1. Technological embeddedness as a determinant of techno-entrepreneurship

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INTRODUCTION

Stinchcombe (1965) argued that the technical and economic conditions of a particular enterprise determine its appropriate organizational form (p. 160). Based on this, ecological studies have investigated the mechanism of the interplay between technology and entrepreneurship (Astley, 1985; Ruef, 2000; Aldrich and Ruef, 2006; Owen-Smith and Powell, 2004). These studies agree with the concept that technology imprints organizational forms across populations.¹ Yet, the research focus is mainly entrepreneurship rather than the nature of technology. That is, technological conditions have been considered as given: neither what kind of technology nor which characteristics of technology can influence the entrepreneurial processes have been specifically touched upon. In this chapter, taking the perspective of community ecology (Astley, 1985), we attempt to specify the technical conditions related to the emergence of new organizational forms.

In particular, to further understand how organizational forms can be influenced by technical conditions at a community level, we incorporate two views into community ecology: embeddedness (Polanyi, 1944; Granovetter, 1985; Zukin and DiMaggio, 1990) and social construction of technology (Pinch and Bijker, 1984; Orlikowski, 1992, 2000). Based on Polanyi (1944), embeddedness is theoretically understood to overcome the limitation of economic theories by considering social, cognitive, cultural, and political structure. In organization science, embeddedness provides an important motivation to identify the relevant social structure related to economic activities. Meanwhile, social construction of technology deals with how technology is developed by social actions (Pinch and Bijker, 1984; Orlikowski, 1992, 2000; Klein and Kleinman, 2002). These social aspects of technology have highlighted that how individuals interpret the technology will further develop the structure of the technology (Pinch and Bijker, 1984).

Combining the concepts of embeddedness and the social construction of technology, this chapter identifies characteristics of technology

constraining or facilitating entrepreneurship, termed as *technological embeddedness*. Technological embeddedness refers to the extent to which *de novo* organizations (or entrepreneurial firms) are related to a differentiated technology. That is, the interconnections between an organization and its technological domain will occur beyond the organizational boundary. In fact, technology-based entrepreneurship can have multiple industries as a common technology can be used to develop different products (Zucker et al., 2007). From this standpoint, this chapter explains how technological embeddedness is found around technology at and beyond the population level. Specifically, we discern four entrepreneurial patterns at a community level, driven by the nature of technology. Given that a community bears diverse organizational actors at a population level, we consider how a population utilizes a certain type of technology, and specify entrepreneurial patterns driven by the nature of technology: *local specialism*, *global generalism*, *specialized generalism*, and *generalized specialism*.

This chapter is organized as follows. First, we will conceptualize technological embeddedness, based on community ecology, embeddedness, and social construction of technology. Second, we define four entrepreneurial patterns in views of how differently a technology is utilized across populations and how many social actors at a community level engage in the development and utilization of a technology. Third, we specify each entrepreneurial pattern. Lastly, we will discuss how technological embeddedness is related to entrepreneurial ecosystems.

THEORETICAL BACKGROUND

Community Ecology

Population ecology is interested in the rise and fall of organizations within a population, which are dependent on how organizations fit their environment (Hannan and Freeman, 1977, 1989; Carroll and Hannan, 2000; Hannan et al., 2007). However, population ecology fails to explain why and how populations emerge because it only focuses on single existing populations. Besides, as Astley (1985) pointed out, population ecology has generally not considered the community level,² preferring to focus on population dynamics rather than on the emergence of new populations.

In response to this, community ecologists explore relationships between several populations to understand how a certain community³ plays a role in the emergence and evolution of diverse organizations (Freeman and Audia, 2006; Astley, 1985; Ruef, 2000; Aldrich and Ruef, 2006). By emphasizing the fact that a community is composed of organizations

whose origin populations are heterogeneous and interrelated, scholars in community ecology attempt to encompass and complement the population ecology perspective. In particular, given that the conception of community reflects changes in societal norms and values as well as technological innovations (Aldrich and Ruef, 2006), organizational communities set the context within which new populations emerge. Accordingly, there are three different features which differentiate community ecology from population ecology (Astley, 1985).

