

**Spontaneous vs. Policy-Driven: The Origin and Evolution of the Biotechnology Cluster
The Case of Bay Area in the United States and Zhangjiang Hi-Tech Park in China**

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ABSTRACT

Biotechnology industry is at the heart of the fast-growing knowledge-based economy. One of the distinguishing characteristics of biotech industry is clustering. A cluster, like an organism, will experience origin, growth, and decline/reorientation. Our study constructs a framework to analyze biotech clusters with different origins, “spontaneous and policy-driven”, through their life cycles. We use Bay Area in the United States and Shanghai Zhangjiang Hi-Tech Park in China as two cases to represent spontaneous and policy-driven biotech clusters. This study fills the gap of previous literature by providing a side-by-side comparison between two types of biotech clusters in the evolutionary process. Drawing from two cases, the success factors both biotech clusters own are human capital and financial capital, but the underlying forces for formatting and providing these factors are different. The fundamental difference between two cases lays on entrepreneurship, social capital and network patterns. Moreover, social capital and the accompanying networks are main factors shape a cluster’s configuration. It is essential to know the dynamics and essence of different types of clusters for both policy makers and academic researchers.

Key words: biotechnology cluster, spontaneous, policy-driven, origin, evolution

1. INTRODUCTION

Biotechnology (biotech) industry is at the heart of the fast-growing knowledge-based economy. As the industry expands, it has become a focal point of many local, regional, and state economic development strategies. One of the distinguishing characteristics of biotech industry is clustering. We can easily name some famous biotech clusters worldwide, such as Bay area in the United States, Cambridge in the United Kingdom, Heidelberg in Germany, and Shanghai in China.

Clusters are a geographically proximate group of interconnected companies and associated institutions in a particular field, including product producers, service providers, suppliers, universities, and trade associations (Porter, 1998). A cluster, like an organism, will experience origin, growth, and decline/reorientation. Our study constructs a framework to analyze biotech clusters with different origins, “spontaneous and policy-driven”, through their life cycles. Two research questions are addressed: What are success factors affecting the formation of the two types of the clusters? Which success factor(s) contribute mainly on shaping the configuration a cluster?

We use Bay Area in the United States and Shanghai Zhangjiang Hi-Tech (ZJHT) Park in China as two cases to represent spontaneous and policy-driven clusters. This study fills the gap of previous literature by providing a side-by-side comparison between two types of biotech clusters in the evolutionary process across countries.

Drawing from two cases, we found that the success factors both biotech clusters own are human capital and financial capital, but the underlying forces for formatting and providing these factors are different. Moreover, the fundamental difference between two cases lays on entrepreneurship, social capital and network patterns. Finally, social capital and the accompanying networks are main factors shape a cluster’s configuration. It is essential to know

the dynamics and essence of different types of clusters for both policy makers and academic researchers.

This paper includes five sections. Section 2 presents theoretical background. Section 3 suggests analytical framework. Section 4 demonstrates two cases of biotech clusters —Bay Area in the United States and ZJHT Park in China. Section 5 concludes with discusses research findings, contributions, limitations and future direction.

2. THEORETICAL BACKGROUND

Clusters is defined as the geographical concentration of different actors such as interconnected companies, specialized suppliers, service providers, institutions, which compete and cooperate in the same industry (Chiesa and Chiaroni, 2005). The argument that clustering benefits a region's economy can be traced back to Marshall's (1920) external economies. Following Marshall's argument, Arrow (1962) analyzed the nature of invention and technological advance, and Romer (1986) further developed specialization. Together, a new theory regarding innovation and the growth of clusters is generated by their studies and is known as the "Marshall-Arrow-Romer" (M-A-R) theory.

Cluster theory has been a popular research area for economists and geographers for decades. In 1990, Harvard Business School professor Michael Porter examined industrial cluster from the perspective of the strategy and discussed the national and regional competitiveness. Until then, cluster economy became a target for public policy (Rosenfeld, 2005). Porter argued that the role of locations has been long overlooked in the age of open global markets in the field of strategic management. Porter points out that "the enduring competitive advantages in a global economy lie increasingly in local things - knowledge, relationships, motivation - that distant rivals cannot match" (Porter, 1998).

A strand of studies has been aware of the importance of the dynamics of clusters (Porter, 1998; Chiesa and Chiaroni, 2005; Tan, 2006), while many previous studies concentrated on the participants and advantages of a cluster. Wolfe and Gertler (2004) pointed out that there remains a lack of consensus over how clusters are started and to what extent their emergence can be set in motion by conscious design or policy interventions. So, why does a industry/cluster appear in a particular location? How does it start? How does it grow? What are the important ingredients in its growth? In this study, the life cycle of an industrial cluster is constructed as shown in Figure 1. We map this life cycle from the origin, growth, to decline/reorientation of an industrial cluster.

< Insert Figure 1 here >

2.1. Origin

Different clusters have their own origins. For example, Boston-based companies relied heavily on public research organizations in the origin, and Bay Area biotech firms relied heavily on venture capital in the origins (Owen-Smith and Powell, 2006). According to Porter (1998), the birth of a cluster might be rooted on historical circumstances, prior existence of supplier industries, or even chance. Clusters have their origins in a confluence of events: opportunity, existence of raw materials (including ideas, skilled human capital, etc.), emergence of an anchored firm, or some unexpected events, such as downsizing of the public sector to inspire the entrepreneurs locally (Feldman et. al, 2005).

