AGGLOMERATION IN ACTION

DO CHINESE HEALTH SCIENCES PARKS FOSTER INNOVATION AND ECONOMIC GROWTH?

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August 2024

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Acknowledgments

As I approach the completion of this thesis, I am filled with deep gratitude. First and foremost, I would like to express my utmost respect and sincere thanks to my supervisors, Professor Alexander Lord and Professor Yiquan Gu. Under your meticulous guidance, I have not only gained professional knowledge but also developed a rigorous academic mindset and a commitment to excellence. Your dedication and balanced approach to mentorship have profoundly shaped my academic journey. Every step of this thesis, from conception to completion, reflects your wisdom and effort. Your supervision has been invaluable in guiding my progress.

I am also deeply grateful to all the interviewees who generously shared their time, valuable information, and unique insights for this research. Your contributions were crucial to the completion of this thesis. Since this research did not receive specific funding from public, commercial, or non-profit organizations, your support holds even greater significance. Thank you for your invaluable assistance.

Throughout the challenging process of pursuing my Ph.D., I often faced difficulties and moments of doubt. In these times, I am most grateful for my mother's unwavering support, which has been my constant source of strength. When I expressed my desire to pursue a doctoral degree at the age of 40, she encouraged me without hesitation. Her belief in me gave me the courage to persevere, and her support allowed me to focus on my studies while she took care of my family.

Reflecting on the challenges my mother has endured—lifting our family out of poverty and raising me from a child on a remote island to a well-educated professional with international experience—reminds me of her incredible strength and determination. Her unwavering dedication and ability to overcome obstacles have been a constant source of inspiration. Throughout this journey, her resilience and kindness have been my anchor.

Pursuing this doctorate has reshaped my thinking, providing new insights into society and life. I have learned to apply an academic perspective to both work and social phenomena, deepening my understanding beyond academic knowledge. These insights are the true value of this journey.

Finally, I wish to extend my heartfelt thanks to everyone who has supported me throughout this journey—my supervisors, family members, friends, colleagues, as well as working partners and clients. Your trust, support, and encouragement have been invaluable. This thesis is the product of our collective efforts, and I will forever cherish this experience.

To all who have helped and supported me, you are the most valuable part of my academic journey. Your encouragement has been a guiding light, allowing me to continue exploring and discovering. This acknowledgment is my most sincere expression of gratitude and respect to each of you.

Abstract

This thesis examines the integration of the Triple Helix model in Chinese health sciences parks, where academia, industry, and government collaborate to drive innovation and economic development. While health sciences parks worldwide promote innovation through co-location and resource clustering, or agglomeration, China's model strategically combines these benefits with policies designed to advance national biotechnology and health sector goals. This study explores how Chinese health sciences parks contribute to regional and national development, functioning as adaptive ecosystems that exemplify the Triple Helix framework and leverage agglomeration to amplify innovation.

Starting with a global overview of science parks, the analysis compares Chinese health sciences parks with international examples such as Research Triangle Park in the United States and Cambridge Science Park in the UK. Driven by policies like the 'Torch Plan,' almost half of China's national-level industrial parks are now dedicated to health sciences, positioning them as essential to China's vision for a high-tech, knowledge-driven economy.

Through case studies of five prominent Chinese health sciences parks—Zhangjiang China Pharmaceutical Valley, Shenzhen Biomedicine Innovation Industrial Park, Suzhou's BioBay, Xi'an Biomedical R&D Cluster, and Zhongguancun Life Science Park—this thesis employs the Triple Helix Theory to analyse how the dynamic interplay between government, academia, and industry influences each park's development. This approach provides a nuanced understanding of how each park addresses unique challenges and leverages its strengths, influenced by the distinct roles and contributions of each helix component. The research illustrates the flexibility of the Triple Helix model in fostering academic collaboration, commercial viability, and government support, ultimately creating robust, self-sustaining innovation ecosystems. Findings underscore the importance of long-term strategic planning, technological adaptability, and balanced Triple Helix collaboration, all enhanced by the advantages of agglomeration in health sciences industry.

The thesis concludes with policy and practical recommendations, emphasizing China's health sciences parks as models for other emerging economies. China's experience highlights how government-facilitated infrastructure, combined with Triple Helix integration and the benefits of agglomeration, creates resilient clusters that drive innovation and contribute to economic growth, offering valuable insights for science park development globally.

List of Abbreviations:

Abbreviation	**Expansion**
AI	Artificial Intelligence
AMGen	Applied Molecular Genetics Inc.
Bayer	Bayer et comp.
BD	Becton, Dickinson and Company
BIO	Biotechnology Industry Organization
BioBay	Suzhou Biomedical Industrial Park
Biogen	Biogen Inc.
BioM	Munich Biotech Cluster
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CNY	Chinese Yuan
CSP	Cambridge Science Park
Covid-19	Coronavirus Disease 2019
CRO(s)	Contract Research Organization(s)
DNA	Deoxyribonucleic Acid
ETDZ(s)	Economic and Technological Development Zone(s)
FDA	The U.S. Food and Drug Administration
GDP	Gross Domestic Product
GMOs	genetically modified organisms
GSK	GlaxoSmithKline
HIDZ(s)	High Technology Industrial Development Zone(s)
HKEx	Hong Kong Stock Exchange
IND	Investigational New Drug
IP	Intellectual property
IPO(s)	initial public offering(s)
MAR	Marshall–Arrow–Romer
MNC(s)	multinational corporation(s)
MSP	Manchester Science Park
PPP(s)	public-private partnership(s)
WTO	World Trade Organization
R&D	research and development
RTP	Research Triangle Park
SASAC	State-owned Assets Supervision and Administation Commision of the Sate Council, PR China.
SBIIP	Shenzhen Biomedicine Innovation Industrial Park
SEZ	Special Economic Zones
SIP	Suzhou Industrial Park
SIPAC	SIP Administration Committee
SME(s)	small and medium-sized enterprise(s)
SOE(s)	state-owned enterprise(s)
STAR Market	Science and Technology Innovation Board of Shanghai Stock Exchange
STEM	science, technology, engineering, and mathematics
SUSTech	Southern University of Science and Technology
SZU	Shenzhen University
URE(s)	university-owned enterprise(s)
XBCB	The Xi'an High-tech Zone Biomedical R&D Cluster Base
ZCPV	Zhangjiang China Pharmaceutical Valley
ZLSP	Zhongguancun Life Science Park
Z-Park	Zhongguancun Science and Technology Park
Z-Park Committee	Management Committee to Zhongguancun Science and Technology Park Management Committee

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Chapter 1. Introduction: Science Parks in International Context

The primary aim of this thesis is to investigate the role of health sciences parks in fostering innovation and economic growth in China, with a particular emphasis on the planning, management, and collaborative mechanisms that contribute to their effectiveness. The core argument centres on the longstanding and evolving relationship between science and industry, a driving force of economic progress since the nineteenth-century Industrial Revolution (Bernal, 1953). This dynamic has continued to advance with each technological leap—from the commercialization of academic science (Czarnitzki, Hussinger, & Schneider, 2011) to the emerging foundations of the Fourth Industrial Revolution. Today, science, technology, engineering, and mathematics (STEM) disciplines are essential for industrial innovation. This interdependence has spurred policymakers worldwide to explore mechanisms for systematically nurturing science-industry collaboration. One of the most tangible responses has been the establishment of science parks: purpose-built environments where academia, government, and industry intersect to generate and commercialize innovation.

Science parks are key components of the knowledge-based economy, facilitating ecosystems where research, innovation, and entrepreneurship converge (Etzkowitz & Leydesdorff, 2000). As international networks expand, science parks have become strategic for regional development, advancing technological progress and fostering global collaboration (Squicciarini, 2008). The proliferation of science parks worldwide has inspired extensive research on their roles, impacts, and the factors contributing to their successes and challenges (Ferguson & Olofsson, 2004; Bigliardi et al., 2006). Identified as essential players in regional and national innovation strategies, science parks have drawn attention for their potential to drive economic growth and competitiveness.

China has shown a particularly strong commitment to the science park model, through fostering collaboration among academia, industry, and government—a model known as the Triple Helix, first implementing it in the 1988 Torch Plan, which established high-tech industrial zones and entrepreneurship centres nationwide. By the end of 2019, approximately 193 of China's 387 national-level industrial parks (168 high-tech zones and 219 economic zones) specialized in health sciences, accounting for nearly half of the total. This intense focus on health sciences parks presents academic questions about the design, development, and effectiveness of these parks in promoting innovation and academia-government-industry collaboration.

China's significant growth and shift toward health sciences call for a systematic examination, as existing literature primarily covers general science parks or isolated case studies on specific parks, rather than a comprehensive review of health sciences parks in China. This thesis contributes to the literature on place-based innovation through an in-depth exploration of health sciences parks in China, with implications for policy and practice. By analysing the specific characteristics, strategic planning, and collaborative models within these parks, the study enhances our understanding of the mechanisms driving innovation in health sciences, particularly in China. Focusing on diverse case studies across various regions largely through interviews, this empirical investigation highlights the factors influencing park success, the roles of local governments, academia, and industry partnerships, highlighting the adaptability needed for implementing the Triple Helix model within Chinese institutions and across China's diverse landscapes. The thesis has the following specific objectives and research questions:

Objectives:

- Analyse the role and evolution of health sciences parks within the broader international context of science parks.
- Explore the distinctive characteristics of health sciences parks in China, with a focus on planning, design, and sectoral focus.
- Assess the factors influencing location decisions and competitive dynamics among health sciences parks in China.
- Examine the role of academia-industry-government collaboration in the operation and success of these parks.
- Provide policy recommendations for enhancing the contribution of health sciences parks to regional and national innovation agendas.

Research Questions:

General overarching:

With so many potential locations to choose from what makes some locations more or less attractive to businesses and scientific researchers? Furthermore, to what extent does these market preferences influence the planning of heath science parks?

From these general overarching questions, I can formulate a group of specific research questions that will define the limits of this study.

Specific questions:

1. To what extent does the Triple Helix accurately account for the process by which health sciences parks have developed in China?
2. Has the state-orchestrated nature of health science park development in China contributed to any variations in how they have developed in contrast to the well-researched examples from Western settings?
3. What drives business decision making with regard to choosing a health sciences park? What variables are most important in determining where businesses choose to locate?
4. What drives scientist decision making with regard to choosing a health sciences park? What variables are most important in determining where businesses choose to locate?
5. To what extent do local decision makers consider the most important determinants of the location decisions made by businesses and scientists when implementing plans for the development of health sciences parks?
6. Do health sciences parks compete for some potential occupants? How do they compete? What incentives are used to attract desirable companies/scientists.

Overviews:

To achieve the research objectives, the thesis is organised into 9 chapters.

Chapter 1. Introduction: Science Parks in International Context

This chapter briefly introduces the concept of science parks, contextualizing it within global innovation and economic strategies.

Chapter 2. Science Parks in Theory: Understanding the Case for Place-Based Innovation

This chapter delves into the theoretical underpinnings of science parks, examining the concepts of knowledge spillovers, agglomeration, and the Triple Helix model. It also explores the principles and practices of science parks and their historical development.

Chapter 3: Health Sciences Parks

This chapter focuses on health sciences parks, discussing their unique characteristics, as well as providing a brief on the first health sciences park and some other representative science parks around the world.

Chapter 4: Health Sciences Parks in China

This chapter examines the emergence and development of health sciences parks in China, analysing their unique characteristics and their role in the country's healthcare and life sciences industries.

Chapter 5. Studying Health Sciences Parks: Data Collection, Methodology, and Research Design

This chapter outlines the research methods, data collection techniques, and ethical considerations involved in studying health sciences parks, as well as the approach to interpreting and reporting findings.

Chapter 6. Case Studies

This chapter presents detailed case studies of selected health sciences parks, highlighting their unique attributes, challenges, and successes, as well as their contributions to innovation, collaboration, and economic growth within the healthcare and life sciences sectors.

Chapter 7. Analysis on the Case Studies

This chapter compares and contrasts the case studies, identifying common factors and best practices that contribute to the success of health sciences parks.

Chapter 8. Implications for Policy and Practice: Lessons Learned from Health Sciences Parks

This chapter discusses the implications of the research findings for policymakers, park managers, and other stakeholders involved in the development and operation of health sciences parks, especially for China. It offers recommendations based on the lessons learned from successful health sciences parks.

Chapter 9. Conclusion

This concluding chapter synthesizes the key findings of the thesis, highlighting the role of science parks, and particularly health sciences parks, in fostering innovation and economic growth in both international and Chinese contexts. It reiterates the importance of understanding the factors that contribute to the success of these innovation hubs and their impact on regional development, the healthcare and life sciences industries, and the broader economy. The chapter also reflects on the implications of the research findings for policy and practice and offers directions for future research in this area.

Chapter 2. Science Parks: Understanding the Case for Place-based Innovation

Science parks have become an important feature of many modern urban landscapes. The versatility of the concept can be seen in the diversity of settings where it has been implemented. However, behind this superficial variety in places that now accommodate science parks as part of their urban fabric the underlying concept remains consistent: providing a physical space in which private businesses, government support and scientific research mix can result in innovative products and services.

This raises some important academic questions. Firstly, what is the economic theory that provides the evidentiary basis for this underlying concept? Secondly, what is the empirical experience of those science parks that have existed, in various places, since the 1950s and 1960s? Thirdly, what lessons can be learnt from the existing literature regarding what works and why? This final question entails a host of practical issues that relate to the specifics of science park design: where should they be located; how large should they be; what should be their theme; how should they be planned to fit into the existing urban landscape?

In this chapter, these three related issues are systematically reviewed.

2.1 The Origination of Science Park Phenomenon

The origin of the science park phenomenon can be traced back to the early post-World War II era, particularly the establishment of Stanford Industrial Park in 1951, which is widely recognized as the world's first science park. This initiative was conceived by Stanford University's desire to solve financial challenges and foster closer relationships between academia and industry (Löfsten & Lindelöf, 2002). The model combined the R&D capabilities of a university with the commercial acumen of the private sector, fostering an environment where academic research could transition seamlessly into marketable innovations (Diez-Vial & Montoro-Sanchez, 2016). The success of Stanford Industrial Park inspired the development of similar parks globally, emphasizing the role of universities in regional economic development (Siegel, et al., 2003). Science parks have since become crucial nodes in innovation ecosystems, combining talent, technology, and capital to drive regional and national economic growth (Link & Scott, 2006). The science park phenomenon reflects an evolution in the relationship between universities and the business sector, aiming to bridge the gap between theoretical research and practical application.

2.2 Science Parks in Theory: Agglomeration and the Triple Helix

The academic case for science parks can be found in a body of literature on economic geography that provides the theoretical basis for collecting capital investment, entrepreneurship, and scientific research together in one physical space (Hobbs, Link, & Scott, 2017). Fundamentally, the origins of this academic literature can be traced back to the neoclassical idea of 'knowledge spillovers' and the parallel development of agglomeration economics and finally its popularization in the triple and quadruple helix theories of urban and regional development.

2.2.1 Knowledge Spillovers

Knowledge, as a resource, yields extensive external effects, or spillovers, resulting in the accumulation of knowledge and the continuous production of new knowledge based on acquired competencies, skills, and experience (Corredoira & Rosenkopf, 2010). This phenomenon, known as knowledge spillovers, is pivotal for driving innovation and economic growth. Arrow (1962) and Romer (1990) extensively discuss the significance of knowledge spillovers in fostering technological progress and regional development. These spillovers facilitate the exchange of ideas among individuals and entities, driving innovation (Carlino, 2001). Geographical proximity amplifies the likelihood of knowledge spillovers, leading to the clustering of innovative activities in specific regions or science parks (Breschi & Lissoni, 2001). They are facilitated by various channels, including informal interactions among researchers, joint research projects, and the mobility of skilled workers (Jaffe, et al., 1993).

Two primary types of knowledge spillovers are recognized: internal and external. Internal knowledge spillovers occur within an organization, leading to the creation of new goods and/or services, while external spillovers occur between entities outside an organization (Trachuk & Linder, 2019). Theoretical Perspectives, there are three principal schools of thought on knowledge spillovers include the 'MAR Spillovers’, 'Jacobs Spillovers’, and 'Porter Spillovers' (Trachuk & Linder, 2019).

MAR Spillovers

The origins of the academic thinking on knowledge spillovers can be found in the combined works of Alfred Marshall, Kenneth Arrow and Paul Romer. The consonance of the three economists thinking on this subject has led to their combination in the so-called “Marshall-Arrow-Romer” models (MAR). Marshall–Arrow–Romer (MAR) spillovers, Porter spillovers and Jacobs spillovers are three types of spillovers. (Trachuk & Linder, 2019)

The Marshall–Arrow–Romer (MAR) theory of knowledge spillovers has its origins in the 1890 work of English economist Alfred Marshall combined with that of US economists Kenneth Arrow (1962) and Paul Romer (1986). The formal combination of these three bodies of work was accomplished when Edward Glaeser, Hedi Kallal, José Scheinkman, and Andrei Shleifer drew common conclusions that allowed for the identification of the MAR spillover model in 1992 (Jaffe, et al., 2000). According to MAR theory, the concentration of firms in one sector (industry) facilitates scientific knowledge transfer between these firms encouraging growth and innovation (Cerchione & Esposito, 2017). Employees of different companies within the same sector (industry) from a common labour pool exchange ideas for new products and processes (Cerchione & Esposito, 2017). The connection to agglomeration economics can be found in the logical next step: the higher the concentration of employees with similar specialization within a territorially delineated “travel to work area” (TTWA) the greater the possibility for the exchange of ideas that can further lead to innovative solutions (Cerchione & Esposito, 2017). Frequently the latest data on technological breakthroughs and know-how keeps its value for a very short period, spreading among the professional community afterwards (Cerchione & Esposito, 2017). That is why firms aim to locate their research and development (R&D) centres close to the sources of such data determining the formation of technological clusters (Glaeser, et al., 1992).

Jacobs Spillovers

In 1969, Jane Jacobs developed another theory of knowledge spillovers. Under Jacob's model, the proximity of firms from different industries is understood to affect how well knowledge travels among firms to facilitate innovation and growth (Carlino, 2001). This is in contrast to MAR spillovers, which focus on firms in a common industry. Jacobs used the conclusions of her work to argue for diversity as the major engine for social and economic innovations, because "the greater the sheer number of and variety of division of labour, the greater the economy's inherent capacity for adding still more kinds of goods and services" (Jacobs, 1969). Jacobs also argued that the rate of innovation is greater in cities with competitive market structures as competitive local environments foster the introduction of new methods and new products. Whereas this is in contrast to the MAR view which predicts that local monopoly is superior to local competition because innovating firms recognize that neighbouring firms may imitate their ideas without compensation; therefore, firms in locally competitive environments may invest less in R&D because they do not reap the full benefit of such investment (Carlino, 2001).

Porter Spillovers

Porter (1990) agrees with the MAR model that the most important technological externalities are within industry and knowledge spillovers in specialized, geographically concentrated industries stimulate growth both in the specialized industries and in the cities where they are located. However, the effect of local competition marks the primary difference between MAR and Porter's models (Carlino, 2001). Porter argues that local competition as opposed to local monopoly fosters imitation and the pursuit and rapid adoption of innovation, thus favouring the transmission of knowledge in specialized, geographically concentrated industries (Glaeser, et al., 1992).

The above three prevailing theories on knowledge spillovers differ fundamentally in two aspects. First, they diverge on the origin of these spillovers—whether they emerge from within a specialized industry or across a variety of diversified, yet geographically proximate industries. From this perspective, both MAR and Porter's theories emphasize industry-specific spillovers, while Jacobs highlights the benefits of industrial diversity. Second, these theories differ in their views on the role of local competition in fostering innovation. Jacobs and Porter argue that local competition encourages innovation, in contrast to the MAR theory, which suggests that concentrated industry power, akin to local monopolies, could inhibit innovation.