First, the notion of punctuated equilibrium is identified. Since the community approach focuses on the inter-population relationships, it suggests that most organizational change must occur in the process through which new populations are born and old ones die. From this standpoint, community ecologists argue that equilibrium is regarded as a period of negligible change in population forms, which is punctuated by discrete origins and extinctions; the evolution of populations thus moves with an episodic tempo.

Second, the direction of evolution is unpredictable. Instead of assuming the diversity of organizational forms is in equilibrium (Hannan and Freeman, 1977), community ecology assumes the eventual adoption of a particular variant form is dependent on a multitude of change events. This ensures randomly directed changes in population forms. In other words, the birth of new organizations opens up new avenues of development in what is inherently an unpredictable pattern of evolution.

Lastly, community ecology conceives of “quantum speciation,” in which certain factors retard evolutionary change to the gradualistic pattern by suppressing the emergence of radical mutation. If any forces to change population forms are isolated in some manner, the evolution of the population forms would not occur. The type of events emphasized at the community level depends to a considerable extent on the pressures posed by technical and institutional environments on organizations within the community (see Scott and Meyer, 1991). This argument is also related to Stinchcombe (1965) who maintained that only when the social structure characterizes appropriate economic or technical conditions can new organizations be formed and existing organizations persist. In his argument, the social structure itself can be the quantum speciation because the institutional pressures from the social structures inhibit the variation derived from mutation.

In sum, by relaxing the assumption regarding equilibrium and by considering the change in population forms at the community level, community ecology has much more room to explain how new organizational forms originate than the original formulation of population ecology (Aldrich and Ruef, 2006).

Embeddedness

Embeddedness is a core concept in economic sociology in investigating economic actions affected by social structures (Polanyi, 1944; Granovetter, 1985; Zukin and DiMaggio, 1990; Callon, 1998; Uzzi, 1996). The rise of economic sociology was related to the embeddedness arguments because in the 1980s sociologists found the neoclassical-economics paradigm difficult to reconcile in a social world in which utility maximization counts for more than power, group membership, or patterned interactions (Zukin and DiMaggio, 1990). They adopted the idea of Polanyi (1944), emphasizing that the modern nation-state should not be understood with only discrete elements and thus economic markets cannot be disembedded from social structure. The concept of embeddedness has been developed as the social structure which can influence economic action (Granovetter, 1985; Uzzi, 1996, 1997).

Comparing to the original definition by Polanyi (1944), the contemporary use of embeddedness states that economic actions are constrained or facilitated in systems of social relations (Granovetter, 1985; Zukin and DiMaggio, 1990; Uzzi, 1996). Granovetter (1985), in one very influential interpretation of embeddedness, argued with the notion that social structures have the power to constrain economic actions. He regarded social structures as inter-personal informal relationships in economic relations. In contrast, Zukin and DiMaggio (1990) explained that economic actions are constrained or facilitated in systems of social relations. Based on this conception, they split the concept of embeddedness into four categories: cognitive, cultural, social, and political embeddedness. Likewise, Callon (1998) identified the problem of calculativeness in economic markets. He argued specifically that the premise that social agents can calculate their economic decisions cannot precisely explain our society. In fact, the notion of calculativeness is echoed by Granovetter's criticism of transaction cost economics. That is, the concept of embeddedness illuminates the social influence of economic behavior.

The criticism of economic theories with embeddedness is further elaborated by Zukin and DiMaggio (1990). They note that the term "embeddedness" illustrates the limitations of the dominant paradigm of social science, neoclassical economics: the crisis of individual rationality. The crisis of the theory of the firm and the crisis of macroeconomic theory in economic theories is not valid. As a way of identifying failures of the neoclassical tradition, they referred to the contingent nature of economic action with respect to cognition, culture, social structure, and political institutions.

