formation and/or early years of industry formation. An advantage of the variation in sampling frame and research design is the ability to compare patterns within and across industries. However, the current lack of longitudinal data on industry histories precludes a systematic identification of the fraction of user founded firms over time, or their relative performance.

Type of Knowledge or Innovation Utilized in Firm Formation: User entrepreneurship is rooted in the user innovation process, wherein users identify a variety of needs not fulfilled by existing products (Riggs and von Hippel, 1994), immerse themselves in the use of an innovation (Ogawa, 1998; Tyre and von Hippel, 1997; von Hippel, 1994), and/or garner resources through participation in user innovation communities (Franke and Shah, 2003; von Hippel and Von Krogh, 2003). While users may lack broad based market knowledge across heterogeneous consumer segments that established firms possess, they experience the shortcomings of existing products and services within their own context firsthand. As a result, some consumers become user innovators—altering the product and/or creating new features such that their needs are fully satisfied (Franke and von Hippel, 2003), and subsequently, a subset of user innovators become entrepreneurs. Table 3 underscores findings across industries that both unique knowledge of novel needs *and* expertise and contextual knowledge that facilitate potential solutions are pre-requisites for user entrepreneurship. In the professional use context, scientists combined unmet needs and technological acumen to develop the first probe microscope, and founded firms after realizing similar unmet needs from other scientists (Shah and

Mody, 2014). In the personal use context, video game enthusiasts created an industry around a novel animation technology, Machinima, by leveraging their expertise and knowledge to form firms around a variety of products stemming from their creative endeavors (Haefliger et al., 2010). Similar patterns are observed in the other industry contexts (Baldwin et al., 2006; Fontana et al., 2013; Shah and Tripsas, 2007; Winston Smith and Shah, 2013).

Not surprisingly, as seen in Table 3, user entrepreneurship is almost entirely based on product innovation. Users are uniquely positioned to create products that fulfill unmet needs, but often lack knowledge of operational and organizational processes.

Dimensions of the Teece Framework—Complementary Assets, Appropriability Regimes and the Industry Life Cycle: User founded firms have access to few complementary assets, given that their knowledge context centers on creation and use—not production. Firms founded by users, similar to academic founded firms, face formidable barriers to entry due to complementary assets related to manufacturing and distribution channels. Sometimes, and particularly at industry inception, users borrow complementary assets from the related industries: for example, Haefliger et al. (2010) document how user founded firms in the field of Machinima animation leveraged complementary assets from the video gaming industry. Importantly, user founded firms often compensate by utilizing a unique complementary asset: user communities (Shah, 2005; Shah and Mody, 2014; Shah and Tripsas, 2007). User entrepreneurs often begin their journey from innovators to entrepreneurs by freely diffusing ideas with other users with similar needs, and participating in collaborative development practices of user innovation communities (Shah, 2005; Shah and Tripsas, 2007). In the personal computer industry, Steve Wozniak shared all his designs for the Apple I computer with the Homebrew Computer Club *before* he and Steve Jobs founded Apple Computer (Freiberger and Swaine, 1999).[7] Similarly, many user entrepreneurs across a wide range of industries—rodeo kayaking, probe microscopy, windsurfing, skateboarding, snowboarding industries, and juvenile

[7] While a case may be made that Steve Wozniak was an employee entrepreneur, given his employment at a firm in a related industry (HP) prior to starting Apple, Freiberger and Swaine (1999) document the overriding and important role of "use." The personal computer was largely created by hobbyists such as Steve Wozniak who engaged in innovation in order to tinker and design for themselves.

products—shared ideas freely (Baldwin et al., 2006; Shah, 2005; Shah and Mody, 2014; Shah and Torrance, 2013; Shah and Tripsas, 2007). User communities serve as complementary assets by providing three benefits: feedback regarding improvements, creation of a potential market, and information regarding the value proposition or existence of a potential entrepreneurial opportunity. These benefits are critical particularly for user founded firms that create either altogether new industries or new niches (Shah, 2005; Shah and Tripsas, 2007; Winston Smith and Shah, 2013).

While most of the industry contexts represented in user entrepreneurship studies seem to enjoy strong appropriability regimes and patent protection generally, these likely result in barriers to value appropriation rather than enabling firm formation, particularly in end-use contexts, for two reasons. First, policies governing intellectual property protection disfavor user entrepreneurs due to standards imposed for meeting the non-obviousness criteria: to be granted a patent, an innovation must be "useful, novel, and non-obvious" (Shah and Torrance, 2013). To determine non-obviousness, courts seek to understand whether the innovator had more or less knowledge than the "person having ordinary skill in the art" (PHOSITA) (Dzeguze, 2009; Meara, 2002). In operationalizing the PHOSITA, courts have systematically used the *absence* of prior formal education in the area as indicative of non-obviousness: therefore, individuals *not* having formal education, particularly in science or engineering training, often fail to meet the non-obvious standard (Dzeguze, 2009; Meara, 2002; Shah and Torrance, 2013). Given an emphasis on the innovator's training rather than the innovation's content, a patent for the same innovation might be upheld for an innovator with education and overturned for an innovator lacking formal education or training in the field. Accordingly, a number of user-held patents have been challenged and overturned, based on the argument that ideas of lay-persons or tinkerers without specialized knowledge in the field should not have been granted patents in the first place (Shah and Torrance, 2013). Second, the norms of user communities, critical as complementary assets, encourage free diffusion of innovations; thus, even if users acquire patents, they sometimes choose not to enforce them (Shah, 2005).

User entrepreneurship is prevalent in both the early and late stages of the industry life cycle. Many of the studies in Table 3 investigate industries created by users: personal computers, extreme sports, Machinima, and atomic force microscopy industries (Freiberger and Swaine, 1999; Haefliger et al., 2010; Shah and Mody, 2014). While this may likely reflect selection factors in the sampling design, studies utilizing longitudinal data are also consistent with higher incidence of user entrepreneurship early in an industry. Baldwin, Heinerth & von Hippel (2006), for instance, model and show that user founded firms were most likely to enter early, and their entry rates declined as the industry sales took off and established firms began to enter. Further, firms founded by users are also likely to emerge later in the industry life cycle, where they largely occupy niche market spaces (Shah and Tripsas, 2007) or trigger technological discontinuities (Tripsas, 2008).

Firm Formation & Relationship with Established Firms in the Industry: Three studies report on the fraction of new ventures in an industry that are founded by users—these range from approximately 34% of start-up activity in the semiconductor industry (Fontana et al., 2013) to a staggering 84% in the juvenile products industry (Shah and Tripsas, 2007) and 100% in the probe microscopy and Machinima industries (Haefliger et al., 2010; Mody, 2006). Cross-sectional, survey-based research finds that over 45% of U.S. startups producing an innovative product or service for sale that survive to age 5 are founded by innovative users (Shah et al., 2012).

User entrepreneurship is most prevalent in new industries or unserved market niches. Based on Table 3, user founded startups are most likely to occupy complementary positions or have no overlap with established firms, who are focused on mass production and marketing (Caves and Porter, 1977; Hannan and Freeman, 1989). Studies of sports equipment (Baldwin et al., 2006; Shah, 2005) show that user founded firms created new industries or niches based on needs unmet by established firms in related fields of sports equipment that fell in the "long tail" of the distribution (Anderson, 2008). Thus, user founded firms had no strategic overlap with existing firms until the new industries took off due to entry by established firms and other entrants. Later, user founded firms either became the established firms themselves (e.g. Apple in personal computers; Freiberger and Swaine, 1999); exited the industry, often due to acquisition by existing firms (Baldwin et al., 2006; Shah, 2005); or co-existed as complementary producers satisfying niche needs (Haefliger et al., 2010). Co-existence with established firms by occupying complementary niche markets is also the dominant relationship when users form new firms to address unmet needs in mature markets (Shah and Tripsas, 2007; Tripsas, 2008; Winston Smith and Shah, 2013).

The lack of direct competition between user founded startups and established firms is striking across the studies reviewed in Table 3. Collaborative relationships seem to be infrequent as well—only one study documents corporate venture capital relationships and transfer of knowledge between established firms and user founded startups (Winston Smith and Shah, 2013). In part, this may be due to the disadvantaged position of user founded firms in the markets for technology as a result of a lessened ability to protect their intellectual property legally (Shah and Torrance, 2013),[8] combined with a lack of appreciation for their ideas by established firms. However, the Winston Smith and Shah (2013) study highlights that user founded firms may be particularly valuable as innovation seedbeds to established firms, and calls for additional studies examining the extent of alliances or acquisition activity between established firms and user founded firms.

