Post-print: Experiences and Implications from the Development of World Science and Technology Innovation Centers

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Abstract

[目的/意义] An in-depth comparative analysis of experiences in the construction and development of international innovation clusters holds significant reference value for the construction of China' s science and technology innovation centers. [方法/过程] This paper examines typical internationally renowned innovation clusters, including Silicon Valley in the United States, Research Triangle Park in North Carolina, Tsukuba Science City in Japan, Munich High-Tech Industrial Park, and East London Tech City in the United Kingdom, and summarizes the common characteristics of science and technology innovation centers. [结果/结论] The insights gained are as follows: supporting and regulating the construction of science and technology innovation centers through charters and institutions; building a favorable environment to attract outstanding talent globally; guiding the development of emerging industries to generate radiating effects from innovation clusters; supporting entrepreneurship to effectively promote technology transfer and innovation commercialization; and establishing a council mechanism with multi-stakeholder participation to avoid excessive government intervention.

Full Text

The Construction of World Science and Technology Innovation Centers: Experiences and Enlightenment

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Abstract

This study aims to derive valuable insights for constructing global science and technology innovation centers in China through in-depth comparative analysis of international innovation cluster development experiences. The paper examines five renowned innovation clusters: Silicon Valley (USA), Research Triangle Park (North Carolina, USA), Tsukuba Science City (Japan), Munich High-tech Industrial Park (Germany), and East London Tech City (UK), summarizing their shared characteristics. The findings suggest five key implications: (1) support and regulate center construction through statutes and institutional frameworks; (2) create a friendly environment to attract global talent; (3) guide emerging industry development to generate radiating effects from innovation clusters; (4) support entrepreneurship to effectively advance technology transfer and innovation commercialization; and (5) establish stakeholder council mechanisms to avoid excessive government intervention.

Keywords: science and technology innovation center; innovation clusters; experiences
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Since 2010, Chinese scholars have produced extensive research on the development experiences of international science and technology innovation clusters, with numerous publications analyzing renowned cases such as Silicon Valley and Tsukuba from various perspectives. As construction of science and technology innovation centers in Beijing and Shanghai advances, this research has deepened considerably. The authors participated in investigations of world-famous innovation clusters around 2011, with primary output documented in *Theory and Practice of Innovation Cluster Construction* [1].

Conceptually, innovation clusters and science and technology innovation centers share many similarities: both aggregate innovation elements, serve as origins of innovative technologies and business models, attract and mobilize social resources from within and beyond the region, continuously generate and transfer R&D outcomes toward common goals, and create new technology products and services that impact socioeconomic development. However, subtle differences exist: science and technology innovation centers place greater emphasis on leadership and preeminence in innovation activities, and from a long-term perspective, often function as cradles of scientific, technological, and industrial revolutions. Rather than delving into conceptual distinctions, this paper focuses on analyzing internationally representative cases with distinctive features and notable achievements, to distill experiences and insights beneficial for domestic center construction.

1.1 Silicon Valley

Located in northern California and southern San Francisco Bay Area, Silicon Valley derives its name from its origins as a hub for silicon-based semiconductor research and production. Today, it stands as the global epicenter of the electron-

ics and computer industries, pioneering high-tech innovation and development, with approximately 1,500 computer companies established in the region [2].

The primary characteristic of Silicon Valley is the concentration of research and industrial strength. The region is anchored by several top-tier American universities with robust research capabilities, primarily Stanford University and UC Berkeley, along with other UC campuses and Santa Clara University. Additionally, over 70 federal laboratories and R&D centers are situated in the area. Silicon Valley is built upon a foundation of high-tech small and medium-sized enterprises, while also hosting tech giants including Google, Facebook, HP, Intel, Apple, Cisco, NVIDIA, Oracle, Tesla, and Yahoo.

Second is the aggregation of high-end talent. Despite comprising less than 1% of the U.S. population, Silicon Valley accounts for 5% of national GDP and attracts millions of technical professionals worldwide, including thousands of U.S. National Academy members and over 30 Nobel laureates. The proportion of highly educated professional technical staff is exceptionally high, often exceeding 80% of employees in enterprises. Skilled immigrants constitute one-third of engineers in most tech companies, demonstrating strong economic contribution and talent attraction.