2.2.2 Agglomeration

All three schools of thinking on knowledge spillovers discussed in the previous section have clear geographic implications. Knowledge spillovers require the development of a common pool of labour that is spatially connected to a locally significant industry. It has correspondingly become common to think of knowledge spillovers and innovation as counterparts to the geographic assemblage of industrial specialisms. This school of thinking has come to be known as agglomeration economics. The idea of agglomeration economies, which emphasizes the spatial concentration of firms, industries, and knowledge, has clear geographic implications. Knowledge spillovers, in this context, require a critical mass of human capital and industry-specific expertise that are geographically clustered, often within urban areas or specialized industrial districts (Beaudry & Schiffauerova, 2009). As industries and firms cluster together, they form a localized ecosystem where ideas can flow freely and where the shared resources foster innovation and growth. This phenomenon has been widely discussed in terms of agglomeration economies, which refer to the benefits derived from firms and people locating close to one another in dense urban environments or industrial clusters (Combes & Gobillon, 2015). When firms form clusters of economic activity, particular development strategies flow in and throughout this area of economic activity. This helps to accumulate information and the flow of new and innovative ideas among firms for the achievement of what economists call increasing returns to scale (Glaeser, 2010).

The argument for agglomeration is underpinned by the assumption that cities or industrial clusters, by virtue of their size, density, and specialization, create fertile ground for knowledge spillovers. Scholars have long argued that urban environments, due to their capacity to gather diverse human capital and expertise, are more conducive to innovation and entrepreneurial activities (Romer, 1987). The accumulation of human knowledge in these agglomerations accelerates the rate at which new ideas are generated, enhancing not only individual human capital but also fostering a more dynamic innovation environment (Combes & Gobillon, 2015).

However, while agglomeration is often viewed as an inherently beneficial process, it is not without its complexities and potential downsides. One key issue is that agglomeration does not always equate to a win-win scenario (Saxenian, 1996). The benefits of agglomeration may be unevenly distributed, with certain sectors, firms, or individuals capturing the majority of the knowledge spillovers while others are left behind. This can lead to increased competition, especially in highly concentrated sectors, where smaller firms or newcomers struggle to access the same resources or market opportunities as more established players. In some cases, agglomeration can lead to displacement rather than development (Saxenian, 1996), particularly for local businesses or industries that find it difficult to compete with larger, more resource-rich firms within the cluster.

Moreover, while the flow of knowledge and ideas is central to the concept of agglomeration, it is important to recognize that such flows are not guaranteed. The effectiveness of knowledge spillovers is contingent on the quality of connections (Breschi & Lissoni, 2001) between firms and institutions, and not all clusters are equally conducive to these interactions (Morrison & Rabellotti, 2009). In some cases, firms may become isolated in specialized silos within the cluster, limiting the potential for cross-sectoral collaboration and innovation. The presence of dominant firms or institutions within a cluster can also result in barriers to entry (Porter, 1998; Storper & Venables, 2004) for smaller players, creating a less competitive and less inclusive innovation environment.

Additionally, the role of science parks in fostering agglomeration should be critically assessed. While science parks are often designed to stimulate innovation through the co-location of academia, industry, and government, the results are not always as positive as expected. Science parks can sometimes prioritize commercial interests or the goals of large corporations over the more diverse needs of the local community or smaller entrepreneurs. This can lead to unequal development (Feldman, 1994; Saxenian, 1996) within the park, where larger, resource-rich firms receive the lion's share of benefits from the park's infrastructure, while smaller startups or academic institutions may struggle to gain the same level of support.

Furthermore, the physical design and planning of science parks can either facilitate or hinder the flow of ideas and knowledge. While dense clustering may encourage informal knowledge exchange in some cases, the physical layout of a park, its management structure, and its cultural dynamics can either promote or restrict interaction between firms and between academia and industry. Thus, the success of science parks in fostering innovation may depend as much on organizational factors (Löfsten & Lindelöf, 2002; Bruneel, et al., 2012) and social capital (Nahapiet & Ghoshal, 1998; Bathelt, et al., 2004; Adler & Kwon, 2002) as it does on the mere concentration of resources.

Many recent papers on agglomeration economies have followed the MAR and Jane Jacobs understanding of agglomeration and have emphasized the role that cities can play in accelerating the flow of ideas. The core idea at the centre of information-based agglomeration economies is that, as the collective well of human knowledge increases in larger and larger urban agglomerations, so too the potential for innovations grows. The interaction of people with specialist knowledge in urban areas both enhances the development of person-specific human capital and increases the rate at which new ideas are formed (Combes & Gobillon, 2015). Nevertheless, it is essential to question whether agglomeration is inherently beneficial in the context of rapid urbanization and specialization. As urban areas grow and industries become increasingly specialized, the risk of economic segregation (Florida, 2002; Musterd & Ostendorf, 2013) also increases. Large-scale agglomeration can drive up costs of living, create environmental pressures, and lead to social inequalities, which can undermine the very innovation and growth it seeks to foster. Furthermore, if not managed effectively, agglomeration can exacerbate regional disparities (Martin & Sunley, 2003), with wealth and talent being concentrated in a few urban centres at the expense of less-developed areas.

In summary, while the concept of agglomeration economics has clear merit in explaining the geographic clustering of industries and the role of knowledge spillovers in fostering innovation, it is essential to critically assess its complexities. The benefits of agglomeration should not be taken for granted, and the role of science parks in encouraging innovation must be understood within the broader context of local development strategies and social dynamics. A more nuanced understanding of agglomeration, one that accounts for the potential for displacement, inequality, and uneven development, will provide a more comprehensive framework for evaluating its role in contemporary industrial and urban development.

2.2.3 Triple Helix and Extensions of the Model

Triple Helix Model

The Triple Helix model, a significant concept derived from the academic exploration of agglomeration and knowledge spillovers, was first theorized by Henry Etzkowitz and Loet Leydesdorff in the 1990s, with the publication of “The Triple Helix, University-Industry-Government Relations: A laboratory for Knowledge-Based Economic Development” (Stanford University Triple Helix Research Group, 2011). Further developed by Etzkowitz and Leydesdorff (1995), it evolutes from focusing on the synergistic interaction between business, university-based research, and government to foster economic and social development (Dumais, et al., 2002) and has become a foundational concept for understanding the interactions between university, industry, and government in fostering innovation. It presents a dynamic framework where these three entities—each traditionally occupying distinct roles—

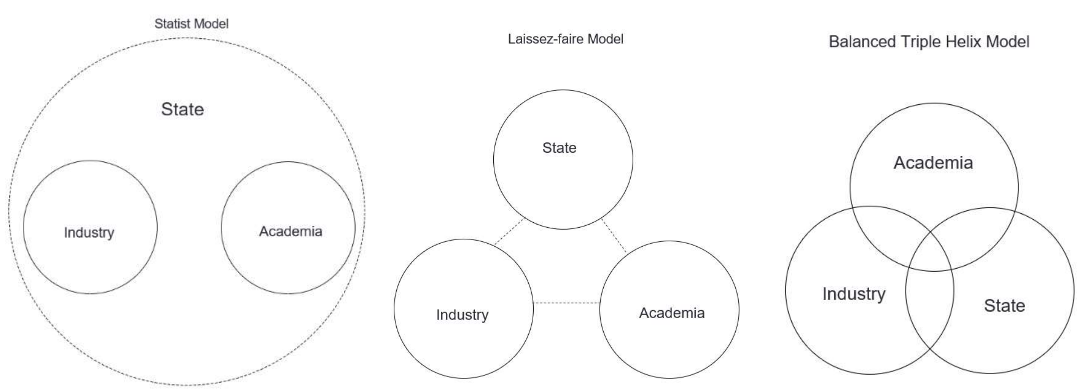
interact and evolve into new hybrid institutions. As these interactions increase, the boundaries between government, industry, and academia blur, leading to the creation of entities like technology transfer offices and science parks (Leydesdorff, 2012; Smith & Leydesdorff, 2012). In this context, universities are no longer just centres of education and research; they become active participants in commercializing knowledge and fostering innovation ecosystems (Etzkowitz & Leydesdorff, 2000).

The theory of the Triple Helix model of innovation is presented by three circles (helices), representing university, industry, and government, respectively. Each component in the model is associated with an 'initial role' (Etzkowitz & Leydesdorff, 1995): universities are heavily engaged in research and supplying a highly educated workforce; industries are responsible for production and commercialization, and governments regulate markets (Smith & Leydesdorff, 2012). As interactions increase within this framework, each component evolves to adopt some characteristics of the other institution, which then gives rise to hybrid institutions, such as technology transfer offices and science parks (Leydesdorff, 2012). Etzkowitz and Leydesdorff theorized the relationship between the three components (helices) and explained the emergence of these new hybrid organizations (Leydesdorff, 2012).

The model theorizes that the strength of interactions among these three components varies according to a country's developmental stage. In underdeveloped nations, the interactions between university, industry, and government are often siloed, with limited collaboration, while middle-income countries display moderate and less integrated connections (Kimatu, 2016). In developed countries, strong collaborations and high degrees of integration are often realized through well-established science parks and research clusters (Etzkowitz, 2003). The Triple Helix model has been lauded for its ability to explain the mechanisms through which innovation emerges from these interactions, particularly in knowledge-intensive sectors.

Etzkowitz and Leydesdorff (2000) and Etzkowitz (2003) delineate three Triple Helix models: the statist model, the laissez-faire model, and the balanced model (Figure 1). The balanced model integrates elements from both the statist and laissez-faire approaches, promoting collaborative interactions while maintaining autonomy (Etzkowitz, 2008).

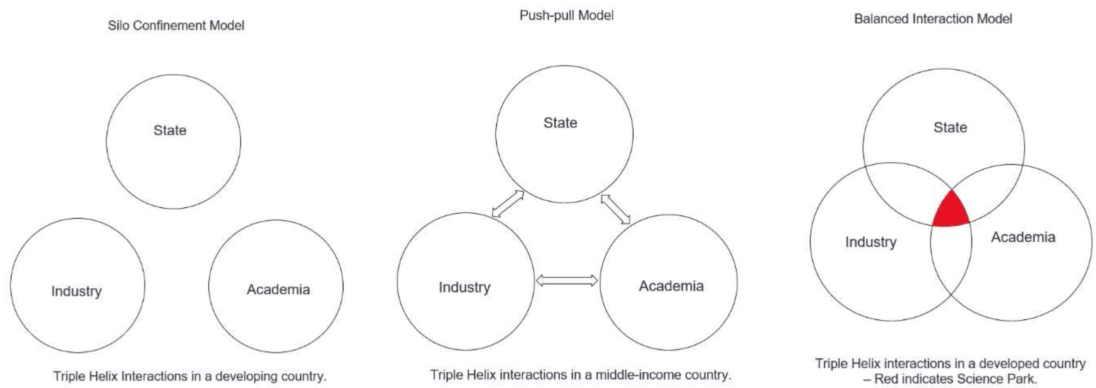
Figure 1: Types of The Triple Helix Models



Source: drawn by the author based on the models in Etzkowitz and Leydesdorff (2000) and Etzkowitz (2003).

The strength of interactions among university, industry, and government varies across nations' developmental stages, with underdeveloped countries often characterized by distinct separation between the three components of the model (1st panel in Figure 2), middle-income nations displaying moderate interactions where the functions are distinct and less collaborative in nature (2nd panel in Figure 2), and developed countries fostering strong collaborations exemplified (3rd panel 3 in Figure 2) (Kimatu, 2016).

Figure 2: Triple Helix Interaction Across Nations' Development Stages



Source: drawn by the author based on the models in (Kimatu, 2016)

However, the model's simplicity—while effective in certain contexts—has also been criticized for glossing over the complexities of these interactions. Critics argue that the model assumes an idealized, cooperative relationship between the three helices, whereas in reality, tensions and power imbalances often exist (Hekkert et al., 2007). For example, the dominance of government or industry over academia may stifle creativity or limit the free flow of ideas. Moreover, the model's focus on innovation as a linear, somewhat deterministic process may neglect the disruptive potential of non-institutional actors, such as grassroots organizations or independent innovators, who are often excluded from formal science park structures (Fritsch & Lukas, 2001).

Furthermore, the model tends to prioritize economic objectives—such as commercializing academic research and attracting investment—at the expense of broader societal goals like inclusivity or social justice. The exclusion of marginalized communities or the failure to address the social and environmental impacts of innovation can lead to uneven development and perpetuate existing inequalities (Gibbons, 1994). In this regard, while the Triple Helix model offers useful insights, it requires refinement to account for the complexities of innovation in practice, particularly when applied to different socio-political and economic contexts.

Quadruple Helix Model

Building on the Triple Helix model, Carayannis and Campbell (2009) first posed the quadruple helix model in 2009 (Cavallini, et al., 2016) as an extension of the Triple Helix understanding of the ingredients of innovation. In the quadruple helix model, a fourth component was added to the framework of interactions between university, industry and government (Kimatu, 2016), which is the public, consisting of civil society and the media (Galvao, et al., 2019). This extension acknowledges that innovation does not occur in a vacuum and that societal involvement is critical for ensuring that the benefits of innovation are equitably distributed. Public engagement is seen as essential for aligning the goals of innovation with societal needs and values, particularly in sectors with broad social implications, such as health, education, and environmental sustainability (Galvao et al., 2019). The Quadruple Helix framework aims to bridge the gaps between innovation and civil society, under which the fourth helix, the public is brought to match the demands and needs of society to better enable innovation. The framework emphasizes the societal responsibility of universities, in addition to their role of educating and conducting research.

The quadruple helix is the approach that the European Union has intended to take for the development of a competitive knowledge-based society (Carayannis & Campbell, 2009) and has been applied to various European Union-sponsored projects and policies.

While the Quadruple Helix model expands on the Triple Helix by incorporating the public as a key actor, it is not without its critiques. A central concern is the assumption that public participation will automatically lead to positive outcomes. Engaging the public in decision-making and innovation is important, but the model often overlooks the complexities of such engagement. For example, public involvement can become superficial if stakeholders lack the necessary expertise or if the process is dominated by powerful interest groups, leading to tokenistic participation rather than meaningful dialogue (Pohl & Hadorn, 2007). Moreover, broadening the innovation process to include the public may inadvertently slow decision-making, introduce inefficiencies, or dilute innovation objectives.

Additionally, the model tends to treat "the public" as a homogeneous entity, overlooking the diversity and fragmentation within civil society. In reality, there are a wide array of competing interests and stakeholders—such as environmental NGOs, local communities, labor unions, and indigenous groups—each with their own priorities. Engaging such a diverse group requires nuanced strategies to ensure that marginalized or underrepresented voices are heard, without being co-opted by dominant interests (Felt et al., 2013). Thus, while public involvement is a valuable aspect of the Quadruple Helix, the model's assumptions about its effectiveness and the challenges of managing diverse public interests warrant closer scrutiny.

Moreover, the top-down nature of many innovation policies and the emphasis on institutionalized actors such as universities and corporations may limit the potential for more grassroots, community-driven innovation. While the Quadruple Helix promotes public involvement, it does not always provide adequate mechanisms for democratic participation, particularly in regions or sectors where innovation processes are still controlled by elite institutions or large corporations. This could undermine the inclusivity that the model strives to promote, leading to a situation where only certain voices are heard and certain issues are prioritized (Pohl & Hadorn, 2007).

Etzkowitz and Leydesdorff recognized the importance of including 'the public' as a foundational element rather than a separate entity, arguing that democratization and public participation are essential for a bottom-up approach in university–industry–government relations (Etzkowitz & Leydesdorff, 2002). This approach advocates for a more sustainable and socially engaged direction in technological development, emphasizing the necessity of rethinking interaction dynamics to increase public involvement and accountability in innovation policies.

Quintuple Helix Model

Building on the Triple Helix and the Quadruple Helix, Carayannis and Campbell (2010) introduced the Quintuple Helix model, which incorporates a fifth component: the natural environment (Kimatu, 2016). This extension acknowledges the increasing importance of ecological factors and environmental sustainability in contemporary innovation processes, particularly in the context of global challenges such as climate change, biodiversity loss, and environmental degradation (Carayannis et al., 2012).

The Quintuple Helix conceptualizes the interaction between five subsystems: university, industry, government, civil society, and the natural environment. In this framework, the natural environment is not simply a passive backdrop for innovation but an active driver for knowledge production and technological development. The natural environment, including the challenges it presents, is seen as a source of innovation opportunities, motivating the development of green technologies, eco-innovation, and sustainability practices. For instance, innovations aimed at addressing climate change, reducing carbon emissions, and promoting resource efficiency are framed as critical components of the knowledge economy, and the Quintuple Helix positions these innovations as central to the modern socio-ecological landscape (Carayannis et al., 2012).

The Quintuple Helix model stresses the need for a socio-ecological approach to innovation, wherein societal values, needs, and ecological considerations are deeply integrated into the knowledge creation process. In this way, it moves beyond traditional economic models of innovation by placing emphasis on societal responsibility, sustainability, and inclusivity. According to Carayannis and Campbell (2010), the model is especially relevant in the context of the knowledge society, where the production and dissemination of knowledge are increasingly intertwined with societal challenges and environmental imperatives.

While the inclusion of the natural environment as a fifth helix reflects a forward-thinking and comprehensive understanding of innovation, this extension is not without its critiques. One of the primary criticisms of the Quintuple Helix model is that, while it acknowledges environmental and societal concerns, it does not fully address the tensions between these goals and traditional economic objectives. The model assumes that integrating environmental and societal factors into innovation will automatically lead to sustainable outcomes. However, there are often trade-offs between economic growth and environmental sustainability, particularly in industries that rely on fossil fuels or resource extraction. Critics argue that the model oversimplifies the process of reconciling these competing interests, potentially underestimating the complexity of balancing environmental, economic, and social goals (Tushman & Anderson, 2004).

In practice, the Quintuple Helix model's emphasis on sustainability may encounter resistance from industries and policymakers whose priorities are primarily focused on economic growth and technological advancement without sufficient consideration for the environmental costs. The model's idealistic vision of collaboration between the five helices can sometimes be at odds with the realpolitik of innovation systems, where power dynamics, vested interests, and resource constraints often impede genuine cooperation. For example, while the natural environment is positioned as a key driver for innovation, industries that are deeply entrenched in environmentally harmful practices may not be fully motivated to adopt green technologies unless they are incentivized through strong policy measures or financial motivations (Hoberg, 2009).

Moreover, another criticism is that the Quintuple Helix may lack operational clarity in terms of how the interactions between the five subsystems unfold in practice. While the model presents a broad, theoretical framework for socio-ecological innovation, its real-world application may face difficulties in terms of coordination, governance, and resource allocation across such a diverse range of actors. The challenge of managing and aligning the interests of universities, industries, governments, civil society, and environmental considerations requires new forms of governance that go beyond traditional models of innovation management (Gibbons, 1994).