Performance: The performance of user founded firms has received little systematic attention in the scholarly work on user entrepreneurship. This is perhaps to be expected, since the nascent literature is more focused on establishing the importance of the phenomena and factors leading to firm formation by users. Thus, evidence on performance of user founded startups is mostly anecdotal. Exceptions are studies by Malerba, Adams and Fontana (2013) on semiconductors, and Shah, Reedy and Winston Smith (2012) across multiple industries. Malerba, Adams and Fontana (2013) find user founded firms to be more innovative, and have higher probability of survival relative to other entrants. Shah et al. (2012) find a bi-modal pattern of performance across user founded startups, reflecting important differences between professional users and end-user startups. Both types of firms are more innovative and more likely to receive venture financing than other startups in the sample; however, firms founded by professional-users are less likely to rely on self-financing and are higher performing in terms of revenues while the opposite is true for end user founded firms.

[8] Indeed, given the inability to compete, user innovators may forgo founding a firm and instead diffuse their innovation freely to manufacturers (Harhoff et al., 2003; von Hippel, 1988).

Among the studies that provide anecdotal evidence, many note that survival of user founded startups is conditional on their making the requisite investments in complementary assets related to manufacturing and distribution (Baldwin et al., 2006). Many user founded startups in sports industries (Shah, 2005), and in probe microscopy (Shah and Mody, 2014) have continued to survive, while others appropriated value through acquisition by established firms.

Summary: User Entrepreneurship: User entrepreneurship is spurred by individuals dissatisfied with existing commercial product offerings, and exists across a wide variety of industrial contexts: technical and non-technical, aimed at professional and end-users. The product innovations introduced by user founded firms routinely embody altogether new features or functionality: these products range from "first-of-type" creations that ignite altogether new product classes to variants of existing products. User founded firms tend to possess few complementary assets, and while they appear to emerge in both strong and weak appropriability regimes, can experience difficulties in enforcing their intellectual property. Users appear most likely to found firms in the early or mature stages of the industry life cycle. There are relatively few instances of user founded firms either collaborating or directly competing with established firms, they either have no overlap or complement established firms. While studies of performance are few, there seem to be some evidence that in addition to continuing operations (often centered on building a strong brand), user founded firms are also likely to pursue acquisition as a successful exit strategy.

THEORETICAL FRAMEWORK

Our synthesis across the three literature streams is scaffolded on the theoretical framework defined by Teece (1986), which we refine in two critical ways. First, we build a case for systematic increases in the importance and strength of complementary assets and appropriability regimes due to endogenous industry evolution forces to formally posit interactions among these factors. Second, based on the above literature review, we incorporate heterogeneity in the knowledge context within which new ventures originate their innovations. Our refined framework permits us to compare and contrast patterns in new firm formation and their performance across different knowledge contexts to formulate both stylized facts and propositions (Table 4).[9] Our first set of stylized facts and propositions relate to differences within- and across- knowledge contexts, and the next set of propositions relates to implications for firm formation, entry patterns over the course of the industry life cycle, relationships with established firms, and performance.

Evolutionary Changes in Complementary Assets and Appropriability Regimes

Teece (1986) identified complementary assets, appropriability regimes, and industry life cycle as factors crucial in determining an innovator's ability to profit from an innovation. These three factors have direct effects on the new venture's ability to profit from innovation, and also interact with one another. While Teece (1986) formally developed a two-way interaction model between complementary assets and the appropriability regime, his treatment of the interaction of these factors with industry evolution was more ad-hoc.

Changes in Complementary Assets over the Industry Life Cycle: Our discussion of changes in the availability and importance of complementary assets over the course of the industry life cycle is intentionally brief due to its widespread acceptance in prior work. As noted by Teece (1986) himself, "complementary assets do not loom large" (p. 291) in the early stages of the industry evolution. In the early stage, specialized assets are developed internally by the innovating firm (Stigler, 1951). While generic assets may be available, specialized assets need to be co-developed with the innovation, given high transactions costs and hold-up risks (Argyres and Bigelow, 2010; Qian et al., 2012). As industries mature, so does the industry specific stock of knowledge, resources and capabilities, due to both the irreversible investments undertaken by the early entrants, and the development of specialized suppliers because of reductions in technological uncertainty and transactions costs (Argyres and Bigelow, 2010; Gort and Klepper, 1982; Qian et al., 2012; Stigler, 1951). Well-developed industry specific norms and standards increase the importance of access to complementary assets, since these assets become critical co-requisites to the provision of the product or service (Teece, 1986). For example, Mitchell (1991) documented that established

[9] We develop stylized facts based on consistency of observed patterns from the above literature review, and propositions based on integrating these patterns with our theoretical framework.

distribution channels were important complementary assets in the medical diagnostics industry, and subsequent innovators lacking these assets were at a significant disadvantage.

For the focal innovator, the changes in availability and importance of complementary assets over the industry life cycle represent important differences in the barriers to entry and performance. While lack of complementary assets in early stages increases the burden of co-development of specialized complementary assets (Stigler, 1951), the barriers to entry and subsequent performance are higher later in the industry life cycle given the presence of established firms with complementary assets (Teece, 1986). Further, while entry into the industry in the mature stages may be facilitated by well-developed markets for complementary assets, the profitability and survival of innovating firms may be lowered by the higher bargaining power of the holders of complementary assets.

Changes in Appropriability Regimes over the Industry Life Cycle: Appropriability regimes have predominantly been related to cross-sectional rather than temporal variance arising from the availability of legal instruments for intellectual property protection (Arrow, 1962; Levin et al., 1985), and treated as exogenous to both firm and market structure (Teece, 1986). Few studies focus on why the strength and importance of appropriability regimes may be endogenously driven (Pisano, 2006).[10]

There are, however, reasons to believe that the *strength* of appropriability regimes tends to increase over the industry life cycle. Merges and Nelson (1990) note that a *patent's scope*—the claims that define the extent of property rights subject to control by suing for infringement—is subject to

[10] We note, as do Jaffe (2000) and Pisano (2006), that it is difficult to tease out cause and effect of "exogenous" policy changes and "endogenous" temporal variations when studying industries that evolved in the latter part of the 20th century, since landmark acts, court decisions and patent policy changes occurred in the context of, and were impacted by, strategic actions of key industry players. The "exogenous" changes in policy that impacted appropriability regimes have created temporal changes in many industries that gained prominence (in part due to these shifts) in the last quarter of the 20th century (Jaffe, 2000). Appropriability regimes in the information technology and biotechnology industries—industries that disparately form the basis of studies related to entrepreneurship and innovation—have strengthened substantially due to changes in policies and procedures at the US patent office, Justice Department, and Federal Trade Commission (Jaffe, 2000). The reversal of attitudes regarding the "monopoly power" granted by patents as being pro-innovation rather than anticompetitive was followed by dramatic increases in establishment of property rights through patenting (Jaffe, 2000; Kortum and Lerner, 1999). These changes, coupled with the expansion of patent protection for software and financial services products and processes, impacted information technology in particular (Hall and Ziedonis, 2001; Jaffe, 2000; Kim and Marschke, 2005). Concurrently, changes in innovation policies for public funding (e.g. the Stevenson-Wydler Act and the Bayh-Dohl Act in 1980), coupled with the ability to patent research tools, had profound implications for increases in appropriability regimes in biotechnology and genomics (Jaffe, 2000).

significant discretion by Patent Office examiners and the legal courts. In the early stages of the industry, when the development of the technology is uncertain and unknown ex ante, Merges and Nelson (1990) provide systematic evidence of legal controversies around the scope of patents awarded to innovators. The ability of early innovators to profit from technological development in several industries they study—including automobiles, aircrafts, disposable blade safety razors, synthetic materials and modern biotechnology—depended on the resolution of debates and courtroom battles around patent scope. The case studies illuminate the lack of clarity regarding the scope of claims of early patents, causing Jaffe (2000) to remark that "applying consistent standards for patentability may be particularly difficult in new and rapidly changing fields" (p 553). Definitions of patent scope become clearer as an industry matures. In part, this is due to the cumulativeness of innovations in an industry, inasmuch as later innovations build on earlier breakthroughs and are thus subject to stricter definitions of boundaries (Jaffe, 2000; Merges and Nelson, 1990). As Merges and Nelson (1990) note, in mature industries, "the issues relating to patent scope change largely because particular technologies become established (p 908)." Thus, even though these industries represent strong appropriability regimes in cross sectional comparisons, they nonetheless had a *de facto* period during the early stage of the industry life cycle where appropriability regimes were not well defined.