Some other studies also provide evidence that serendipitous events or entrepreneurs are the forces to create clusters (e.g. Feldman and Schreuder, 1996; Klepper, 2002). Emphasizing on the role of outstanding individuals in the cluster creation, Phillips (2006) points out that these outstanding individuals - change agents, visionaries, godfathers/godmothers, opinion leaders, connectors, mavens - shape attitudes and events, communicate across the right networks, and

think outside the box . For example of Northwest in the United States, the Portland Northwest Education Cluster was originated as a professor's idea at the Oregon Graduate Institute and an investment banker in the region (New York Times, 2007).

2. Growth: Success Factors

Once a cluster begins to form, a self-reinforcing cycle promotes its growth, especially when local institutions are supportive and local competition is vigorous (Porter, 1998)). Studying the biotech clusters in five European countries (Denmark, Germany, France, Italy and United Kingdom), Chiesa and Chiaroni (2005) described the dynamics of cluster formation as

Once the process is started, a virtuous cycle often begins. The strong presence of new innovative biotechnology companies increases the area attractiveness, facilitating the establishment of new sites from large biotechnology or pharmaceutical companies. The academic origin of some companies, moreover, facilitates the establishment of strong links and networks between industry and science. These two effects, in turn, reinforce the industrial and the scientific base of the area and therefore provide the basis for the generation of new ventures and so on (Chiesa and Chiaroni, 2005, p.167).

Five success factors in the evolutionary process of a biotech cluster are discussed in this study. The first success factor is strong science and industry base. Two things are crucial to a biotech cluster formation in Chiesa and Chiaroni's (2005) virtual cycle of an industrial cluster: (1) scientific and industrial base; and (2) strong networks between industry and science. Cluster creation in biotech is actually driven by the continuous generation of new science-based companies, so-called Dedicated Biotech Firms, DBFs. Strong scientific and industry base flourish the growing of both academic and industrial spin-offs.

3. Decline/Reorientation

Although most successful clusters prosper for decades at least, they can and do lose their competitive edge and decline due to both external and internal threats (Porter, 1998). The external threats include technology discontinuities, a shift in buyer's need, etc.; and the internal threats include internal rigidities and the losing of innovative abilities, etc. By contrast, some scholars argued that a cluster does not decline, but the firms within it will reorient to a new development (Feldman et. al, 1996) or should have a sustaining activity after its effective growth. The sustainability implies coasting, or a relaxation of vigilant scanning for crises and opportunities (Phillips, 2005).

3. THE ANALYTICAL FRAMEWORK

Drawing the perspective of the life cycle of an industrial cluster, we observe that different origins and different success factors shape a cluster. As mentioned earlier, spontaneous and policy-driven clusters are two major forms of the cluster creation. An interesting phenomenon shows that most spontaneous clusters exist in the western countries, such as the Bay area in the United States, Cambridge in United Kingdom and Marseilles in France; but the policy-driven clusters appear largely in the Asian countries, such as Shanghai ZJHT Park in China, Tokyo-Kanto in Japan, and HsinChu Science Park in Taiwan.

In this study, we use case study to analyze these two types of biotech clusters (spontaneous and policy-driven) in their origin and growth stages. We try to answer the following questions through comparing and contrasting the two cases:

- (1) What are success factors affecting the formation of two types of the clusters?
- (2) Which success factor(s) contribute mainly on shaping the configuration a cluster?

Case study of an individual cluster is the most common approach in the qualitative studies (Wolfe and Gertler, 2004). Because case study can capture the dynamics of a cluster, many

studies focused on intensive case study of industrial clusters (e.g. Chiesa and Chiaroni, 2005; Poudier and John, 1996; Saxenian, 1994). We use the Bay Area in the United States and Shanghai ZJHT Park in China as the two cases to represent spontaneous and policy-driven clusters separately.

Drawing on literature reviews, we construct an analytical framework of cluster formation, as shown in Figure 2. In each case, we first introduce its origin and describe the brief history of its growth. Next, we examine how these success factors work to promote the growth of each cluster.

< Insert Figure 2 here >

4. TWO CASES OF BIOTECH CLUSTERS - BAY AREA IN THE UNITED STATES AND ZJHT PARK IN CHINA

4.1. Spontaneous Cluster: Bay Area in the United States

4.1.1. Formulation

(1) Origin: the Cooperation between Scientists and Venture Capitalists

The Bay Area is a biotech cluster created by scientists and venture capitalists. The leading research institutes--Stanford University, University of California, Berkeley (UC Berkeley), and University of California, San Francisco (UCSF) --created the technology, tools, and intellectual climate necessary to build a new industry. Following the pioneering work of Syntex Corporation and Cetus Corporation (founded in Berkeley in 1971), a university researcher (Herb Boyer, a UCSF biochemist) and a venture capitalist (Bob Swanson), founded Genentech, the world's first biotech company in 1976, which started the world oldest biotech cluster in the Bay Area (Office of the Governor of the State of California, 2003).

(2) Rapid Growth: academic spin-offs

The biotech industry in the Bay Area experienced a tremendous growth in its first decade because the effort of scientists and the financial input by venture capitalists. The agreement of

Supreme Court that life forms could be patented in 1980 also speeded this growth. Most of the biotech companies in the area were academic spin-offs. In the past thirty years, biotech industry in the Bay Area has grown to over 800 companies, employing 85,000 people and generating over \$2 billion in exports annually.¹ Table 1 highlights financial status of biotech companies in 2005 by geographic area in the United States. It shows that the Bay Area stayed in the leading place in this industry, no matter in the number of public companies, market capital, revenue, or R&D investment.