The Quintuple Helix model provides a compelling vision for integrating environmental and societal concerns into the innovation process, recognizing that knowledge production and technological advancements must increasingly be aligned with the broader goals of sustainability and social responsibility. It also highlights the importance of public engagement and the need for cross-sector collaboration in addressing complex global challenges. However, the model also faces several important criticisms, primarily around its assumptions of seamless cooperation between the five helices and its idealistic view of environmental sustainability. The real-world complexities of reconciling economic, environmental, and social goals are often much more contentious, involving significant power dynamics, trade-offs, and resistances from various stakeholders. Moreover, the model's focus on institutionalized actors may limit the potential for more inclusive, grassroots innovation that could be more adaptable to local needs and context. As such, while the Quintuple Helix model represents an important step in conceptualizing a more holistic and inclusive approach to innovation, its practical application requires greater attention to the challenges of power relations, stakeholder engagement, and governance. Future research should explore ways to operationalize the Quintuple Helix more effectively, particularly in addressing the barriers to genuine collaboration and inclusivity and ensuring that the benefits of innovation are equitably distributed across society and the natural environment.

Evolution of the Triple Helix Models

Cai and Etzkowitz (2020) offer a comprehensive exploration of the Triple Helix model's development, emphasizing the evolving dynamics of collaboration among universities, industries, and governments as a driving force for innovation and economic growth. Originally conceptualized in the 1990s, the Triple Helix model has shifted from a straightforward framework highlighting these three pillars to a more intricate structure that adapts to different national and regional contexts, illustrating how varied political, cultural, and economic factors shape the interactions within each helix. The study not only outlines the core theoretical constructs and origins of the Triple Helix model but also reviews its global adaptations and implementations. For instance, the model's flexibility has allowed it to adapt across diverse innovation ecosystems, from state-led economies to market-driven contexts, underscoring its versatility. Countries with strong state involvement, like China, have integrated the model to reinforce government-led innovation through close collaboration with academic institutions and industry. In contrast, in more decentralized and market-oriented systems, such as the United States, the model has adapted to emphasize industry-driven research with government support and academic partnerships, promoting private-sector leadership in innovation.

One of the model's strengths lies in its integration with broader social science frameworks, including institutional logics and social network theory. These frameworks enrich the model by providing nuanced insights into the roles, motivations, and constraints of each actor in the innovation ecosystem. For example, institutional logics offer a lens through which to examine how differing priorities among universities, industry, and government can either hinder or drive collaborative efforts. Similarly, social network theory highlights the importance of relationships and trust-building in fostering effective partnerships, revealing that successful innovation ecosystems often emerge from dense, well-connected networks that transcend organizational boundaries.

While the Triple Helix and its extensions provide valuable frameworks for understanding innovation systems, they are not without limitations. Critics argue that the idealized view of collaboration within these models often overlooks power imbalances and resource inequalities among the three helices. Cai and Etzkowitz (2020) also address critiques of the model, particularly the assumption of an equal, harmonious partnership between the three actors. In reality, power imbalances, conflicting goals, and resource disparities can hinder collaboration, requiring adaptable strategies to align the interests of each helix. Looking forward, the model's flexibility presents multiple avenues for further research and practical application, particularly in developing economies where innovation ecosystems are still maturing.

Overall, the evolution of the Triple Helix models reflects a recognition of the need for flexibility, inclusivity, and sustainability in innovation systems. As the challenges facing modern society become more complex, the role of the Triple Helix and its extensions in guiding innovation remains crucial, providing a robust foundation for creating dynamic, adaptable, and socially responsible innovation ecosystems.

The evolution of the Triple Helix models has opened new research avenues and practical applications in developing innovation ecosystems. These models continue to be relevant in policy design, as they provide a structured way to align academic research, industrial goals, and government policies with societal needs and environmental concerns. To strengthen the Triple Helix framework, future research should explore nuanced governance mechanisms, foster multi-level stakeholder engagement, and integrate digital technologies that facilitate cross-sector collaboration (Leydesdorff & Strand, 2013).

2.2.4 From Theory to Practice: realizing the science park vision

The academic research reviewed above underscores the essential role of space and proximity in understanding how knowledge is generated, disseminated, and shared. Central to theories of agglomeration economics, university-industry-government partnerships, and knowledge spillovers is geography—each element hinges on stakeholder proximity. This geographic focus has shaped policies aimed at fostering innovation-driven economic growth, leading to the establishment of purpose-built environments known as science parks. These parks are designed to leverage close interactions to accelerate innovation, translating academic and technological research into commercially viable outcomes.

However, the history and context of science parks reveal complexities and contentions that challenge the notion of these parks as universally beneficial. Originally developed in the mid-20th century, early science parks were not solely centres for innovation but were also linked to national security concerns, specifically in nuclear and defence technology. For instance, science parks in the United States, such as the Stanford Research Park, provided physical spaces where military research could thrive alongside private-sector innovation, which raised ethical and social concerns regarding the role of military funding in shaping scientific research agendas. This aspect of science parks, where defence and industrial interests intersect, has sparked debates about the social accountability of science and technology initiatives tied to such facilities.

Moreover, science parks have been criticized for their role in urban regeneration strategies that may inadvertently contribute to economic gentrification. While they often aim to revitalize urban or suburban areas by attracting high-tech industries and skilled workers, the outcomes are sometimes mixed. Gentrification—a byproduct of higher property values and the influx of more affluent residents—can displace existing communities, raising concerns about inclusivity and equitable economic growth (Harvey, 1989). In this sense, science parks have been seen by some as instruments that prioritize economic development over social equity, which can create tensions within urban planning.

Further critiques highlight the uneven success rates of science parks in achieving their goals. Although some parks, such as Cambridge Science Park in the United Kingdom, have succeeded in fostering innovation ecosystems, others have struggled with low occupancy rates and limited economic impact. This disparity often arises from varying regional contexts, local capabilities, and the sustainability of public funding, indicating that science parks are not a one-size-fits-all solution. Scholars argue that without careful integration into local economies and alignment with regional strengths, science parks can become isolated “innovation islands” that fail to stimulate broader economic activity (Cooke, 2001; Massey & Wield, 1992).

Additionally, the commercial objectives of science parks can sometimes overshadow academic and public interests. With a strong focus on market-driven outputs, there is a risk that research within science parks becomes overly commercialized, prioritizing profitability over broader societal benefits. The shift towards private funding and commercialization can limit the scope of research to topics that promise immediate returns, potentially at the expense of fundamental research that lacks direct commercial application but could have long-term societal impacts (Benneworth & Charles, 2005).

Despite these critiques, science parks continue to evolve as key components of innovation ecosystems. Some parks are now integrating social and environmental objectives, expanding beyond purely economic goals. The emergence of “sustainable science parks” or “innovation districts” aims to address prior limitations by promoting more inclusive, mixed-use developments that foster innovation while also accommodating affordable housing, public spaces, and environmental sustainability (Katz & Wagner, 2014). Such models seek to balance the commercial aims of science parks with public needs, potentially offering a more holistic approach to urban and regional development.

The following sections will delve deeper into the emergence and evolution of science parks, critically examining how they embody the theoretical principles of agglomeration, knowledge spillovers, and university-industry-government interactions, while also acknowledging the critiques that challenge the straightforward application of these models.

2.3 Science Parks in Principle

Science Parks are perhaps best understood as the physical response to the theory on economic development set out above. As evidence on the economic value of commercialising scientific research has grown many governments around the world have sought to create planned spaces where innovation could flourish. The science park theory posits that a concentrated effort to support the growth and development of high-tech industries in a specific area can lead to increased innovation and economic success. To translate this theory into practice, science parks must adhere to a set of guiding principles that define their purpose, structure, and operations. These principles include:

a. Proximity and Collaboration: One of the main objectives of science parks is to facilitate the interaction between academia, industry, and government institutions. By fostering close proximity and collaboration, science parks aim to create an environment that stimulates knowledge exchange, resource sharing, and the development of new ideas (Etzkowitz & Klofsten, 2005).
b. Infrastructure and Support Services: Science parks must provide the necessary physical infrastructure and support services to attract and retain high-tech companies. These services can include access to advanced research facilities, technology transfer offices, and business incubators that assist in the development and commercialization of new ideas (Phan, Siegel, & Wright, 2005).
c. Networking and Community Building: Science parks must actively promote networking and community-building activities among their tenants. These activities can include industry-academia workshops, conferences, and social events that facilitate connections between individuals and organizations (Ratinho & Henriques, 2010).
d. Adaptability and Flexibility: Science parks must be adaptable and flexible to respond to the changing needs of their tenants and the broader economic landscape. This can include diversifying the sectors represented within the park, adjusting their support services, and updating their physical infrastructure to accommodate new technologies and industries (Löfsten & Lindelöf, 2003).
e. Long-term Commitment and Vision: Science parks require a long-term commitment from stakeholders, including government, academia, and industry, to ensure their continued success. This includes a shared vision for the park's development and a commitment to provide ongoing support and investment in its growth (Link & Scott, 2006).

Science parks in principle provide the spatial counterpart to the theories of economic development discussed above. By following the prescriptions of theories such as the triple/quadruple/quintuple helix it follows that science parks could potentially create an environment that fosters innovation, collaboration, and economic growth. These principles include proximity and collaboration, infrastructure and support services, networking and community building, adaptability and flexibility, and long-term commitment and vision. Balancing these principles is crucial to the successful development and operation of science parks and their ability to contribute to regional economic development. This perspective acknowledges that there is no one-size-fits-all approach to the design and management of science parks and encourages practitioners to adapt the theoretical foundations of science parks to suit their specific regional, sectoral, and institutional contexts (Ratinho & Henriques, 2010). The remainder of this chapter will set out how the science park concept has developed and the academic questions that remain relevant to their operation in the twenty-first century.

2.4 Science Parks in Practice

2.4.1 The First Science Park – Stanford Research Park, US

As the economic theory emphasizing the potential benefits of creating spaces where science and industry could interact gained widespread acceptance, the first physical science parks emerged. The original and still best-known example can be traced back to the 1950s, when the Stanford Industrial Park, now known as Stanford Research Park (Etzkowitz & Klofsten, 2005) was founded. This pioneering initiative aimed to create a hub of innovative technology companies in close proximity to Stanford University, thereby leveraging the academic and research capabilities of the university to spur the growth of local high-tech industries (Link & Scott, 2006).

In 1951, with vacant land set up by Stanford University, Frederick Emmons Terman, dean of the school of engineering courted technology corporations to become tenants of a newly conceived space reserved for industries in the nascent technology sector (Carayannis, Barth, & Campbell, 2012). With the moving in of Hewlett-Packard, General Electric and Kodak as its first tenants, an immediate effect was the ease of access to employment opportunities for Stanford's graduates, which enabled Stanford University to further retain talent and strengthen research capabilities. As a joint initiative between Stanford University and the City of Palo Alto (Gillmor, 2004), Stanford Research Park was considered a paradigm of regional development policies and many governments tried to replicate its success in their own contexts (Luger & Goldstein,1991). Reputational improvement was beneficial to secure as much academic funding as possible which further extended the scientific research capabilities of Stanford University. After decades, driven by Stanford Research Park bringing business, government, and university together, it has transformed the Silicon Valley area from one of the poorest regions in the USA into a global centre of technology, finance, education and research. Since the inception of Silicon Valley, the high-tech cluster phenomenon has seized the imagination of public policymakers. Hundreds of similar high-tech clusters have been created in various parts of the world, and their numbers continue to grow as cluster formation is increasingly adopted as an important economic development tool and as an integrated part of strategies for national and regional innovation (Diez-Vial & Montoro-Sanchez, 2017).

2.4.2 Global Spread of Science Parks

The success of the science parks in the United States inspired the development of similar parks around the world (Ben-Joseph, 2005), such as the Sophia Antipolis Science Park in France (established in 1974) and the Cambridge Science Park in the United Kingdom (established in 1970) (Garnsey & Heffernan, 2005). These early examples of science parks set the stage for the proliferation of the concept globally. A few years later, science parks in Italy, such as the Bio-industry Park del Canavese established in the mid-1970s and the Trieste AREA Science Park established in 1978 (areasciencepark, 2021; Bigliardi, et al., 2006) also developed rapidly. By the 1960s and 1970s the establishment of parks was extended in Europe and Japan and in the 1980s strong growth was observed in England, France, Germany, Sweden, Finland, Belgium and other economies of Southeast Asia (Zhang, 2005). In this global region, Japan was the first Asian country to establish science parks. The Japanese Ministry of International Trade and Industry master-minded the technopolis program, a national plan to create a series of new science cities in the country's peripheral areas to simultaneously promote new technologies and develop lagging regions (Kanematsu & Pharr, 1989). Other newly industrialized and developing countries in Asia and Oceania also built various types of science parks, among them Taiwan's Hsinchu Science Park, South Korea's Daedeok Innopolis, Singapore's Kent Ridge Science Park, Bangalore's International Tech Park, and Australia's Technology Park Adelaide (Liang, 2011). Since the 1950s, a series of science parks, technology parks, and science cities have also been established in the former Soviet Union and countries in Eastern Europe, such as the Novosibirsk Technopark in 1957, and the Moscow State University Science Park in 1992 (Liang, 2011).

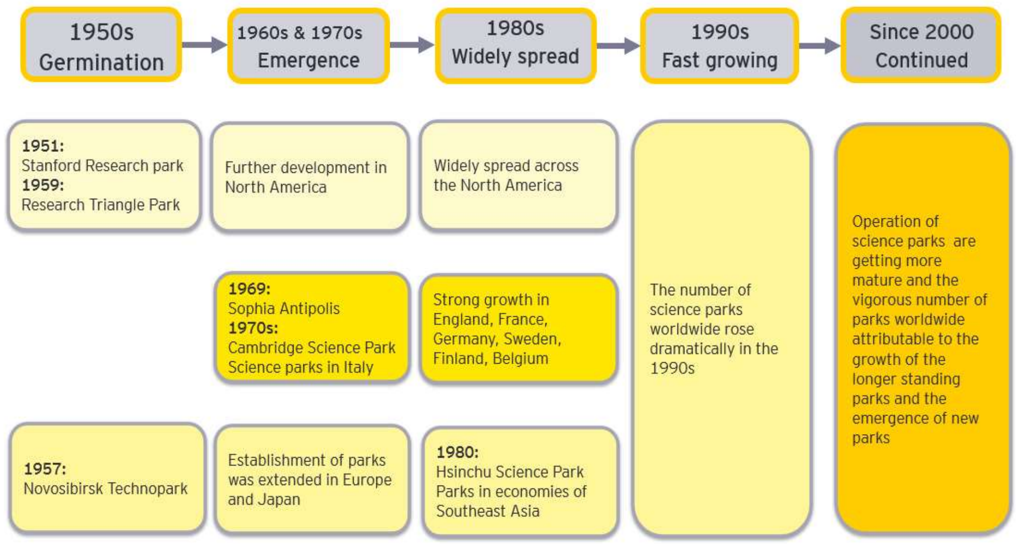
Throughout the latter half of the 20th century, science parks expanded in both number and scope. In addition to high-tech industry-focused parks, other sectors such as life sciences, biotechnology, and creative industries began to be included in the science park model (Ratinho & Henriques, 2010). It is difficult to approximate the current number of science parks, as the figure depends on varying definitions, but, according to the International Association of Science Parks (IASP), by 2000, there were 1,240 science and technology parks worldwide (Ferguson, 2004; Liang, 2011). This expansion and diversification of science parks was driven by several factors, including the increasing recognition of the importance of knowledge transfer between academia and industry, the need for specialized infrastructure and resources to support innovation, and the desire of governments and regional authorities to promote economic development through the attraction and support of high-value-added industries (Phan, Siegel, & Wright, 2005).

In the 21st century, science parks have continued to evolve and adapt to the changing landscape of innovation and economic development. They have become more focused on promoting collaboration and interaction among their tenants and with external partners, providing a range of support services such as incubators, technology transfer offices, and networking events to foster the growth of tenant companies (Löfsten & Lindelöf, 2003). Additionally, the concept of science parks has expanded to encompass other related initiatives, such as innovation districts, technology clusters, and research parks, which share similar objectives but may differ in terms of their spatial configuration, governance structures, or sectoral focus (Benneworth & Dassen, 2011).

2.4.3 Summary of the History of Science Parks

The emergence and subsequent evolution of science parks has seen the term come to encompass a wide range of experiences from relatively small developments attached to long-established universities to large-scale, bespoke facilities designed to attract both academic and commercial interests to a 'neutral' area. The process by which science parks have evolved is represented in Figure 3.

Figure 3: The history of science parks practice



Source: Author.

In summary, the history of science parks is characterized by a continuous process of evolution and adaptation to the changing dynamics of innovation, collaboration, and economic development. From their beginnings in the mid-20th century as hubs for high-tech industries, science parks have diversified to include a wide range of sectors and have increasingly focused on promoting interaction and knowledge transfer among their tenants and with external partners. As science parks continue to evolve in the 21st century, they remain a critical tool for fostering innovation, collaboration, and economic growth within a regional context.

2.5 Conclusion

In conclusion, Chapter 2 has provided an in-depth overview of the science park phenomenon, exploring its origins, theoretical underpinnings, principles, and examples of practical implementation. The analysis presented in this chapter has underscored the importance of science parks as physical embodiments of innovation ecosystems, where location, infrastructure, and support services converge to create environments conducive to fostering ground-breaking ideas and their transformation into tangible economic and societal benefits (Etzkowitz & Klofsten, 2005; Phan, Siegel, & Wright, 2005).

As this study has explored the evolution and development of science parks in general, it is important to recognize that certain industries may become more prominent within these innovation ecosystems due to various factors. The emergence of health sciences parks highlights the significance of this specialized industry within the broader context of science parks. The establishment of health sciences parks can be attributed to a combination of natural factors, such as regional strengths in life sciences research and the presence of leading academic institutions, and strategic planning efforts by governments, universities, and private organizations to foster the growth of a specific industry (Garnsey & Heffernan, 2005). Health sciences parks play a crucial role in promoting collaboration between academic institutions, research organizations, and private companies, which drives advancements in healthcare, biotechnology, and pharmaceuticals. Moreover, the growing global demand for innovative healthcare solutions and the increasing emphasis on personalized medicine (Ginsburg & Phillips, 2018) have accelerated the need for specialized parks that focus on the health sciences sector (Ahn & Meeks, 2008).

In the following chapters, I shift focus from the broader concept of science parks to a more detailed examination of health sciences parks. These specialized environments stand out due to unique features and characteristics that set them apart from other types of science parks. Specifically, their design and planning have proven especially effective in fostering innovation, making them essential hubs for regional and economic development. China's remarkable growth as a global leader in health sciences park development provides an intriguing case study. This rapid expansion combines factors such as government policy interventions, economic growth, and a flourishing healthcare sector, underscoring the importance of health sciences parks in driving innovation. This deeper exploration will highlight the distinctive features and impacts of health sciences parks, particularly within China’s context. It will offer insights into why these parks are increasingly vital for economic advancement, collaborative research, and the creation of innovation ecosystems. By examining the Chinese model, this study will enrich the academic discourse on science parks and place-based innovation, offering valuable perspectives for policymakers, practitioners, and researchers on leveraging health sciences parks to promote innovation and sustainable growth.

Chapter 3. Making Space for Health: the Development of Health Sciences Parks

Chapter 2 provided a comprehensive overview of the theoretical foundations fuelling the worldwide expansion of science parks, while also spotlighting some unanswered questions regarding China's ascent to global leadership in this domain. This chapter delineates the transition from general science parks to those predominantly focused on health sciences, a shift driven by the burgeoning growth of this sector. In this chapter, the narrative focuses on China, aiming to unravel the complex dynamics of why the health sciences industry has flourished in specific settings where health sciences parks have been established. It examines both natural and orchestrated factors that contribute to the development and success of these specialized parks. Through this lens, the chapter argues for a deeper exploration of China's new wave of health sciences parks, situating them within the unique developmental trajectory of the Chinese context.