The *importance* of the appropriability regime also increases over the life cycle. In the early stage of the industry, innovators may choose to not to utilize intellectual property protection—either due to lack of incentives or due to prevailing norms in their industries— even though they have access to intellectual property rights protection. In the early stages of an industry, the size of the market is small, and the potential of the technological applications are often unknown (Agarwal and Bayus, 2002; Jaffe, 2000; Merges and Nelson, 1990). Thus, innovators may be more prone to underestimate the returns from establishing property rights (Shah and Torrance, 2013). However, as the industries mature and grow in size, the returns from patenting increase (Hall and Ziedonis, 2001; Jaffe, 2000). This is not only because the marginal return from establishing property rights is higher given increased market size and competition (Jaffe, 2000), but also because ownership of intellectual property becomes more strategically important due to increases in thickets of intellectual property rights and cumulativeness of innovations (Hall and Ziedonis, 2001; Ziedonis, 2004).

For the focal innovator, stronger appropriability regimes favor the innovator inasmuch as they establish property rights, but they also increase barriers to entry and subsequent performance. It is not clear ex ante whether weaker appropriability regimes in early stages of the life cycle help or hurt innovators: broad scope patents may both enable early innovators (Kitch, 1977), but also preclude subsequent technological development by other innovators (Merges and Nelson, 1990). However, as industries mature, concomitant increases in the strength of appropriability regimes may tip the balance in favor of increased barriers to entry and performance. While ownership of intellectual property may incentivize entry, the presence of established firms with intellectual property thickets that also have strong protection (Ziedonis, 2004) increases barriers to entry and performance. Firms holding property rights in the same space may have higher bargaining power relative to the innovators. Consistent with the entry promoting and entry deterring effects of strong appropriability regimes, Cockburn and MacGarvie (2011) show that ownership of patents facilitates entry by an innovator, but the stock of cumulative patents relevant to the market acts as a barrier to entry. Comparing across markets with high and low thickets of patents, Cockburn and MacGarvie (2009) show that innovators in the former experience delays in venture capital funding.

Heterogeneity in Innovation Based on the Knowledge Context

Different entrepreneurial origins endow founders with different knowledge bases (See Table 4). Employees are situated in firms that produce for the industry in which they subsequently found a firm. Through their employment experience, they garner knowledge of the existing technology, operational processes, and underserved customer niches—and draw from this knowledge for innovations that form the basis of new firm formation. While some of the technological and market knowledge possessed by employee founded firms may also be possessed by academic or user founded firms, operations knowledge is possessed uniquely by firms founded by employees.

In contrast, academics create new technologies within research institutions. They found firms to further develop and diffuse technologies they themselves have developed. The innovations they exploit are often uniquely developed within their own lab, and while perhaps disseminated through publication, these innovations are often also protected through patents and formally owned by the university (Murray and Stern, 2007). Finally, users are propelled to innovate to satisfy a need left unfulfilled by existing products and services (von Hippel, 1988). They found firms based on innovations that stem from knowledge that is generally unique to the user experience (Riggs and von Hippel, 1994). The insights that propel users to innovate tend not to be known or understood by established firms (Winston Smith and Shah, 2013). Systematically distinct innovations thus appear to be generated within each knowledge context, which form the basis of their entrepreneurial origins.

Stylized Fact 1: *The knowledge context of entrepreneurship systematically impacts possession—and exploitation—of different types of innovation: employee entrepreneurship is more likely to combine technological, operational and market innovations relative to the academic and user entrepreneurship, while academic and user entrepreneurship will differentially focus on technological and market innovations respectively.*

The lack of operational knowledge restricts the ability of academic and user founded firms to introduce process innovations. These entrepreneurs tend to found firms around product or service innovations, though some products and services may be utilized by existing firms in process innovations. [11] In contrast, employees found firms around both product and/or process innovations, since their knowledge context permits opportunity recognition that enable both types of innovation. Product innovations may stem from internal R&D activities, or due to knowledge of a broad range of market needs, and process innovations stem from existing operational knowledge. Accordingly,

Stylized Fact 2: *Academic and user entrepreneurship is more likely to result in introduction of product innovations, whereas employee entrepreneurship is more likely to result in introduction of product and/or process innovations.*

Integrative Theoretical Framework: Complementary Assets, Appropriability Regimes, the Industry Life Cycle & the Knowledge Context

Per our theoretical framework, differences in complementary assets and appropriability regimes emerge across firms and over the industry's evolution. All three factors—complementary assets, the appropriability regime, and the stage of industry evolution— will impact entrepreneurial firm formation across the knowledge contexts. We begin with "main effects" propositions for

[11] Although we focus on product and process innovations, innovations in techniques and services are also important. Given the dearth of literature on these innovations, both overall and in the studies we review, we do not focus on these innovations here. Examining the role of employee, academic, and user entrepreneurs in developing and commercializing technique and service innovations would be a fruitful topic for future studies.

complementary assets and appropriability regimes, and then turn to the impact of their changes over the industry life cycle on each type of entrepreneurship.

Due to their founder's prior employment experience in the same industry, employee founded firms are likely to possess knowledge of relevant complementary assets, as well as knowledge pertaining to how to build, recreate or transfer such assets (Campbell et al., 2012). This knowledge provides firms founded by employees with a significant advantage over firms founded by academics and users; an advantage that improves their ability to profit from their innovations (Teece, 1986). In contrast, academic founded firms are unlikely to possess knowledge of the complementary assets required for product market entry. The professional and career histories of academic entrepreneurs tend to be almost exclusively composed of formal education, post-doctoral, and faculty positions. As a result, they are unlikely to possess knowledge relating to the complementary assets required to commercialize their innovations. Along similar lines, user founded firms generally possess limited or no knowledge of the complementary assets required for product market entry, beyond a self-created brand or reputation for innovation(Shah, 2005). Again, user innovators are a heterogeneous group possessing varied career and personal histories. As a result, a small number of users may possess knowledge of complementary assets relevant to commercializing their product, perhaps through employment in the same or related industry (Franco, Malerba and Fontana, 2013). However, most users will not possess this knowledge as their *past* experience is as a user of a product or service—and not as a manufacturer of that product or service. Together, this results in the following proposition:

Proposition 1: *Access to complementary assets is a higher barrier to entry for academic or user entrepreneurship, relative to employee entrepreneurship.*

As discussed earlier, the strength of appropriability regimes may encourage or discourage firm formation (Cockburn and MacGarvie, 2011). While property rights provide innovators the ability to appropriate value, they also increase barriers to entry due to accumulated stock of property rights of existing firms (Ziedonis, 2004). Strong appropriability regimes, in general, seem to favor employee and academic entrepreneurship relative to user entrepreneurship (See Table 4). Even though some scholars have noted that intellectual property enforcement by existing firms reduce mobility options for employees (Ganco et al., 2013), overall, studies find that employees who found firms largely circumvent these barriers given their use of tacit knowledge, and through strategic positioning in markets (Agarwal et al., 2004; Klepper and Sleeper, 2005; Marx et al., 2013). For firms founded by academics, strong appropriability regimes have also served a largely enabling role; patent protection has been identified as an important driving factor behind the high rates of academic entrepreneurship in the biotechnology and information technology industries (Mitton, 1990; Scott, 2008). However, user entrepreneurs, even in strong appropriability regime contexts, face the PHOSITA constraint: while academics and employees often pass the operationalization of PHOSITA based on their education, training and experience, user's intellectual property is often called to question and overturned on these grounds (Shah and Torrance, 2013).[12][13] Taken together:

Proposition 2: *The strength of appropriability regimes is a higher barrier to entry for user entrepreneurship, relative to employee and academic entrepreneurship.*

In addition to the "main effects" described above, systematic changes in complementary assets and appropriability regimes as industries evolve have implications for firm formation across the three sources of innovation. We discuss five such "interaction" effects below.