Third is the massive scale of venture capital. In Silicon Valley, technology inventors typically do not transfer their achievements but instead establish high-tech enterprises themselves. Consequently, the region hosts over 1,000 venture capital firms and 2,000 intermediary service agencies, with innovation venture capital consistently accounting for approximately one-third of total U.S. venture investment. Silicon Valley venture capital institutions not only provide funding to promising companies but also offer consulting services in management, accounting, legal affairs, and advertising, assisting in organizational restructuring and network building—playing a pivotal role in the growth of companies like Apple and Intel.

Fourth is its value system and innovation culture. Silicon Valley has cultivated a unique cultural model that epitomizes high-tech culture, characterized by entrepreneurial values that embrace risk-taking, tolerate failure, and encourage rebelliousness; humanistic management emphasizing individual worth and information sharing; ultra-fast talent mobility; flexible work arrangements; and relentless pursuit of efficiency and speed.

1.2 North Carolina Research Triangle Park

Established in 1959, the Research Triangle Park (RTP) in North Carolina is located at the center of a triangle formed by Duke University, the University of North Carolina, and North Carolina State University. As a globally renowned science park, it has attracted major corporations such as Bayer, BASF, Cisco, IBM, and Nortel to establish R&D centers, housing over 100 research institutions and forming 14 industrial clusters in pharmaceuticals, biotechnology, tobacco, and other sectors [3].

The park' s initial funding came entirely from private and corporate donations. Its primary objectives were to attract American enterprises to establish new research institutions and production facilities, create new industries for North Carolina, and leverage research outcomes to transform traditional industries, thereby driving statewide economic development. Consequently, the private, non-profit Research Triangle Foundation assumed responsibility for park development, investment promotion, and management. The foundation' s council comprises 11 representatives from government, universities, and enterprises, overseeing construction and planning while refraining from interfering in internal affairs of park entities. This model enabled systematic state government-university collaboration, integrating education, research, and production, which critically shaped the park' s development direction and enhanced the state' s economic standing.

University-industry cooperation is well demonstrated in RTP. In 1965, IBM established its Systems Communications Division research laboratory in the park, catalyzing the entry of numerous high-tech enterprises. The same year, the U.S. Department of Health' s National Institute of Environmental Health Sciences also relocated to RTP.

A key feature of RTP is its collaborative governance model among government, academia, and industry, preventing excessive administrative intervention. Core enterprises play a vital role in the park' s formation and development, gradually building industrial clusters through spin-offs, fission, innovation, and imitation. Continuous upgrading and innovation sustain RTP' s development. Over one-third of park-employed experts come from the three universities, which rapidly commercialize academic achievements through intermediary agencies, while park enterprises sponsor university research funding.

1.3 Tsukuba Science City

Conceived in 1958 as part of Tokyo' s metropolitan development plan to relocate all national research and education institutions to a satellite city, Tsukuba has evolved into an internationally renowned comprehensive research hub [4].

Currently focused on life sciences innovation and green technology, Tsukuba Science City hosts 31 prestigious public research and education institutions, including Tsukuba branches of Japan' s RIKEN institute. Notable contributions include Professor Hideki Shirakawa' s synthesis of high-performance film polyacetylene, earning the 2000 Nobel Prize in Chemistry, and CYBERDYNE' s development of the world' s first voice-controlled exoskeleton 'Hybrid Assistive Limb' (HAL), leveraging research from Tsukuba University, Tokyo University, and the National Institute of Advanced Industrial Science and Technology.

A crucial feature of Tsukuba is that all its operations are grounded in legislation and policy frameworks. Laws such as the *Tsukuba Research and Academic City Construction Act* and the *Tsukuba Research and Academic City Development Master Plan* provide essential safeguards for park development, complemented

by preferential measures that accelerate growth. For technology transfer, an official intermediary mechanism was established—the Tsukuba Global Innovation Promotion Organization (TGI)—as a core platform for economic-academic-government collaboration. Comprising government officials, Tsukuba University research institutions, and enterprise representatives, TGI proactively collects information on scientific achievements and industrial needs within the city, facilitating sharing through its cooperative networks.