3.1 General Concept of Health Sciences

‘Health sciences’ is a collective name for an expansive field that spans numerous disciplines, all dedicated to understanding, researching, and applying knowledge to improve the health of living organisms. This interdisciplinary domain harmonizes elements from biology, medicine, and health studies, aiming to enhance the well-being of individuals and communities alike. The World Health Organization (WHO) has highlighted the pivotal role of health sciences in propelling public health forward, emphasizing the importance of research and innovation in addressing contemporary health challenges (WHO, 2020). The term "biotechnology" was first introduced by Károly (Karl) Ereky in 1919, setting the stage for what would become a key component of the health sciences field (Fa´ri & Kralova´nszky, 2006). Yet, the modern chapter of biotechnology is often dated to 1971, when Paul Berg's innovative gene-splicing experiments established the foundations for recombinant Deoxyribonucleic Acid (DNA) technology—a milestone that resulted in the award of the Nobel Prize in Chemistry in 1980 for his seminal work on the biochemistry of nucleic acids, especially concerning recombinant DNA (Science History Institute, 2017a). The trajectory of biotechnology took a significant leap forward in 1972, courtesy of Herbert W. Boyer and Stanley N. Cohen. Their work, which involved the successful engineering of a bacterium to replicate foreign genetic material, effectively inaugurated the era of recombinant DNA technology. This technological advancement not only signified a major scientific breakthrough but also unveiled vast commercial potential, as demonstrated by the founding of Genentech. Boyer and Cohen's venture into Genentech marked the beginning of biotechnology's impactful journey in medical science, pioneering the application of genetic engineering to healthcare solutions (Science History Institute, 2017b). This narrative underscores the complexity and depth of the health sciences field, showcasing its roots in the science of biotechnology and its evolution through ground-breaking research and innovative applications. The integration of various scientific disciplines within health sciences underscores its critical role in advancing healthcare, medicine, and public health initiatives.

The development of the biotechnology and pharmaceutical sector was significantly shaped by the regulatory changes that followed medical crises, notably the thalidomide disaster of the early 1960s (Carpenter, 2010). This catastrophic event, which resulted in thousands of infants being born with severe malformations due to their mothers' intake of thalidomide during pregnancy, served as a critical turning point (Kim & Scialli, 2011). In response, the United States, Great Britain, and other nations undertook a comprehensive overhaul of medicine testing regulations, introducing a stricter regulatory framework that mandated extensive premarketing research from pharmaceutical companies (Woolf, 2021). This enhanced scrutiny necessitated not only rigorous research but also in-depth communication and interaction with governmental authorities. The new regulatory environment intensified the pressures of time, cost, and efficiency on pharmaceutical companies, given the heightened supervision and fierce market competition. This paradigm shifts in regulatory oversight fostered a culture of collaboration between the biotechnology industry, academic institutions, and government bodies. Such collaborative efforts were instrumental in driving the industry's advancement, ensuring that the development and commercialization of biotechnological innovations adhered to the highest safety and efficacy standards. This tripartite partnership—among academia, government, and the private sector—has become a cornerstone of the biotechnology industry's ongoing development, highlighting the importance of integrated efforts in overcoming challenges and fostering innovation in the health sciences domain.

By the 1980s, biotechnology had emerged as a burgeoning industry, marked by the formation of the Biotechnology Industry Organization (BIO), the world's premier advocacy group. BIO represents an extensive network of member companies, state biotechnology groups, academic and research institutions, and related entities across the United States and in over thirty countries globally (Biotechnology Innovation Organization, 2021). This period witnessed biotechnology's most significant and impactful achievements, predominantly in the pharmaceutical sector. These achievements include the development of ground-breaking medicines, enhancements to existing medications, and the production of generic pharmaceuticals. Within the industry, biopharmaceuticals have experienced the most rapid growth, despite their relatively short history of just 40 years. This swift ascent began with the market introduction of the first genetically engineered medicine, recombinant human insulin, in 1982. The U.S. Food and Drug Administration's (FDA) approval of Humulin, Eli Lilly's recombinant insulin produced using Genentech's specially engineered bacteria, marked a historic milestone. It was the inaugural pharmaceutical product manufactured through recombinant DNA technology, positioning it among the earliest genetically engineered products accessible to consumers (Biotechnology Innovation Organization, 2021).

Transitioning into the 21st century, the biotechnology field has significantly expanded, incorporating new disciplines like genomics, recombinant gene techniques, applied immunology, and the creation of innovative pharmaceutical therapies and diagnostic tests (Bhatia, 2018). This growth has cemented biotechnology's critical role in advancing medical science and healthcare, driving both improvements in current medicine and the potential for future breakthroughs. A holistic perspective reveals how biotechnology, pharmaceuticals, medical devices, and health technologies intertwine to create advanced healthcare solutions. This integration marks a strategic shift towards more personalized, efficient healthcare through the fusion of various scientific fields, including the application of artificial intelligence (AI) and machine learning for precision medicine.

The evolution from the first genetically engineered medicine to today's biopharmaceuticals and genomic medicine highlights a move towards healthcare that is not just effective but also personalized and accessible. The modern understanding of health sciences reflects this blend of biotechnology, pharmaceutical research, medical devices, and new health technologies, paving the way for a future where healthcare innovation offers tailored, efficient, and accessible solutions for all.

3.2 Characteristics of the Health Sciences Industry

The rapid expansion and global spread of the health sciences industry have been propelled by a complex interplay of economic, social, and political forces. This dynamic sector's growth reflects not just the rising demand for innovative healthcare solutions but also a broader societal commitment to enhancing public health outcomes. Economically, the industry benefits from substantial investments in R&D, driven by the promise of significant returns on successful medical breakthroughs. Socially, factors such as an aging global population and increased health and wellness awareness have spurred demand for more effective and personalized healthcare solutions. Politically, governments worldwide are acknowledging the pivotal role of health sciences in strengthening national healthcare systems, thereby facilitating innovation-friendly policies and streamlining regulatory approvals. These combined forces create a fertile environment for the ongoing growth and evolution of the health sciences industry, positioning it as a crucial player in shaping the future of global health and medicine.

Economically, the health sciences industry has seen remarkable growth in value, a trend that is vividly captured in the statistical analysis of the revenue of the worldwide pharmaceutical market from 2001 to 2020. The data reveals a substantial expansion, with the market size escalating from US$390 billion at the close of 2001 to an impressive US$1,270 billion by the end of 2020 (Mikulic, 2021). This growth trajectory highlights the sector's potential for further expansion, driven by a growing global population, an increasing number of elderly individuals, and the rising prevalence of certain diseases. Moreover, the expansion of the consumer base and the recent global health crises, such as the Coronavirus Disease 2019 (Covid-19) pandemic, have highlighted the need for swift medical responses, further driving market value and attracting new participants to the field.

The essence of the health sciences industry lies in its knowledge-intensive nature, propelled by an unwavering commitment to innovation and rigorous research. The sector thrives on the synergy of diverse disciplines, integrating cutting-edge technologies like AI and machine learning to enhance healthcare delivery and treatment customization. This investment in R&D fuels the discovery of new treatments and technologies, with innovation and successful technology commercialization being central to the industry's growth.

Commercial investment in biosciences has a unique character, often involving long discovery and development lead times and an uncertain regulatory approvals process (Rosson, 2003). This requires significant financial investments, presenting challenges for small and medium-sized innovators but also opportunities for alliances or acquisitions by larger industry players (Rosson, 2003). Despite the market-driven nature of the industry, goals to improve global public health and efforts to strengthen human security play important roles, underscoring the ethical imperative to reduce global health inequities through innovative technological applications (National Academy of Sciences, 2015).

The health sciences sector's heavily regulated environment ensures the safety, efficacy, and quality of pharmaceuticals and medical devices. Regulatory bodies set strict guidelines that must be followed from research to market approval, highlighting the industry's commitment to ethical standards, particularly in clinical trials and patient care. Moreover, the industry's sensitivity to changes in healthcare policies, insurance coverage, and economic conditions influences market access and the adoption of new technologies and therapies, reflecting its complex interplay with economic, social, and political factors.

The industry's concentrated nature in certain spaces, typically around knowledge centres like universities and research institutions, forms the basis for industry agglomeration. This is evident in clusters like the Boston area in the United States, home to leading research institutions and a major hub for the health sciences market (Cooke, 2003). The interdisciplinarity and complexity of knowledge within the industry have created emergent barriers, leading to a refined division of labour and the formation of efficient value chains. Health sciences parks, designed to support industry development, play a crucial role in this ecosystem.

In summary, the health sciences industry is characterized by its dynamic growth, driven by economic investments, social demands, and political support. Its knowledge-intensive and innovative nature, combined with the complexities of commercial investment and regulatory environments, shapes a sector that is not only crucial for advancing public health but also reflective of the broader societal commitment to improving health outcomes worldwide.

3.3 The Specific Characteristics of Health Sciences Parks

The rapid growth and continuous innovation in the health sciences industry have catalysed the development of health sciences parks, specialized ecosystems designed to accelerate advancements in healthcare technology. Diverging from traditional science parks, these parks are shaped by the unique confluence of economic, social, and political influences, specifically catering to the needs of the biotechnology, pharmaceutical, and medical device industries. The emergence of science and technology parks initiated a concerted effort to cultivate collaborative innovation. The transition towards specialized parks, like health sciences parks, reflects the evolving complexity and specialization within the sciences, particularly driven by the necessity for environments dedicated to addressing the multifaceted challenges of health and medicine through interdisciplinary collaboration. Health sciences parks stand out for their advanced infrastructure, engineered to facilitate leading-edge R&D while meeting the strict regulatory requirements inherent to the health and biomedical sectors.

A cornerstone of health sciences parks is their strategic focus on promoting interdisciplinary collaboration and knowledge exchange. This is achieved by congregating research institutions, universities, hospitals, and private enterprises within an ecosystem that is conducive to enhancing communication and collaborative efforts. Such integration exemplifies the concept of agglomeration—whereby proximity fosters innovation through shared resources and collaborative networks (Duranton & Puga, 2004). Moreover, the parks' direct access to healthcare institutions and clinical resources underscores the importance of clusters in expediting the transition of laboratory discoveries into practical patient care innovations.

Furthermore, health sciences parks exemplify the Triple Helix model of innovation, where synergies between academia, industry, and government fuel the development of new technologies (Cooke & Leydesdorff, 2006). This symbiotic relationship with government policies and initiatives not only cultivates an innovation-rich environment but also strategically positions these parks as key drivers of regional economic development. The specialized focus of these parks, encompassing areas from biotechnology to digital health, aligns seamlessly with the evolving trends of the industry and the strategic research agendas set by governments, thereby attracting companies and investors with aligned interests and expertise.

The rise of health sciences parks is a testament to the dynamic response required to meet the escalating demands of the health sciences sector, spurred on by global health challenges and the continuous pursuit of medical breakthroughs. Their development, shaped by a confluence of factors including government policy, industry dynamics, and urban planning, underscores their instrumental role in fostering innovation and stimulating economic growth within the health sciences landscape.

In the remainder of this chapter the goal is to outline the development of some specific health sciences parks as spaces specifically designed to provide a territorial counterpart to the Triple Helix model: clearly defined locations where state-commercial-academic sectors interact to generate innovation.

3.4 Research Triangle Park: The World's First Health Sciences Park

3.4.1 Development History

The development history of the Research Triangle Park (RTP), initiated in 1959 (Link & Scott, 2003b), is a narrative of transformation and innovation that reshaped North Carolina's economy. Initially dominated by agriculture, with heavy reliance on tobacco, textiles, and furniture manufacturing (Link & Scott, 2003), the state faced an economic challenge, marked by a significant 'brain drain' as university graduates sought better opportunities elsewhere (Research Triangle Park, 2018). This period, characterized by North Carolina's ranking as 49th out of 50 nations in the United States per capita income, called for a strategic intervention to reverse the downward spiral and catalyse a new economic paradigm (Link, 2002).

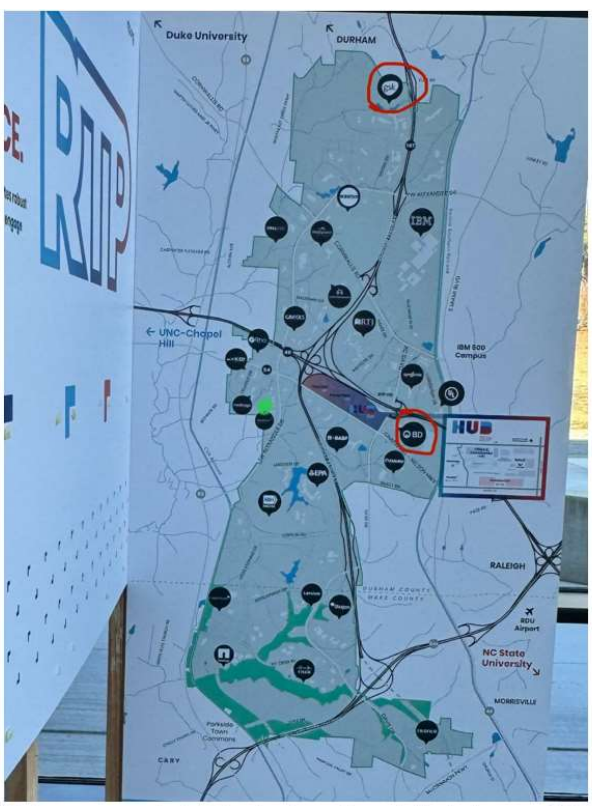
Governor Luther Hodges, who served from 1954 to 1961, played a central role during these formative years (Link, 1995). Utilizing his influence, Hodges facilitated the collaboration between government and industry, leveraging the academia strength. This initiative aimed to diversify and stimulate the state's economy through science and technology. However, attracting innovation and investment to RTP initially proved challenging, given the park's nascent status and the economic landscape of the time, which was less conducive to the rapid emergence of technology startups and innovative enterprises (Research Triangle park, 2018). Hodges tapped Archie Davis, the first president of the Research Triangle Foundation, established as a not-for-profit organization to raise the capital to make it happen. With a strong background in banking and finance, Davis effectively used his connections and influence in raising the necessary capital, rallying support from across the state to purchase land for the park, including endeavours with the American Academy of Arts and Sciences (Rohe, 2011). This effort underscored a foundational principle: RTP was to operate as a private not-for-profit, a legacy of Davis's vision and the generosity of his donors (Research Triangle park, 2018). His efforts, alongside Hodges', laid the groundwork for RTP's value proposition, emphasizing strategic location and the synergy of nearby research universities.

From its inception, RTP was strategically positioned to capitalize on its proximity to three major research universities: North Carolina State University, Duke University, and the University of North Carolina at Chapel Hill (Link, 2002). The collaboration with these academic institutions became increasingly central to RTP's mission (McCarthy, 2018), especially as specialized centres like the Lineberger Comprehensive Cancer Center at the University of North Carolina were established in 1975, marking a significant move towards health-related research and signalling the formation of the first health sciences park within RTP. The foundation of the North Carolina Biotechnology Center in 1984, building on the existing strengths of the earlier-established Cancer Center, solidified RTP's reputation as a leading hub for health sciences research.

Over the decades, RTP grew from hosting primarily large firms like IBM and Burroughs Wellcome to becoming a nurturing ground for entrepreneurial ventures and startups, with a focus on high technology like health sciences. The park's collaborative model facilitated the success of contract research organizations and spurred advancements in biosciences. This development history underscores the transformation of RTP into a dynamic ecosystem where government, business, and academia collaborate to foster innovation and economic growth. Through strategic leadership, visionary planning, and the leveraging of academic excellence, RTP has established itself as a model for innovation parks worldwide.

3.4.2 Geographical and Strategic Foundations

Figure 4: Map of Research Triangle Park



Picture source: photo taken by the author at site in January 2024

Spanning over 7,000 acres (approximately 28 km²), the strategic positioning of RTP has played a critical role in its development. Its advantageous location, amidst the Piedmont region's Raleigh, Durham, and Chapel Hill—collectively known as "The Research Triangle"—has been a cornerstone of its development and success. This geographical positioning is not merely a matter of convenience but a deliberate strategy to leverage the academic and research strengths of three neighbouring major research universities: Duke University, the University of North Carolina at Chapel Hill, and North Carolina State University. The proximity to these institutions facilitates a rich tapestry of collaboration and innovation, making RTP a beacon of the Triple Helix model where academia, industry, and government join forces to drive forward scientific and technological advancement (Link & Scott, 2003).

Central to RTP's ethos is the promotion of specialized centres and initiatives that focus on cutting-edge fields such as biotechnology, pharmaceuticals, and environmental sciences. These entities are not only at the forefront of R&D but also exemplify the park's commitment to fostering joint research projects and the creation of spin-off companies. Such endeavours are critical for translating academic research into tangible innovations that can benefit society at large, thereby embodying the practical application of the Triple Helix model of innovation.

Moreover, RTP's strategic location extends beyond its academic adjacencies to include key transportation infrastructure. Positioned near Interstate 40 and the Raleigh-Durham International Airport, RTP benefits from enhanced accessibility that ensures easy connections on both a national and international scale. This logistical advantage is complemented by short commute times to the airport and surrounding residential areas, bolstered by efficient regional transit services. Such connectivity is indispensable for RTP's stature as a dynamic centre of innovation and collaboration, attracting a broad spectrum of talent ranging from researchers and entrepreneurs to professionals, all drawn to the park's vibrant ecosystem.

The Research Triangle Foundation, a private not-for-profit entity, is pivotal in overseeing RTP's governance and development. This organization facilitates partnerships and projects that span the breadth of government, industry, and academia, thereby ensuring that RTP's mission to foster innovation through collaboration is realized. The governance structure of RTP is thoughtfully aligned with the park's overarching mission, with stakeholders that include the state of North Carolina, the federal government, the foundational universities, and the multitude of private sector companies that have set up operations within the park. This diverse ownership and management model has been instrumental in providing a robust platform for growth, development, and the continuous nurturing of an innovation ecosystem.

3.4.3 Regulatory Milestone and Government’s Role

The regulatory landscape of biotechnology has undergone significant evolution, particularly marked by the landmark 1980 Supreme Court decision in Diamond v. Chakrabarty (Caselaw, 1980), which set a transformative precedent for the biotechnology industry (Bagley, 2013) and Research Triangle Park (RTP) in particular. This pivotal ruling allowed for the patenting of genetically modified organisms (GMOs), thereby establishing a legal framework that catalysed an era of unprecedented growth in biotechnological research and investment. By enabling the patenting of life forms, this decision facilitated a surge in innovation within RTP, providing inventors and companies the necessary legal protection for their inventions and thereby securing a competitive edge in the global market (Caselaw, 1980).

In the wake of this legal milestone, regulatory bodies adapted to the new landscape by streamlining patent processes and establishing clear guidelines for health sciences research and product development. These measures ensured that companies within RTP could confidently navigate the complexities of biotechnological innovation while adhering to public safety and ethical standards, thus promoting a conducive atmosphere for research and exploration (Bagley, 2013).

In the early 2000s, RTP's collaborative model was further enriched by the addition of two pivotal organizations: the North Carolina Biotechnology Center and the Microelectronics Center of North Carolina. As the first state-funded non-profits in the United States dedicated to promoting the success of small firms in life sciences and microelectronics, these centres embodied the state's proactive approach to supporting the biotechnology sector. The provision of loans, grants, counselling, and networking opportunities underscored a hands-on policy that not only facilitated the growth of biotechnological firms but also positioned North Carolina as a leading state in bioscience employment and a global frontrunner in vaccine research and manufacturing (Research Triangle Park, 2018).