< Insert Table 1 here >

4.1.2. Spontaneous Success Factors in the Evolutionary Process

Many success factors arise in the Bay Area simultaneously. The formula of the effective growth process of biotech industry in the Bay Area can be described as: the government funding goes through universities and research institutions to keep the local “innovative engines” running and venture capital help making scientific fruits of basic research transfer to practical uses. The shared prosperity² is supported by the entrepreneurial spirit and social capital which establishes the networks among universities, spin-offs and venture capital firms to make the Bay Area growth and prospering. Each factor is described separately in detail as follows.

(1) Strong Scientific Base

The Bay Area is home to numerous research universities and institutions, anchored by the three major universities: Stanford University; UC Berkeley and UCSF. These world leading universities created strong scientific base for the Bay Area. In 1973, Herb Boyer and Stanley Cohen, two Stanford geneticists collaborated to perfect the “recombinant DNA technology”, which has been used as a basis for much of the scientific progress that biotech has made in cloning cells and drug production (Robbins-Roth, 2001). The recombinant DNA technology has driven the development of modern biotech and the legendary company, Genentech. Table 2

shows the number of biotech related patents in the nine biotech clusters in the United States. Because the strong science base, many scientists founded biotech start-ups with their own research results. Figure 3 discloses that there are more than 170 academic spin-offs from local universities or research institutions in the Bay Area.

< Insert Table 2 here >

(2) Abundant Public and Private Financial Funding

A. Public Funding for Basic Science

The Bay Area enjoys tremendous financial support from both public and private sources. Venture capitalists are very active among different financial supports. In the federal government level, National Institute of Health and National Science Foundation (NSF) are main financial supporters for the biotech basic research. The local leading universities receive immense amount of R&D funding from these two government departments annually. For instance, according to the NSF, the top universities located in the North California received a record \$2.8 billion in R&D funding in 2007.³ The large research funding makes those universities are able to produce more research results; moreover, they can do technology transfer as well as generate more academic spin-offs.

B. Venture Capital Funding

Venture capital plays the most important financial support for the biotech start-ups from innovation to commercialization. Biotech product development is very lengthy and costly. It takes on average 10 to 12 years for a biotech drug to pass from the initial research stage to the commercialization stage. The cost of this process is estimated to be more than US\$500 million (Ng, 2006). Table 3 shows that the Bay Area received the largest amount of venture capital investments in the biopharmaceutical industry from 1995 to 2001. Moreover, almost half of the

highly active venture capital firms located in the Bay Area. The large number of local active venture capitalists fuels the biotech start-ups in this region. The Bay Area is now home to 34% of active US venture capital firms and this regional concentration has existed since the 1980s.

< Insert Table 3 here >

(3) Splendid Entrepreneurship

Great entrepreneurship has been existed in the Bay Area for a long time. The Bay Area Economic Forum, a public-private partnership to support the economic vitality and competitiveness of the region, narrate the region on its website: ⁴ “The success of the Bay Area economy is built on an unparalleled culture of entrepreneurship.” In addition, Ahmed Enany, the chief executive officer of the Southern California Biomedical Council, identifies the entrepreneurial spirit as the key to the success of biotech industrial cluster in the Bay Area (Efendioglu, 2006). Stuart and Sorenson (2003) explored regional differences by determinants of the local founding rate, in which entrepreneurs assemble the resources to start new companies. In their findings, the predicted IPO rate and the rate of new venture creation are relatively high in the Bay Area [28].

(4) Valuable Social Capital

Bay Area owns valuable social capital which promotes innovation and competitiveness. Cohen and Fields (1998) found that the social capital in the Silicon Valley created by a world of strangers, instead of a community of dense civic engagement (nobody knows anybody else’s mother there). They argued that “Silicon Valley would be hard-pressed to present the image of a close-knit civil society that, according to the social capital theorists, is the precondition for economic prosperity”. But Silicon Valley owns a vastly different kind of social capital (Cohen and Fields, 1998). They describe it as:

In Silicon Valley, social capital can be understood in terms of the collaborative partnerships that emerged in the region owing to the pursuit by economic and institutional actors of objectives related specifically to innovation and competitiveness. It is the networks resulting from these collaborations that form the threads of social capital as it exists in Silicon Valley (Cohen and Fields, 1998, p.3).

Also, Phillips (2006) remarks that “In the U.S., where tech entrepreneurship has flourished, investors, entrepreneurs and employees have learned to trust each other with eyes widely open.” On the trust base alliance, Bay Area develops its valuable and unique social capital to encourage innovation and competitiveness which are necessary for the growth of biotech industry. This argument is demonstrated by Stuart and Sorenson’s (2003) study which implied that Bay Area affords more opportunities to create new ventures than other areas because it holds rich social capital.

(5) Tight Networking within a Spontaneous cluster

Without strong networks among research institutions, biotech start-ups, and venture capitalists, the Bay Area cluster could have never been as successful as it is today. Beginning with the story of Genentech, the Bay Area has been developing strong ties between start-ups and venture capital firms. And, the networking activities in the Bay Area are never static. Owen-Smith and Powell (2005) found that direct links among Bay Area small DBFs outweighed the links among DBFs with venture capital firms and DBFs with public research organizations by 1999.

In the initial stage, DBFs linked with venture capital firms and research institutions, because financial support and industrial incubator facilitate the commercialization of the innovation. When the industry reaches a more mature stage, the networks among DBFs link with each other better in Bay Area. The case of Bay Area provides evidence that a tight, complicated and delicate networking is developed spontaneously by the demand of the participants in the cluster. In

addition, the continuous networking will evolve naturally over time, as the description in Kauffman's (1993) concept of "spontaneous sources of order".

4.2. Policy-Driven Cluster: Shanghai ZJHT Park in China

4.2.1. Formulation

(1) Origin: Appears in a Governmental Planned Area

Although ZJHT Park was established in 1992 as a national-level scientific park designed for high-technology development, the development of biotech industry has not started until 1996, when the agreement of National Shanghai Biotechnology and Pharmaceutical Industry Base (NSBPIB) signed to support and promote the development of biotech industry in ZJHT Park.