TGI designates recognized research outcomes as transformation projects, attaching corresponding industrialization research funding and awarding them to enterprises through competitive bidding, significantly enhancing corporate participation. Currently, Tsukuba is leveraging its status as an 'International Strategic Comprehensive Special Zone' to establish itself as a globally prominent science and technology innovation center and park specializing in life sciences and green technologies.

1.4 Munich High-tech Industrial Park

Established in 1984 through joint investment by the Munich municipal government and Chamber of Commerce, the Munich High-tech Industrial Park serves as Germany' s R&D hub for electronics, microelectronics, and electromechanical engineering. With high concentrations of university research institutions and enterprises, the park has evolved around high-tech companies that drive the establishment of supporting firms, earning it the moniker 'Bavarian Silicon Valley.'

The park now hosts hundreds of electronics companies, including the world-renowned Siemens. Germany' s 'elite universities' —the University of Munich and Technical University of Munich—provide continuous streams of research outcomes and talent. The headquarters of the Max Planck Society and Fraunhofer Society for the Promotion of Applied Research are both located in Munich, with multiple affiliated institutes present in the park.

The park' s entrepreneurship incubation model features several important characteristics. The Munich municipal government established a dedicated management and investment promotion center with supervisory committees, representing the government in providing comprehensive services to incoming enterprises. Aimed at incubating innovative companies and boosting employment, the government invested in constructing high-tech enterprise incubation buildings accessible only to technologically sophisticated firms. The government supports establishing specialized supplier networks to facilitate resource access and reduce procurement costs. Typically, new enterprises and sectors undergo pilot testing in the park before successful models are transplanted elsewhere to spawn new park zones. Incubation building rents are 5-15% below local market rates, with complimentary services including business centers, telephone, conference, and warehouse facilities. The park signs cooperation agreements with universities and research institutions, granting enterprises priority access to R&D outcomes.

Regular consulting and intermediary events jointly organized with professional associations and research institutions directly facilitate exchanges and collaboration with enterprises.

1.5 London East Tech City

Originating from Silicon Roundabout, London' s East Tech City began as a high-density technology industrial park with only 85 tech enterprises in early 2010. That same year, the UK government launched the 'Tech City' national strategy, committing £400 million to support its development, aiming to address the shortage of homegrown tech giants and position London as 'one of the world' s technology centers' [5].

Subsequently, East Tech City experienced rapid growth. By 2013, East London housed 3,200 startups, becoming Europe' s fastest-growing tech hub. Major corporations including Cisco, Intel, Amazon, Twitter, Qualcomm, Facebook, and Google established presences, while financial institutions like Barclays launched specialized financing services for startups. Europe's oldest and largest 'new-type' tech incubator, Seedcamp, also established its base there.

The rapid expansion of East Tech City is inseparable from its promotional efforts. The city strengthens international connections and attracts talent, enterprises, and capital through websites, international seminars, and active participation in EU innovation forums. The London municipal government prioritizes promotion, with the mayor personally advocating for London' s entrepreneurial advantages and appointing CEOs of key enterprises as promotional ambassadors. For instance, Michael Smith, CEO of the renowned UK children' s online game developer Mind Candy, regularly conducts roadshows abroad to publicize policies such as entrepreneur visas and investment tax relief.

2 Characteristics of Science and Technology Innovation Centers

Synthesizing the aforementioned cases and related research, we posit that science and technology innovation centers are aggregation zones for innovation elements and nodes for science and technology resource allocation; birthplaces of leading innovative ideas and technologies, and pioneering experimental grounds for innovative products and business models. From a long-term perspective, they also serve as cradles of scientific, technological, and industrial revolutions. Their typical characteristics encompass four dimensions (Figure 1 [Figure 1: see original paper]): excellence in institutions and infrastructure, capacity for original R&D and technology transfer, university-industry-research collaboration capability, and regional driving effect [6].

