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INTERCOMMUNITY RELATIONSHIPS AND COMMUNITY GROWTH IN CHINA'S HIGH TECHNOLOGY INDUSTRIES 1988–2000

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In this study, we examine how intercommunity relationships affect the growth of organizational communities. Using a unique panel dataset on 53 technology development communities in China spanning 1988–2000, we found that regional community density, a community's geographic proximity to the nearest community and its domain overlap with the nearest community have an inverted U-shaped relationship with the community's growth. These non-monotonic results suggest that adjacent communities have both mutualistic and competitive effects on each other. Theoretical and managerial implications are discussed. Copyright © 2008 John Wiley & Sons, Ltd.

INTRODUCTION

Scholars from several disciplines have paid increasing attention to the emergence and growth of organizational communities.[1] According to Porter (1998a: 78), organizational communities are 'geographic concentrations of interconnected companies and institutions in a particular field,' and they encompass an array of linked industries and other entities important to competition. It has been argued that the creation of organizational communities is a vehicle for developing technological competitiveness and catalyzing economic growth at the nation, state, and city levels (Porter, 1998a; Romanelli and Khessina, 2005). Not surprisingly, several governments have placed the development of organizational communities at the center of their national development programs (Enright, 1999; Mathews, 1997; Perez-Aleman, 2005).

Considering the economic and technological significance of organizational communities, what factors can affect their growth? Some theorists have focused on the external resource conditions and argued that a panoply of superior natural, industrial, and institutional resources (Aldrich and Ruef, 2006; Chiles, Meyer, and Hench, 2004; Krugman, 1991) and social networking with access

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[1] Scholars have used a plethora of terms to describe the organizational community phenomenon such as organizational communities (Aldrich and Ruef, 2006; Astley, 1985; Freeman and Audia, 2006; Wade, 1995, 1996), regional industrial districts or clusters (Krugman, 1991; Piore and Sabel, 1984; Porter, 1998a, 1998b; Romanelli and Khessina, 2005; Tallman *et al*., 2004), incubator regions (Schoonhoven and Eisenhardt, 1993), industrial systems (Saxenian, 1994), and science parks and incubators (Phan, Siegel, and Wright, 2005). The common theme in this research stream is that each describes a geographically bounded locale within which multiple populations or industries exist in a community of relationships. For example, Freeman and Audia (2006: 145) conceptualize community as a set of relations between organizational forms or places where organizations are located in resource space or in geography. Similarly, Aldrich and Ruef (2006: 243) define an organizational community as a set of coevolving organizational populations joined by ties of commensalism and symbiosis.

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to cutting-edge information (Sorenson, 2003; Stuart and Sorenson, 2003) give rise to particular regional capacities for community growth. Alternatively, other scholars have emphasized the role of within-community relationships in supporting community growth. For example, Saxenian (1994) observed that despite beginning from 'relatively similar' starting points after World War II, the Silicon Valley region in northern California outperformed Boston's Route 128 because the Silicon Valley is a regional network-based industrial system that creates greater regional flexibility and technological dynamism, which in turn promotes collective learning among firms (Saxenian, 1994: 2–9). Perez-Aleman (2005) argued in the context of two successful communities in Chile that community growth depends on building institutions that enable coordinated learning among firms to improve capabilities, processes, and products.

While these studies have contributed substantially to our nascent understanding of community growth, there are gaps in the extant literature. As noted above, previous studies have focused either on external resource conditions of a specific community (e.g., Krugman, 1991) or endogenous factors within a specific community (Perez-Aleman, 2005; Saxenian, 1994). Beyond these two views, in cases of multiple communities, it is likely that intercommunity relationships will have important consequences for community growth. For example, Porter (1998a: 89) noted that an industrial cluster could affect the productivity of other clusters. Tallman and Phene (2007) found that knowledge flows (in terms of patent citations) within regional clusters are not significantly different from those between regional clusters in a domestic context. This finding implies that the boundaries of communities are open and porous and do not prevent knowledge from flowing from one community to another. Furthermore, Saxenian and Hsu (2001) noted that the external connections of the Hsinchu Science District in Taiwan with Silicon Valley in the United States (through the flows of people, information, and know-how) provided Hsinchu with an additional impetus for its sustained growth. More generally, Barnett and Carroll (1987: 400) noted that organizational interdependence can exist between communities of organizations although most existing research has focused on interdependence between individual organizations.

In this study, we adopt an ecological perspective (Aldrich and Ruef, 2006; Astley, 1985; Barnett and Carroll, 1987; Freeman and Audia, 2006; Hannan and Freeman, 1977, 1989) to explore how intercommunity relationships affect community growth. From an ecological perspective, two or more communities are interdependent if the presence of one affects the outcomes of the other. We argue that organizational communities have both mutualistic and competitive effects on one another, and we delineate three dimensions of intercommunity relationships: regional community density (i.e., the number of communities in the same region), a community's geographic proximity to the nearest community, and a community's domain overlap with the nearest community. We propose that each of these dimensions will have an inverted U-shaped relationship with a focal community's growth due to the joint effects of mutualism and competition. We explore these ideas in the context of all 53 national technology development zones created in China between 1988, when the first was founded in Beijing, and 2000. National technology development zones are conceptualized as technology communities that contain several technology-related populations of firms.

This study contributes to a greater understanding of community phenomena, especially the impact of intercommunity relationship on community growth. Prior studies of organizational communities have focused on either the external resource conditions of a specific community or on endogenous factors within a specific community. Hence, the literature has implicitly treated communities as if they are independent of one another. In contrast, this research assumes that organizational communities are interdependent. We delineate three dimensions of intercommunity relationships (i.e., density, geographic distance, and domain overlap) and examine how these dimensions affect the growth of geographically dispersed organizational communities containing multiple interrelated populations of firms in the context of China's national technology development zones. Thus, this study elaborates the spectrum of possible explanations for community growth.

Our study differs from existing ecology studies and extends the ecology perspective in two important ways. First, most existing ecology studies have focused on interdependence between firms within a population (i.e., industry) and have examined the growth or decline of the population or

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the growth or decline of firms within a population (Aldrich and Ruef, 2006: 37). In their summary of the extensive population ecology research published between 1983 and 2006, Hannan, Polos, and Carroll (2007: 31) observed that gaining the requisite institutional knowledge about multiple populations poses a formidable empirical challenge. Not surprisingly research on interpopulation relations within a community has progressed slowly (Aldrich and Ruef, 2006: 250) as have studies of community-level processes for similar reasons. This study advances the literature by applying an ecological perspective to examine the overall economic growth of geographical clusters of numerous interrelated populations of firms in the context of China's national technology development zones. Building on the few exemplary studies of communities that exist (e.g., Ruef, 2000; Wade, 1995, 1996), we have created a multicommunity, longitudinal dataset that enables analyses of how intercommunity relationships affect community growth over time. Therefore, this study extends existing knowledge by testing the extent to which an ecological perspective can be applied to communities that are geographic clusters of multiple populations of firms (instead of a single population).

Second, our study also contributes to the ecology literature by simultaneously examining the multiple dimensions of intercommunity relationships described above. In contrast, previous ecology studies have typically examined one of these dimensions (primarily density) at the organizational or population level. Furthermore, while the inverted U-shaped effect of density has been widely examined in the population ecology literature (we also develop a hypothesis on density to closely link our study to the existing ecology literature), existing studies of geographic proximity (Sorenson and Stuart, 2001; Stuart and Sorenson, 2003) and domain overlap between organizations (Baum and Mezias, 1992; Baum and Singh, 1994a, 1994b; Dobrev, Kim, and Hannan, 2001; Podolny, Stuart, and Hannan, 1996) have primarily examined their monotonic effects on a variety of outcomes. In comparison, this study proposes that geographic proximity and domain overlap between adjacent communities will have both mutualistic and competitive effects, and thus we expect to observe an inverted U-shaped relationship of each with community growth.