First, cognitive embeddedness is "the ways in which the structured regularities of mental processes limit the exercise of economic reasoning"

(Zukin and DiMaggio, 1990: pp. 15–16). Given that the cognitive capacity of human beings is limited (March and Simon, 1958), individuals' behavior cannot be fully rational. Rather, environmental factors will critically influence human behavior through cognitive processes. Such behavior, which is influenced by cognitive processes, in turn influences economic actions.

Second, cultural embeddedness is “the role of shared collective understandings in shaping economic strategies and goals” (Zukin and DiMaggio, 1990: p. 17). It says that culture constitutes the structures in which economic self-interest is played out (Scott, 2014; Meyer and Rowan, 1977).

Third, structural embeddedness or social embeddedness is what Granovetter argued for in relation to social networks. Social networks or social relations are templates that channel market exchanges and facilitate collective action in markets (Uzzi, 1996, 1997; Banerjee, 1992; Bikhchandani et al., 1992). Accordingly, the different types of social networks lead to different behaviors (Granovetter, 1995; Burt, 1992).

Lastly, political embeddedness is “the manner in which economic institutions and decisions are shaped by a struggle for power that involves economic actors and nonmarket institutions, particularly the state and social classes” (Zukin and DiMaggio, 1990: p. 20). As Perrow (1986) pointed out, several aspects of bureaucracy, associated with power structure, particularism, hierarchy, and conservatism, influence economic strategies. Also, laws, public policies, or governmental regulation affect the way individuals produce and consume goods and resources. In short, the notion of embeddedness implies that economic theories have a myopic perspective of our real world because they ignore sociological perspectives as critical factors.

Technological Embeddedness

In a broad sense, embeddedness is understood as the interrelation of human action with a certain aspect of social structure. By specifying social structure, we can specify different properties of embeddedness, such as a cognitive structure within a social actor (cognitive embeddedness), a cultural structure in a society (cultural embeddedness), a relational structure among social actors (social embeddedness), and a power structure in a societal boundary (political embeddedness). We posit that technology and organizational arrangement around technology can constitute a social structure. According to a view on the social construction of technology (Pinch and Bijker, 1984; Orlikowski, 1992, 2000; Klein and Kleinman, 2002), the interplay between human action and social structure exists

in the evolution of technological areas. Pinch and Bijker (1984) emphasized that technological development is driven by how humans interpret technology. Related to this, Orlikowski (2000) elaborated how people enact structures which shape their use of technology, pointing out that “technology is developed through a social-political process which results in structures (rules and resources) being embedded within the technology” (p. 405). That is, technology is a product of human interaction, which, in turn, influences each individual’s behaviors. For example, scientists who develop new knowledge into a feasible technology can themselves found or be involved in founding new firms based on that technology (Stuart and Ding, 2006). This means that the formation of a new organization can be identified by the interactions of social actors involved in developing and utilizing the technology they have.

In fact, Astley (1985) pointed out that the nature of technologies on which populations are based is crucial in the evolution of populations. He argued that a common technology links different populations together, fusing the populations into “functionally integrated systems, or organizational communities” (Astley, 1985: p. 225). Within a community, the adoption of a given technology by its organizations and populations may stall subsequent technological change due to inertia (Tushman and Romanelli, 1985). In addition, based on the notion of punctuated equilibrium (Tushman and Romanelli, 1985), new technology is typically introduced by new organizations embedded in different populations and is less likely to be adapted by existing organizations because of inertia. Also, as increasing numbers of *de novo* organizations are founded, over time they are likely to differentiate into several specialist populations, nonetheless still based on the same overriding science and technology base (Aldrich and Ruef, 2006; Astley, 1985).