ZJHT Park is located in the middle part of Pudong New Area with a planned area of 25km², comprising Technical Innovation Zone, Hi-Tech Industry Zone, Scientific Research and Education Zone, and Residential Zone. China's national science and technology policy has targeted biotech as a key industry as early as in 1986 (the the National High-Tech Research & Development Plan, or the 863 Plan) and the Torch program in 1988 also directed the high priority of the biotech industry. In the national Ninth Five Year Plan (1995-2000), the Chinese government further stressed the importance of biotech R&D. In responding to the central government policy, in 1996, the agreement of NSBPIB established the biotech industry in ZJHT Park. NSPBIB has influenced the movement of key research institutes to resettle in the Park, such as the Chinese Human Genome Center, the Institute of Materia Medica and the Shanghai Chinese Medical University and its affiliated hospital (Prevezer and Tang, 2006).

< Insert Figure 4 here >

(2) Growth: Governmental Planned Development

In 1999, Shanghai Municipal Committee and Municipal Government made the strategy of "Focus on Zhangjiang" and identified the IC industry, software industry, biomedicine as the

leading industries of the Park to play a leading role in innovation, and ZJHT Park began to develop rapidly ever since.

After 10 years of development, the Park has established a framework for biomedicine industry and information industry chain and innovation chain. As a result, ZJHT Park is emerging as one of the major biopharmaceutical parks in China. By the end of 2004, the Park owned 141 biomedicine companies, and 57 of them were foreign-owned. The number of employees in the biotech industry also exceeded 10,000 at the time, and among them, 253 were returning from abroad and 413 people owned Ph.D. degrees (See Table 4).

< Insert Table 4 here >

4.2.2. Governmental Role in the Evolutionary Process

The main force in ZJHT Park's growth process in the biotech sector is the aggressive intervention of the park administration and the state and municipal governments by providing human resource and financial support.

(1) Policy Planned Human Resource

Unlike many clusters benefits from the proximity to universities and research institutions, the research force in ZJHT Park is incubated and centered by the government. There were neither research institutions nearby nor a good environment for industry development in the first place; however, with the strong commitment of the government, led by Shanghai Institute of Materia Medica and Shanghai University of Traditional Chinese Medicine, more than 30 research institutions team up with about 10 foreign company owned R&D centers (e.g. Dupont, Roche etc.) and about 210 small-to-mid size local biotech companies to form a regional innovative system (Zeng and Xiao, 2006). The 8,580 biotech-related researchers provide a sufficient knowledge base for ZJHT Park's future development in the biomedicine sector. Outside the Park, Shanghai

Jiao Tong University and Fudan University provide ZJHT Park with high-quality manpower and on-job training (Lai and Shyu, 2005).

The Park also aims on the entrepreneurship spirit of Chinese overseas scientists. The policies planned for returnees include low rent, tax breaks and living needs (Zweig, 2005). In the end of 2004, there were 253 returnees in the Park. Partly a result of these policies, the trend for Chinese overseas scientists to return and found a high-tech company has been accelerating. The number of companies founded by returnees in Shanghai has increased at the rate of one per day since 2002, reaching 3,000 and amounting to a total investment of USD 660 million by the end of 2004.⁵ In 2003, there were 50 biotech companies founded by returnees, among the approximately 500 newly-founded companies in ZJHT Park (Sternberg and Müller, 2005).

(2) Government Financial Support

The government is the main financial supporter for the biotech companies in the Park. The venture capital system is immature and weak in China. According to Prevezer and Tang (2005), venture capital companies have not emerged in China until around 1996 and the emergence process started with some local governments that set up investment institutes which supplied funds to start-ups and incubators in high-tech parks. It looks like that China government has tried to replace the role of the venture capitalist in the beginning of cluster formation. In October 21, 2006,—Shanghai Pudong New Area Venture Fund, a first policy-directed venture fund supported by the local government, was established with the amount of 125 million USD. The fund aims on attracting a 2.5 billion USD venture capital.⁶ Table 5 presents the amount of government granted to start-ups in 2004.

< Insert Table 5 here >

Some anecdotes could help us understand more about the government role in providing financial funding. After interviewing with total 35 entrepreneurs and industry experts, Sternberg

and Müller (2005) found that biotech entrepreneurs depended heavily on the state-run investors, especially the Shanghai Commission of Science and Technology, Shanghai Venture Capital and the Ministry of Science and Technology. In addition, the government also uses tax incentives to encourage the development of biotech companies. For instance, the revenue of a R&D institution engaged in business of technology transfer, technology development, related technological consultation, and technical service can exempt from business tax.

The following are success factors proposed by our framework but missing or not established in the ZJHT Park.