In the following pages, we describe the context of the study by explaining how technology development zones were first created and have subsequently grown in China. Then, we present our conceptual framework and hypotheses, discuss the research design and measures, and report our empirical findings. We conclude by discussing implications of these results for theory, future research, and managerial implications.

CONTEXT OF THE STUDY

The creation of technology communities has been viewed as a powerful vehicle for developing technological competitiveness and catalyzing economic growth at the nation, state, and city levels (Porter, 1998a, 1998b). In an attempt to duplicate the success of the U.S.'s Silicon Valley in developing high-technology industries, the Chinese central government launched its 863 Program in March 1986, which formalized China's intent to establish national technology development zones to encourage local entrepreneurship in high-technology industries as a means of building China's future technology capabilities. The first national technology development zone was established in 1988 in Beijing, and by 1998 an additional 52 national technology development zones were created throughout China.

All national technology development zones are governed by State Council regulations (i.e., *Relevant Policies and Regulations on National Technology Development Zones*, 1991). The regulations require that zones foster collaboration between a university-based research center, an innovation center that will provide applied technology for product development, and commercial firms that can provide product manufacturing and marketing (DFL International, 1999: 23–24). Zones are open to both domestic and foreign high-technology investors and are composed of a mixture of specific industrial populations in certain technology industries that are considered new and 'high technology' in China. These include electronic information, integrated optical and advanced manufacturing, biotech and pharmaceuticals, new materials, new energy, aeronautical engineering, ocean technology, high technology agriculture, environmental protection, and nuclear applications.

Firms in the national technology zones enjoy preferential policies that include tax reductions, facility and land use rights, and import privileges, among others. For example, firms in the zones pay

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an income tax of 15 percent, which is less than half the normal tax rate of 33 percent. Taxes for new entrants are waived for the first three years, with an additional 50 percent reduction in taxes over the subsequent three years. Because the primary purpose of the national technology development zones is to promote technological innovation, only qualified firms are allowed to enter the zones. To qualify for entry, a firm must be certified as 'high-tech' by the Administrative Committee of a zone by conducting business activities in targeted high-technology industries, by having a top management team composed of engineers or scientists, having 20 percent of employees be college graduates, and having at least three percent of sales spent on research and development (Li and Atuahene-Gima, 2001). The high-tech status of entrants is further monitored and renewed by the Administrative Committee of a zone on an annual basis.

As a group, China's technology development zones have grown dramatically in their first decade of existence. Figure 1 reveals that revenues for all zones reached 460 billion (in 1990's renminbi [RMB] value) between 1988 and 2000. However, zones have grown differentially. For example, although both were founded in 1991, the Shanghai Zone reached RMB 75.1 billion in revenues in 2000, whereas the Taiyuan Zone in Shanxi province reached only RMB 7.7 billion in the same year. We may ask: What factors account for these zones' differential growth rates?

Because our analysis includes geographic proximity as a dimension of community interdependence, the reader may find it useful to visualize the geographic distribution of national technology development zones in China. Figure 2 shows that all are located in cities, typically formed where earlier organizing has concentrated one or more organizations or institutions specializing in science-based technology research. For example, the Beijing Technology Development Zone is located in the Haidian District of Beijing, which is home to the Chinese Academy of Science, Peking University, Tsinghua University, and other research institutes and government think tanks.

Figure 2 also reveals that China's national technology development zones are not evenly distributed throughout the country. All provinces, municipality cities, and autonomous regions contain at least one zone, with the exception of three of China's innermost province/autonomous regions (Qinghai Province, the Tibet, and Ningxia Autonomous Regions), which are mountainous and sparsely populated. Also, some provinces have more zones than others, ranging from one to six per province. Furthermore, some zones are in close proximity to others, whereas others are relatively distant from the nearest zone. The variable geographic distribution of national technology zones throughout the country provides an opportunity to examine how intercommunity relationships affect community growth. In the next section, we draw upon an ecological perspective to develop theory and research hypotheses.

THEORY AND HYPOTHESES

Interdependence between communities: mutualism and competition

In ecological theory, organizations are considered to be interdependent when they affect each other's

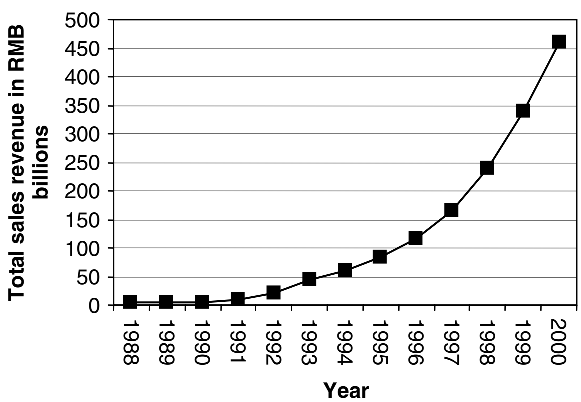

Figure 1. Total sales revenue for all zones 1988–2000 (in 1990 RMB)

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Figure 2. Geographic locations of national technology development zones in China*

fates (e.g., growth and mortality). There are two generic forms of organizational interdependence: competition and mutualism. As Barnett and Carroll (1987) noted, 'When organizations negatively affect one another, they are competitive. When they enhance each other's viability, organizations are mutualistic' (Barnett and Carroll, 1987: 400). The density dependence model of the population ecology literature captures competition and mutualism between individual organizations within a population (Barnett, 1990; Barnett and Carroll, 1987). This model, originated by Hannan and Freeman (1989), proposes that an initial increase in the number of organizations in a population improves survival chances of the individuals, indicating mutualism between organizations. Mutualism occurs because organizations 'making similar demands on the environment combine their efforts, intentionally or otherwise' to improve an emerging population's position (Aldrich, 1999: 302). However, as a population increases beyond a certain point, competition for similar resources increases mortality, due to increased competition between organizations. The mutualistic benefits of an initial increase in density, combined with the competitive effects of further increases, create an inverted U-shaped effect of population density on organizational outcomes.

As Barnett and Carroll (1987) noted, 'Organizational interdependence can exist at several levels: between individual organizations, between populations of organizations, and between communities of organizations. *For the most part, current organizational researchers think only of the organizational level*' (Barnett and Carroll, 1987: 400, italics added). In this study, we focus on interdependence between communities and examine how intercommunity relationships can affect community growth. Drawing upon prior work on interdependence between organizations, we propose that interdependence between communities has two forms: mutualism and competition. In our research context (i.e., national technology development communities), mutualism between technology communities derives from the greater and more generalized attention that multiple related communities can attract from external audiences to their locations. It has been noted that although

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natural, industrial, and institutional resources are critical for community emergence and growth, substantial uncertainty surrounds the nature as well as the location of the relevant resources for organizing at the outset of new industries (Arthur, 1990; Rauch, 1993). Hence, prospective entrepreneurs and investors may have only a tangential understanding of actual resources present in a given locale. For this reason, Romannelli and Khessina (2005) argued that it is *perception* rather than actual resources that forms the basis for external audiences' understandings about a region's attractive characteristics and thus their investment decisions. In particular, organizational communities are 'the principal, observable features of regional industrial identities, informing the perceptions of audiences about the region and, therefore, the salient public indicators of regional suitability for particular kinds of business activity' (Romannelli and Khessina, 2005: 345).