Similarly, Callon et al. (1992) used the term techno-economic networks to describe technological innovation. A techno-economic network refers to “a coordinated set of heterogeneous actors – public laboratories, technical research centers, industrial firms, financial organizations, users, and public authorities – which participate collectively in the development and diffusion of innovation and which via numerous interactions organize the relationships between scientific-technical research and the marketplace” (Callon et al., 1992: p. 220). This concept indicates that technology and human actions co-evolve over time, so that we cannot consider these areas separately. Taken together, technological embeddedness is understood as the interplay between technology and human action.

The concept of technological embeddedness is further understood by distinguishing the level of organization. At the organization level, technology can be understood in terms of what kind of technology is created

(Anderson and Tushman, 1990), how a technology is developed (Pinch and Bijker, 1984), or how a new technology influences individual behaviors (Barley, 1986). Meanwhile, at the population level, technology can be understood differently. There are interrelationships among different technologies, which are created and developed by different populations (Chesbrough, 2006). A technology in one population can be applied to other populations and many breakthrough technologies can arise when two different technologies are combined. In other words, the configurations and reconfigurations of technologies from diverse populations lead to social interactions between populations who develop a technology and those who utilize it.

TECHNOLOGICAL EMBEDDEDNESS AND ENTREPRENEURIAL PATTERNS

To explain the concept of technological embeddedness, we consider entrepreneurial processes. According to Carroll and Khessina (2005), in ecological perspectives, entrepreneurship is understood as founding events, that is, the establishment of new organizations and their viability in early years. This indicates that entrepreneurial processes encompass all kinds of action related to creation of new organizations. In the concept of technological embeddedness, entrepreneurial processes are particularly understood as the creation of new organizations driven by a technology. And this indicates that social actors, whether they are individuals, organizations, or populations, play a central role in creating new organizations by adopting a new technology. Taken together, we can conjecture that technology can facilitate or constrain the emergence of new organizations as well as the evolution of existing organizations. However, the type of technology that can be critically involved in the entrepreneurial process has not been specifically investigated. To understand how and what technology is intertwined with the emergence of new organizations, we demonstrate how different types of technology shape different organizations.

Four Representations of Technological Embeddedness

The concept of technological embeddedness is identified with (1) how a technology is applied across industries (populations), called *breadth*, and (2) how many organizations adopt a technology within a population, called *depth*. *Breadth* is related to the level of technological applications across populations, whereas *depth* indicates the level of technological

		Breadth	
		Low (confined to a specific population)	High (applied to multiple populations)
Depth	Low (small no. of incumbent organizations)	Local Specialism – e.g. technologies from firm R&D	Generalized Specialism – e.g. nanotechnology
	High (large no. of incumbent organizations)	Specialized Generalism – e.g. watch movement technology	Global Generalism – e.g. technologies from scientific research

Figure 1.1 Nature of technology

adoption within a population. With the two characteristics of technological embeddedness, we can begin to understand the nature of technology. For example, if a technology is characterized by low *depth* and low *breadth*, the technology is less likely to be adopted within a population and to be applied to different populations. It means that the technology is developed for a very specialized purpose. On the other hand, a technology whose *breadth* and *depth* are both high is perceived as global generalism,⁴ where all social actors, regardless of populations, use this technology. Such a globally generalized technology makes different organizing patterns to specialized technology.

Accordingly, based on these two dimensions, depth and breadth, we classify four natures of technology: *local specialism*, *global generalism*, *specialized generalism*, and *generalized specialism*. Figure 1.1 presents the classification. According to this classification, we can find out different organizational patterns of new technology-based firms in heterogeneous populations. This specification of entrepreneurial patterns driven by the nature of technology reflects how technological embeddedness unfolds.

Entrepreneurial Patterns by Nature of Technology

Local specialism

Local specialism refers to the nature of technology which is developed for particular organizations. According to the classification of Figure 1.1, local specialism is characterized by a small number of organizations applying the focal technology to a population and a small number of populations adopting it. As such, an example of local specialism can be any technology developed through firm R&D activities. Figure 1.2 exhibits how local specialism emerges at the population level.