Existing studies suggest that academics and users may be more likely than employees to initiate changes that trigger the formation of new industries, given the knowledge base that they draws upon. Academics are involved in creating novel technologies, and such "science push" innovations can form the basis for altogether new industries or shift the technological basis of existing industries (e.g. advances in biotechnology and information technology; See Table 2). Users identify a variety of unmet and often recognized needs as part of their day-to-day activities. Addressing these needs may help create "demand pull" technological discontinuities (e.g., the

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[12] Note that some user entrepreneurs—those whose educational training overlaps with the area in which they innovate—may be able to fully leverage the patent system to protect their ideas, e.g. medical doctors who create novel devices to use on behalf of their patients (Cox, 2013; Winston Smith and Shah, 2013) or semiconductor users (Fontana et al., 2013).
[13] The theorizing and propositions contained in this manuscript focus on user entrepreneurship, not user innovation. That factors that support or inhibit one, may affect the other differently. For example, while user innovation may continue even in strong appropriability regimes (within or independent of user communities), a strong appropriability regime may limit users' ability to commercialize their innovations, hence limiting user entrepreneurship.

typesetter industry, Machinima; See Table 3) that result in altogether new markets and industries (e.g., probe microscopy, various sports industries discussed in Table 3). Further, even in mature industries, user founded firms may introduce niche markets that serve the long tail of the distribution (e.g. juvenile products; medical devices; See Table 3). On the other hand, firms founded by employees are less likely to enter in the early stages of the industry life cycle (almost all industries discussed in Table 1), though they do sometimes introduce new generations of technologies drawing on past experience (e.g. disk drives, lasers; See Table 1).[14] In short, academic founded firms possess knowledge to introduce novel technologies and user founded firms possess knowledge to offer products and services that embody novel features and functionality (See Table 4).

Importantly, in the early stages of industries, complementary assets and appropriability regimes do not act as barriers to entry and profitability to user and academic entrepreneurship. The lack of well-developed complementary assets and stock of accumulated intellectual property in new, *tabula rasa* industries implies that user and academic founded firms, and also develop the cospecialized complementary assets and knowledge to become one of the "dominant incumbents" themselves (e.g. Genentech in biotechnology; Apple in personal computers, per studies in Tables 2 and 3). Thus, disadvantages faced by users due to complementary assets and appropriability regimes (Proposition 1 and 2), or by academics due to complementary assets (Proposition 2) are less salient in the early stages of the industry evolution. Accordingly,

Proposition 3a: *The creation of altogether new industries, niche markets and technological discontinuities are more likely to be triggered by academic or user entrepreneurship, than by employee entrepreneurship.*

As discussed in our theoretical framework, the strength and importance of complementary assets and appropriability regimes increases over the industry life cycle. Both factors favor employee founded firms, for reasons articulated in Propositions 1 and 2. Additionally, per Stylized Facts 1 and 2, operational knowledge possessed by employee founded firms enables their entry with process

[14] It may be argued that by definition, employee entrepreneurship cannot result in the creation of technological discontinuities that lead to new industries, since the term presupposes presence of industry incumbents. However, employee founded firms are not highlighted as pioneers even in extant industry evolution studies that account for existing firms in obsolescing or related industries as "incumbents." These studies highlight that early entrants are largely either diversifying firms, or startups with founders who did not stem from existing firms (Carroll et al., 1996; Chen et al., 2012; Klepper and Simons, 2000; Moeen and Agarwal, 2013).

innovations critical for cost and economies of scale related advantages in the growth and mature stages of the industry. Thus, as a corollary to Proposition 3a, and consistent with Gort & Klepper's (1982) observation that the source of critical information shifts over the course of the industry life cycle from outside the industry to within-industry sources, employee entrepreneurship will represent a higher fraction of new firm formation among the three knowledge sources.

Both academic and user founded firms face higher barriers to entry and profitability due to complementary assets, and user founded firms are additionally disadvantaged even when appropriability regimes are strong (See Table 4). As industries evolve, user entrepreneurship may be more likely to be suppressed relative to academic entrepreneurship. The ability of academic founded firms to benefit from strong appropriability regimes may, as discussed in detail later, lead these firms to collaborate with established firms, rather than develop their own complementary assets. To the extent that user entrepreneurship does occur as industries evolve, it is likely to occur when saliency of either complementary assets or appropriability regimes is not high. Thus, user founded firms may enter niche markets left unattended by incumbents, where neither complementary assets nor appropriability regimes represent barriers. Accordingly, we have the following three propositions:

Proposition 3b: *Strengthening complementary assets and appropriability regimes over the industry life cycle favor employee entrepreneurship relative to both academic and user entrepreneurship.*

Proposition 3c: *Among academic and user entrepreneurship, strengthening complementary assets and appropriability regimes over the industry life cycle will favor academic entrepreneurship more than user entrepreneurship.*

Proposition 3d: *Strengthening complementary asset and appropriability regimes over the industry life cycle will cause user entrepreneurship to occur in niche markets that are left unattended by existing firms.*

Propositions 3b-d suggest that increasing entry by employee founded firms and decreasing entry by academic and user founded firms will be observed as an industry evolves. When these entry patterns are viewed in conjunction with Stylized Fact 2—which discusses the types of innovations likely to be introduced by firms stemming from each knowledge context—the mechanisms underlying oft-observed patterns in product and process innovation over the course of the industry life cycle are brought into sharp relief.

We posit that heterogeneity in the knowledge contexts underlying new firm formation complements existing explanations of differing rates of product and process innovations over the course of the industry life cycle. Extant models either rely on exogenous introductions of dominant design, begging the question of where the dominant design comes from (Abernathy and Utterback, 1978), or simply assume increasing focus on process innovation by incumbent firms due to increasing returns to R&D investment (Klepper, 1996). Focusing our attention on entrant heterogeneity, we explain differing rates of product and process innovation based on evolutionary changes in the underlying complementary assets and appropriability regimes, which impact entry by different entrepreneurs stemming from different entrepreneurial origins. The relative patterns of entry have implications for the types of innovations that are introduced over time.

Specifically, in the early stage of the industry life cycle, higher rates of entry by academic and user entrepreneurs suggest that high levels of product innovation should be observed—a pattern born out in many studies of industry evolution. In contrast, in the growth and mature stages, new firm formation is largely the result of employee entrepreneurship, with its accompanying focus on product *and* process innovations. Hence, more process innovations are introduced—again, a pattern observed in a number of empirical studies. Synthesizing from these observations, we have:

Proposition 3e: *Process innovation increases over time and product innovation decreases as industries evolve partially as a function of increasing employee entrepreneurship and decreasing academic and user entrepreneurship.*

Relationships with Established Firms & Performance

Not all firms are created equal. Employee, academic, and user founded firms commercialize distinct types of knowledge and have differential access to complementary assets and appropriability instruments. These differences affect their relationships with existing firms and performance.

Existing studies suggest that employee, academic, and user founded firms tend to interact with established firms in distinct ways (Table 4), and these relationships can be explained by our theoretical framework. Based on Proposition 1, employee founded firms utilize technological, operational and market knowledge acquired due to employment experience, suggesting a high overlap of knowledge with existing (parent) firms. As noted in Proposition 3 and 4, employees are also able to transfer or recreate complementary assets, and benefit more from strong appropriability regimes. Tacit industry specific knowledge is more easily transferred through employee entrepreneurship as well. Together, this implies that employee-founded firms do not *need* the resources provided by established firms, and are least likely to form collaborative relationships with them. Indeed, employee founded firms are in a strong position to compete with established firms, and scholars have consistently documented a negative performance impact of employee entrepreneurship on their parent firms (Agarwal et al., 2013; Phillips, 2002). While employee founded firms may sometimes occupy adjacent (niche) markets and initially avoid direct competition, scholars have noted that increases in overlap and hence competition over time even in such instances (Agarwal et al., 2004; Christensen, 1997; Klepper and Sleeper, 2005).

In contrast, academic founded firms tend to exploit knowledge based on scientific research; thus their knowledge context may complement rather than substitute for the knowledge embodied in established firms. Importantly, academics lack operational and market knowledge to take their innovations to market on their own, as noted in Proposition 1. Further, academic founded firms are likely to benefit from strong appropriability regimes (Proposition 3), but less likely to have access to complementary assets (Proposition 2). Thus, they are more likely to found firms that participate in the markets for technology or ideas, rather than directly competing with existing firms. In the early industry stages, academic founded firms may build these complementary assets, absent their availability elsewhere. However, even in such instances, academic founded firms are likely to pursue collaboration with established firms in related industries (e.g., biotechnology firms partnering with pharmaceutical firms). As complementary assets and accumulated intellectual property rights by other innovators increase over the industry life cycle, such collaborative relationships become even more critical for academic founded firms.

User founded firms tend to commercialize products that address novel market needs (Stylized Fact 1), however, their access to complementary assets and strong intellectual property protection is often weak (Proposition 1 and 2). As a result, users are likely to pioneer new industries where neither complementary assets nor appropriability regimes present barriers to entry. As industries evolve, user innovators face formidable barriers from existing firms with their complementary assets. Unlike academics, user innovators are also disadvantaged in their ability to protect their intellectual property, and thus cannot participate in the market for ideas. Indeed, scholars have noted that while some may still enter (but not perform very well), most choose to forgo firm formation and just share their ideas, either selling it or providing it for free to established firms (Harhoff et al., 2003; von Hippel, 1988). User founded firms are likely to appear in mature industries only in niche markets that have no overlap with established firms or that complement markets occupied by existing firms. Thus, we have the following three propositions.