Romannelli and Khessina (2005) further argued that the presence of multiple related communities can attract greater and more generalized attention from external audiences. The reason is that when important external audiences such as suppliers, buyers, and venture capitalists interact with organizations in one community, they are more likely to become aware of organizations in other communities if these communities are located in a proximate network of cross-community exchanges (Romannelli and Khessina, 2005). As a result, the presence of multiple technology communities within a specific region can enhance the region's capacity for technology development. This can affect individuals' decisions about where to locate their talents, entrepreneurs' decisions about where to locate businesses, and investors' decisions about where to invest financial resources, which in turn can lead to mutual benefits for these technology communities.

Competition among organizations generally arises from the joint dependence of multiple organizations on the same set of finite resources (Hannan and Freeman, 1977, 1989). At the community level, because key resources sought by technology communities such as technology entrepreneurs, scientists, engineers, technology project managers, and venture capitalists are in short supply in China, technology communities in a specific region are in a state of competitive interdependence. Ruef (2000) defined carrying capacity as '*the maximum number of organizations having some identity (potential or realized) that can be supported by the environment at a particular point in time*' (Ruef, 2000: 678, italics in original). When environmental carrying capacity is greater than that required, the surplus can support greater demand and one can anticipate increased community growth. In contrast, when community size reaches the environment's carrying capacity, increased competition will likely decrease community growth. In our research context, the combined resource requirements of multiple technology communities are greater than the resource requirements of a single community alone. Hence, as the joint resource requirements of multiple communities approach a region's carrying capacity for technology development, one can anticipate decreased community growth.

In summary, we argue that interdependence between communities has two forms: mutualism and competition, which will jointly affect community growth. In this study, we focus on three dimensions of intercommunity relationships: regional community density, a focal community's geographic proximity to the nearest community, and a focal community's domain overlap with the nearest community. Regional community density is defined as the number of organizational communities in a specific region (a province or equivalently autonomous region and municipality city). Geographic proximity captures the spatial distance between a focal community and the nearest neighboring community. Domain overlap captures a focal community's industry specialization relative to the nearest community. By systematically examining the effects of these three dimensions, we are able to offer a more complete picture of the role of intercommunity relationships in community growth.

We argue that each of these dimensions affects the levels of mutualism and competition between communities. The functional form of mutualism and competition between communities that we expect draws upon the logic of the density dependence model of the population ecology literature (Barron, West, and Hannan, 1994; Hannan and Freeman, 1977, 1989; Haveman, 1993). The density dependence model assumes that legitimacy (which leads to mutualism) grows with density at a decreasing rate, while competition grows with density at an increasing rate (Haveman, 1993: 594). Similarly, we propose that mutualism between

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communities grows with regional community density, geographic proximity, and domain overlap, at a decreasing rate, while competition between communities grows with these dimensions at an increasing rate.

More specifically, mutualism between communities grows with these dimensions at a decreasing rate because there is a ceiling on the process when multiple related communities generate more generalized attention from external audiences. As a result, the marginal mutualistic benefit becomes smaller as these dimensions increase. Furthermore, in our theory competition between communities comes from constraints arising from the joint dependence of these communities on the same set of finite resources. When resource demands of communities are far below the carrying capacity of the environment, the marginal increase in competition between communities associated with increase in these dimensions is limited. However, as these dimensions further increase, the marginal increase in competition between communities becomes greater as available resources decrease and resource demands of these communities are approaching the carrying capacity of the environment. As a result, competition between communities grows at an increasing rate with an increase in these dimensions. Therefore, at low levels, increases in these dimensions serve primarily to enhance mutualism between communities. At high levels of these dimensions, increases strengthen competition far more than mutualism. Therefore, we expect to observe an inverted U-shaped effect of these dimensions on community growth. However, we acknowledge that since this ecology logic has been mainly tested at the organizational level in previous studies, the question of whether this logic holds at the community level is still empirically open. Thus, the predictions of this study are partially exploratory, and we aim to empirically test this logic in the context of China's national technology development communities.

Regional community density and community growth

As noted earlier, previous studies have applied the density dependence model to examine the impact of density on organizational founding, growth, and mortality rates and have found substantial support for this model in a variety of organizational populations (Carroll and Hannan, 2000). Given the consistency of empirical results supporting an inverted U-shaped relationship between density and organizational outcomes, it is reasonable to predict that community density may have a similar effect on community growth. This has yet to be tested, but it is an important empirical question. The reason is that the number of technology communities in a specific region not only will reflect the competition among the communities but will also provide opportunities for resource flows and leveraging across community boundaries (Porter, 1998b; Tallman and Phene, 2007).

We argue that an initial increase in regional community density will have a positive impact on community growth due to the mutualistic benefits discussed above. When the number of technology communities in a region is low, increases in density heighten recognition that a given region is appropriate for technology development—or, to use Romanelli and Khessina's (2005) term, the region's industrial identity for technology development. As a result, important external audiences such as prospective entrepreneurs, technology talents, and investors will increasingly associate the region with technology development activities and direct their investment decisions toward the region accordingly. This will mutually benefit all of the technology communities—e.g., China's national technology development zones—in the region. This conjecture is consistent with previous research. For example, in a study of organizational form evolution among disk array producers, McKendrick and colleagues (2003) observed that the presence of relatively large groups of similar organizations in a region helps to draw the attention of external observers and thus promotes the development of a new organizational form.

However, as regional community density continues to increase, competition between communities in the region will increase, which will gradually erode the benefits of mutualism. Competition with others is likely to undermine an individual community's growth because communities in the same region draw upon and compete for a common resource pool. In our research context, it is not uncommon that national technology development zones in a specific region (e.g., a province) compete for resources and support from both the central and provincial governments. Also, these

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zones tend to attract resources from a limited set of entrepreneurs and investors. Thus, as the number of technology communities in a region further increases, combined resource requirements of these communities are more likely to reach the region's carrying capacity (Ruef, 2000). Resources required in common become scarce, making it difficult for the individual communities to continuously grow. Combined, the mutualistic benefits of increased numbers when regional community density is low plus the competitive pressures placed on communities when density increases will jointly create an inverted U-shaped relationship between regional community density and community growth. Thus, we propose the first hypothesis of this study:

Hypothesis 1: Regional community density will have an inverted U-shaped relationship with a community's growth.

Geographic proximity to the nearest community and community growth

The ecology literature has paid a fair amount of attention to geographic proximity/distance at the organizational level. The basic argument in this stream of research is that geographic proximity between organizations will facilitate resource flow and knowledge spillovers by providing opportunities for both planned and serendipitous interactions (e.g., Baum and Mezias, 1992; Sorenson and Stuart, 2001). At the community level, the importance of geographic proximity between communities has also been discussed by several scholars (e.g., Porter, 1998a, 1998b; Tallman and Phene, 2007). For example, Tallman and Phene (2007) argued that geographic proximity plays an important role in knowledge flows across geographic boundaries of clusters. However, our knowledge of how geographic proximity may affect community growth is still limited, and empirical evidence is particularly lacking.

Further, some of the earlier ecology studies did not directly measure geographic distance between organizations. Instead, they utilized binary density measures and examined the density dependence model on different geographic scales (e.g., density at the national level versus density at the local level) (Stuart and Sorenson, 2003: 239). In general, these studies found that the effect of density is stronger when density is measured on a more limited geographic scale (e.g., Baum and Mezias, 1992; Carroll and Wade, 1991; Kuilman and Li, 2006; Lomi, 1995; Sorenson and Audia, 2000). There are some exceptions, however. In their study of Manhattan hotels, Baum and Haveman (1997) found that a new entrant's geographic distance to existing hotels is negatively related to its size difference with existing hotels and positively related to its price difference with existing hotels. In a study of the spatial distribution of venture capital investments, Sorenson and Stuart (2001) found that geographic distance between a venture capitalist's main office and the location of a target firm reduces the likelihood that the venture capitalist will invest in the target firm. Furthermore, in another study of biotechnology firms, Stuart and Sorenson (2003) found that geographic proximity to other biotechnology firms, biotechnology patent inventors, venture capital firms, and leading universities have a positive impact on founding rates.