Figure 1.2 Local specialization

Given that firm values (or competitive advantages) are enhanced by firm-specific resources or capabilities (Penrose, 1959; Barney, 1991), firms are likely to develop their own technologies which cannot be easily copied by their competitors (Henderson and Cockburn, 1994; Kogut and Zander, 1992; Peteraf, 1993). In fact, the positive impact of R&D intensity on firm performance has been widely examined empirically (Deeds, 2001; Kelm et al., 1995; Grabowski and Vernon, 1990; Vernon and Gusen, 1974). Firm-specific technology (i.e. local specialism) can enhance the firm's unique values.

From an ecological perspective, local specialism yields specialists, who seek a particular group of customers (Hannan and Freeman, 1977; Carroll and Hannan, 2000). This implies that firms with local specialism tend to search for niches⁵ and as a result, local specialism yields organizational forms which can reinforce the differentiated aspects of the technology in the industry, such as competency-enhancing organizations (Anderson and Tushman, 1990). Such competency-enhancing organizations are understood as subgroups, branches, corporate venturing, or spinoffs (York and Lenox, 2014; Khessina and Carroll, 2008). For example, Barnett and Freeman (2001) found that in the U.S. semiconductor industry, firms tend to sequentially organize multiple subgroups to introduce multiple products simultaneously to increase their survival rates. Similarly, these kinds of organizational forms (or multiple subgroups) are found in the bicycle industry (Dowell and Swaminathan, 2000), the mainframe computer systems market (Greenstein and Wade, 1998), the automobile industry (Carroll et al., 1996), the television receiver industry (Klepper and Simons, 2000a), and the computer workstation manufacturers market (Sorenson, 2000).

However, the organizations characterized by local specialism (mainly firms) may suffer from the paradox of differentiation (Zhao et al., 2017; Deephouse, 1999). As R&D activities intensify within a firm, the firm can construct differentiated technology. Yet such unique technology can limit the firm's innovation activities. For example, if the technology which is unique in the industry is not compatible with other competing technologies, the industry cannot accept such technology (Carroll and Hannan, 2000; Clark, 1987). That is, if firms seek unique or differentiated technology in the industry, this technology is not easy to follow for other social actors, including competitors (see Clark, 1987). As such, the technology may be less likely to be adopted throughout the populations, leading to a failure in gaining legitimization of the technology driven by local specialism at the population level.

Specialized generalism

Specialized generalism is the nature of technology generalized only within a particular population. This means that at a community level, the specialized generalism is identified as a technology specialized for particular populations. According to the classification of Figure 1.1, the specialized generalism is characterized by a large number of organizations applying the focal technology at a population (or high depth) but a small number of populations adopting it (or low breadth). Accordingly, specialized generalism is particularistic. Within a certain population, the technology is standardized or exists as a dominant design. Yet, the technology cannot be applied to the other populations. For example, watches characterized by a mechanistic movement technology are relatively dominant in a luxurious watch industry, but not in the whole watch industry. Figure 1.3 presents how technologies characterized by specialized generalism appear at the population level.

From competition theory (Hannan and Freeman, 1977), we can see that specialized generalism produces generalists and the population is dominated by a small number of organizations. The microprocessor industry is an example. Microprocessors are based on a specialized technology for personal computers. Since the late 1960s, technology has been developed to integrate the whole function of a central processing unit (CPU) into a single chip, or integrated circuit (IC) (Osborne, 1980). Such technology of the integration of multipurpose functions on to a chip is dominant in the personal computer industry. And it became a dominant design in the computer processor industry (Betker et al., 1997; Goettler and Gordon, 2011; Gordon, 2009).

In fact, populations shaped by specialized generalism tend to have a form of oligopoly in their economic structure (Klepper and Simons, 2000b; Carroll and Hannan, 2000). The industries characterized by specialized generalism (e.g. dominant designs) tend to be commanded

Figure 1.3 Specialized generalism

by organizations which own those dominant designs (Anderson and Tushman, 1990; Barnett and Hansen, 1996). Even though the dominant designs can be changed by different organizations, the distribution of the population is dominated by a small number of organizations. Accordingly, the industries with their own dominant design tend to deter the entry of new organizations (Suarez et al., 2015).