This symbiotic relationship between regulatory milestones, governmental support, and the biotechnology sector's dynamism has been paramount in establishing RTP as a premier hub of biotechnological innovation. The legal recognition of the patentability of GMOs, coupled with the government's active role in creating an enabling environment, has catalysed significant advancements in biotechnology within RTP. This has had profound implications for regional economic growth, healthcare advancements, and the broader scientific community. The effective interplay between legal frameworks and supportive government policies has not only spurred innovation but also ensured that such advancements are aligned with public welfare and ethical considerations, thus demonstrating the critical importance of regulatory and societal frameworks in guiding scientific exploration (Rai & Eisenberg, 2003).

The Diamond v. Chakrabarty decision and its aftermath highlight the complex interdependencies between legal frameworks, government policy, and scientific innovation. As RTP continues to evolve, the lessons learned from this period underscore the necessity of maintaining a balanced approach to regulation - one that encourages innovation while safeguarding public interest and ethical standards. This holistic perspective is essential for sustaining the momentum of biotechnological advancements and ensuring that such innovations contribute positively to society. As RTP and similar innovation ecosystems navigate the future of biotechnology, the continued collaboration among legal, governmental, and scientific communities will be vital in addressing the challenges and seizing the opportunities that lie ahead in this rapidly evolving field.

3.4.4 Leading Industry Players’ Effect

The relocation of Glaxo (now GlaxoSmithKline, GSK) to Research Triangle Park (RTP) in 1983 marked a transformative phase in the park’s evolution towards a premier centre for health sciences. This move not only highlighted RTP's emerging prominence in pharmaceutical R&D but also acted as a catalyst for additional investment and talent inflow. The arrival of GSK within RTP initiated a trend that attracted other major players such as Biogen Inc. (Biogen) and Becton, Dickinson and Company (BD), which specialize in biotechnological research and medical technology & devices, respectively. As marked in Figure 4, GSK and BD are located in the north and east, respectively, as circulated in red, while Biogen is located in the west with a green dot put. The geographic placement of these firms within RTP forms a strategic triangle, contributing significantly to the diversification of the health sciences ecosystem within the park (Link & Scott, 2003).

This clustering of leading health sciences entities within a concentrated area has profound implications for RTP’s development and the broader regional economy. Michael Porter (2000) highlights the importance of such clustering effects in attracting startups and established firms, providing access to a skilled workforce, and creating an environment conducive to innovation and collaboration. This influx of industry leaders has been instrumental in the growth and development of Contract Research Organizations (CROs) within RTP. CROs, with their expertise in pre-clinical research, clinical trials, regulatory affairs, and data management, have been key in efficiently bringing innovative therapies and products to market, facilitating the transition of research discoveries to practical applications in medicine, medical devices, and diagnostic tools.

The presence of these industry giants not only enhances RTP's economic diversity but also lays the groundwork for partnerships extending beyond the park's boundaries. Collaborations with adjacent universities, healthcare systems, and external entities are fostered, creating a comprehensive network of interaction and cooperation that benefits the wider scientific and medical communities. Such collaborations expedite the pace of innovation within the health sciences sector, facilitate the commercialization of research, and contribute to workforce development by providing training and skill enhancement opportunities critical for the industry's growth.

The contribution of industry leaders to the contract research sector and biosciences in RTP has extended beyond scientific innovation to generate significant economic benefits. The expansion of CROs and advancements in biosciences have led to job creation, attracted further investment, and bolstered the region's global standing as a hub for life sciences R&D. This economic and scientific progress positions RTP as a model demonstrating how strategic clustering of industry leaders and supportive services can drive both economic development and scientific advancement.

The success of RTP in attracting and retaining health sciences industry leaders is attributable to several factors. The park’s strategic location, proximal to major research universities and with convenient access to transportation infrastructure, offers an ideal setting for companies seeking to capitalize on academic partnerships and access a talented pool of researchers and professionals. Moreover, the governance structure of RTP, managed by the Research Triangle Foundation, plays a crucial role in promoting an environment that fosters innovation and collaboration, thereby facilitating the park’s continued growth and development in the health sciences sector.

3.4.5 Economic Impact

The "Evidence & Opportunity 2020" report by the North Carolina Biotechnology Center (NCBiotech, 2021) highlights the profound economic impact of the health sciences sector in North Carolina, with a specific focus on RTP. As a fulcrum of innovation and economic activity, RTP plays a critical role in driving the regional economy, evidenced by its substantial contribution to employment, wages, benefits, and overall economic output. In 2020, the health sciences sector within North Carolina, centralized around RTP, directly employed 67,000 individuals across 752 distinct companies, while indirectly supporting an additional 224,000 jobs state-wide. This sector not only generates $16.8 billion in wages and benefits but also contributes significantly to the state's economic output, amounting to $84 billion, along with generating $2.3 billion in state and local taxes. Such metrics underscore the pivotal role of the health sciences industry in enhancing North Carolina's economic landscape and highlight RTP's integral function in cultivating a culture of innovation, job creation, and economic growth. (NCBiotech, 2021)

RTP's economic influence is emblematic of the synergistic relationship between strategic industry clustering and innovation-led growth. By fostering a collaborative ecosystem that integrates the efforts of academia, industry, and government, RTP has positioned North

Carolina as a leading centre for health sciences R&D. This collaborative model, as conceptualized in the Triple Helix theory of innovation (Etzkowitz & Leydesdorff, 2000), emphasizes the dynamic interplay between these sectors in spurring economic and social development. RTP embodies this model by facilitating partnerships and networks that leverage the strengths and resources of each sector, resulting in high levels of innovation, commercialization, and entrepreneurship within the health sciences field.

The economic vitality within Research Triangle Park (RTP) and its adjacent regions is driven by multiple pivotal factors. Primarily, the aggregation of health sciences companies alongside the proximity to prominent research universities has cultivated a highly skilled workforce. This concentration has fostered a cycle of talent attraction and retention, crucial for the sustained growth and competitive edge of the health sciences sector. Additionally, RTP's strategic positioning and its comprehensive infrastructure, encompassing extensive transportation networks and cutting-edge facilities, streamline business operations and logistics. This, in turn, enhances RTP's appeal, drawing investment from a broad spectrum of domestic and international entities.

Moreover, RTP's role in the health sciences sector's growth is reflected in its ability to drive innovation through R&D activities. The park serves as a nexus for cutting-edge research, where breakthroughs in biotechnology, pharmaceuticals, and medical devices are translated into commercial success stories. This focus on innovation not only contributes to the sector's economic output but also has broader societal benefits, including the development of new therapies and treatments that improve public health outcomes.

The economic benefits associated with RTP, and the health sciences sector extend beyond direct employment and financial metrics. The sector's growth stimulates demand in related industries, including construction, real estate, and professional services, contributing to a multiplier effect that amplifies its economic impact. Furthermore, the sector's contribution to state and local tax revenues supports public services and infrastructure, enhancing the quality of life for North Carolina residents.

3.4.6 Summary

As the first health science park, RTP stands as an illustration of the Triple Helix theory in action (Link & Scott, 2003), showcasing the dynamic interplay between academia, industry, and government to foster innovation (Etzkowitz & Leydesdorff, 1995 & 2000), particularly within the health sciences sector. At the heart of RTP's evolution into a health sciences innovation hub lies its strategic utilization of university resources, geographical positioning, and comprehensive planning. This has been further supported by key regulatory milestones alongside government policies in promoting innovation. The deliberate clustering of industry leaders within RTP fosters a vibrant ecosystem conducive to interdisciplinary collaboration, drawing investment and high-end talent that bolster the park’s competitiveness on a global scale.

Strategically developed to meet the evolving demands of a diverse tenant base, RTP has honed its focus on sectors at the forefront of health sciences. Beyond providing workspaces, RTP’s master plan emphasizes a community-centric approach, advocating for a work-life balance through the inclusion of recreational spaces, cutting-edge laboratories, and comprehensive amenities designed to promote well-being, innovation, and collaboration

(Research Triangle Park, 2018). Strategic partnerships play a crucial role in enhancing RTP's connectivity, seamlessly integrating it with the wider region and reinforcing its status in the global innovation ecosystem.

3.5 Health Sciences Parks in the UK: Manchester and Cambridge

Manchester Science Park, UK

Manchester Science Park (MSP), established in 1984, represents Europe's pioneering initiative dedicated to health sciences, technology, and advanced materials, as noted by Quintas, Wield, & Massey (1992). With over 150 business spanning in 2.27 km² and managed by Bruntwood SciTech, a private property management company, MSP was a collaborative effort spearheaded by Manchester City Council, supported by academic institutions like the University of Manchester and Manchester Metropolitan University. This collaboration aimed at catalysing the growth of Manchester's knowledge economy, aligning with strategic plans to bolster regional development (Mspl.co.uk, 2021).

The initial development strategy of MSP focused on fostering collaborations between government and industry. This approach, recognized by Siegel, Westhead, & Wright (2003) as a foundational strategy for university science parks, aimed at securing essential capital, navigating regulatory landscapes, and establishing crucial industry linkages. Such an approach provided fertile ground for the attraction of further investments and the nurturing of high-technology sectors within the park.

Over time, MSP's development strategy evolved to emphasize the significant role of academic institutions in research and innovation, marking a shift towards a more integrated Triple Helix model of innovation (Etzkowitz & Leydesdorff, 2000). A notable achievement in this evolutionary journey was the launch in July 2020 of a state-of-the-art health innovation and precision medicine campus, a collaborative endeavour between Manchester University, NHS Foundation Trust and Manchester Science Partnerships. This development signifies MSP's transformation into a strategic consortium encompassing public, private, academic, and clinical partnerships, all geared towards advancing Manchester's knowledge economy (Mspl.co.uk, 2021).

The evolution of MSP from a government and industry collaboration to a comprehensive model embodying the Triple Helix theory illustrates the effective application of this theory in real-world contexts. The park's trajectory underscores the importance of government-led initiatives in the early stages, providing policies and funding that serve as a catalyst for the growth of small and medium-sized enterprises (SMEs). As MSP matured, the incorporation of academic and clinical partnerships highlighted the synergistic potential of aligning efforts across public, private, academic, and clinical spheres.

This progression to a public, private, academic, clinical partnership model exemplifies the Triple Helix theory in practice, demonstrating the theory's applicability in fostering innovation through structured interaction between university, government, and industry. Such a model, as evidenced by MSP's development, facilitates a robust platform for innovation, leveraging the collective strengths and resources of each sector to drive economic and technological advancement.

Cambridge Science Park, UK

Established in 1970 by Trinity College at the University of Cambridge, Cambridge Science Park (CSP) has been a pivotal force in driving the "Cambridge Phenomenon", a transformative movement that has positioned Cambridge as a leading global technology and innovation hub. This transformation, detailed by Segal, Quince, & Whittaker (1985); Keeble (1989) and further analysed by subsequent scholars, showcases the park's evolution from leveraging the university's knowledge base to becoming a diverse technology nexus (Powell & Snellman, 2004). This evolution expanded its focus with an emphasis on health sciences since 1987 (Cambridge Science Park, 2021). By the late 1990s, health sciences emerged as the park's leading technology area (Cambridge Science Park, 2021), mirroring the sector's global expansion and the park's agility in adapting to technological shifts.

Figure 5: The Bradfield Centre, Cambridge Science Park

Picture source: photo taken by the author at site in May 2023

CSP's strategic location facilitates over 7,250 professionals working across more than 170 innovative companies, thriving in 40,000 square feet (approximately 3,716 m²) of space optimized for collaboration and innovation. The 2017 inauguration of the Bradfield Centre, the building as shown in the picture at left (Figure 5), is a testament to the park's commitment to fostering a vibrant community of technologists and entrepreneurs. (Cambridge Science Park, 2021)

The innovation ecosystem of Cambridge Science Park has been significantly enriched not only by spin-outs from the University of Cambridge but also by the establishment of major pharmaceutical and medical technology companies such as Bayer et comp. (Bayer), Applied Molecular Genetics Inc. (AMGen), and BD within its precincts. This clustering of industry giants alongside academic spin-offs creates a synergistic environment that fosters innovation and collaboration. A testament to the park's strategic importance in the pharmaceutical research arena is AstraZeneca's decision in 2013 to relocate its global headquarters and strategic R&D centre to the Cambridge Biomedical Campus, which is situated in CSP. This move highlights the critical mass of knowledge, research capability, and innovation potential concentrated in the region, exemplifying the cluster effect where the proximity of companies and institutions accelerates innovation and growth within the sector.

Trinity College, as the landlord, provides crucial strategic oversight, while the operational and developmental agenda is propelled forward by the park's dedicated management team, aiming to expand its research and business growth potential further. While the park exemplifies a university-driven approach within the Triple Helix framework, the role of government in facilitating this ecosystem's success is substantial yet underarticulated. Governmental involvement, through both regulatory support and the provision of infrastructure, complements the contributions of academia and industry. This tripartite collaboration underlines the necessity of a supportive policy landscape and robust public infrastructure to nurture innovation ecosystems effectively.

CSP's operational ethos and governance embody the Triple Helix model of innovation (Etzkowitz & Leydesdorff, 2000), where academia (Trinity College and the University of Cambridge), industry (the myriad of businesses within the park), and government (through supportive regulatory and infrastructural frameworks) synergize to create a conducive environment for technological and economic progression. CSP stands as a prime example of the Triple Helix model in action, with the University of Cambridge's pivotal role in its inception and growth highlighting the importance of academic institutions in regional innovation systems. This ecosystem has proven fertile, with university-sourced knowledge and resources igniting significant advancements and growth. The dynamic interaction among academic knowledge, governmental facilitation, and industrial collaboration has been instrumental in pushing the boundaries of science and technology, cementing the park's status as a crucible of global innovation.

A chronology of the development of health sciences park

Figure 6 offers a comparative insight into a total of ten health science parks located in countries including U.S., UK, Japan, France, Singapore, and Germany. Established between 1975 and 2006, these parks demonstrate the varied development styles and key features employed to stimulate innovation and economic growth in the health sciences sector.

Figure 6: The development styles of the selected health sciences parks:

Development style	Name of health science parks	Country location	Year of est.	Key characteristics
University dominated •Originally driven by university knowledge, facilities and funding	Cambridge Science Park	UK	1987	Adequate recreation facility to attract university technologies and high-end talents
	University of Maryland BioPark	U.S.	2004	An optimized incubation environment with professional operation
	Technology Enterprise Park	U.S.	2006	Lack of clear positioning at beginning, with incomplete facilities & insufficient funding
Government dominated •largely rely on government input including policies and funding •a good soil of small and medium-sized enterprises	Manchester Science Park	UK	1984	Close cooperation between government and enterprises, with leverage of social resources
	Saito Life Science Park	Japan	2004	Operated by government with strong drive to ensure technology transfer to industry
	Biopolis	Singapore	2004	Government and leading enterprises jointly promote the development of the industry
Hybrid drive •Strong interactions between university, government and industry •Examples of triple helix model of innovation	Research Triangle Park	U.S.	1975	A habitable business environment favorable to attract high-end talents around
	Munich Biotech Cluster	Germany	1997	Formed by spillover of pharma companies, ena bled by Act change and government funding
	Lyon's Bioparc	France	2005	The market-oriented operation of association membership brings the industry vitality

Source: author's own diagram

The development of health sciences parks reflects diverse contexts, evolutionary histories, strengths, challenges, regional contexts, and cultural landscapes. These variances give rise to distinct development styles and core attributes, highlighting the versatile strategies employed to foster growth in the health sciences sector. When examined through the lens of the Triple Helix theory, which emphasizes the collaboration among universities, industries, and government, these development styles reflected by the above 9 parks in Figure 6 can be categorized into three primary development styles: University-Dominated, Government-Dominated, and Hybrid.

University-Dominated Parks:

University-Dominated Parks can be understood as those health sciences parks where the origins of the park's development are located in academia. Their growth is driven by the resources of universities, including academic expertise, facilities, and funding. These parks are typically situated near their partner universities, promoting effortless collaboration between academic researchers and resident businesses.

For instance, Cambridge Science Park is dependent upon one of Cambridge's oldest and most prestigious colleges, Trinity, for the land that the park occupies. it could also be argued that the park thrives due to its association with the University of Cambridge, creating a fertile ground for R&D in various scientific fields (Etzkowitz & Zhou, 2017). The University of Maryland BioPark (UM BioPark, 2021a and b) in the U.S. benefits from its affiliation with the University of Maryland, Baltimore, offering biotech and pharmaceutical firms opportunities for collaborative research and access to advanced facilities (Perman, 2016). Similarly, the Technology Enterprise Park (gatech.edu, 2021a and b) in Atlanta, the U.S. associated with the Georgia Institute of Technology, serves as a nexus for biomedical innovation and digital health (Tornatzky, 2002).

These examples highlight the pivotal role of universities in fostering innovation ecosystems. They provide startups and established enterprises alike with access to cutting-edge research, top-tier talent, and opportunities for high-impact collaboration that advance science and technology.

Government-Dominated Parks

Government-Dominated Parks showcase a development strategy where government leadership is crucial within the Triple Helix framework. This approach is marked by deliberate government actions including planning, funding, and policy enactment, aiming to spur innovation in the health sciences sector. Starting with specific focus areas, these parks grow through phases of resource allocation and incubation activities.

For instance, Manchester Science Park (Mspl.co.uk, 2021) in the UK has thrived due to government initiatives that cultivate a supportive environment for technology and science startups, as well as small and medium-sized enterprises (SMEs) (Garcia, 2004; Harper, 2003). Singapore's Biopolis (JTC.org.sg, 2021), with its goal to become a hub for biomedical sciences, benefits from substantial government investment and strategic policy implementation, attracting international corporations and researchers (Waldby, 2003; Sandström, 2009). Similarly, Japan's Saito Life Science Park (Saito.tv, 2012) exemplifies how government leadership can enhance industry and research collaboration, even in the face of strict regulatory landscapes (Yoda & Kuwashima, 2019).

These cases highlight the indispensable role of government in guiding and accelerating industry development, particularly in nurturing SMEs. Through infrastructure development and encouraging partnerships between academic institutions and the private sector, governments play a key role in driving growth within the health sciences.

Hybrid Parks

Hybrid Parks epitomize a balanced approach where the collaborative efforts of government, academia, and industry drive innovation. This model leverages a combination of government policies, academic research, and industrial strength to foster a thriving ecosystem for health sciences and technology. The evolution of such parks is marked by vibrant partnerships and interactions.

As discussed in chapter 3.4, Research Triangle Park (RTP) in the U.S., for instance, serves as a leading example, benefiting from strong connections between universities and industry, enhanced by supportive state policies, making it one of the largest research parks worldwide. In Germany, the Munich Biotech Cluster (BioM) (BioM, 2021 & 2008) exemplifies how government actions, alongside contributions from the pharmaceutical industry and academia, can create a nucleus for biotechnology advancements (Kerviler, et al., 2007; Zeller, 2001). Lyon's Bioparc (Lyon-Entreprises.com, 2018) in France further illustrates this model, thriving on government support and collaboration with local universities and businesses to promote R&D in health products (Invest-hub.org, 2020).

These instances highlight the Hybrid Drive model's ability to merge the strengths of its triple constituents—government, academia, and industry—into a powerful force for innovation and economic growth in the health sciences. Through building infrastructure, enhancing research collaborations, and offering financial backing, hybrid parks present a well-rounded strategy for sectoral progress.

3.6 Continuity and Contrast between Health Sciences Parks

The development of the above health science parks across the U.S. UK, Europe and Asia, reveals significant points of continuity and contrast. Whilst the Triple Helix theory provides a general framework for understanding the collaborative synergy between universities, industry and government (Etzkowitz & Leydesdorff, 2000). Etzkowitz (2008) It is clear from the foregoing discussion that, whilst each park involves all three essential components of the Triple Helix, the precise formula for how these three helices could come together varies quite considerably from context to context.