(3) *A Missing Ingredient: Entrepreneurship*

Although ZJHT Park aimed on the Chinese overseas scientists partly due to their entrepreneurship, entrepreneurship is still “the missing ingredient” in most Chinese Science and Technology Industry Parks (STIPs). After interviewing in several STIPs (including ZJHT Park), Watkins-Mathys and Foster (2006) conclude that what appears to be missing still among STIP-based firms are entrepreneurship and management skills. In fact, the entrepreneurship was missing but is emerging in China when we look at the number of growing private companies like Lenovo China. This new phenomenon after China turns to more open economy can be learned from Peng’s (2006) book:

“In Mainland China, for nearly decades, there had been virtually no entrepreneurship, thanks to harsh communist policy. In the last two decades, as policies in China become more entrepreneur-friendly, the institutional transitions have opened the floodgates of entrepreneurship, contributing to a booming economy. In a nutshell, it is not what in people’s “blood” that make or breaks entrepreneurship; it is what institutions encourage or constrain that explains it. (Peng, 2006, p.200)”

(4) *Differential Social Capital: Guanxi*

Some scholars use the term “*Guanxi*” to describe social capital in China.⁷ It is impossible to ignore *Guanxi* when doing business in China. In Watkins-Mathys and Foster’s (2006) study, all parties related to STIPs recognized the importance of good *Guanxi* for developing their business activities. Generally, *Guanxi* refers to under-table relationship among specific groups based on mutual benefit exchange. Most of the time, it even refers to the networking with government departments in the business world. But too much *Guanxi* might create an exclusive and close network for some specific groups which do not benefit innovation and competitiveness. Watkins-Mathys and Foster’s (2006) study provides some evidence to this concern. In their interview, Watkins-Mathys and Foster (2006) reported that the main challenge of doing business in China is to develop good *Guanxi* with the departments of local government in order to gain access to larger customers. In China, it is a crucial topic to build up social capital which facilitates innovation and competitiveness.

(5) *A Loose Networking in the Policy-Driven Cluster*

There is no tight networking among biotech companies in ZJHT Park currently. The aggressively governmental intervention attracts high-quality human and financial capital to the Park, but tight networking is not easy to create among the research institutions, biotech companies and venture capital firms by government policies. In ZJHT park, there is a developing links between the local government and biotech companies. Prevezer and Tang (2005) found a symbiotic relationship between the local government and biotech companies, which has formed the backbone for the positive feedback between local government initiatives and entrepreneurial responses. In other words, biotech companies in the Park make more efforts to network with the local government other than with other companies or venture capital firms in both initial and growth stage. The reasons are: the first, the financial support is mainly from the government funding or from quasi-government institutions; the second, a good relationship with the

government helps biotech companies to communicate their needs with the government, such as regulation change or the needs of basic infrastructure.

5. DISSCUSSION AND CONCLUSION

5.1. Research Findings

We summarize a comparison between Bay Area and ZJHT Park from the origin to the growth stages, as shown in Table 6. Several research findings are examined by the two cases of different origins and success factors in the evolutionary process.

< Insert Table 6 here >

The first, the success factors both biotech clusters own are human capital and financial capital, but the underlying forces of two cases for formatting and providing these two factors are very different. Table 6 clearly presents that China government has been the main provider for both human capital and necessary funding in ZJHT Park. In contrast, academic spin-offs and venture capital are the two major powers for human and financial capital in the Bay Area.

The second, we show the fundamental difference between two cases lays on entrepreneurship, social capital and network patterns. In fact, entrepreneurship, social capital, and networks are intertwined in the evolution of an industrial cluster. The splendid entrepreneurship and valuable social capital promote tight networking in the Bay Area. The dynamic networking in the Bay Area shapes its configuration today and still evolves in the future. In contrast, ZJHT Park is planned by government. The two success factors of human and financial capital initiate the biotech cluster in ZJHT Park. However, the still emerging entrepreneurship plus lacking of social capital result on loose networks in the Park. Although the concern is *Quanxi*, the Chinese version social capital, might defer the networking among biotech companies. ZJHT is still a young biotech cluster which needs time to demonstrate its ability to adapt to the environment in its further growth.

Finally, we demonstrate the different configuration of clustering and networking in the evolutionary process of the two cases. In the Bay Area, biotech companies linked to research institutions and venture capital firms in the initial stage, and the links shift to connect biotech companies with each other more in the mature stage. In contrast, ZJHT Park has better links between the biotech companies and the government in both initial and growth stages. The implication from Bay Area case is it owns the capacity to evolve and adapt to the environment due to its rich culture, history and social capital for innovation and competitiveness. The organic, active interaction between factors shapes a more checkered but ginger cluster. Since ZJHT Park is planned by government within a definite boundary, it is in a relatively artificial order. Nevertheless, we could not conclude that ZJHI Park will not develop its evolving capacity to adapt to the environment due to its youngness.

5.2. Research Contributions

There are three major contributions in this study. The first contribution is that a side-by-side comparison between two types of biotech clusters, “spontaneous and policy-driven”, is lacking in the literature⁸. Many previous studies compared clusters with the same origins or in a nearby geographic area. It is essential to know the dynamics and essence of different types of clusters through the industrial cycle. The second, the cross-country comparative analysis shed lights on how culture, history, and social capital shape configuration of different clusters. From analyzing these two cases, our study shows that country-specific institutional context is very valuable in shaping national innovation system (Bartholomew, 1997).

Finally, the precise origins and growth processes of two cases provide a valuable insight. Many cluster studies have difficulty in identifying the precise origins and the critical founding events. The critical issue is how to draw policy lessons on the formation of clusters when their precise origins are so difficult to ascertain (Wolfe and Gertler, 2004). Our study overcomes this

problem and compensates the literate body from this perspective. Moreover, our study demonstrated the intertwined and dynamic relationship among success factors in the evolutionary process which is valuable in cluster developing.

5.3. Limitations and Future Direction

Three limitations are addressed in this study. The first limitation is the presented data. Statistics about US patent and venture capital in Table 2 and 3 which are the best data we could find so far, since we cannot access other statistics regarding the metropolitan area in the United States more recently. However, the trend of statistics did provide insights of the R&D and financial capacity in the Bay Area and other clusters in the United States. The second limitation is that we focus on the discussion of biotech clusters only. The biotech industry has unique characteristics such as high-educated scientists and large financial capital, etc. It might be not appropriate to generalize the findings to the industrial clusters in other industries. Finally, this study has limited to compare origin and evolution of two-type cluster on two cases. Two cases, Bay Area in the United State and ZJHT Park in China, may not be the only or the best representatives in this study. In the future research, we hope to see both better qualitative and quantitative research will be conducted to give more in-depth and comprehensive view of the origin and evolution of industrial clusters further.