By directly measuring geographic proximity between adjacent communities, in this study we examine how spatial heterogeneity affects community growth. More importantly, while previous studies have only examined the monotonic impact of geographic proximity/distance, we propose that geographic proximity between adjacent communities will have an inverted U-shaped effect on community growth. We argue that at low levels of geographic proximity between a focal technology community and the nearest community (i.e., when the focal community is distantly located from others), increases in geographic proximity can produce mutualistic benefits. First, increases in geographic proximity between adjacent technology communities increase the chance of intercommunity learning. Porter (1998a) observed that industry clusters located in close geographic proximity to others have a greater chance of learning about and deploying cutting-edge information about markets and technologies than more isolated clusters. To illustrate, he discussed the location of multiple, related clusters including vineyards, wineries, winemaking equipment producers, wine-related university research, etc. in the Napa wine region as a key source of the region's ongoing economic vitality. Second, increases in geographic proximity between adjacent technology communities also enable communities to draw greater attention to themselves from external audiences. As geographic proximity between adjacent communities increases, external audiences' search costs

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can be reduced. As a result, when external audiences (e.g., buyers, suppliers, and venture capitalists) interact with organizations in one community, they are more likely to learn about organizations in another community if these communities are located proximately (Romanelli and Khessina, 2005).

However, as a focal technology community's geographic proximity to the nearest community further increases, competition between these communities is likely to increase. This is because closely located communities will draw upon resources from the same geographic locations, thus creating greater competition for limited resources. For example, technology communities like the national technology development zones in China implicitly compete with one another to create innovative technologies, which requires the recruitment of engineering talent as well as technical 'stars' (Owen-Smith and Powell, 2004). According to Ruef (2000), as geographic proximity between adjacent populations further increases, their combined size is more likely to reach the carrying capacity of the common location from which they draw resources.

In summary, we argue that at low levels of geographic proximity between adjacent technology communities, increases in geographic proximity produce mutualistic benefits. At high levels of geographic proximity between adjacent technology communities, increases in geographic proximity increase intercommunity competition. The net effect produces mutualism at low levels of geographic proximity and the effect shifts to competition at high levels of geographic proximity. Accordingly, we propose the following hypothesis:

Hypothesis 2: A focal community's geographic proximity to the nearest community will have an inverted U-shaped relationship with the focal community's growth.

Domain overlap with the nearest community and community growth

In the organization literature, an organization's *domain* consists of the claims it makes with respect to products offered, services provided, and populations served (Levine and White, 1961; Thompson, 1967). The overlap of two organizations' domains refers to the fraction of the focal organization's domain duplicated by the domain of the other (Baum and Singh, 1994a, 1994b; MacArthur, 1972; McPherson, 1983). A standard postulate of the ecology perspective is that the intensity of the competitive pressure exerted by one organization on another is proportional to domain overlap between these organizations (Hannan and Freeman, 1989; MacArthur, 1972). In studying Canadian day-care centers, Baum and Singh (1994a, 1994b) operationalized domain overlap as overlap in markets served (age of children served). They found that the number of organizations present in the focal organization's domain (i.e., overlap density) is negatively related to organizational founding and positively related to organizational mortality. Dobrev *et al*. (2001) operationalized domain overlap as overlap in automobile producers' spread of engine capacity and found that overlap density has a positive effect on organizational mortality. Operationalizing domain overlap as overlap in patents and patent citations, Podolny *et al*. (1996) found that a firm's domain overlap with others in the population is negatively related to its growth. More formally, Hannan *et al*. (2007) theorized that 'The expected intensity of the competitive pressure exerted by one organization on another normally equals zero if their fundamental niches do not overlap. Otherwise, the expected intensity of the competitive pressure rises monotonically with the thickness of the overlap of their fundamental niches' (Hannan *et al*., 2007: 195–196).

Domain overlap is also an important element in understanding intercommunity relationships, although empirical research on this issue is very limited. For example, Porter (1998b) illustrated cluster intersections (i.e., industry overlaps) by observing that in Massachusetts such interactions 'have proven to be fertile breeding grounds for new companies' (Porter, 1998b: 241). In this study, we define a focal community's domain overlap with its adjacent community as the extent to which the focal community's major industries correspond to those of the nearest community. We are interested in how domain overlap between two adjacent communities may affect the growth of the focal community.

As noted earlier, prior ecology research has mainly focused on the competition among organizations with overlapping domains, suggesting a monotonic effect of domain overlap. However, Hannan *et al*. (2007: 197) raised the possibility that the competitive effect of domain overlap may be

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overridden by the legitimation effect (i.e., legitimation leads to mutualism between organizations) when legitimation is low. In other words, when legitimation is low, an increase in overlap (due to an associated rise in density) can increase legitimation of the organizational form. Hence, domain overlap should have a nonmonotonic relationship with organizational outcomes. However, to the best of our knowledge no research has explicitly examined this possibility. In our context, while legitimation may not be a concern for technology communities (because the Chinese government created them and assigned strong economic incentives to motivate firms to locate within them), we argue that domain overlap between adjacent communities may affect community growth through both mutualistic and competitive effects and thus will have an inverted U-shaped impact on community growth.

More specifically, at low levels of domain overlap between adjacent communities, increases in domain overlap can produce mutualistic benefits. First, adjacent communities with overlapping domains are more likely to engage in cross-community communication, resource flows, and information exchange. Managers and entrepreneurs may easily share information with others across communities. The common need for skilled employees creates mobility opportunities for employees to move easily from one community to another, and this promotes learning between adjacent communities and helps with the discovery and implementation of new ideas, which translate into higher growth. For example, Porter (1998a) argued that the economic benefits of clustering depend upon the presence of multiple interrelated industry clusters with complementary interests that promote information sharing, innovation, and entrepreneurship. Second, adjacent communities with overlapping domains also attract greater and more generalized attention from external audiences (Romanelli and Khessina, 2005: 352). Sorenson and Stuart (2001) showed that venture capitalists are more likely to invest in industries outside their normal industry experience if they have previously partnered with other venture capitalists with experience in these industries. Extending this finding from venture capitalists to other external audiences, we argue that external audiences of organizations in one community are more likely to interact with organizations in the adjacent community if these communities have overlapping industry domains. This is because when adjacent communities have overlapping industry domains, external audiences' prior experience with organizations in one community can be applied in the other community.

However, at high levels of domain overlap between adjacent communities, further increases in domain overlap will lead to competition between adjacent communities as the two are likely to require similar resources (e.g., technical experts and project managers in a particular industry). Their combined requirements for these resources are more likely to reach the location's carrying capacity for these particular resources (Ruef, 2000), and as a result community growth will decrease. Furthermore, when domain overlap between adjacent communities is very high, adjacent communities are homogeneous. In general, homogeneity can restrict creativity, innovation, and the range of strategic responses (e.g., Abrahamson and Fombrun, 1994). At the community level, when adjacent communities have excessive domain overlap, resources attracted from external audiences or generated within these communities will become more homogeneous (Romanelli and Khessina, 2005). As a result, the pace of innovation in these communities is likely to decline, which can also lead to lower community growth.

In summary, we argue that initial increases in domain overlap between adjacent communities produce mutualistic benefits but that further increases in domain overlap create more homogeneous communities competing for the same or overlapping resources. Combined, we propose an inverted U-shaped relationship between domain overlap and community growth.