Success in these parks, whether university-dominated, government-led, or hybrid, relies on the effective collaboration across academia, industry, and government. Common strategies include the implementation of supportive policies like funding initiatives, tax incentives, and infrastructural improvements that are pivotal in promoting high-tech innovation. These initiatives bolster R&D efforts, with academic institutions pushing the scientific and technological envelope. Directed investments, sourced from either university funds or government policies, demonstrate a commitment to specific advancements within health sciences and technology (Etzkowitz & Leydesdorff, 2000). The primary goal of these parks is to stimulate economic growth and regional development. They strive to create environments that not only attract top talent but also facilitate the transfer of university-developed technologies to industrial applications. The inclusion of recreational facilities and optimized incubation spaces is also crucial for their success.

Operating within capitalist frameworks across various geographical locations, health science parks are shaped by the distinct institutional frameworks of their respective countries. These range from the federal republic system in the U.S., to the parliamentary democracy with a constitutional monarchy in the UK and Japan, the parliamentary republic systems of Germany and Singapore, and the presidential system in France. Despite the diversity of these governmental structures, they profoundly influence the policies and operational practices within the parks, particularly in how they facilitate collaboration among industry, academia, and government.

Although these parks align with market-oriented policies that promote competition and innovation, they also strategically integrate government and academic involvement. This integration is tailored to accommodate specific regional and national economic strategies and cultural values, supporting a market-driven growth model. This model prioritizes private enterprise and competitive industries, with the overarching goal of advancing health sciences and enhancing the socio-economic status of both local and national economies. Such an approach aligns closely with capitalist principles of development and profit maximization (Etzkowitz & Leydesdorff, 2000). However, it is in China where the concept of the health sciences park has really taken off – over 2000 new health sciences parks (Huang, 2020) since 2005 have been established in China. For this reason, the focus for this research is the specific development of health sciences parks in China. To make this case further the following chapter is designed to provide a comprehensive account of how China became such an important site for the location of health sciences parks.

Chapter 4. The Emergence of China as the Global Home of Health Sciences Parks

The previous chapter provided a clear rationale for using the Triple Helix model as the principal theoretical lens for this research. However, it is important to note that this model was primarily developed through inductive theorizing within Western contexts. Despite its widespread adoption, the model has faced criticism for its limited consideration of a broader set of national contexts (Balzat & Hanusch, 2004; Shinn, 2002) and wider social settings (Cooke, 2005). Although Etzkowitz and Leydesdorff, the model's proponents, acknowledge variations between Western and non-Western countries, they also recognize differences within Western societies themselves (Cai, 2014).

In response to calls for alternative theories more suited to non-Western contexts (Liu & Jiang, 2001; Williams & Woodson, 2012; Eun, Lee, & Wu, 2006; Zawislak & Dalmarco, 2011; Bernasconi, 2005), Cai (2014) proposed enhancing the model's context sensitivity. Cai's approach utilizes insights from institutional logics, recognizing that innovation systems involve complex interactions among various organizational actors—government, businesses, universities, research institutes—and are also shaped by interplays with institutional factors such as governmental policies and social norms (Edquist, 1997; Lundvall, 1992; Kumaresan & Miyazaki, 1999; Nelson, 1993).

Cai (2013) identifies the institutional logics underpinning the Triple Helix model in Western societies and suggests these logics as a benchmark framework to understand how the model could be adapted in non-Western contexts, particularly China. Studies on the implementation of the Triple Helix in China have shown a distinct approach, characterized by a top-down, government-led model in line with China’s centralized governance and state-led economic planning (Zhou, 2006; Zhou & Peng, 2008; Cai, 2014). This approach contrasts with the institutional logics observed in Western contexts, where in general there is a more balanced interplay between the government, industry, and academia despite differences in each practice.

Cai (2014) explores how the unique institutional logics in China could either promote or impede the development of the Triple Helix model. He suggests that to optimize innovation policies, China should not only adjust elements of its institutional environment to facilitate interactions among innovation actors but also innovate in developing its own Triple Helix modes that align with its unique institutional settings.

Health science parks have become integral to China's economic strategy, particularly following the country's rapid industrialization in the 1990s. In contrast to the world's first science parks, which originated organically through a 'bottom-up' approach where regions with strong academic research capabilities gradually commercialized, China's approach is markedly top-down. The Chinese government meticulously crafts every aspect of these parks, from selecting locations to planning and integrating academic and commercial entities, characterized by their state-driven creation, large scale, and significant numbers. This centralized management style aligns the parks closely with national development objectives and distinguishes them from their Western counterparts. Unlike the spontaneous, organic developments in the West that evolved into commercial hubs and were later recognized and formalized into health science parks, the concept in China has been deliberately engineered by the government, resulting in a unique breed of parks strategically designed in terms of location, facilities, and integration with crucial academic and commercial institutions.

The deliberate, centralized planning in China’s health science parks contrasts with the more organic, market-driven evolution seen in the West. In the West, science parks typically grew out of existing academic research hubs, which gradually commercialized and eventually evolved into formal health science parks. In China, however, the concept has been strategically engineered by the government, with careful consideration of location, infrastructure, and the integration of key academic and commercial institutions. These distinctive features of China's approach warrant a deeper investigation into how health science parks function as both innovation hubs and economic drivers within the national landscape.

This study aims to explore several key aspects of health science parks in China, including the role of China’s institutional and governance structures in facilitating collaboration between universities, industry, and government. It will examine the specific barriers and enablers of innovation within this framework, particularly the extent to which health science parks have been designed through urban planning processes to foster the knowledge spillovers and broader innovation predicted by the Triple Helix theory. Additionally, the research will explore the factors that attract talent to these parks in a highly competitive environment, where numerous alternatives are available, and the strategies that health science parks employ to compete for and incentivize talent, including both location and relocation incentives.

By unpacking the institutional logics and developmental strategies that underpin the design and operation of these parks, the chapter will provide a comprehensive analysis of how China’s health science parks are not only physically co-located but also strategically designed to bring together government, corporate, and academic interests. This model of integration is more pronounced in China than in any other country, and understanding how these parks facilitate collaboration and innovation is essential to appreciating their role in driving China's broader economic development.

This analysis will provide a comprehensive account of how the concept of health science parks, originating from countries like the U.S. and the UK, has been adapted and implemented in China, and the distinct impacts of this adaptation. By examining the rise of health science parks in China and their points of continuity and contrast with pioneering parks in regions such as North Carolina and Cambridge, this chapter will uncover critical, yet under-researched questions. These include the sequencing and integration of government, industry, and academic expertise within these parks and the practical outcomes of such configurations.

Furthermore, as these parks have developed and matured, new questions arise concerning their interrelations and the decision-making processes of mobile companies and researchers seeking the most opportune parks. The following chapters will explore these dynamics, setting the stage for a series of specific research questions that will guide the subsequent analysis of China’s approach to health sciences parks. This exploration not only enhances our understanding of China's economic and scientific advancements but also illustrates the country's strategic use of health science parks to bolster its technological capabilities.

4.1 Science Park Emergence Because of the Reform and Opening Up

4.1.1 Economic Reform and Opening Up

China's economic transformation, initiated by the reform and opening-up policy in 1978, marked a significant departure from a centralized planned economy to a dynamic market-oriented system. This pivotal shift, characterized by reduced economic controls and an emphasis on private sector development, unlocked China's economic potential, propelling it to become the world's second-largest economy by 2010 (Naughton, 1995; Wu, 2019).

The deregulation provided greater autonomy to enterprises, which had previously been stifled under stringent state controls. This newfound freedom revitalized private entrepreneurship, enabling businesses to transition from adhering to state-set quotas to engaging in market-driven operations responsive to consumer demands and competitive pressures (Walder, 1995). As a result, the roles of state-owned enterprises (SOEs) evolved, contributing to the rise of a vibrant private sector instrumental in driving economic growth and fostering innovation. The enhanced agility of private enterprises and the strategic shift in the management approach of SOEs notably improved the quality of goods and services. This advancement attracted more foreign investment and facilitated China's integration into the global economy. The introduction of multinational corporations (MNCs) further catalysed this growth, introducing advanced technology, increasing market competitiveness, and contributing to economic dynamism.

These sweeping reforms illustrate China’s strategic adaptation to an evolving global economic landscape. By effectively managing its transition, China has integrated into the global economic system while striving to maintain social stability and promote sustained economic health. This approach has not only spurred domestic economic growth but has also positioned China as a key player in the global market, reflecting its shift towards a more open and market-driven economy.

4.1.2 Transformation of Government Function and Emergence of Science Parks

The reform era in China marked a pivotal shift in the government's role, transitioning from direct economic planning and management to a more regulatory and facilitative function. This transformation, as detailed by Naughton (2007) and Xu (2011), involved the decentralization of economic controls and the stimulation of market competition through a series of regulatory reforms (Lardy, 1998; Brandt & Rawski, 2008). The government began focusing more on providing essential infrastructure and public services while fostering an environment conducive to innovation and economic growth. Moreover, the reform era's shift towards a regulatory and facilitative government role also involved the establishment of sciences parks, which have played a crucial role in advancing economic growth through high-tech development (Lu & Lazonick, 2001). A critical initiative was the introduction of Special Economic Zones (SEZs) in 1980, aimed at attracting foreign investment and enhancing market freedoms. This initiative quickly expanded with the creation of numerous Economic and Technological Development Zones (ETDZs) between 1984 and 1986, which further liberalized the economic landscape. The Torch Plan of 1988 continued this trend by focusing on technology transfer and fostering high-tech entrepreneurship, laying the groundwork for the widespread establishment of science parks across China. By 2018, China had established 168 High Technology Industrial Development Zones (HIDZs) and 219 ETDZs, strategically positioned in key economic hubs to maximize commercial activity. These science parks provided incentives such as tax breaks and streamlined administrative procedures, attracting a mix of domestic and international businesses and promoting rapid industrialization and the adoption of modern management practices (China Association of Development Zones, 2018).

A significant outcome of these transformation was the shift in economic decision-making power to municipal governments. These local governments transitioned from passive regulators within a planned economy to proactive, entrepreneurial agents of local development (Wu & Zhang, 2007). This change mirrors global trends towards entrepreneurial governance, particularly observed in the West during the 1990s (Harvey, 1989). In China, this transformation, which empowered local governments to adopt a more strategic approach, aligning their decisions with local interests to enhance economic competitiveness.

4.1.3 Institutional Reform of Academia

The transition of Chinese academia to embrace market-oriented practices has been a nuanced and incremental process, particularly evident in the establishment of university-owned enterprises (UREs) since 1999 (Cai, 2014). Despite the intent to boost market dynamics, simply transforming public institutions into commercial entities does not automatically ensure market-oriented success (Christensen & Lægreid, 2007).

Historically, the Chinese research environment from the 1950s through the 1970s was dominated by research institutes prioritizing research, with universities primarily dedicated to teaching, a system heavily influenced by the Soviet model. This began to change in the 1980s when China started adopting reforms inspired by the American educational system, which favours a blend of teaching and research within comprehensive universities (Cai, 2014). Intellectual property (IP) laws in China were first established in the 1950s and revised to meet international standards by the 1980s. These laws are crucial for technology development and acquisition (Cai, 2014). However, weak enforcement has often undermined trust between knowledge creators and users, leading many universities to commercialize innovations internally through UREs to sidestep complex external negotiations (Eun, Lee, & Wu, 2006). Over the years, there has been a significant shift from reliance on traditional University Research Establishments (UREs) to more diverse forms of university-industry collaboration, such as joint research projects, technology transfer initiatives, and the creation of spin-off companies. These newer forms of collaboration are more effective at integrating academic research into the market (Mowery, et al., 2004; Etzkowitz, 2008).

This evolving landscape demonstrates a growing recognition of the need for active engagement between academia and industry, fostering an environment where scholarly research can be more readily translated into marketable and practical solutions. These developments not only enhance the economic value of academic research but also contribute to the overall dynamism and competitiveness of China’s market-oriented economy.

4.1.4 Summary

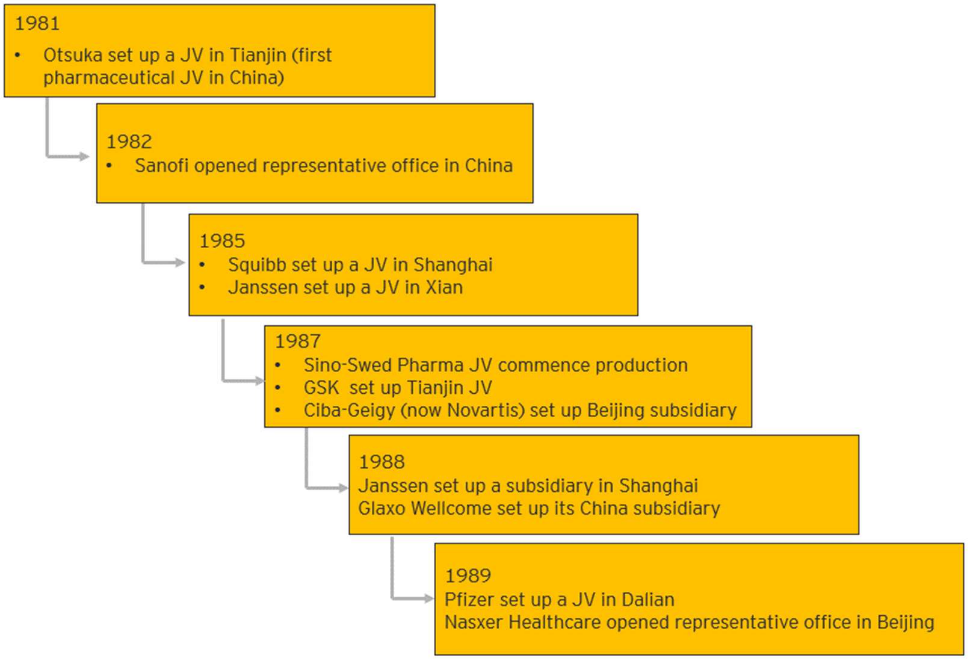
In summary, China's reforms since the late 1970s have steered a significant shift from a centralized planned economy to a market-oriented framework. This transition has been highlighted by deregulation, bolstering of the private sector, and the strategic incorporation of multinational corporations, all of which have synergistically propelled economic growth and innovation. The government's pivot to a more facilitative role, evidenced by the creation of science parks, has been instrumental in spurring high-tech advancements and fostering a competitive market landscape. Additionally, academia has experienced institutional reforms, resulting in the emergence of UREs and an increasingly market-aligned research environment. Collectively, these changes have not only elevated China's global economic status but also reflected the nation's dedication to social stability and economic sustainability through strategic reforms and active participation in the global economy, aligning well with the Triple Helix theory's components of government, industry, and academia.

4.2 Health Science Industry in China

The development of China's health sciences industry, closely linked to the nation's economic progress, has experienced rapid growth due to increasing market demand, global integration (Sapir & Mavroidis, 2021), and policy liberalization (Sun, et al., 2008). Healthcare initiatives (Ma, et al., 2008) have been geared towards improving public health and stimulating economic activity in this sector, reflecting a growing market influenced by rising living standards and public health awareness (Xinhuanet, 2016; Npc.gov.cn, 2020). Factors such as an aging population, pollution, and changing cultural attitudes have expanded consumer groups from those needing essential medical treatments to those seeking over-the-counter products and elective procedures. This shift is evident as healthcare expenditure as a percentage of total consumption for rural and urban residents rose significantly from 2009 to 2020 (stats.gov.cn, 2020a). Despite a forecasted slowdown in China's economic growth to about 5% by 2025, the health sciences sector remains poised for substantial expansion, given its relatively low GDP proportion compared to developed countries like the U.S. and Japan (stats.gov.cn, 2020b; statista.com, 2020).

The entry of MNCs significantly influenced this trajectory, beginning with Otsuka—a Japanese pharmaceutical company that established a joint venture in China in 1981. This initial success attracted further MNC investments, driven by policies favouring MNCs during China's reform era. These policies enabled MNCs to introduce advanced, patented pharmaceuticals at competitive prices and engage in collaborative research projects with local health institutions without the regulatory constraints typically imposed on domestic firms (Hu, 2007). Figure 7 provides a timeline of MNCs' activities in China over the opening up period beginning in 1981:

Figure 7: 1980s global multinational pharmaceutical companies in China



Source: author's own diagram.

Post China's accession to the World Trade Organization (WTO), this trend accelerated, with more MNCs establishing R&D centres in China, thereby enhancing local expertise and technological capabilities. By 2016, these MNCs had invested over CNY 80 billion (approximately USD 12 billion) in research centres across China (Chen, 2021), highlighting the significant impact of foreign direct investment on the industry.

Figure 8: R&D centres set in China by MNCs during 2002-2009

Year of establishment	Name of enterprises with China R&D centre(s)	Location
2002	AstraZeneca	Zhangjiang·China Medicine Valley
	Novo Nordisk	Beijing Zhongguancun
2003	Eli Lilly	Zhangjiang·China Medicine Valley
	GSK	Tianjin
2004	Roche	Zhangjiang·China Medicine Valley
2005	Pfizer	Zhangjiang·China Medicine Valley
	Sanofi-aventis	Zhangjiang·China Medicine Valley
	Johnson & Johnson	Zhangjiang·China Medicine Valley
2006	Novartis	Suzhou Changshu
2007	GSK	Zhangjiang·China Medicine Valley
	Novartis	Zhangjiang·China Medicine Valley
2008	Sanofi	Zhangjiang·China Medicine Valley
	Takeda	Zhangjiang·China Medicine Valley
2009	AbbVie	Zhangjiang·China Medicine Valley
	Bayer	Beijing

Source: author's own diagram.

China's domestic Contract Research Organizations (CROs) emerged as essential components of the health sciences ecosystem, capitalizing on cost advantages and robust clinical resources. Entities like Wuxi PharmaTech exemplified this trend, aligning with government standards to offer competitive global services (NMPA.gov.cn, 2003; Kaitin, 2008; Xia & Gautam, 2015). These CROs are characterized by their knowledge-intensive nature, relying on a talented pool of scientists and researchers, including China-born scientists with international experience who often led these organizations (Fan & Gagnon, 2011).

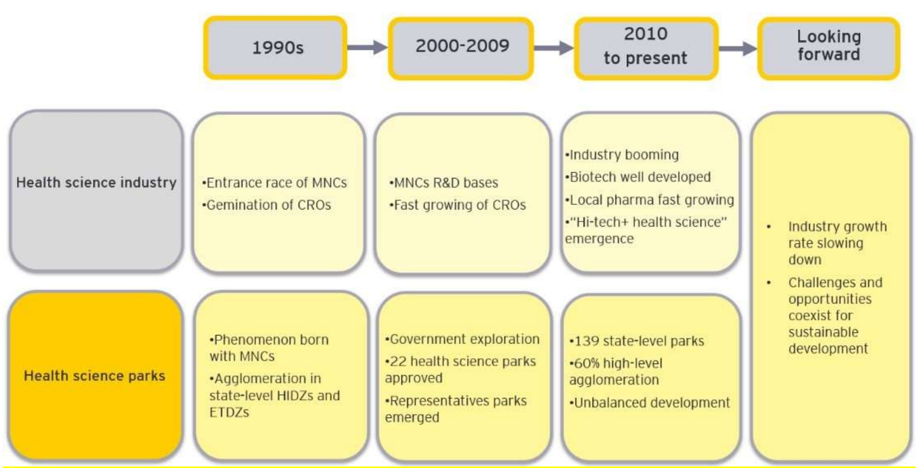
Government initiatives have furthered this growth by streamlining pharmaceutical approval processes, enhancing IP protection, and fostering international collaborations. These strategic actions, combined with financial incentives such as R&D funding, tax breaks, and subsidies, alongside targeted talent attraction schemes, have reduced the costs associated with R&D (Cadorin, Klofsten, & Löfsten, 2019). This have spurred innovation and made China an attractive location for pre-clinical research and clinical trials. The lower costs alongside abundant clinical resources and large patient groups have expedited pharmaceutical development cycles significantly (Kaitin, 2008).