3 Implications

Based on the above research, comparison, and analysis, we derive five implications for constructing science and technology innovation centers.

3.1 Supporting and Regulating Center Construction Through Statutes and Institutional Frameworks

For instance, the Japanese government enacted the *Tsukuba Research and Academic City Construction Act* and *Tsukuba Research and Academic City Development Master Plan* to support and regulate Tsukuba' s development, stipulating three land use categories: central, residential, and research zones. The South Korean government implemented the *Special Act on Fostering the Daedeok R&D Special District*. Since 2011, the UK government has invested £400 million to support East London Tech City development under its funding legislation. Enterprises particularly value London' s fair, transparent legal system and appropriate regulatory framework.

3.2 Creating a Friendly Environment to Attract Global Talent

Survey data from the U.S. think tank Information Technology and Innovation Foundation (ITIF) reveals that over one-third of American innovators were born outside the United States, and more than 17% are non-citizens. Silicon Valley has cultivated a distinctive corporate culture featuring ultra-high talent mobility, first-name basis with superiors, casual dress, flexible working hours, telecommuting, and employee stock ownership. This seemingly casual culture has become a crucial talent attraction feature. In 2017, the UK government clarified and reaffirmed its policy to recruit 1,000 outstanding talents annually from abroad. The visa is granted through a process where relevant institutions endorse exceptional talent qualifications before work visa application. Specifically, the East London Tech City management authority reviews and certifies 200 outstanding applicants in digital technology fields each year.

3.3 Guiding Emerging Industry Development to Generate Radiating Effects from Innovation Clusters

The Munich High-tech Industrial Park closely integrates with Munich' s biotechnology cluster, nurturing numerous biotech companies. The Japanese government sequentially implemented the 'Industrial Cluster Program' and 'Knowledge Cluster Program' to support Tsukuba in building innovative enterprises and rapidly developing internationally competitive SMEs into industrial clusters. The sustained development of North Carolina' s Research Triangle Park results from continuous industrial upgrading and innovation within the cluster, transforming an agriculture-based region into emerging industrial clusters centered on electronic information and biopharmaceuticals. Market-oriented universities and research institutions constitute the foundation and core of this upgrading and innovation.

3.4 Supporting Entrepreneurship to Effectively Advance Technology Transfer and Innovation Commercialization

In Silicon Valley, for example, technical R&D and talent cultivation by research institutions and universities closely integrate with industrial development and enterprise needs, forming a community of shared interests. Enterprises provide funding and research topics, accessing and utilizing advanced technologies at lower costs, while research institutions and universities contribute intellectual and technical resources, ensuring research outcomes better align with market demands. The industrial cluster in North Carolina' s Research Triangle Park constitutes an organic system comprising enterprises, universities, research institutions, government, financial bodies, and intermediary agencies, enabling major organizations and firms within the cluster to independently conduct R&D across biotechnology, information technology, materials science, environmental protection, and pharmaceuticals.

3.5 Establishing Stakeholder Council Mechanisms to Avoid Excessive Government Intervention

The Munich municipal government established a dedicated management and investment promotion center with supervisory committees for its high-tech industrial park. Affiliated with both the municipal government and Chamber of Commerce, the center represents the government in providing comprehensive services to park enterprises. North Carolina' s Research Triangle Park is managed by the private, non-profit Research Triangle Foundation, whose council comprises representatives from government, universities, and enterprises, responsible for park construction and planning guidance without interfering in internal affairs of individual entities. France' s Sophia Antipolis Science Park primarily employs a joint association management system with corresponding organizational structures. The association comprises the regional council, provincial government, and chamber of commerce where the park is located, overseeing infrastructure development, land management, and investment promotion.

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Author Contributions

Liu Qing: Designed research framework, provided guidance and refined the paper.
Li Hong: Conducted literature research and wrote the paper.

Note: Figure translations are in progress. See original paper for figures.