Proposition 4a: *Relative to academic and user entrepreneurship, employee founded firms are more likely to have competing relationships with existing firms.*

Proposition 4b: *Strengthening complementary assets and appropriability regimes over the industry life cycle will result in increases in collaborative relationships between academic founded firms and existing firms.*

Proposition 4c: *Strengthening complementary assets and appropriability regimes over the industry life cycle will result in no overlap or complementary positions between user founded firms and existing firms.*

Relatively little empirical work compares the differential performance of firms founded by employees, academics, and users. It is important to recognize that entrepreneurs from each entrepreneurial origin contribute distinct types of knowledge to the industry (Stylized Fact 1), hence each type of firm is likely to excel on different performance parameters.

Survival or continued presence in product markets is the most widely used performance metric in the literature, and on this dimension, employee founded firms seem advantaged relative to academic and user founded firms.. There are multiple reasons for this: employee founded firms may commercialize products based on more established, less uncertain, technologies, and target existing, less uncertain market niches. They are also more likely to be able to appropriate value from their innovations through complementary assets and tight appropriability. The survival of employee founded firms is further bolstered by the fact that they are more likely to enter in the growth stages of the industry (Table 1), in which opportunities are munificent (Hannan and Freeman, 1989).

However, a focus on product market commercialization and survival precludes examination of other modes of value capture, such as those in markets for technology, and markets for corporate control. Not surviving or competing in the focal product market should not be equated as failure. Indeed, Moeen and Agarwal (2013) show that many firms, particularly startups, who may be considered failures by this metric, captured significant value by occupying support roles in industry ecosystems through alliances and acquisitions. Allying with or being acquired by existing firms are particularly attractive strategies for academic and user founded firms, given their relative lack of complementary assets. Doing so allows these two types of firms to focus on their core competencies by exploiting their appropriable knowledge resources, and developing a strong brand name and reputation within their domain of expertise.

The survival rates across the three entrepreneurial contexts are also conditioned by industry evolution. While Propositions 1 and 2 highlighted the role of complementary assets and appropriability regimes as higher barriers to entry for academic and user innovators relative to employee innovators, the same rationale may also be at play as barriers to survival. User and academic founded firms that enter in the early stages of the industry are less disadvantaged by these factors than those that enter later. The *tabula rasa* nature of the industry during the inception stages levels the playing field; investments in the co-development of complementary assets and broad scope protection afforded by less defined appropriability regimes (Merges and Nelson, 1990) may enable not only survival, but also overall performance (see empirical evidence reported in Tables 2 and 3). However, as industries mature, the strengthening of complementary assets and appropriability regimes adversely impacts not only new firm formation by academics and users, but also survival conditional on entry. Thus, even if academic and user innovators found new firms, they may be more likely to exit through acquisition.

Proposition 5a: *Employee-founded firms have higher survival rates than academic or user founded firms.*

Proposition 5b: *Academic and user founded firms are more likely to capture value through alliances or acquisitions, relative to employee founded firms.*

Proposition 5c: *As industries evolve, academic and user founded firms experience a decrease in the likelihood of survival and an increase in the likelihood of acquisition as an exit strategy.*

DISCUSSION AND CONCLUSION

Entrepreneurial origins matter. These origins systematically result in differences in knowledge and capabilities, incidence and patterns of new firm formation, relationships with established firms, and performance. The mechanisms underlying the differences relate to the interplay of the knowledge context, complementary assets, appropriability regimes, and evolution of industries. In explicating the mechanisms, and the differences arising from the knowledge sources of entrepreneurship, our paper contributes to the age-old issue related to the paradox of innovation: the question of when and how value can be appropriated from a good "so intangible as information" (Arrow, 1959). Building on the "profiting from innovation" framework (Teece, 1986), we relax the implicit assumption that knowledge held by innovators from different knowledge contexts is homogenous, and systematically integrate heterogeneity in the knowledge context with the model's original three factors. Based on empirical findings in the literatures on employee, academic and user entrepreneurship, we show that the knowledge source of entrepreneurship is critical not only in determining who profits from innovation and how, but also the manner in which industries evolve.

We contribute to this special issue's focus on entrepreneurial innovation by showing that the knowledge context from which a new venture arises shapes the venture's trajectory in myriad ways. By showing that systematic differences exist between startups—and that these differences influence the types of entrepreneurial innovations commercialized—we provide policymakers, managers, and investors with a novel basis for policymaking and managerial decision making that affords them the ability to promote distinct types of entrepreneurial activity at different points in time, based on the resources at hand as well as the economic and societal needs to be satisfied.

Theoretical Contributions: For industry evolution scholars, we relate endogenous changes in complementary assets and appropriability regimes to patterns in new firm formation and performance across knowledge contexts. Specifically, we highlight that appropriability regimes may change as industries evolve. This temporal variation critically impacts innovators within each knowledge context. By integrating empirical insights across employee, academic and user entrepreneurship, we show that the increasing strength and importance of complementary assets and the appropriability regime differentially affects new firm formation by each type of innovator, their relationships with existing firms, and their resultant performance. Doing so also allows us to provide a more nuanced explanation of the dynamics of the industry life cycle. Our augmented industry life cycle model provides a possible explanation for Gort & Klepper's (1982) observation that information sources in an industry shift from external to internal over time, as well as for patterns in increasing and decreasing rates of product and process innovation over time. Specifically, industry evolution models largely focus on incumbent-entrant dynamics (Gort & Klepper, 1982) and assume that higher process innovation as industries mature occurs due to incumbent investments in process R&D (Klepper, 1996). Our model highlights that shifting information sources result not only from incumbent-entrant dynamics, but also due to the heterogeneity in the entrant pool. Our model also suggests that established firms take entrepreneurial origins into account when considering knowledge exchanges, alliances, and acquisitions, and strategic positioning vis-à-vis startups. Such an "industry ecosystem approach" (Adner and Kapoor, 2010; Moeen and Agarwal, 2013) helps illuminate important and evolving roles of established firms and startups from each knowledge source, and have implications for integrating literatures on markets for technology (Arora et al., 2001) and industry evolution.

We contribute to the entrepreneurship literature by synthesizing the seemingly disparate literatures on employee, academic and user entrepreneurship through a parsimonious model wherein four factors may explain many of the patterns observed within and across knowledge contexts. Further, much of the extant literature has focused on the contributions to industry and economic progress of employee entrepreneurship, with a smaller literature highlighting the contributions of academic entrepreneurship, and an almost miniscule literature investigating user entrepreneurship. On occasion, scholars have identified employee entrepreneurship as the "dominant" mode of startup activity based on logics of prevalence or performance (i.e., survival) (Fontana et al., 2013; Sorensen and Fassiotto, 2011). Our synthesis suggests that such views be revisited: entrepreneurs from different knowledge contexts contribute distinct capabilities to an industry, and may occupy alternative positions within an ecosystem.[15] Rather than focusing on relative dominance or importance, our theorizing suggests that each source of entrepreneurship plays a critical and irreplaceable role in industry development and evolution. Economic and societal progress may require the presence of a rich, interwoven knowledge ecosystem.

Policy Implications: Our findings suggest that a diverse innovation ecosystem may be necessary for industry creation and development, because employee, academic, and user founded firms each bring distinct and necessary knowledge to the industry. Further, the role of each knowledge context as a fountainhead of entrepreneurial innovation evolves as industries mature. Thus, a clear implication from our study is that rather than a one size fits all innovation policy, a thriving ecosystem may be created by attention to the micro-level heterogeneity among individual founders based on their knowledge context. Our theorizing suggests ways to design programs to potentially expedite the evolution of industries or—perhaps more fittingly—support the evolution of industries whose progress seems to have slowed or stalled. For example, policies aimed at providing access to complementary assets and resources for fledgling academic- and user-founded firms in early stage industries might encourage more rapid commercial introduction of novel innovations, and facilitate a more rapid understanding of what the marketplace desires. In the growth and mature stages, concurrent attention to factors that facilitate employee entrepreneurship, and thriving markets for technology and corporate control may help foster a vibrant innovation ecosystems, where all three types of entrepreneurial firms contribute to the creation of value. In contrast, supporting innovation in a stagnant, established industry, may involve creating programs to ignite or seek out academic and user innovation, and then support the commercialization of promising technologies. Overall, such strategies require a level of micro-analysis—taking into account both the state of the industry and the ability of innovators from various knowledge contexts to provide resources and insights—that, to our knowledge, has rarely been practiced. The extent to which such investments should be made

[15] Note that preliminary results from several unpublished studies suggest that user-founded firms tend to be more innovative than employee- or academic-founded firms (Cox, 2013; Fontana et al., 2013; Winston Smith and Shah, 2013).

by private investors, established firms, and/or governments is worthy of further analysis and discussion.