Hypothesis 3: A focal community's domain overlap with the nearest community will have an inverted U-shaped relationship with the focal community's growth.

Controls

Thus far we have argued that three dimensions of intercommunity relationships will have an inverted U-shaped relationship with community growth. To test these hypotheses, we also control for alternative explanations for community growth. At the community level, we control for community age, institutional origin, community research intensiveness, and export intensiveness. We also control

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for attributes of the city in which a community is located, including the city's political status, gross domestic product (GDP), population, industry structure, number of higher education institutions, and foreign direct investment (FDI). Furthermore, we control for calendar year dummies in our models. The rationale for each is discussed in the measurement section.

METHODS

Research design and data sources

Our data include all 53 national technology development zones that were founded in China from their inception through the year 2000. Data were collected from several sources. One is a proprietary report (2001) provided by the Chinese Ministry of Science and Technology (MST), which provides data on each zone's annual sales revenue, export revenue, number of employees, and number of R&D personnel, from the first year that the zone was founded through the year 2000. We collected additional information on China's national technology development program and on each zone from the MST Web site (http://www.most.gov.cn/English/index.htm) as well as the individual zones' Web sites. We also employed a research assistant from Renmin University in Beijing to telephone zone administrators throughout the country to verify information obtained from public sources, and these administrators' responses helped resolve questions when information conflicted across sources. To develop a better understanding of China's technology development program, we conducted exploratory and semi-structured interviews with zone administrators and a range of entrepreneurs in four different technology development zones (Beijing, Xi'an, Shanghai, and Shenzhen).

Furthermore, we studied China's economic growth programs and policies since the 1980s in order to distinguish additional variables that might influence zone growth. Relying on data from China's Statistical Yearbooks for the relevant years, we identified longitudinal data on each city's annual GDP, its population size, the number of universities and colleges, the size of the city's FDI, and its industry structure.

As these national technology development zones are well delineated geographically by the government itself, there is no empirical ambiguity regarding geographic location of a zone or which industrial populations are included within it. These zones also have a well-defined origination date due to policy actions of the government. With a clear origination date for each zone, the research design employed here avoids left-censoring a zone's history because we capture data from the first year that each new zone was founded; this also allows us to avoid model misspecification and biased conclusions regarding patterns of growth (Hunt and Aldrich, 1998). Annual data from the founding years were collected for the zones and their city contexts.

Finally, because our data are a yearly time series, observations for each of the 53 national technology development zones were pooled. In our model estimations, the dependent variable is lagged by one year behind the independent and control variables. The final data for analysis include 434 zone years.

Measures of independent variables

Following Barnett's (1990: 45) measure of local population density, we calculated *regional community density* separately for each community for each year by using the number of national technology development zones within a focal community's provincial location. We focused on the province level to measure regional community density because national technology development zones located in the same province are subject to the provincial government's administration and support. Hence, all zones in a given province share common rules and regulations that govern their operations. Empirically, a province may have multiple national technology development zones, while a city can have only one at maximum, and thus only the specification of a region at the provincial level provides variation in regional community density. The values of this variable ranged from 1 to 6 in our data.

Consistent with previous studies on geographic proximity (e.g., Baum and Haveman, 1997; Stuart and Sorenson, 2003), we measured *geographic proximity* of a community to the nearest community as follows. We first measured the geographic distance between communities as the natural log of the distance, in kilometers, between the city where the focal zone is located and the city where the next closest zone is located. As China's main form of intercity transportation is the railroad, distances between the paired cities were derived from

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China's Railroad Bureau data on railroad transportation distances, in kilometers. The (logged) values of geographic distance ranged from 3.40 to 7.58. To transform geographic distance into a measurement of geographic proximity, we subtracted the values of geographic distance from the maximum value of 7.58 in the data to obtain the values of geographic proximity. The values of geographic proximity ranged from 0 to 4.18.

Consistent with Podolny and colleagues' (1996) measure of niche overlap at the organizational level, we measured a community's *domain overlap* with the nearest community as the extent to which a focal zone's major industries corresponded with those of the next closest zone. We first identified a zone's primary industries based on three sources: (1) the MST's Web site, (2) individual technology zones' Web sites, and (3) a publication that introduces each of these zones, including their industry foci (Sun and Zhang, 2001). Next, our research assistant in Beijing telephoned each zone's administrators to verify the industry information gathered for each zone. We asked whether and when a zone experienced significant changes in its major industries from its founding through the year 2000. Among the 53 zones, 9 zones experienced significant changes, and these occurred when a new major industry emerged in a zone. Data on a zone's major industries were then updated to reflect the time-based change in its industry mix. Domain overlap was calculated as the percentage of the focal zone's major industries that were also present in its next closest zone in the prior year. This measure varies from 0 (i.e., none of a focal zone's major industries were present in the next closest zone) to 100 percent (i.e., all of a focal zone's major industries were present in the next closest zone).

Measures of control variables

As noted earlier, we have controlled for the following variables that could provide alternative explanations for community growth. *Community age* was measured as the number of years that have transpired between a zone's founding year and the current year, calculated annually. *Community institutional origin* refers to the fact that some of the 53 national technology development zones were initially founded by the central government, whereas others (e.g., Xi'an Zone and Nanjing Zone) were initially founded by provincial governments and later upgraded to national status by the central government. Community institutional origin was coded as 1 if a zone was initially founded as a national zone with sponsorship, recognition, and support from the central Chinese government, and 0 otherwise. *Community research intensiveness* was calculated as the ratio of R&D personnel to total personnel in all firms in a zone at the prior year's end. *Community export intensiveness* was measured as the ratio of the value of export sales to all sales for all firms within a zone in the prior year. These variables were updated annually.

To control for the political importance of a community's city locale, we took advantage of the fact that in China there exists a clear political hierarchy of cities. The administrative areas in China are divided into provinces, autonomous regions, and municipalities directly under the central government. Whereas provinces and autonomous regions maintain their own local governments situated in the capital cities, the municipality cities report directly to the central government in Beijing. Provincial capitals are the political center of each province and autonomous region and have their own provincial resource bases. All other cities—called subprovincial cities—are contained within a province or an autonomous region and are subject to political control from its provincial government. We created two dummy variables by using subprovincial cities as the base comparison group: *municipality city* and *provincial capital city*.

Local city GDP (in RMB 10,000) was controlled because it indicates the size of the local economy, the growth of which could in turn influence growth of the local technology zone. The measure was corrected for inflation and log transformed in the prior year. We also controlled for the local city's population as an indicator of the size of the local supply of labor. *Local city population* was measured in 10,000s and log transformed in the prior year. We controlled for *local city industry structure*, measured as the proportion of service industries in the city's GDP in the prior year. This measure is used in China to capture the extent to which a city is industrialized.

We also controlled for the *number of higher education institutions* (i.e., universities and colleges) in a city (log transformed), which could influence community growth by providing educated workers for the technology development zones. We

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controlled for *city foreign direct investment (FDI)*, measured as capital invested in a city by sources not from China but rather from a company headquartered outside of China. FDI includes all foreign capital invested in a given city in the prior year, and data were updated annually. As FDI data in China's Statistical Yearbook are in U.S. dollars (US \$10,000), data were transformed to Chinese currency (RMB 10,000) using the exchange rate at the end of the corresponding year. The measure was further corrected for inflation and finally log transformed.

Furthermore, China has experienced substantial economic, social, and institutional change since the first zone was founded in 1988. To account for the possibility that the growth of China's high technology development zones may vary systematically over years, our models controlled for calendar year dummy variables (Podolny *et al*., 1996). The inclusion of the calendar year dummy variables can also distinguish the effects of zone age from the effects of calendar time.