In summary, the development of the health sciences industry has positioned China as a critical player in the global health sciences landscape, characterized by a competitive, dynamic, and technologically advanced market environment. This general growth in this industrial sector has created a national context where the development of the health sciences has required specific spaces, purpose designed for this industry.

4.3 Evolution of Health Sciences Parks in China

The development of health sciences parks in China has been an integral part of the country's strategy to integrate into the global value chain and enhance indigenous innovation. This process has been heavily influenced by structured government planning, regulatory frameworks, and significant capital investments, all aimed at propelling the health sciences industry forward. These efforts have led to the creation of a dynamic network of parks that both respond to and shape global industry trends through a synergistic interplay of government directives and industry participation. The development history is summarized in Figure 9.

Figure 9: Development history of Chinese health sciences industry and parks



Source: author's own diagram.

4.3.1 Early Development and Agglomeration (1990s to Early 2000)

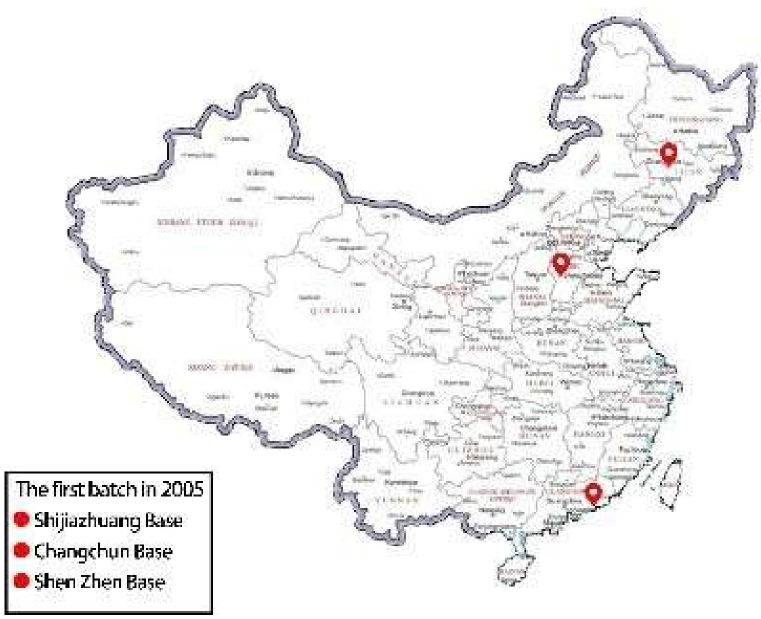
Dating back to the 1990s, China's initiative to establish High and New Technology Development Zones (HIDZs) and Economic and Technological Development Zones (ETDZs) marked the nascent phase of health sciences parks. This period was characterized by the entrance of pharmaceutical MNCs (Figure 8) such as Bayer, Merck, and AstraZeneca, which were drawn by economic reforms that facilitated foreign investments and technology transfer. Cities like Beijing and Shanghai quickly became central hubs, supported by their robust infrastructure and strong academic and business networks. The establishment of the Zhangjiang Hi-tech Development Zone in 1996 was a pivotal moment, setting the stage for what would become known as the Zhangjiang China Pharmaceutical Valley (ZCPV), an initiative bolstered by both national and local government endorsements (Xia & Gautam, 2015).

4.3.2 Expansion and Maturation (2000 to 2009)

The early 2000s witnessed an accelerated growth in pharmaceutical MNCs and the local CRO industry, stimulated by China's accession to the WTO in 2001. The expansion was marked by the creation of pharmaceutical R&D centres (Figures 8) and CROs, enhancing technology transfer and knowledge spillover within these clusters. Notably, the establishment of Zhongguancun Life Science Park (ZLSP) in 2000 exemplified focused governmental efforts to position these parks as competitive global innovation centres (Wang & Chen, 2018). The National Development and Reform Commission's approval of 22 health sciences industry bases between 2005 and 2007 further highlights the strategic national effort to foster dense clusters of innovation (Figure 10).

Figure 10: Landscape of approved national-level health sciences parks during 2005 to 2007

(Figure 10 is provided for illustrative purposes within this research paper. For a comprehensive and authoritative depiction of Chinese territory, please refer to the official map published by the Chinese authorities.)



Source: charted by the author based on public information.

Source: charted by the author based on public information.

Source: charted by the author based on public information.

The landscape in Figure 10 are provided for illustrative purposes within this research paper. Due to constraints in time and funding, the scope of this research does not extend to parks in Hong Kong, Macao, and Taiwan. However, it is important to acknowledge that the exclusion of these regions does not diminish the significance of their parks or their contributions to the development of China's economy. The chart presented above is intended solely to display the parks relevant to this study and should not be considered a comprehensive representation of China. The complete territory of China should be based on the map officially published by the Chinese authorities.

4.3.3 Modern Era and Global Integration (2010 to Present)

China's health sciences parks have become central to the country's strategic development in biotechnology and healthcare over several decades. Over 2,000 health sciences parks now exist across China – far more than any other since country - reflecting the vast scale of the nation's population and market (Huang, 2020). As of 2019, there are 193 national-level health sciences parks focusing on sectors like biopharma and medical devices, with key examples including Suzhou Biomedical Industrial Park (BioBay) and Zhongguancun Life Science Park (ZLSP) (CCID & sinaMed, 2020). These parks are seen as crucial for driving domestic technology transfer and industry agglomeration, aligning with global trends in leveraging health sciences parks to foster sustainable development and regional economic enhancement (Compagnucci, Lepore, & Spigarelli, 2020).

4.3.4 Summary

The development history of Chinese health sciences parks exemplifies the Triple Helix model of innovation in China. They are characterized by heavy government involvement and large-scale development, play a pivotal role in the nation's innovation landscape. Government support is instrumental, providing strategic plans, policies, funding, and tax incentives to nurture these ecosystems (Xie, et al., 2018). The development scale of health sciences parks in China in terms of the number, size and development speed, are typically larger than their global counterparts, reflecting the vast market and population, and are designed to facilitate the formation of specialized clusters, enhancing the innovation ecosystem (Huang, 2020). This evolution underscores China's adoption of the Triple Helix model, whereby government, industry, and academia collaborate to foster innovation.

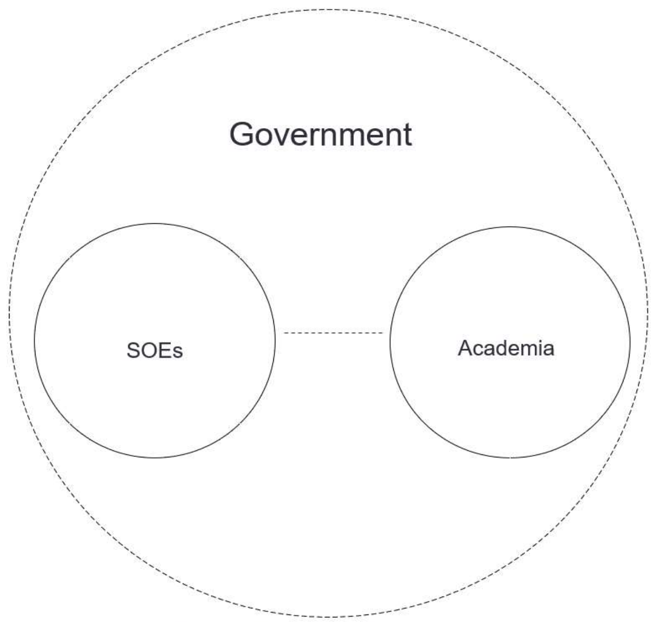
4.4 Changes in Applicability of Triple Helix Innovation in China

4.4.1 Limited Applicability in Pre-reform China

The applicability of the Triple Helix theory in China has experienced a profound transformation following the economic reforms of the late 1970s. Before these reforms, the potential of the Triple Helix model was significantly constrained by the centralized governance system, minimal market dynamics, and limited academic independence (Zhou & Peng, 2000). During this era, the nation prioritized subsistence over innovation.

The innovation system in pre-refrom era China is perhaps best understood as exemplifying a statist version (Figure 11) of the Triple Helix model in accordance with Etzkowitz, et al. (2007: p.16). In the configuration that the nation state encompasses academia and industry and directs the relations between them (Etzkowitz & Leydesdorff, 2000), universities and research institutions of China primarily focused on fulfilling state development plans and adhering to political agendas, rather than cultivating an innovative or autonomous academic environment. Research priorities were dictated by the government, which also controlled funding, stifling the potential for a balanced interaction among the three helix stakeholders (Naughton, 2007). The absence of a significant private sector and stringent restrictions on or no foreign investments further constrained the dynamics necessary for the Triple Helix model. SOEs monopolized industries, including health sciences, operating without the competitive or innovative pressures that might arise in a more market-driven environment (Lin, et al., 2020). Such an overwhelmingly dominant government role obstructed any real collaborative interplay between the three sectors, rendering the Triple Helix theory incompatible in a setting where academia and industry were subordinates to state directives, lacking true autonomy or profit motives (Walsh, 2010).

Figure 11: Statist Model In China In Pre-reform Era



Source: Illation from Tripe Helix Model

4.4.2 Health sciences parks post the Chinese reform agenda

The transition towards a market-oriented economy since the late 1970s has been pivotal in enhancing the applicability of the Triple Helix model within China. This shift has marked a significant departure from the previous central planning model. As China's economic and political landscape evolved, these three sectors have carved out distinct yet complementary roles, cultivating an environment conducive to innovation and development. China's adoption and adaptation of successful international experiences, particularly in the establishment of science parks, have provided fertile ground for innovation. These parks serve as the physical and operational manifestation of the Triple Helix model, fostering a collaborative ecosystem where each helix can thrive and contribute to a dynamic innovation process. The evolution from a simple Triple Helix model to a more complex and compound driving model has been evident in the strategic development of health sciences parks. These parks bring together strategic government policies that provide direction and support, substantial industrial investments that offer resources and market acumen, and focused academic research that drives discovery and innovation. The synergy among these elements propels advancements in health technologies and biopharmaceuticals, positioning China as a key player in these fields.

4.4.3 Adapatability in Health Sciecnes Parks

Initially, industrial parks in China were established to provide factory output for Western companies, embodying a model where "innovation" occurred in the MNC's home countries while manufacturing was executed in China. Over time, attracted by the favorable commercial environment, skilled talent, and cost advantages, pharmaceutical MNCs began to establish R&D centers in specific locations within China (as described in Figure 8 of Chapter 4.2). As China's economy has grown, so too has its emphasis on scientific and technological advancement. Recognizing the critical role of innovation in driving economic growth, the government has actively implemented policies to foster collaboration among academia, industry, and government sectors. These policies include creating incentives for industry-academia partnerships and providing substantial funding for R&D. This dynamic application of the Triple Helix model, with the government acting as a catalyst, has significantly enhanced interactions between industry and academia. Such collaborations are now fostering the creation of new knowledge and the development of innovative technologies, contributing to high-quality economic growth. Consequently, some health science parks in China are evolving beyond manufacturing hubs to become centers of innovation, benefitting from the synergies created by these strategic efforts. As China continues to refine its innovation strategies, the Triple Helix model offers a valuable lens through which to view and bolster the collaborative dynamics among government, industry, and academia. This approach, emphasizing synergy and interdependence, is poised to propel China's future innovations and reinforce its status as a global leader in science and technology, particularly within its health sciences parks.

4.4.4 Summary

In summary, the applicability of the Triple Helix innovation in China has seen significant changes since the late 1970s economic reforms. Initially, the centralized governance and lack of market dynamics and academic independence limited its potential. However, the shift towards a market-oriented economy has enhanced the model's applicability by fostering a more interdependent relationship among government, industry, and academia. The establishment of science parks, especially in health sciences, has been instrumental in this transformation, providing a collaborative environment for innovation. As China continues to develop its innovation strategies, the Triple Helix theory remains a relevant framework for understanding and strengthening the collaborative dynamics among the three sectors.

4.5 Health Sciences Parks of China from Triple Helix Perspective

Over recent decades, China's health sciences parks have experienced substantial evolution in their innovation systems, particularly regarding the institutional relationships between government, business, and academia. The implementation of the Triple Helix theory within these parks has been dynamic, evolving significantly since the year 2000.

4.5.1 Silo Confinement Under Statist Model Prior to Year 2000

Prior to year 2000, the innovation systems in the health sciences parks of China refected Silo Confinement Model of Triple Helix (Kimatu, 2016). As discussed in prior chapters of this analysis, back to then the emergence of private businesses and the gradual independence of academia following institutional reforms just established the three compoents participating in the Triple Helix. However, initial interactions among government, business and academia were limited.

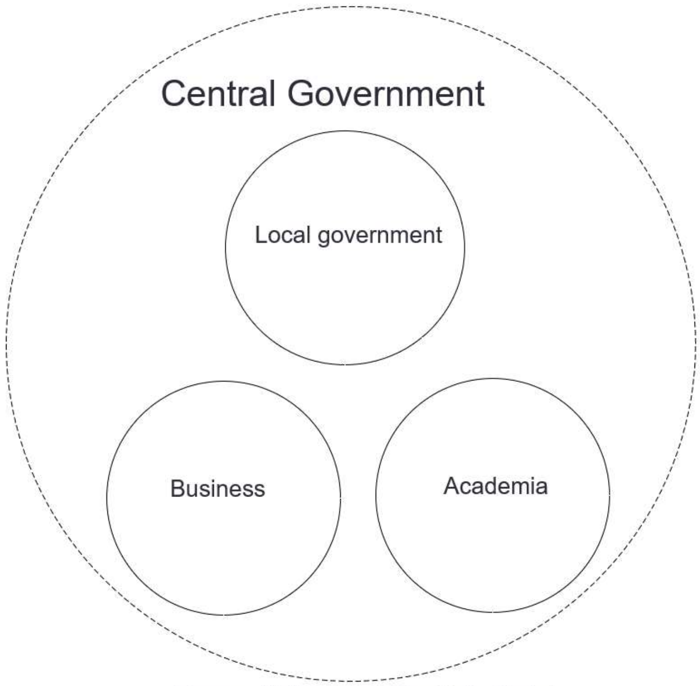
China's governance system is designed to manage its vast and diverse landscape effectively, balancing centralized authority with regional autonomy. The central government holds ultimate control over national policies, economic management, taxation, critical infrastructure, and international representation, including crisis leadership (Chen & Guan, 2011). Meanwhile, local governments play a crucial role in the regional innovation system development, implementing national policies, managing regional public services, and adapting bylaws to local conditions. They leverage the intangible assets of regional clusters to foster innovation and drive economic growth, a strategy that aligns with national objectives while allowing for regional specificity (Cai & Liu, 2015). Triple Helix literature treats government as a single spiral in the Triple Helix interactions, Cai and Liu (2015) make distinction between central and local government in the Triple Helix framework in China. Hereinafter, the author will separate the central and local government of China in presenting the Triple Helix models applied in China.

The central government holds ultimate control over national policies, economic management, taxation, critical infrastructure, and international representation, including crisis leadership (Chen & Guan, 2011). Meanwhile, local governments play a crucial role in the regional innovation system development, implementing national policies, managing regional public services, and adapting bylaws to local conditions. They leverage the intangible assets of regional clusters to foster innovation and drive economic growth, a strategy that aligns with national objectives while allowing for regional specificity (Cai & Liu, 2015).

Prior to the year 2000, SOEs continued to dominate the health sciences industry, focusing on pharmaceutical production and distribution, as well as public health related busienss. MNCs managed most of their R&D internally or through international CROs. Local private entities just emerged often employed fast-following strategies rather than pioneering original innovations. Concurrently, academia lagged behind in conducting cutting-edge research, limiting its contributions to the innovation ecosystem.

This configuration did not significantly foster the creation of knowledge-based jobs, vital for advancing a knowledge-intensive economy (Kimatu, 2016). Analysis identified a critical shortfall in meaningful interactions among the key stakeholders—government, academia, and industry under such a model (Etzkowitz & Leydesdorff, 2000; Etzkowitz, 2003). They in fact practically work in independent silos as shown in Figure 12. This lack of synergy led to innovation stagnation.

Figure 12: Statist Model in Health Sciences Parks Of China Prior to Year 2000



Source: Illation from Tripe Helix Model

4.5.2 Laissez-faire Model Since Year 2000

Addressing the challenges of the previous model, China adopted a more integrated approach after the turn of the millennium, emphasizing collaboration and knowledge exchange among the government, academic institutions, and industry. According to the State Council of China (2006), the country has increased investment in technology and taken significant steps towards building a high-performance innovation system and knowledge economy. It is a symbolic strategic shift for revitalizing China's innovation landscape and enhancing its contribution to national economic development.

This transformation involved moving from a Silo Confinement Model to a more laissez-faire approach, which allowed for greater autonomy and interaction among universities, industries, and government entities. Marked by further decentralization of control and encouragement of private sector participation into biotechnology, pharmaceutical and medical devices, which is contrasted sharply with the past, where SOEs dominated. The new environment proved conducive for private enterprises, fostering innovation and growth.

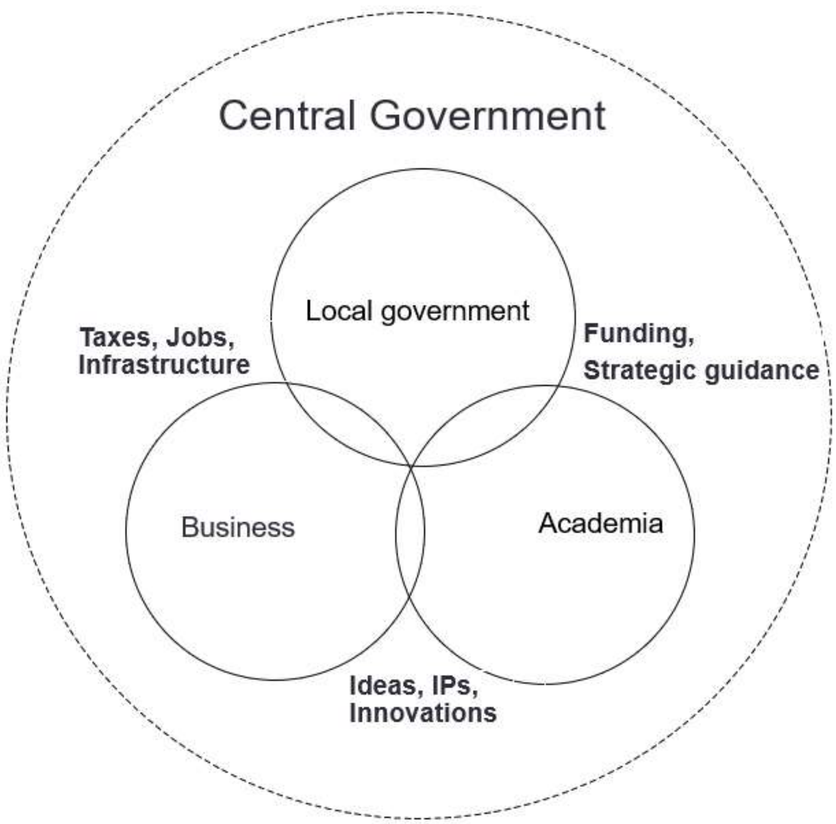
As detailed in section 4.2, China's accession to the WTO catalysed the establishment of MNC R&D centres and the rise of domestic CROs like WuXi PharmaTech. These entities leveraged cost advantages and skilled talent to offer globally competitive services. The presence of these MNCs and CROs facilitated technology transfer and knowledge spillovers, significantly enhancing the capabilities of local companies through access to advanced equipment and innovative medicine development processes.