Importantly, our work also highlights that innovation programs should be evaluated not with the common yardsticks of firm survival, but the extent to which the knowledge diffuses and "lives on" through individuals' mobility and entrepreneurial activity. The manner in which value is created and captured may differ across the entrepreneurial knowledge context, and even though programs fostering innovation across heterogeneous contexts may seem costly in terms of firm "failures," the transfer of knowledge through founders may ultimately increase the number of viable firms—and jobs—that are generated, as well as the speed at which stable jobs are generated.

Further, since many policies are implemented at regional levels, most current models of the development of regional clusters of firms focus on a single source of knowledge—universities (e.g. Shane, 2001) or firms (e.g. Klepper, 2007). A singular focus on one knowledge context may cause excessive attention by policy makers to entrepreneurial entry stemming from that source, to the detriment of other knowledge contexts. For example, a focus on firms as innovation hotbeds may result in policies aimed at fostering employee entrepreneurship and mobility by devoting attention to non-compete clauses, or patent enforcement. Alternatively, a focus on universities as fountainheads of knowledge may result in policies aimed at fostering academic entrepreneurship, through robust technology transfer and venture acceleration programs. In contrast, our analysis suggests that regional economic growth might be most robust when *multiple* knowledge sources are in place and insights from various sources can co-mingle: users for insights that trigger the creation of new products and product features (i.e. to indicate what problems need to be solved); universities for the development of technological knowledge, as well as education and skill development; and existing firms for the transfer of operational knowledge. To point, just prior to the personal computer revolution, Silicon Valley had the benefit of an established set of related, preexisting industries (e.g., semiconductors), several universities (Stanford and Berkeley, as well as a host of smaller institutions), and a strong collective of users (the Homebrew Computer Club). Knowledge was developed by each of these sets of actors, and flowed across these sources as well (Freiberger and

Swaine, 1999). Accordingly, a policy implication from our study is that while more recent, "triple helix" models (Etzkowitz and Leydesdorff, 2000) that focus on the importance of interactions between universities, firms and government are a step in the right direction, there is an additional need to embrace user communities in the mix. Geographic regions where all three knowledge sources are present may be most likely to emerge as hosts for new industrial clusters.

From a legal perspective, our findings suggest that interpretation of the non-obviousness clause of patent doctrine be revisited to ensure that the knowledge of innovators of all backgrounds be afforded the same protections. As applied, existing doctrine would result in the *same innovation* receiving different protection based solely on the educational qualifications of the innovator: if an innovation was made by an individual with educational credentials in the subject matter if would receive protection, whereas the same innovation might not be protected if the innovator did not possess educational qualifications in the subject matter. User innovators and entrepreneurs bring unique knowledge and insights to society—knowledge and insights that may have taken considerable effort and time to accumulate and apply, regardless of their educational qualifications.

Opportunities for Future Research: Very few studies examine employee, academic, and user founded firms simultaneously (an exception is Winston Smith and Shah, 2013). Further examination of the differences and similarities between firms stemming from different entrepreneurial origins within the same context—rather than connecting piecemeal insights on the causes and consequences of each type of entrepreneurial activity across sampling frames and studies, as we have done here—is critical to improving and refining our understanding of how entrepreneurial origins shape and influence a startup's trajectory. Thus, research that complements our approach in building theory from existing empirical insights by testing the propositions laid out provides clear opportunities for the future.

To gain theoretical traction, we deliberately focused on "pure form" firms founded by employee, academic, or user entrepreneurs. In practice, some firms may be founded by teams of entrepreneurs hailing from different entrepreneurial origins or even by founders whose career history spans multiple entrepreneurial origins. Indeed, some of the empirical papers explicitly note performance advantages for such hybrid startups (e.g. Wennberg et al., 2011). Examining the paths traversed by and the performance of these startups would provide additional data with which to confirm or challenge our theory, as well as provide practical guidance for entrepreneurs. Our theory suggests that startups whose founding teams include users and employees should be privileged in that they possess both innovative knowledge as well as complementary assets; in contrast, founding teams that include users and academics might suffer from too many innovative ideas. Extending our arguments further, the temporal aspects of innovation development should be considered when building entrepreneurial teams. For example, academic entrepreneurs may need to consider their strategy before bringing on a business or operational expert: if they have considerable research in which to engage before licensing out or commercializing their ideas, it may be fruitless (and resource reducing) to bring an employee founder on board.

Another fruitful avenue for future research would be to compare the performance of new ventures stemming from different knowledge contexts across a variety of outcome variables. Such work would highlight the differential contributions of various entrepreneurial origins and understand how the actions of these firms complement one another and contribute to within-industry heterogeneity. Such work might examine outcomes as acquisitions (Arora and Nandkumar, 2011) growth (Clarysse, Bruneel, et al., 2011; Clarysse, Wright, et al., 2011),[16] or sales, job creation, serving new or underserved markets, and innovation.

Conclusion

Innovation is critical to economic growth and social progress and startup firms are a key vehicle through which innovations are developed and diffused. Understanding the factors that shape and influence the trajectories of startup firms is critical to understanding how to build and support industrial ecosystems. In this paper, we augment Teece's seminal (1986) work theoretically by highlighting that importance of the knowledge context from which a firm stems, and that the strength and importance of complementary assets and the appropriability regime evolve over the industry life cycle. We develop a unified model that highlights the mechanisms that drive new firm

[16] Clarysse, Bruneel and Wright (2011)and Clarysse, Wright and Van de Velde (2011) examine growth outcomes of new ventures, and the latter in particular highlights that academic and employee founded firms may achieve growth using alternative strategies of pursuing growth in product markets vs. growth in the market for technology.

formation, their relationship with established firms, and performance. We hope that our model provides insights useful to policy-makers and entrepreneurs engaged in supporting the emergence and development of industries.

Table 1: Empirical Studies on Employee Entrepreneurship

Industry	Study	Time Period Covered	Sampling Frame	Type of Knowledge	Type of Innovation	Complementary Assets	Appropriability Regime	Stage of Industry Life Cycle	Percentage of Employee Founded De Novo Entrants	Relationship with Established Firms at Founding	Performance
Automobiles; Construction; Consulting; Semiconductors	Garvin (1983)	Histories of various industries	Anecdotal	Market knowledge, operational knowledge	Product and process	Physical capital	NA		NA	Competition in early stages; cooperation in late stages	Not studied
Automobiles	Klepper (2002, 2007)	1895-1966	Comprehensive longitudinal history	Technological knowledge	Product and process	Physical capital Organizational knowledge, agglomeration effects	Strong	Growth and late stages; successful employee founded firms enter earlier	24%	Competition (foundings due to strategic disagreements)	Employee founded firms outperform all entrants in terms of survival
Biotechnology	Mitton (1990); Stuart and Sorenson (2003a; 2003b)	1978-1995	Comprehensive longitudinal history	Technological knowledge	NA	Upstream access to scientific knowledge and downstream access to markets	Strong	Growth and late stages	45%	Competition (lower IPO probability in more concentrated regions)	Not studied
Disk drives	Agarwal et al. (2004); Christensen (1997); Franco and Filson (2006); McKendrick et al. (2009)	1977-1997	Comprehensive longitudinal history	Technological knowledge, market knowledge	Product and process	Physical capital and Organizational knowledge	Strong	Growth and late stages; significant fraction of early movers in new generations are employee founded firms	25%	Competition (most employee founded firms entered in same generation as parent firm) or no overlap	Employee founded firms outperform all entrants in terms of survival
Fashion Design	Wenting (2008)	1858-2005	Comprehensive longitudinal history	Technological knowledge, market knowledge	Product and process	NA	Weak	Growth and mature stages	42%	Competition	Employee founded firms outperform all entrants in terms of survival
Footwear	Sorenson and Audia (2000)	1940-1989	Comprehensive longitudinal history	Technological knowledge, market knowledge	Product and process	Location and agglomeration effects	NA	Not discussed	NA (states with higher density of incumbents have higher firm formation rates)	Competition	Growth and survival negatively related to geographical concentration
Information Technology and Communication	Ellis et al. (2008)	1932-2005	Comprehensive longitudinal history	Technological knowledge, operational knowledge	Product and process	NA	NA	Growth and late stages	82%	Competition	Not studied