Analysis of community growth

To examine the effects of intercommunity relationships on community growth, we estimate models of growth in terms of a zone's *annual sales revenues*. These data are collected by the zone administrators from the resident firms, then they are aggregated to the zone level and reported annually to the MST, which publishes the data. Sales revenue data were updated annually (in Chinese RMB 1,000) and corrected for inflation (using RMB value in 1990).

Following prior research on organizational growth (e.g., Barron *et al*., 1994; Baum and Mezias, 1992; Podolny *et al*., 1996; Sorensen, 1999), we model community growth in sales revenue as a function of a community's sales revenue and a number of covariates that can affect community growth:

$$S_{i,t+1}/S_{it} = (S_{it})^{\alpha-1}\exp(\beta x_{it} + \varepsilon_{i,t+1}), \qquad (1)$$

where S is a time-varying measure of community sales revenue, α is an adjustment parameter that indicates how growth rates depend on community sales revenue, and β is a vector of parameters characterizing the effects of covariates (x_{it}). If we take the log of Equation 1 and rearrange terms, we have the log-linear model:

$$\ln(S_{i,t+1}) = \alpha\ \ln(S_{it}) + \beta x_{it} + \varepsilon_{i,t+1.} \qquad (2)$$

The data are arranged in the form of a pooled cross-section time series dataset, with each zone contributing a time series of observations of differing lengths. The length of each zone's time series differs because these zones may be founded in different years. In a pooled cross-sectional dataset, zones have multiple observations corresponding to each year of observation. However, these observations may not be independent of one another. A robust variance estimator for cluster data can correct for nonindependence. It essentially treats each cluster (i.e., all observations associated with one zone) as a super-observation that contributes to the variance estimate and thus generates robust estimates (Westphal and Khanna, 2004). Thus, we included the robust option in our models to calculate robust standard errors for coefficients (Stata, 2003: 328).

RESULTS

Table 1 reports means, standard deviations, and correlations of all variables except calendar year dummies used in the analysis. Table 2 presents the estimates of the models on community growth. Model 1 includes controls only, Model 2 adds the effects of regional community density and its squared term, and Model 3 includes the effects of geographic proximity and its squared term. Finally, Model 4 includes the effects of domain overlap and its squared term.

Hypothesis 1 predicts that regional community density has an inverted U-shaped relationship with community growth. In Model 2 in Table 2, the coefficient for regional community density is positive and significant ($b = 0.15$, $p < 0.01$), and the coefficient for its squared term is negative and significant ($b = -1.4E\text{-}2$, $p < 0.05$). Thus, Hypothesis 1 is supported.

Based upon the results of Model 2, if all other variables take their mean values, a zone's expected sales revenue is 1.31 billion (in 1990 RMB) when regional community density is 1. The highest expected zone sales revenue is 1.80 billion (in 1990 RMB), which occurs when regional community density is 5. However, the expected zone sales revenue would be 1.72 billion (in 1990 RMB)

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Table 1. Means, standard deviations, and correlations of all variables in analyses[a]

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Community sales (log)	14.31	1.30	—													
2. Regional community density	2.73	1.65	0.12	—												
3. Geographic proximity to the nearest community	2.66	0.93	0.25	0.57	—											
4. Domain overlap with the nearest community	0.80	0.16	0.07	0.33	0.40	—										
5. Community age	6.37	2.68	0.63	−0.08	−0.03	−0.07	—									
6. Community institutional origin	0.68	0.46	−0.01	0.09	−0.04	0.04	−0.20	—								
7. Community research intensiveness	0.12	0.06	−0.05	−0.31	−0.15	−0.11	−0.18	0.01	—							
8. Community export intensiveness	0.11	0.14	0.20	0.31	0.22	0.04	0.14	0.03	−0.34	—						
9. Municipality city	0.07	0.25	0.35	−0.26	0.07	−0.20	0.08	0.19	0.14	0.05	—					
10. Provincial capital city	0.44	0.49	−0.07	−0.29	−0.26	0.06	0.10	−0.21	0.27	−0.31	−0.24	—				
11. City GDP (log)	14.43	0.82	0.67	0.16	0.30	0.02	0.40	0.04	0.03	0.22	0.45	−0.08	—			
12: City population (log)	8.34	0.68	0.39	−0.21	0.08	−0.05	0.13	0.08	0.29	−0.24	0.42	0.12	0.55	—		
13. City industry structure	0.37	0.09	0.31	−0.09	−0.19	−0.22	0.40	0.04	0.12	0.05	0.17	0.37	0.20	0.01	—	
14. No. of higher education institutions in the city (log)	2.26	0.94	0.25	−0.46	−0.25	−0.22	0.11	0.00	0.50	−0.30	0.40	0.55	0.33	0.61	0.41	—
15. City FDI (log)	10.59	2.93	0.37	0.28	0.36	0.09	0.22	−0.14	−0.18	0.32	0.24	0.03	0.41	0.12	0.24	0.02

N = 434 zone years. [a] Correlations equal to or larger than 0.10 are significant at the level of $p < 0.05$.

when regional community density further increases to 6 (the largest value in the data). In other words, all else being equal, a zone's expected sales revenue would be 37 percent (= 1.80/1.31-1) greater if regional community density were to change from 1 to 5, and the expected sales revenue would become smaller as regional community density further increases.

Hypothesis 2 predicts that a focal community's geographic proximity to the nearest community has an inverted U-shaped relationship with the focal community's growth. The results of Model 3 show that the coefficient for geographic proximity ($b = 0.48$, $p < 0.001$) is positive and significant and that the coefficient for its squared term ($b = -0.08$, $p < 0.01$) is negative and significant. These results support Hypothesis 2. An examination of Figure 1 shows that the Urumqi zone (which is located in the far northwest of China) is exceptionally distant from the nearest zone. To test the robustness of the proximity findings, we dropped the Urumqi zone and reestimated the model, and the results were consistent with the original finding: the coefficient for geographic proximity is 0.59 ($p < 0.001$), and the coefficient for its squared term is -0.09 ($p < 0.01$). Again, these results support Hypothesis 2.

Based upon the results of Model 3, if all other variables take their mean values, a zone's expected sales revenue is 0.61 billion (in 1990 RMB) when its geographic proximity to the nearest zone is 0 (i.e., a distance of 1,959 kilometers—the largest geographic distance in the data). The highest expected zone sales revenue is 1.64 billion (in 1990 RMB), which occurs when a zone's geographic proximity to the nearest zone is 3 on the proximity scale (i.e., a distance of 98 kilometers). However, the expected zone sales revenue would be 1.55 billion (in 1990 RMB) when a zone's geographic proximity to the nearest zone is 4.18 (i.e., a distance of 30 kilometers—the smallest geographic distance in the data). In other words, all else being equal, a zone's expected sales revenue would be 169 percent (= 1.64/0.61-1) greater if its geographic distance to the nearest zone were to change from 1,959 kilometers to 98 kilometers and the expected sales revenue would become smaller as the geographic distance further decreases.