5.4 Concluding Remarks

Feldman et al. (2005) argued that it is dangerous to conclude that the ingredients of a successful cluster. Regarding a successful cluster, we do need to be very cautious about our inferences. To sum up, two concluding remarks draw from this study. The first, spontaneous clusters have the capacity to evolve. According to Kauffman (1993), spontaneous sources of order provide inherent order that evolution has to work with *ab initio* and always. Our study shows that Bay Area, a spontaneous cluster, originates from academic spin-offs and evolves by

the powers of venture capital and social capital organized by entrepreneurs. Continuous evolution leads to the tight networking in spontaneous clusters. The second, this study demonstrates the presence of social power in the cluster formation. Phillips (2006) proposed that sociology and history trump pure economics in shaping the regional development. It is interesting in observing that how different kind of social capital and the accompanying networks contribute the different configurations of two clusters.

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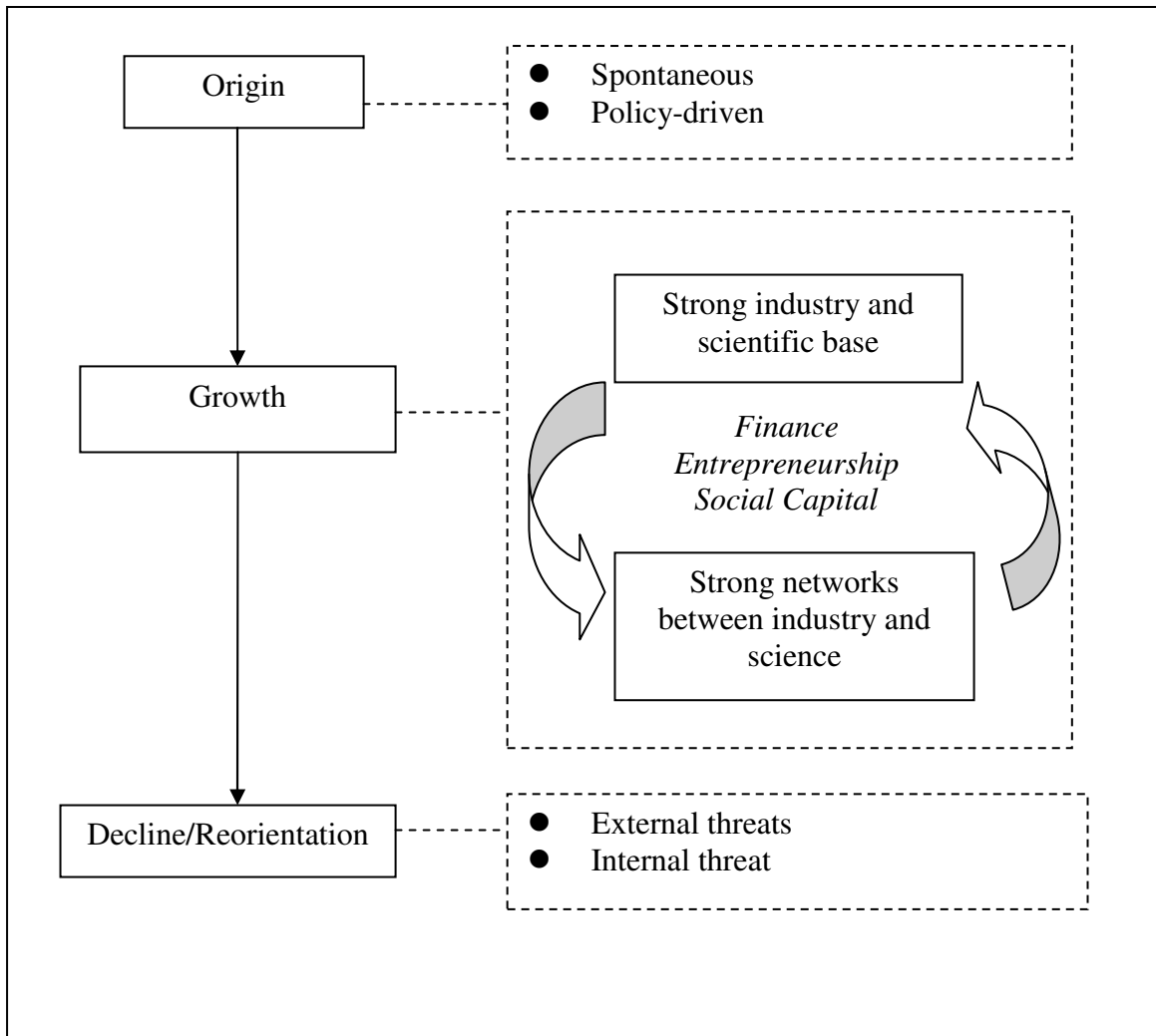