Generalized specialism

Generalized specialism refers to the nature of technology widely applied across diverse populations, where the application of the technology is specialized for particular areas in each population. That is, generalized specialism seeks specialism (i.e. differentiation), but is generalized across populations in a specific area. According to the classification in Figure 1.1, the generalized specialism is characterized by a small number of organizations applying the focal technology at a population (i.e. low depth) but a large number of populations adopting it (i.e. high breadth). If some features of a technology are commonly adopted across populations, the technology is identified as generalized specialism. For example, digital technology is applied to various industries, particularly the TIME industries (Telecommunication, IT/Internet, Media, and Entertainment). Nanotechnology is also an example. That is, we can easily spot the common use of nanotechnology in different fields, such as pharmaceuticals, chemical sciences, material sciences, or biotechnology (Zucker et al., 2007). Figure 1.4 presents how generalized specialism appears at a population level.

From an ecological view, the technologies of generalized specialism reside in diverse populations. This results from instrumentality. By instrumentality, we mean that innovation is actually driven by the capabilities of measurement, or “invention of a method of inventing” (Darby and Zucker, 2005: p.145). In his seminal work, Griliches (1975) argued that innovation breakthroughs unfold when inventing methods are invented and applied to the field and simultaneously sales of the products driven by the new methods of inventing are grown. Adopting this concept of the invention of a method of inventing, Darby and Zucker (2005) found that nanotechnology could be further developed with the invention of microscopes called Scanning Tunneling Microscopes (STMs). Instruments like STMs themselves require specific technologies, but they are utilized to enable inventors to develop their own technologies.

Instrumentality is also found with Artificial Intelligence (AI), which refers to “the study of agents that receive percepts from the environment and perform actions” (Russell and Norvig, 2010: p.viii). While AI does not constitute a particular industry, it contributes various fields, such as

Figure 1.4 Generalized specialism

practical speech recognition, machine translation, autonomous vehicles, smart healthcare, robo-advisory, and household robotics (Russell and Norvig, 2010; Crevier, 1993; Rashid, 2017; Kurzweil, 2005; Krauss et al., 2017). Given that AI develops algorithms to make impersonal things (called agents) carry out particular actions (Russell and Norvig, 2010), such algorithmic approaches, which signify instrumentality, enable diverse industries to develop their own intelligent agents, such as reactive agents, planning agents, or knowledge-based agents.

Generalized specialism is further understood with the use of the term *niche width* (Hannan and Freeman, 1977; Freeman and Hannan, 1983; Dobrev et al., 2001; Carroll, 1985). Niche width refers to a “population’s tolerance for changing levels of resources, its ability to resist competitors and its response to other factors that inhibit growth” (Freeman and Hannan, 1983: p. 1118). That is, technologies characterized by generalized specialism can enhance the niche width in a population as generalized specialism helps integrate into existing technologies (Griliches, 1957; Darby and Zucker, 2005). Accordingly, generalized specialism can be a source of differentiation through inter-area inventions, such as AI-based medical devices. And this results in the formation of various kinds of *de novo* specialists (i.e. newly formed organizations which are differentiated from existing organizations in a population).

Furthermore, given that the technologies of generalized specialism, by nature, are widely applied to other populations, the diverse applications of the technology can appeal to a broad range of customer tastes across populations and, as a result, these technologies can be legitimized throughout the community. For example, we can see that the industrial revolutions in our history have taken place through the increase in the inter-population applications of a technology. For example, steam engines were applied to various kinds of transportation; digital technology now yields various applied technologies across industries. In other words, generalized specialism can be a nucleus of community evolution.