Hypothesis 3 predicts that a focal community's domain overlap with the nearest community has an inverted U-shaped relationship with the focal community's growth. In Model 4, the coefficient for domain overlap is positive and significant ($b =$

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Table 2. Models of growth of China's national technology development zones

Variables	Model 1	Model 2	Model 3	Model 4
Predictors				
Regional community density		0.15**		
		(0.06)		
Regional community density squared		−1.4E-2*		
		(6.5E-3)		
Geographic proximity to the nearest community			0.48***	
			(0.14)	
Geographic proximity squared			−0.08**	
			(0.03)	
Domain overlap with the nearest community				2.30**
				(0.75)
Domain overlap squared				−1.22**
				(0.45)
Controls				
Lagged community sales (log)	0.71***	0.69***	0.67***	0.68***
	(0.04)	(0.05)	(0.05)	(0.04)
Community age	0.00	−0.01	0.00	−0.01
	(0.03)	(0.03)	(0.03)	(0.02)
Community institutional origin	−0.09	−0.11†	−0.07	−0.12*
	(0.05)	(0.06)	(0.05)	(0.05)
Community research intensiveness	0.88†	1.09*	0.53	0.84†
	(0.52)	(0.53)	(0.52)	(0.50)
Community export intensiveness	0.01	0.01	−0.02	0.03
	(0.15)	(0.15)	(0.15)	(0.14)
Municipality city	0.02	0.32*	0.03	0.00
	(0.09)	(0.13)	(0.08)	(0.09)
Provincial capital city	−0.14*	−0.08	−0.15*	−0.25**
	(0.07)	(0.07)	(0.07)	(0.08)
City Population (log)	0.06	0.04	0.01	0.05
	(0.05)	(0.06)	(0.05)	(0.05)
City GDP (log)	0.13**	0.09*	0.12*	0.12*
	(0.05)	(0.04)	(0.05)	(0.05)
City industry structure	0.65	0.41	0.93†	0.86
	(0.59)	(0.51)	(0.56)	(0.57)
City higher education institutions (log)	0.01	0.06	0.07	0.08
	(0.06)	(0.06)	(0.06)	(0.06)
City FDI (log)	0.02*	0.02*	0.02*	0.02*
	(0.01)	(0.01)	(0.01)	(0.01)
Calendar year dummies	Included	Included	Included	Included
Constant	1.67**	2.64***	1.82**	0.97
	(0.56)	(0.62)	(0.62)	(0.64)
F-value	198.38***	181.67***	193.60***	196.24***
R-Squared	0.90	0.91	0.91	0.91

N = 434 zone years. Robust standard errors are reported in parentheses.
Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, †$p < 0.10$ (two-tailed tests).

2.30, $p < 0.01$), and the coefficient for its squared term is negative and significant ($b = -1.22$, $b < 0.01$). These results thus support the prediction of Hypothesis 3.

Based upon the results of Model 4, if all other variables take their mean values, a zone's expected sales revenue is 0.49 billion (in 1990 RMB) when its domain overlap with the nearest zone is 0. The highest expected zone sales revenue is 1.64 billion (in 1990 RMB), which occurs when a zone's domain overlap with the nearest zone is 94 percent. However, the expected zone sales revenue would be 1.49 billion (in 1990 RMB) when its domain overlap with the nearest zone is 100 percent. In other words, all else being equal, a zone's expected sales revenue would be 235 percent (=1.64/0.49-1) greater if its domain overlap with the nearest zone were to change from 0 to 94 percent, and the

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expected sales revenue would become smaller as the domain overlap further increases.

The results reported above support our arguments regarding the nonmonotonic effects of regional community density, geographic proximity, and domain overlap on community growth. As a supplementary analysis, we also estimated zone level fixed-effect models by including 52 zone dummy variables (there are 53 zones in total) in the models. The results of this analysis are reported in the Appendix. These results show that the coefficients for geographic proximity and its squared term are significant. However, regional community density and its squared term, as well as domain overlap and its squared term, are not significant. These nonsignificant results are likely due to the fact that regional community density and domain overlap did not vary substantially over time in this study. Thus, the effects of these variables are not distinguishable from the zone level fixed effects (Judge *et al*., 1985) (c.f. Jensen and Zajac, 2004: 514–516). As a consequence, the zone level fixed-effect models may not be appropriate for testing the hypothesized relationships. Indeed, all of the models with zone-level fixed effects cannot produce F values and the associated p values, suggesting that the coefficients of predictors estimated in these fixed-effect models may not be reliable. Therefore, we interpret our findings based upon the cross-sectional results reported in Table 2. Nonetheless, we acknowledge that our findings may stem from cross-sectional variation in the data.

DISCUSSION AND IMPLICATIONS

In this study, we theoretically articulate and empirically test how three dimensions of intercommunity relationships are expected to affect community growth. With a unique dataset on all national technology development zones founded in China from their inception through the year 2000, we found that regional community density, a focal community's geographic proximity to and domain overlap with the nearest community have an inverted U-shaped relationship with the focal community's growth. These findings support our argument that organizational communities are interdependent and that interdependence between communities, which includes both mutualism and competition, has a significant impact on community growth. While several studies have examined the extent to which populations within a community are interdependent (e.g., Ruef, 2000; Wade, 1995, 1996), we believe this is one of the first empirical studies to demonstrate that organizational communities, each of which contains several populations of firms, have an impact on one another's growth.

Implications for ecology arguments

The existing literature on organizational ecology has provided consistent empirical support for an inverted U-shaped relationship between density and organizational outcomes. This study has demonstrated that regional community density also has an inverted U-shaped relationship with community growth. This finding supports the argument that the number of technology communities in a specific region not only reflects competition among communities, but it also provides opportunities for resource flows and leveraging across community boundaries (Porter, 1998b; Tallman and Phene, 2007).

The significant effects of geographic proximity and domain overlap have important implications for ecology arguments. We have simultaneously examined geographic proximity and domain overlap at the community level, whereas prior ecology research has looked at either one or the other—primarily the latter—and only within organizational populations. More importantly, extant ecology research has only examined the monotonic effects of geographic proximity and domain overlap between organizations on organizational outcomes. These prior studies link increased geographic proximity and domain overlap with increased competition among organizations, and so they have been shown to adversely affect organizations (e.g., Dobrev *et al*., 2001; Podolny *et al*., 1996; Sorenson and Stuart, 2001; Stuart and Sorenson, 2003). In contrast, we proposed and found a nonmonotonic, inverted U-shaped effect of geographic proximity and domain overlap between communities on community growth. These results support the argument that geographic proximity and domain overlap between adjacent technology communities are important dimensions of intercommunity relationships, and that both mutualistic and competitive forces play out between communities in ways that jointly affect community outcomes. Our nonmonotonic theoretical arguments and consistent empirical findings add new insights

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to the effects of geographic proximity and domain overlap and hopefully will inspire future studies to examine these effects in other organizational and community contexts.

Implications for understanding community growth and cluster development

This study has contributed to a better understanding of community growth in several ways. First, to the best of our knowledge, this study is among the first empirical investigations of the role of intercommunity relationships in the growth of organizational communities. While some scholars (e.g., Porter, 1998a, 1998b; Romanelli and Khessina, 2005; Saxenian and Hsu, 2001) have observed the importance of connections between communities, we contribute to the literature by theoretically delineating three dimensions of intercommunity relationships and empirically examining how these different dimensions affect community growth. Our findings on the significant impact of regional community density, intercommunity geographic proximity and domain overlap on community growth demonstrate that organizational communities are interdependent and are particularly affected by their relationships with neighboring communities. Porter (1998b: 241) has suggested that cluster development often becomes vibrant at the intersection of clusters because insights, skills, and technologies from different fields and directions merge, thus sparking new businesses and stimulating innovation. Our study adds greater specificity to Porter's (1998b) insights by showing that cluster intersection can occur along two dimensions: geographic distance and industry overlap between clusters. This study has shown that changes in geographic proximity and domain overlap between adjacent communities alter the outcomes obtainable by a focal community.