Figure 1. Life Cycle of an Industrial Cluster

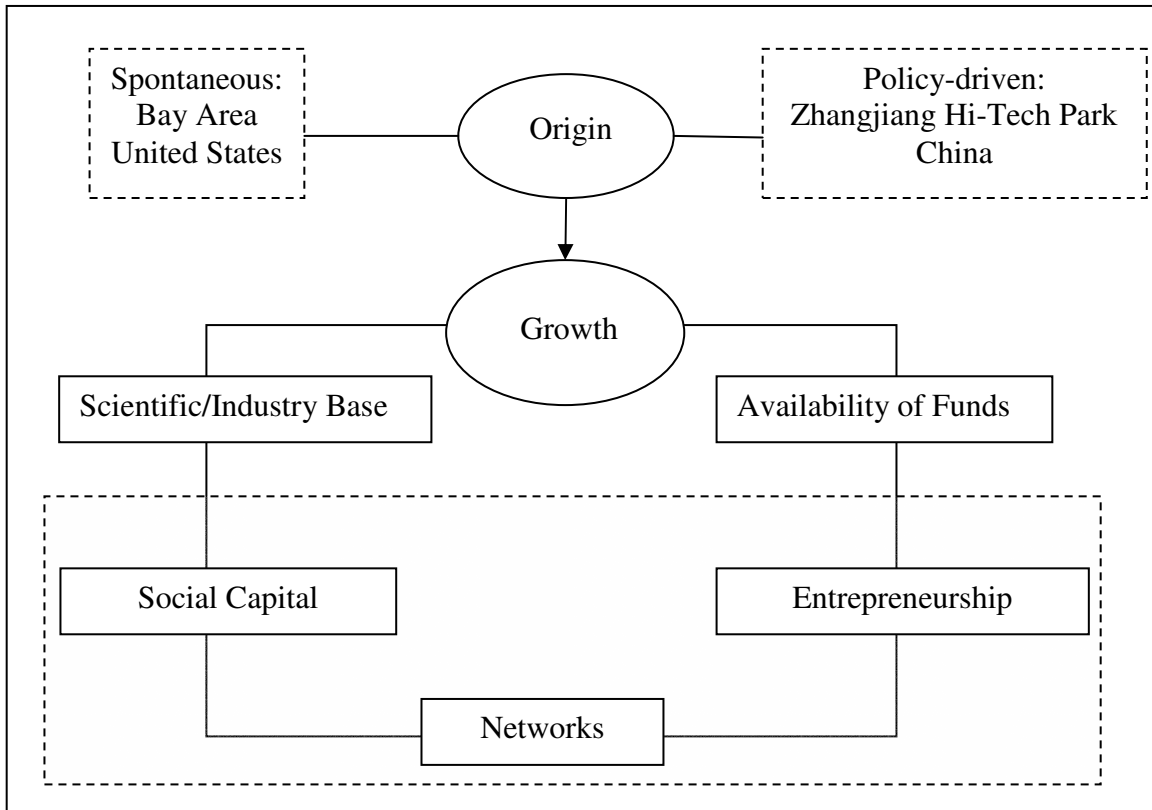


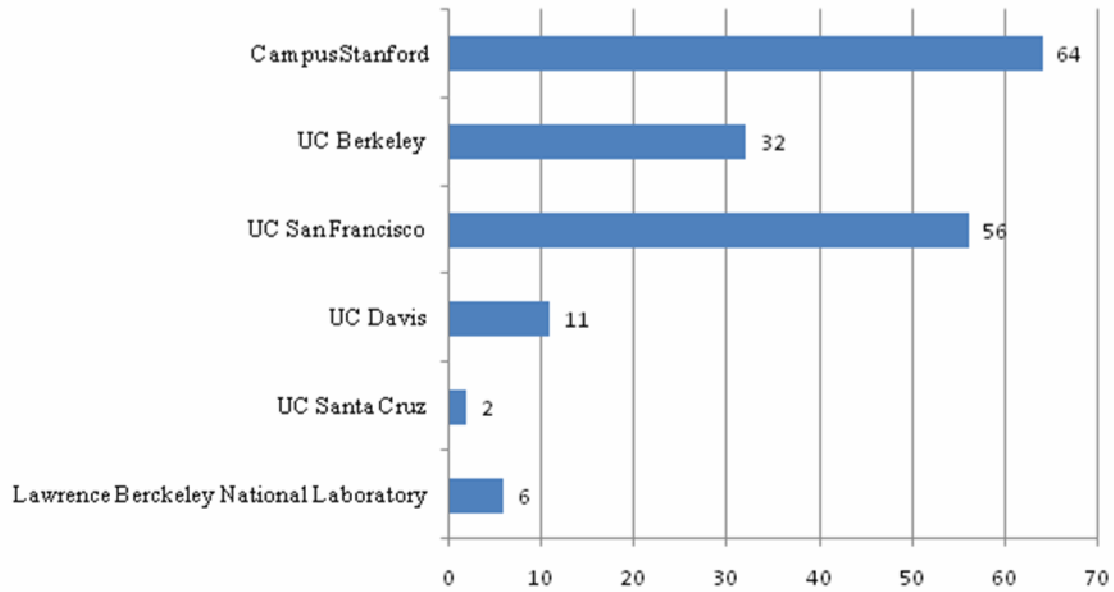
Figure 2. Analytic Framework of Cluster Formulation

Table 1. Selected 2005 U.S. Biotech Public Company Financial Highlights
(by geographic area, (\$m), percent change over 2004)