Global generalism

Global generalism is a concept opposite to local specialism. It refers to the nature of technology which is developed for a whole community (organizations and populations as well). According to the classification in Figure 1.1, global generalism is characterized by a large number of organizations applying the focal technology in a population and a large number of populations adopting it. As such, an example of global generalism can be any technology developed by scientific research (Fleming and Sorenson, 2004; Rosenberg, 1990). Figure 1.5 presents how technologies characterized by global generalism emerge at the population level.

Figure 1.5 Global generalism

Scientific research, which refers to work undertaken primarily for the advancement of scientific knowledge (NSF, 1953), leads to new technology and helps create practical applications of the technology. Given that scientific research investigates the causal mechanisms of various scientific phenomena, organizations involved in developing the research tend to search for useful combinations of prior research, eliminate fruitless paths of research, and motivate themselves to continue even when the results of the research yield negative outcomes (Fleming and Sorenson, 2004; Schumpeter, 1939; Nelson and Winter, 1982; Henderson and Clark, 1990). Through this process, scientific research facilitates developing new technologies or inventions (Malva et al., 2015; Fleming and Sorenson, 2004). For example, the field of biotechnology emerged based on scientific research investigating biological phenomena (Zucker and Darby, 1996). A series of studies examining DNA (deoxyribonucleic acid) became a fundamental basis for biotechnology (Fitzgerald-Hayes and Reichsman, 2009; Evens and Witcher, 1993). With the development of biotechnology, different kinds of industries emerged, such as the pharmaceutical industry (Lim, 2004; Drews, 2000) and life sciences (Powell et al., 2005). And the industrial code for the biotechnology industry in the stock market has been established. This demonstrates how the technology representing the global generalism (i.e. scientific research) can influence the construction of new organizational forms.

Global generalism leads to the emergence of a new innovation-seeking community. The community emergence related to global generalism is understood in terms of open innovation, defined as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation” (Chesbrough, 2006: p. 1). In fact, since the seminal work by Chesbrough (2003), open innovation has been subject to much attention and increasing numbers of scholars have been interested in the importance of collaborative

ecosystems (Chesbrough, 2006; Nambisan and Sawhney, 2007), the roles of external innovation infrastructure (Grimaldi et al., 2011; Nambisan et al., 2012), intellectual property rights (Henkel et al., 2014), and ways of knowledge sharing (Dahlander and Gann, 2010). This suggests that collaborative and collective creation of knowledge can be further facilitated when collaborative environments are present. And such interrelationships among the diverse organizations constitute an innovation-seeking community in which they can take initiatives for further technological innovation (Chesbrough, 2006; Aldrich and Ruef, 2006; Powell et al., 2005; Laumann et al., 1978; Audia et al. 2006).

Ecosystems and Technological Embeddedness

Given the previous literature on ecosystems (or any collectivities consisting of diverse social actors), which mainly focused on the specification of their network structures (Hallen and Eisenhardt, 2012; Wincent et al., 2010), we understand that a technology ecosystem forms as diverse populations increasingly adopt the same technology through the social structure (Dyer and Nobeoka, 2000; Adner and Kapoor, 2010; Moore, 1993). That is, as social actors from different populations become increasingly involved in developing new technology, a technology-based ecosystem around the new knowledge is likely to emerge.

This echoes previous literature demonstrating that the emergence of organizational forms characterized by the interrelationship among social actors can be understood as a product of interrelationships across diverse populations (Astley, 1985; Ruef, 2000; Aldrich and Ruef, 2006). As Larson and Starr (1993) maintained, the organizational forms are created by “the crystallization of stable, committed, revenue-generating, inter-organizational exchange relationships which extend beyond the earlier idiosyncratic and personalized relationships of the entrepreneur” (p. 5). Likewise, Deroian (2002) argued that inter-organizational relationships convey a sufficient level of information for an innovation, which can help the organizational parties engage in technological commercialization. In particular, as the evaluation of the innovation is collectively made through the social networks, it is more likely to form a new organization which plays a role in commercializing the innovation.