Industry	Study	Time Period Covered	Sampling Frame	Type of Knowledge	Type of Innovation	Complementary Assets	Appropriability Regime	Stage of Industry Life Cycle	Percentage of Employee Founded De Novo Entrants	Relationship with Established Firms at Founding	Performance
Lasers	Sleeper (1998); Klepper and Sleeper (2005); Buenstorf (2007)	1961-1994	Comprehensive longitudinal history	Technological knowledge, market knowledge	Product	Over time, knowledge increasingly embedded in physical rather than human capital	Strong	increasing and then decreasing over time	41% employee founded; 23% academic founded (footnote 11)	Largely, competition, but few instances of collaboration or low overlap	Employee founded firms, particularly those representing serial entrepreneurship, outperformed all other entrants
Legal Services	Phillips (2002); Campbell et al. (2012); Carnahan et al. (2012)	1946-1996; 1990-2005	Comprehensive longitudinal history	Operational knowledge	Process	Organizational and other human assets	Weak	NA	27%	Competition (employee founded firms have a negative effect on parent performance)	Employee founded firms with higher quality founders (experience, rank, earnings) are associated with higher survival
Medical devices	Chatterji (2009)	1987-2003	Comprehensive longitudinal history	Operational knowledge	Product	Venture financing	Strong	NA	36%; 29% are academic or users	No overlap	Employee founded firms perform better than other entrants in terms of venture financing and valuation
Semiconductors	Brittain and Freeman (1986); Fontana and Malerba (2010); Ganco (2013); Moore and Davis (2004)	1956-2003	Comprehensive longitudinal history	Technological and operational knowledge	Product and process	Physical capital and Organizational knowledge	Strong	Growth and late stages	41%	Competition (frustration identified as a frequent cause for employee exit)	Employee founded firms perform better than other entrants
Tires	Buenstorf and Klepper (2009)	1905-1980	Comprehensive longitudinal history	Technological and operational knowledge	NA	Location and agglomeration effects	NA	Growth and late stages	85%	Competition	Not studied
Wineries	Simons and Roberts (2008)	1983-2004	Comprehensive longitudinal history	Operational knowledge	Product and process	NA	Weak	Higher entry rates in growth period of non-kosher segment	40%	Competition (employee founded firms entered in same market segment as parents)	Pre-founding experience has positive effects on both size of organization and quality of product
Multi-industry (knowledge intensive services and high tech manufacturing)	Wennberg, Wiklund and Wright (2011)	1994-2002	Comprehensive longitudinal history	Technological knowledge	Not discussed	Not discussed	Strong and weak	NA	94%	NA	Higher growth and likelihood of survival relative to academic entrepreneurship

Table 2: Empirical Studies on Academic Entrepreneurship

Industry	Study	Time Period Covered	Sampling Frame	Type of Knowledge	Type of Innovation	Complementary Assets	Appropriability Regime	Stage of Industry Life Cycle	Percentage of Academic Founded Firms in Sampling Frame	Relationship with Established Firms at Founding	Performance
Biotechnology	Mitton (1990); Stuart and Ding (2006); Stuart et al. (2007); Zucker et al. (1998); Audretsch & Stephan, (1996)	Ranges from 1967 through 2002 across various studies	Comprehensive longitudinal history	Technical knowledge	Product	Drug approval, manufacture, sales, and distribution; social networks that enabled commercialization (Stuart and Ding, 2006)	Strong	Early	54 % of San Diego biotech firms (Mitton, 1990); 50% of all IPO biotech firms filing IPO prospectuses (Audrestch & Stephan, 1996; Stuart et al., 2007)	Collaboration (biotech firms often broker alliance chains between universities and life science companies [Stuart et al. 2007])	Highest market value firms include star academics on their IPO prospectuses (Zucker et al., 2002)
Information Technology: Search Engines	Scott (2008)	1990-2008	Anecdotal case studies of search engine foundings	Technical knowledge	Product	NA	Strong	Early	57% of all entrants	Not discussed	2 of the 3 dominant firms in industry today are academic-founded (Yahoo and Google)
Medicine	Aldridge and Audretsch (2011)	1998-2004	Scientists receiving funding from the National Cancer Institute (25% of interview respondents founded firms)	Technical knowledge	Not discussed	prior board experience, collaboration with industry	Strong	Not discussed	NA	Not discussed	Not discussed
Multi-industry: Computer Science and Electrical Eng. (46%); Biomedical Sciences (32%); Engineering and Physical Sciences (21%)	Kenney and Patton (2011)	1957-2009	All academic founded firms from six North American universities	Technical	Not discussed	History and support for technology transfer activities	Strong	Not discussed	NA	Not discussed	Not discussed
Multi-Industry	DiGregario and Shane (2003)	1994-1998	101 US Universities (represent 85% of all university patents generated in the time frame)	Technical knowledge	Not discussed	University intellectual eminence and equity investments	Strong	Not discussed	8.5% of technology licensed to academic founded firms	Not discussed	Not discussed

Industry	Study	Time Period Covered	Sampling Frame	Type of Knowledge	Type of Innovation	Complementary Assets	Appropriability Regime	Stage of Industry Life Cycle	Percentage of Academic Founded Firms in Sampling Frame	Relationship with Established Firms at Founding	Performance
Multi-industry: Pharmaceutical and Drugs (22%); Medical and Scientific Devices (17%); Computers and Communications (11 %); Chemicals (9%); Industrial Equipment (5%); and misc. others for 27 total industries	Katila and Shane (2005); Nerkar and Shane (2003); Shane (2001); Shane (2004); Shane and Khurana (2003); Shane & Stuart (2002)	1980-1996	Firms based on technology developed at MIT	Technical knowledge	product innovations	Manufacturing intensity (Katila and Shane, 2005); marketing and distribution channels (Shane, 2001); social ties of founders with venture capitalists (Shane and Stuart, 2002); prior entrepreneurship or industry experience of founders (Shane and Khurana, 2003)	Strong	Higher rates of entry in early stages, and declining over industry life cycle (Shane 2001)	13.5% and 26% of licensed technology (Katila and Shane, 2005; Nerkar and Shane, 2004; Shane and Khurana, 2003; Shane and Stuart, 2002)	New ventures created to exploit technology that established firms chose to forgo (Nerkar and Shane, 2004); more likely to enter niche or segmented markets (Shane, 2001)	20% of MIT startups did not survive; lower likelihood of survival in more concentrated industries (Nerkar and Shane, 2004); founder industry experience is positively related to likelihood of IPO, and negatively related to failure (Shane and Stuart, 2002)
Multi-industry	Clarysse, Tartari and Salter (2011)	1992-2006	Academics receiving grants from UK Engineering and Physical Sciences Research Council	Technical	Not discussed	Individual attributes (entrepreneurial orientation and experience) are more important predictors than technology transfer office characteristics	Strong	not discussed	16% of academics were involved in startup activity	Not discussed	Not discussed
High Technology Multi-industry: Biological, chemical, physical, computer sciences, and engineering	Vohora et al. (2004)	Likely in the 1990s	9 academic founded firms from 7 leading UK universities	Technical knowledge	Product innovation	Venture financing, and human capital with market and operational knowledge	Strong	Early stage technology	NA	Approximately 50% are collaborating with established firms in focal industry	33 % advanced to sustainable returns and growth; others had not achieved this stage by end of sample period
Multi-industry; biotech, superconducting materials, semiconductors, electronics	Hsu and Bernstein (1997)	Unclear, likely early to mid-1990s	Case studies of 14 patent licensing efforts at major east and west coast universities	Technical knowledge	Not discussed	Venture financing; agglomeration economies in Boston 128 and Silicon Valley	Strong	Embryonic, most at proof of concept stage	9 of 11 successful licenses involved academic founded firms	Collaboration: Many technologies marketed to established firms	Not discussed