Region	Number of public companies	Market capitalization 12.31.05	Revenue	R&D	Net loss (income)	Cash and short-term investments	Total assets
San Francisco Bay Area	67 0%	162,261 53%	15,431 25%	4,284 5%	246 -60%	11,861 21%	31,951 13%
New England	59 2%	59,582 -3%	8,668 17%	3,019 3%	1,194 -30%	6,222 -8%	24,820 -2%
San Diego	37 3%	19,716 19%	2,760 19%	1,073 0%	718 -6%	3,431 6%	8,192 8%
New Jersey	29 -3%	16,946 38%	1,447 21%	737 -2%	494 -16%	1,950 -13%	3,478 -16%
Mid-Atlantic	19 0%	15,009 3%	1,656 -5%	1,080 4%	659 -10%	2,578 -13%	6,512 -7%
Southeast	20 0%	6,917 0%	1,441 18%	416 21%	176 260%	1,104 26%	2,970 18%
New York State	14 0%	7,333 -31%	757 -9%	578 6%	296 -18%	2,220 12%	3,449 8%
Midwest	11 0%	1,914 -11%	201 -12%	108 -18%	135 -2%	300 -6%	484 -3%
Pacific NW	15 -6%	4,036 -22%	162 -19%	435 -27%	537 -35%	819 -26%	1,245 -26%
Los Angeles/Orange County	11 -8%	99,917 19%	12,511 13%	2,414 -12%	-3,521 57%	6,005 -2%	30,190 0%

So

Source: Ernst and Young, 2006



Source: Biocom, [2]

Figure 3. Academic Spin-offs in the Bay Area since the Origin of the Cluster

Table 2. US Biotech Related Patents (by Geographic Area)

Biotechnology Centers	1975-79	1980-89	1990-99	1975-99
Boston	126	592	3,007	3,725
San Francisco	414	1,173	3,991	5,578
San Diego	23	210	1,632	1,865
Raleigh-Durham	27	204	796	1,027
Seattle	9	93	770	872
New York	1,420	3,590	6,800	11,810
Philadelphia	679	1,309	3,214	5,202
Los Angeles	106	330	1,399	1,835
Washington	121	470	2,162	2,753

Source: Cortright & Mayer, 2002

Table 3. US Venture Capital for Biopharmaceuticals by Region, 1995-2001

Biotechnology Centers	Number	Venture Capital Investments		Highly Active Venture Capital Firms 1995-2001	Initial Public Offerings 1998-2001
		1995-2001 Amount	Share(%)		
Boston	211	1,915,654,300	19.7	10	3
San Francisco	261	3,028,917,500	31.1	21	31
San Diego	169	1,505,896,000	15.4	4	10
Raleigh-Durham	54	379,687,000	3.9	2	1
Seattle	44	419,954,000	4.3	1	8
New York	63	639,099,000	6.6	5	5
Philadelphia	51	457,550,000	4.7	3	2
Los Angeles	26	180,761,000	1.9	1	1
Washington	20	85,150,000	0.9	0	2

Source: [25]

Source: Cortright & Mayer, 2002



Source: Walcott, 2002

Figure 4. The Location of Zhangjiang Hi-Tech Park

Table 4. Statistics on Biomedical Manufacturer at the ZJHT Park in 2004

Number of companies	141
State owned	84
Foreign owned	57
Employees	10,424
Female	5,095
Oversee Returnees	253
Ph.D.	413
Master	750
Number of Patent applied	730
Asset	875
Capitalization (end of year)	1,453
Liabilities (end of year)	622
Revenue	467
R&D investment	56
Profits	-3
Subsidies	2

Source: <http://www.zjpark.com/>; USD Million (RMB: USD=

Table 5. Government Granted to Start-ups in ZJHT Park, 2004

Industry	Number of incubated firms	Grants from National Technology Innovation Fund for Small-Mid Size Business		Grants from Shanghai Technology Innovation Fund for Small-Mid Size Business		Grants from Shanghai Pudong New Area Technology Fund	
		Projects	Amount (1,000USD)	Projects	Amount (1,000USD)	Projects	Amount (1,000USD)
IC-Industry	291	15	1,138	4	104	24	563
Biomedicin	87	6	563	0	0	10	319
Others	35	2	175	4	143	10	179
Total	413	23	1,875	8	246	44	1,060

Source: Zhangjiang Hi-Tech Park Administrative Office. <http://www.zjpark.com/>. (RMB: USD = 8: 1)

Table 6. Comparison for Two Types of Clusters

Cluster Type	Spontaneous Cluster	Policy-Driven Cluster
Example	Bay Area in the United States	Zhangjiang Hi-Tech Park in China
Origin	Birth with the founding of Genentech: the cooperation between a scientist and a venture capitalist in 1976.	Birth in a government planned area in 1996.
Growth: success factors		
(1) Human Capital (Science Base)	Strong scientific capacity supplied by leading universities.	Policy-planned manpower: government actively attracts research talents locally and oversea.
(2) Financial Capital	Abundant governmental and venture capital funding.	Most funding comes from the government.
(3) Entrepreneurship	Splendid entrepreneurships	Emerging entrepreneurship
(4) Social Capital	Valuable social capital for innovation and competitiveness.	Differential social capital: <i>Quanxi</i> .
(5) Networking	Tight networking among biotech companies, venture capital and research institutions at first. Now the direct links among biotech companies became the main networking.	Loose networking among biotech companies, venture capital and research institutions. Biotech companies make more efforts to network with the local government.

Note:

1. See: http://www.baybio.org/wt/home/Industry_Statistics.
2. Although this term was explained by many persons with different meanings, we borrowed the term from Phillips (2005). He argued that “shared prosperity involves the building of industry clusters and social capital, and action-oriented communities that can embrace change.
3. http://www.baybio.org/pdf/IMPACT07_Policy.pdf
4. Please see <http://www.bayeconfor.org/baefregion.html>.
5. It was €330 million in the report. The exchange rate used is GBP: USD = 2: 1.
6. News in www.people.com Oct. 22. 2006, retrieved on Sept, 22, 2007.
7. Knight and Yueh’s (2002) point out that an important aspect of Chinese society – whether in traditional China (-1949), in the period of central planning (1949-1978), or in the period of economic reform (1978-) – is the Chinese variant of social capital known as *Guanxi*.
8. The only one we came across is Efendioglu’s (2006) study.