Hence, in the process of ecosystem formation, technological embeddedness plays a critical role. In particular, we conjecture that either generalized specialism or global generalism is a driver for the formation of technology ecosystems. Generalized specialism, due to the character of instrumentality, enables social actors in a population to configure or reconfigure existing technologies (Griliches, 1957). Likewise, global generalism, rooted

in scientific research, can provide a general framework for each population (Zucker and Darby, 1996). Since those natures of technology are associated with the engagement of diverse social actors, they can be crystallized into a particular organizational form, which could be a technology ecosystem (Hallen and Eisenhardt, 2012; Wincent et al., 2010).

Meanwhile, these characteristics of instrumentality and science base commonly elicit translation issues among different populations. Since each population has its own goals in developing its own technology, even if a technology is applied across populations, the interpretation of the technology by the focal population can be different from that of the originating population (Nielsen et al., 2014). Nielsen et al. (2014) investigated how the Danish home-care sector incorporated mobile IT and how the technology was translated into different local arrangements. They found that mobile IT was first seen as a “fashionable recipe for improvement” but subsequently became the “subject of controversy” (p. 165). That is, in incorporating technology from different populations, social actors in the focal populations should consider different linguistic and material forms across populations. This requires an intermediary organizational form, which can be the technology ecosystem. That is, the emergence of technology ecosystems can not only be “pulled” to enhance the inter-population application of a technology, but can also be “pushed” to facilitate creating consensus on the applicability of a technology across populations.

CONCLUSION

In this chapter, we explain the technical conditions related to the formation of new organizational forms, including organizations, populations, and communities. Drawn from community ecology (Astley, 1985), the mechanism of the interplay between technology and entrepreneurship is elaborated at a community level. In particular, this chapter demonstrates how technology, especially the nature of technology, imprints organizational forms across populations. For this interplay between technology and human action, we coin the term technological embeddedness. And the technological embeddedness is focused on the technological arrangements at a higher level of organization. Specifically, by elaborating on the dichotomy of specialism and generalism at the community level, we illustrate how the different natures of technology influence organizational founding patterns. Also, looking at how technologies have been adopted by different populations over time, we discover, in an evolutionary perspective, why one particular technology is diffused across populations

but others not, or how a technology can be globally generalized or locally specialized.

In addition, the technological-embeddedness approach can provide further understandings on the evolution of organizations. Technology cannot be generalized all at once, because it needs some time to diffuse and be developed throughout the applicable populations. With technologies from specialized generalism, such as microprocessors, organizations with the prevalent technological knowledge in the field are located in a particular population and want to make their technology a dominant design in their industry. Therefore, new organizations mostly emerge from existing firms, consisting of spinoffs/spinouts and mobilizing resources around the firms. On the other hand, with technologies from generalized specialism, such as nanotechnology, the organizations with highly specialized knowledge in a certain field are located across populations and want to make their technology more applicable to other populations. As a result, new organizations, with technology co-located in different populations, are likely to emerge.

In sum, technological embeddedness can shed light on the emergence of technology ecosystems as well as techno-entrepreneurship. By considering technological embeddedness, we can explain the emergence process of technology ecosystems and predict how they will evolve over time.

NOTES

1. A population denotes “the set of organizations with a particular form within a (bounded) social system” (Hannan and Carroll, 1995: p. 29). For example, a population of universities is a collectivity of research-based institutions of higher education.
2. When Hannan and Freeman (1977) adapted early ecological studies to introduce a new level of analysis for population ecology as populations, they explicitly posed the community level as a possible level of analysis.
3. A community is defined as a “set of diverse, internally homogeneous populations which depend crucially on the nature of the technologies on which the populations are based” (Astley, 1985: p. 224).
4. Local specialism and global generalism are viewed at the community level. They are differentiated from specialism and generalism at the population level (Hannan and Freeman, 1977).
5. A niche refers to an “area in constraint space (the space whose dimensions are levels or resources, etc.) in which the population outcompetes all other local populations” (Hannan and Freeman, 1977: p. 947).

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