Industry	Study	Time Period Covered	Sampling Frame	Type of Knowledge	Type of Innovation	Complementary Assets	Appropriability Regime	Stage of Industry Life Cycle	Percentage of Academic Founded Firms in Sampling Frame	Relationship with Established Firms at Founding	Performance
Multi-industry	Lowe (2002); Lowe and Ziedonis (2006)	1981-1999	734 inventions disclosed to the University of California	Technical knowledge	Product	Given importance of incumbents around commercialization and distribution, likely include sales and distribution assets.	Strong	Early stage technologies are more likely to be pursued through new venture formation	36% of inventions licensed to academic founded firms	Cooperation suggested: inventor-founded startups were almost all acquired before introducing new products	Startups are just as likely to commercialize products as established firms.
Multi-industry (knowledge intensive services and high tech manufacturing)	Wennberg, Wiklund and Wright (2011)	1994-2002	Comprehensive longitudinal history of all startups in Sweden during time frame	Technical knowledge; human capital and experience	Not discussed	Industry experience of founders	Not discussed	Not discussed	6% of all entrants	Not discussed	Lower growth and likelihood of survival relative to employee entrepreneurship; industry experience of founders is more beneficial for academic entrepreneurship relative to employee entrepreneurship
Multi-industry	Ensley and Hmieleski (2005)	2001	Sample of startups from 3 southeastern US universities, matched with equivalent high technology non-university startups	Technical knowledge	Not discussed	Team diversity and ability to create coherence	Strong	Not discussed	NA	Not discussed	University startups have lower revenue growth and cash flow than their matched counterparts
Multi-industry	Lockett and Wright (2005)	2002	95 academic founded firms from 48 UK universities	Technical knowledge	Not discussed	Business development capabilities of universities	Strong	Not discussed	NA	Not discussed	Not discussed

Table 3: Empirical Studies on User Entrepreneurship

Industry	Study	Time Period Covered	Sampling Frame	Type of Knowledge	Type of Innovation	Complementary Assets	Appropriability Regime	Stage of Industry Life Cycle	Percentage of User Founded De Novo Entrants	Relationship with Established Firms at Founding	Performance
Animation: Machinima (a new film genre characterized by shooting film in video games)	Haefliger, Jäger, von Krogh (2010)		All firms engaged in the production of films using Machinima	Unique needs, coupled with knowledge of gaming and animation	Varied (due to issues with complementary assets)	Few or none ("borrowed" from video game industry); reputation for innovation and collaboration in user innovation communities	Strong	Early	100%. Seven of seven firms were founded by user entrepreneurs	No overlap	NA
Juvenile Products	Shah & Tripsas (2007); Shah & Torrance (2013)	1980-2007	Firms manufacturing juvenile products	Unique needs, often paired with basic mechanical and sewing skills	Product	Reputation for innovation and collaboration in user innovation communities	Strong and weak. Some user innovations challenged in court.	Late	84% of firms manufacturing juvenile products we founded by user entrepreneurs	No overlap, complement	NA
Medical Devices	Winston Smith & Shah (2013)	1978-2007	All medical device startups receiving corporate venture capital investment	Theorized: unique needs (i.e., (unrecognized needs), problem context, innovation communities	Product	NA	Strong	Late - but examines introduction of highly novel (class 3) medical devices	NA. 51% of corporate venture capital investments are in user-founded firms	No overlap or complement	More innovations and products based on knowledge garnered through CVC relationships from user founded than academic or employee founded firms
Personal Computer	Langlois & Robinson (1992), Freiberger & Swaine (1999)	1975-onwards	Historical account of the personal computer industry	Unique needs	Product	Few or none; reputation for innovation and collaboration in user innovation communities	Strong	Early	NA	No (or very little) overlap	NA
Probe Microscopy	Shah & Mody (2014)	1979-late 1990s	Historical study of probe microscopy from invention through commercialization	Unique needs coupled with technological acumen	Product	Reputation for innovation and collaboration in user innovation communities	Strong	Early	100%. Three of three firms founded to produce probe microscopes were founded by user entrepreneurs	No overlap	No explicit comparison with diversifying entrants, however all three firms are still in existence

Industry	Study	Time Period Covered	Sampling Frame	Type of Knowledge	Type of Innovation	Complementary Assets	Appropriability Regime	Stage of Industry Life Cycle	Percentage of User Founded De Novo Entrants	Relationship with Established Firms at Founding	Performance
Semiconductors	Malerba, Adams, Fontana (2013)	startups founded between 1997-2007	407 innovative startups (i.e. startups generating semiconductor patents). 1010 startups total	Unique needs and contextual knowledge (i.e., "contextual knowledge around final applications")	NA (innovation measured through patents)	NA	Strong	Late	34% of all startups founded between 1997-2007	not discussed	More likely to be innovative and to survive until the end of the study period than firms founded by employee- and other-entrepreneurs
Sports Equipment: Skateboarding, Snowboarding, and Windsurfing Equipment	Shah (2005), Shah & Mody (2014), Shah & Torrance (2013)	Windsurfing (1964-2000); skateboarding (early 1900s-2000); snowboarding (1965-2000)	Development and commercialization histories of 57 innovations across three sports.	Unique needs and contextual knowledge, coupled with basic mechanical skills	Product, Technique	Reputation for innovation and collaboration in user innovation communities	Strong. Some user innovations challenged in court.	Early and growth	NA	No overlap, complement	Many user-founded firms lived for many decades or were acquired for their brand
Sports Equipment: Rodeo Kayaking Equipment	Baldwin, Heinerth & von Hippel (2006)	1970-2000	Industry Case studies	Unique needs, often paired with basic mechanical skills	Product, Technique	Reputation for innovation and competitive acumen in the sports community	Strong	Early	NA	Complement	Survival contingent on investments in manufacturing for lower variable cost production
Sports Equipment: Varied	Fauchart & Gruber (2011)	Early 2000s	Manufacturers in Switzerland, Germany & France	Unique needs	Product	NA	Strong	NA	NA (sampled to maximize variance in founder types)	NA	NA
Stereo Components	Langlois & Robinson (1992)	pre-1930-1980s	Historical account of the development of high-fidelity and stereo systems	NA (some evidence of unique needs, coupled with basic technological knowledge)	Product	Reputation for innovation and collaboration in user innovation communities	Strong	Early	NA	No overlap or complement	NA
Type-setting Equipment	Tripsas (2008)	1886-1990	Identifies triggers of three technological transitions in the typesetter industry	Unique needs (i.e., "customer preference discontinuities")	Product	Few or none	Strong	Late	NA. Two of three technological transitions within the industry were created and introduced commercially by user entrepreneurs	Complement	NA

Table 4: Theoretical Syntheses of Employee, Academic & User Entrepreneurship

Entrepreneurial Origin	Type of Knowledge	Type of Innovation	Complementary Assets	Appropriability Regime	Rates of Firm Formation and Innovation over Industry Life Cycle	Relationship with Established Firms at Founding	Performance
Employee Founded Firms	Knowledge of existing technology, operational processes, and underserved customer segments	Both product and manufacturing process innovations	Knowledge and social networks often span business functions and aid in technology commercialization.	Strong and Weak	Growth, Late	Compete or complement	Outsurvive other start-ups
Academic Founded Firms	Unique technological knowledge	Primarily product	Individual status, reputation	Strong	Primarily early	Collaborate	Not clear. Many firms or their assets successfully acquired
User Founded Firms	Unique knowledge of needs and usage context	Primarily product	Innovative brand. Varied	Strong and weak (many users appear to have difficulty enforcing patents)	Early and late	Complement or no overlap	Almost always highly innovative. Survival varies.
Stylized Facts & Propositions	**Stylized Fact 1:** Entrepreneurs from different entrepreneurial origin systematically possess-and exploit-different types of knowledge.	**Stylized Fact 2:** Academic and user founded firms introduce product innovations, while employee founded firms introduce both product and/or process innovations.	**Proposition 1**: Access to complementary assets is a higher barrier to entry for academic or user entrepreneurship, relative to employee entrepreneurship.	**Proposition 2:** Strength of appropriability regimes is a higher barrier to entry for academic or user entrepreneurship, relative to employee entrepreneurship	**Propositions 3a-e:** High academic and user entrepreneurship in early life cycle stages. As industries evolve, employee entrepreneurship increases, and academic entrepreneurship is favored over user entrepreneurship. User entrepreneurship is more likely to occur in niche or unserved markets in mature stages. These patterns result in decreasing product innovation and increasing process innovation over time.	**Proposition 4a-c:** Employee founded firms are more likely to tend to compete with established firms. Academic founded firms are more likely to collaborate with established firms as industries evolve, and user founded firms are more likely to have no overlap with, or complement established firms as industries evolve	**Proposition 5a-c:** Employee founded firms have higher survival rates relative to academic and user founded firms, who are more likely to capture value through alliances or acquisitions. As industries evolve, academic and user founded firms experience a decrease in the likelihood of survival and an increase in the likelihood of acquisition as an exit strategy.

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