Second, this study examined the extent to which both mutualistic and competitive forces coexist between organizational communities. The few scholars who have addressed intercommunity relationships (Porter, 1998a, 1998b; Romanelli and Khessina, 2005; Saxenian and Hsu, 2001; Tallman and Phene, 2007) have primarily focused on mutualistic effects in the form of intercommunity learning, resource and knowledge exchanges, and enhanced visibility to external audiences. However, the possibility that intercommunity relationships are characterized by the coexistence of mutualism as well as competition has not been otherwise studied. Our study advances this line of inquiry by demonstrating that intercommunity relationships are characterized by a combination of mutualism and competition between organizational communities. Vigorous competition can occur in such areas as acquiring scarce resources and attracting and retaining employees. The presence of multiple communities with overlapping domains and within a certain distance enhances the intensity of competition between communities. Meanwhile, mutualistic benefits also accrue, particularly when two communities have an optimal level of geographic distance and industry overlap. Therefore, we provide a more complete picture of how organizational interdependence operates at the community level.

Practical implications

While we expected that intercommunity relationships would have a significant impact on a focal community's growth, the magnitude of the effects exceeded our expectations. As we saw in the results section of this article, all else being equal, a zone's expected sales revenue would be 37 percent greater if regional community density were to change from 1 to 5, and sales revenue would be smaller as regional community density further increases. All else being equal, a community's expected sales revenue would be 169 percent greater if its geographic distance to the nearest community were to decrease from 1,959 kilometers to 98 kilometers, and sales revenue would be smaller as the geographic distance further decreases. Finally, all else being equal, a community's expected sales revenue would be 235 percent times greater if its domain overlap with the nearest zone were to increase from 0 to 94 percent and would be smaller if the domain overlap further increases.

These findings are especially important considering that most of the variables included in this study are beyond zone administrators' and policy makers' ability to influence, at least in the short term, because geographic, economic, and social differences between communities and regions cannot be changed quickly. In contrast, the extent of domain overlap with other communities represents

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a strategic variable for zone administrators because they can select and modify a zone's industry mix by selectively admitting firms in targeted industries. Similarly, when a new technology development zone is to be founded, manipulating the zone's location and its geographic proximity to the nearest zone is a strategic variable available to policy makers. The location choices for new zones can affect not only a region's community density but also the new zones' geographic proximity to adjacent zones as well as existing zones' geographic proximity to adjacent zones (i.e., one of the newly founded zones may be their adjacent zone). Hence, the strategic implications of our findings are significant, suggesting that zone administrators and policy makers must attend not only to the internal dynamics within a specific zone but also to the zone's relationship with other zones, particularly the number of other zones in the region and the focal zone's geographic proximity to and domain overlap with adjacent zones.

Limitations and directions for future research

The preceding discussion should be considered in light of the study's limitations. One is that it was conducted within a single country during a period of economic transition from a planned economy to a market economy. Other research (e.g., Perez-Aleman 2005) has shown that government actions in several countries can play an important role in facilitating the growth of technology communities. It may be that the government of China has also played a role in community growth beyond the policy it enacted to create the zones and the multiple incentives (e.g., tax, land) it put in place to encourage the founding of technology ventures within the zones. Thus, it is possible that differential growth rates across these technology development zones may simply be due to unmeasured but different reactions to government policies. In this study we have addressed this alternative explanation in two ways. First, we controlled for calendar year dummy variables to capture the overall growth in the Chinese economy over the period of observation and to account for the possibility that the Chinese government may have different policy priorities over time, encouraging technology development in lieu of other economic development options. Second, we controlled for zones' institutional origins (whether a specific zone was initially founded by the central government or by a provincial government) to account for the possibility that the initial policy differences in their founding conditions could have an imprinting effect that subtly influences these zones' growth. Nonetheless, we cannot completely rule out the possibility that unspecified and unmeasured government policies may have a significant impact on the growth of these technology zones.

Further, while we have controlled for many alternative explanations for technology community growth in our research context, an extension of this line of research could make cross-country comparisons to enhance variation in national economies (emerging, developed, etc.), and institutional differences in the governance of such countries. For example, Porter (1998b: 230) has argued that the depth and breadth of industrial clusters in developed economies are usually greater than those in developing economies. Also, cross-country comparisons could include wholly commercial communities like science parks established to make a profit for the developers rather than to serve government priorities.

Second, in this study our arguments are developed at the community level of analysis, and we consider commensalistic relationships between communities because these communities are 'like' social units, and so symbiotic relationships should not apply, at least in the early days of the evolution of these communities (Aldrich, 1999: 301–302). However, one could imagine in the future that communities might become more specialized and thus become 'unlike' one another in fundamental ways. While all would be expected to follow a 'high technology' trajectory (in accordance with China's regulations), one can imagine that some communities will evolve to specialize in subsets of the focal industries that differ in significant ways. For example, among the technologies targeted by China for development are ocean technologies and nuclear applications of technology. It could be argued that research and development in ocean technologies and industrial applications of nuclear technology are sufficiently different to present the potential for symbiotic relationships between communities thus specialized.

In conclusion, to our knowledge no other large-scale study of organizational communities has examined intercommunity relationships to this extent, as most community ecology research has

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focused on within-community population dynamics (e.g., Ruef, 2000; Wade, 1996). In this study, we used a unique dataset on all 53 national technology development zones founded in China from their inception through the year 2000 to investigate how intercommunity relationships affect the growth of organizational communities. We found that regional community density and a community's geographic proximity to and domain overlap with the nearest community have an inverted U-shaped effect on the focal community's growth. Our findings demonstrate that intercommunity relationships have both mutualistic and competitive components.

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Appendix. Supplementary Analysis with Zone Level Fixed Effects[a,b]

Variables	Model 1	Model 2	Model 3	Model 4
Predictors				
Regional community density		−0.06		
		(0.20)		
Regional community density squared		0.03		
		(0.04)		
Geographic proximity to the nearest community			2.29***	
			(0.50)	
Geographic proximity squared			−0.48***	
			(0.13)	
Domain overlap with the nearest community				Automatically dropped
Domain overlap squared				−0.54
				(0.61)
Controls				
Lagged community sales (log)	0.34***	0.34***	0.34***	0.34***
	(0.05)	(0.05)	(0.05)	(0.06)
Community research intensiveness	0.67	0.66	0.67	0.68
	(0.53)	(0.53)	(0.53)	(0.53)
Community export intensiveness	0.19	0.15	0.19	0.19
	(0.22)	(0.22)	(0.22)	(0.21)
City population (log)	−0.01	0.00	−0.01	0.00
	(0.09)	(0.08)	(0.09)	(0.08)
City GDP (log)	−0.01	−0.01	−0.01	−0.02
	(0.05)	(0.05)	(0.05)	(0.05)
City industry structure	0.68	0.69	0.67	0.69
	(0.78)	(0.77)	(0.78)	(0.78)
City higher education institutions (log)	0.15	0.16	0.15	0.15
	(0.12)	(0.12)	(0.11)	(0.11)
City FDI (log)	−0.01	−0.01	−0.02	−0.02
	(0.01)	(0.01)	(0.02)	(0.02)
Zone dummies	Included	Included	Included	Included
Calendar year dummies	Included	Included	Included	Included
Constant	9.56***	9.58***	6.88***	9.77***
	(1.51)	(1.61)	(1.20)	(1.50)
F-value	Can't be estimated	Can't be estimated	Can't be estimated	Can't be Estimated
R-squared	0.94	0.94	0.95	0.94

N = 434 zone years. Robust standard errors are reported in parentheses.
Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, †$p < .10$ (two-tailed tests).
[a] The value of community institutional origin and that of provincial capital city do not vary for a zone in this study period. Further, the value of municipality city only changed for one zone (the one located in Chongqing that was upgraded from a subprovincial city to a municipality city in the study period). These three dummy variables thus are not included in the zone fixed-effects models.
[b] The nonsignificant results related to regional community density and domain overlap are likely due to the fact that these variables did not vary substantially over time in this study. Thus, the effects of these variables are not distinguishable from the zone level fixed effects.

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