This era also saw the formation of industry clusters—geographically concentrated areas where companies from the same sector are located closely, enabling further agglomeration and innovation. Influenced by new market practices introduced by pharmaceutical MNCs, local firms began to differentiate and some emerged as industry leaders, reshaping the sector with innovative approaches and market positioning.

The Chinese government identified life sciences as a strategic priority during this period and began to invest heavily in R&D and infrastructure development. Specialized science parks were established to nurture the growth of this industry, providing health sciences companies and research institutions with targeted support such as access to infrastructure, funding, and policy incentives.

These transformations underpin the strategic design of China's health sciences parks, which have evolved from traditional industrial settings into comprehensive, innovation-driven ecosystems. These parks now increasingly integrate administrative and market-oriented strategies, incorporating public-private partnerships (PPPs) to align public objectives with profit-making initiatives (Audretsch, Link, & Scott, 2019; Hu, 2007). The interactions between the helices are as shown in figure 13.

Figure 13: Laissez-faire Model in Health Sciences Parks Of China Since Year 2000



Source: Illation from Tripe Helix Model

4.5.3 Experiment of Balanced Helix Model

Initially established to provide factory output for Western pharmaceutical development, China's health sciences parks could now be evolving to generate local innovations. As the health sciences industry has developed in China the related question of how the expansion of the industry will be accommodated has become more and more relevant. This shift raises the question of whether such innovations are more prevalent in some locations than others. It's plausible to speculate that health science parks situated near, or with strong connections to, research-intensive Chinese universities may be pioneering pharmaceutical innovations developed domestically. Traditionally, innovation has occurred in the MNCs' home countries, with manufacturing then outsourced to China. However, this dynamic may be changing, with some health science parks potentially transitioning to hubs where both innovation and manufacturing occur within China. This represents a significant shift from the traditional model of Western innovation and Chinese manufacture.

The transformation of these health science parks always integrated the evolution of government, business and academia. This aligns with the definitions provided by the Triple Helix , which emphasizes the equal role of universities in innovation alongside industry and government; the move towards collaborative relationships where innovation policy emerges from interaction rather than top-down directives; and the role of each sector in adopting functions outside their traditional scope, thereby fostering innovation.

Initially, the government played a crucial role in shaping the development of China's health sciences parks. It provided strategic direction, designed infrastructure, and offered regulatory support, creating an attractive environment for investment and innovation. Through various incentives such as tax breaks and streamlined administrative procedures, the government aimed to make these parks appealing to industry partners. This approach was foundational in establishing the parks as centres of innovation and economic activity (Zhen, Ren, & Tang, 2022).

As the parks evolved, significant contributions from the business sector became apparent, with both state-owned and private firms, including multinational corporations, playing pivotal roles. Part of the roles performed by government was shifted to state-owned enterprises or private firms. These entities also provided essential capital, cutting-edge technology, and managerial expertise, crucial for translating academic research into market-ready products, particularly noticeable in the biotechnology sector (Wonglimpiyarat, 2016). This involvement diluted the influence of government and diversified economic activities within the parks.

Academic institutions, aligned with this model, focused increasingly on applied research with direct commercial applications. This shift was supported by government funding schemes that incentivized research with practical outcomes, facilitating the transition from basic research to market-ready innovations (Leydesdorff & Etzkowitz, 2001). The involvement of multinational corporations, particularly in cities like Beijing and Shanghai, further enhanced this dynamic, creating hubs of innovation that extended to nearby cities such as Shenyang, Tianjin, and Suzhou (Zhen, Ren, & Tang, 2022).

This evolving framework facilitated the emergence of hybrid institutions such as technology transfer offices and science parks, crucial for converting academic research into commercial applications. These developments are underpinned by policies promoting public-private partnerships, which balance public objectives with commercial viability, thereby enriching the innovation ecosystem (Zhen, Ren, & Tang, 2022).

Over the years, a few of China's health sciences parks have increasingly aligned with the Balanced Helix Model, which emphasizes equitable collaboration among universities, industry, and government. This shift has been significantly influenced by the evolution of government policies, which have created a conducive environment for this development model.

The government's strategic planning and supportive policies have fostered an ecosystem where academic research, industrial innovation, and regulatory frameworks synergize effectively, enhancing the growth and impact of these parks. This model facilitates a dynamic interchange of ideas and resources, accelerating innovation and ensuring that developments in health sciences are both progressive and sustainable.

The transformation of China's health sciences parks towards forming platforms that implement the Triple Helix model. It demonstrates how balanced collaboration among government, academia, and industry can optimize the development of a dynamic innovation ecosystem. This collaborative approach contributes significantly to national economic development and enhances China's global competitiveness in the health sciences sector, serving as a microcosm of China's broader economic transformation.

4.5.4 Summary

The dynamic evolution of China's health sciences parks through the lens of the Triple Helix model, illustrating a significant transformation in the interaction among government, academia, and industry. Initially constrained by a siloed approach under the Statist model prior to 2000, these parks have transitioned towards a more integrated and collaborative framework. Post-2000, adopting a laissez-faire model, the parks have embraced greater autonomy, facilitating enhanced collaboration and knowledge exchange, which have been crucial for fostering innovation. This shift was catalysed by strategic governmental policies aimed at nurturing a high-performance innovation system. The formation of industry clusters and the establishment of specialized science parks have further solidified the parks' roles as modern, innovation-driven ecosystems. The landscape of health sciences parks in China toward a balanced Helix model have spurred significant technological advancements and economic growth. These developments not only underscore China's commitment to enhancing its global competitiveness in health sciences but also reflect the broader economic shifts within the country, with strengthen on innovation.

4.6 Core of the Triple Helix Framework in China

The Triple Helix framework in China is characterized by the significant role of the government, which collaborates closely with academia and industry to foster innovation and regional development. Unlike in Western contexts, the government in China takes a more prominent position, providing strategic oversight while allowing for localized execution to stimulate innovation and support regional growth.

Central Government's Role in Strategic Planning

The central government in China plays a pivotal role in defining the nation's economic direction through comprehensive strategic planning and policy-making (Huang, 2008). The implementation of Five-Year Plans has been fundamental in guiding national priorities and allocating resources (Naughton, 2018). These plans establish a regulatory framework that directs various sectors of the economy, ensuring that overarching goals are met while supporting economic growth, social stability, and environmental sustainability.

Localized Execution by Local Governments

While the central government sets the framework, local governments are responsible for implementing these policies, adapting them to regional specificities (Zhou & Ma, 2000). This dual governance model allows for a combination of centralized control and localized flexibility, enabling local authorities to customize economic initiatives and public services to fit their unique contexts. Such adaptability is essential for the effective execution of national policies and for fostering regional development that aligns with local dynamics.

Coordinated Development and Innovation

The centralized approach to urban development in China includes meticulous management of land use, infrastructure development, and investment attraction, ensuring that large-scale projects support both national objectives and regional interests (Zhou & Ma, 2000). In instances of conflicting interests, the centralized political system allows for swift decision-making, enabling the central government to provide unified direction and reconcile interests across different levels, thereby efficiently achieving broader economic and social objectives (Heilmann, 2008).

Local Adaptation of the Triple Helix Model

Locally, the Triple Helix model in China illustrates a unique orchestration of interactions between government, industry, and academia (Etzkowitz & Zhou, 2006). Local governments tailor this model to address specific regional needs and conditions, creating environments conducive to customized innovation and knowledge transfer. This localized application enables more precise and effective strategies that meet regional challenges and exploit local opportunities.

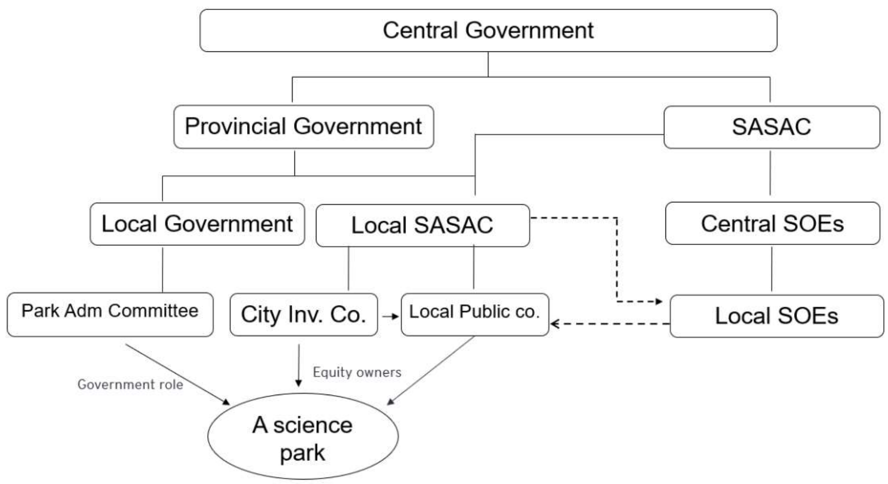
Contrast with Western Systems

Unlike Western systems, which often emphasize decentralization and the separation of powers, China’s centralized decision-making process facilitates rapid policy implementation and a cohesive strategy. This approach has been instrumental in driving China’s swift economic transformation and its emergence as a global power (Naughton, 2018).

In summay, the integration of central and local governmental roles within the Triple Helix framework is vital to China’s method of economic planning and urban development. The strategic direction provided by the central government, combined with the nuanced execution by local governments, creates a dynamic landscape for rapid development and innovation. The adaptation of the Triple Helix model at the local level further enhances this process by improving collaboration between government, industry, and academia, leading to an effective approach for fostering innovation and knowledge transfer. This chapter emphasizes how government-led initiatives are critical in shaping and executing the core components of the

Triple Helix framework in China, making it a fundamental element in the nation's development narrative.

Figure 14: Framework to Form a Government-led Park in China – Government

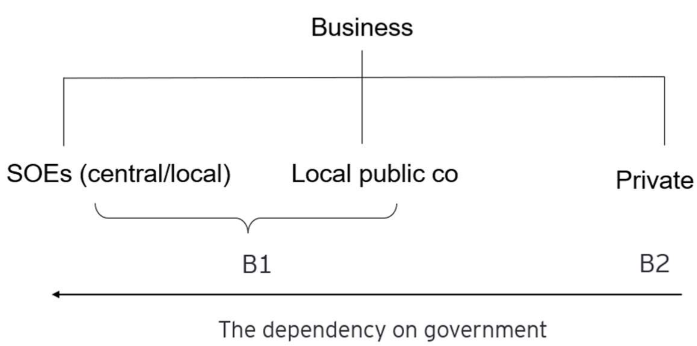


Source: author's own diagram.

Note:
SASAC: State-owned Assets Supervision and Administation Commision of the Sate Council, PR China.
Park Adm Committee: Park Administration Committee
City Inv. Co.: City investment company

Figures 14 is likely diagram illustrating the hierarchical structure involved in the establishment and administration of a government-led park in China. This diagram would effectively depict the top-down approach, starting with directives from the central government and cascading down through administrative levels down to local implementation. Such visual representations highlight the coordinated efforts and synergy between different levels of government, emphasizing their collaborative role in creating a conducive environment for development. The diagram demonstrates how central government directives are translated into concrete local actions, ultimately culminating in a government-led park in China.

Figure 15: Framework to Form a Government-led Park in China – Business



Source: author's own diagram.

Note: central and local SOEs are categorized as B1, private businesses, or those with a majority private stake, grouped as B2.

Figure 15 provides an overview of the business dynamics within a government-led park in China, emphasizing the relationship between various entities and the government. At the core of this structure are SOEs. Central SOEs, which are managed by the central government, play a strategic role in sectors that are essential to the national economy, aligning park activities with government priorities. Local SOEs, owned by local governments or in partnership with central SOEs, focus on regional economic development and community benefits. As depicted in Figure 14, Local Public Companies are typically government-owned or co-owned with local SOEs, sometimes involving private stakeholders who hold non-dominant shares, indicating a significant degree of government influence within the park's business environment. In Figure 15, central and local SOEs are categorized as B1. In contrast, Private Businesses, or those with a majority private stake, grouped as B2 in Figure 15, operate independently of direct government control but are still subject to regulatory oversight. B2 introduce market-driven practices that complement the strategic direction established by the government and SOEs, contributing to a diverse and balanced business ecosystem within the park.

In China, the most renowned universities and research institutions are predominantly public, receiving substantial funding from various levels of government. These institutions are primarily supported by the central, provincial, and municipal government authorities, which provide the financial resources necessary for advanced R&D. Despite their public status, these universities and institutions actively engage in diverse corporate-academia collaborations.

The government inherently engages with B1 entities, which consist of central and local SOEs, and with academia. While B1 entities may not always be highly motivated to innovate due to their close alignment with government directives, they often collaborate with academic institutions within the government-led framework to fulfill strategic objectives. Academia, on the other hand, interacts with both B1 and B2 entities, facilitating knowledge exchange and innovation across different sectors. This dynamic suggests that the depth and extent of interplay among the government, B2 (private businesses), and academia are crucial determinants of a park's success. Therefore, in the discussion that follows, the distinction between B1 and B2 will not be emphasized. Instead, when referring to businesses within the park, the focus will primarily be on B2 entities—private businesses—and their active engagement with the other two helices: government and academia. The interactions involving B2 entities, which are more market-driven and innovation-focused, are critical to fostering a dynamic and sustainable innovation ecosystem within the park. Their collaboration with government and academic institutions is pivotal in driving technological advancements, enhancing competitiveness, and achieving the park's strategic goals.

Adapting to Diversity – vast and varied landscape

Predominantly orchestrated by government-led initiatives and following a top-down planning model, health sciences parks in China nonetheless operate within a framework that requires flexibility due to the country's vast and varied landscape. Each park is shaped by its unique context, influenced by factors such as geographical location, the composition of local industries, the maturity of business ventures, the structure of local talent pools, and proximity to academic institutions. These variables contribute to a diverse tapestry of development stages and strategic approaches across the country, precluding the application of a uniform model (Zhang & Sonobe, 2011).

For instance, a health sciences park in an economically robust region with a well-established industrial base might focus on scaling operations for existing businesses and attracting multinational pharmaceutical corporations. In contrast, a park in a developing area might prioritize incubating startups, fostering local entrepreneurship, and enhancing workforce skills through partnerships with educational institutions (Wei & Leung, 2005; Zhou & Xin, 2003).

The maturity of the business ecosystem within each park also significantly influences its strategic priorities. More established parks may focus on advancing R&D initiatives, while those in earlier stages might concentrate on infrastructural improvements and cultivating a supportive business environment (Liu & White, 2001).

The academic landscape is another crucial determinant in a bio-pharmaceutical park's development trajectory. Parks with access to renowned universities and research institutes can harness these resources for pioneering research and talent development. Conversely, parks with limited academic connections may need to invest significantly in establishing these links or attract talent from outside the region to bolster their innovation capabilities (Chen & Kenny, 2007; Cai & Liu, 2015).

Thus, the evolution of health sciences parks in China cannot be encapsulated by a single developmental model. Each park must forge its path, leveraging its distinct strengths and addressing its specific challenges. This bespoke approach underscores the dynamic nature of China's health sciences sector, which is continually adapting to the shifting landscape of global innovation and economic growth demands.

The diversity and adaptability of these parks reflect not only localized needs and resources but also align with broader national goals of positioning China as a global leader in the health sciences industry.

4.7 Reconfirming the Research Agenda

The foregoing discussion serves to illustrate the development of the health sciences park concept globally and its particular popularity in China. However, as the science park concept matures, and I have increasing evidence from a variety of contexts around the world regarding "what works" (and what might not) we are faced with a number of outstanding questions.

Firstly, how do people determine where science parks are best located? In many western settings the presence of an existing research-intensive university provides the anchor institution around which businesses locate. However, this brings with it constraints in the physical space available for the development of often space-intensive scientific facilities – Cambridge serves as a potentially good example in this respect. By contrast in some settings where science parks are part of rapidly developing economies the whole park can be purpose built. However, this freedom brings with it a variety of choices: where should the park be located, what should be its principal function (or should it be mixed?) and how should it relate to the surrounding area?

The transfer of the health sciences park concept to China discussed in this chapter has seen a breed of parks emerge that are qualitatively different to those in overseas contexts in this significant area: in China the planning and design of the park (their location, facilities and physical integration with other important institutions both academic and commercial) has been orchestrated by government. The result is a huge number of very large-scale parks that have been designed with intention of replicating the types of innovation that have happened in overseas contexts - to become, in the words of Wang, Wan, & Zhao (2014) “development catalysts”. Yet, there is a clear gap in our understanding of whether innovation can be orchestrated or whether there has to be some form of existing innovative activity that commercial and statutory activity can amplify. This offers an important opportunity to test theory. The Triple (so too the Quadruple and Quintuple) Helix theory identifies the important ingredients that are a precursor to innovation – but it provides much less clarity on the degree to which they need to be combined in a specific order.

Secondly, as the landscape of science parks becomes more congested, particularly in areas where there have been notable successes in the sector that have spawned closely proximate replicas, we need to know more about how science parks might relate to one another in the future. There is clearly potential for some science parks to cooperate where they work in cognate areas. However, there is also the potential for place-based competition with some science parks seeks to attract companies and researchers from their existing locations. Furthermore, in the Chinese context – because of how and where health sciences parks have become established and evolved – there is the potential for sites that were originally intended as locations of manufacture to develop into sites of both innovation and manufacture. What features of a health sciences park make this development more, or less, likely?

Thirdly, it is clear from the literature that further research is needed on the behaviour of companies and researchers. What makes a science park attractive to a tech start-up? Why would they choose one location over another? Does the maturity of the business have any bearing on the type of science park environment that they seek? These are all important questions on which I have comparatively little evidence – particularly in China.

Chapter 5. Studying Chinese Health Sciences parks: data collection, methodology and research design

5.1 Introduction

This thesis examines the integration of the Triple Helix model in Chinese health sciences parks, where academia, industry, and government collaborate to drive innovation and economic development. The principal aim of this research is to provide new insights into the process by which health sciences parks are planned in China and the decision making of those businesses and researchers that come to occupy them. In addition to the analysis of the role and evolution of health sciences parks within the global context and their unique characteristics in China as stated in prior chapters, I will assess the factors influencing location decisions and competition, and explore the collaboration between academia, industry, and government in driving park success. The study will also provide policy recommendations to enhance the contribution of these parks to regional and national innovation. To achieve this overall objective, it is critical that an appropriate research design is established. The expression 'research design' describes the overarching framework created for a study to theoretically investigate the research questions and/or test a research hypothesis (Kerlinger, 1986). Dulock (1993) identifies four distinct types of research design - descriptive, correlational, quasi-experimental and experimental. In some academic disciplines the typology of research designs can be understood more widely to encompass formulative design (Akhtar, 2016), review design (Noble & Smith, 2018) and meta-analytic design (Basu, 2017). Varying approaches to research design can be understood as common to different disciplinary identities and academic traditions. However, there is a consensus that the approach to research design should be informed primarily by the requirements of the specific study. It is, therefore, essential that methodological choices are tailored to conceptual demands of the overarching research design.

The literature review of the preceding chapters clearly establishes the case for a research design that provides for an empirical test of the predictions of theories that point to the agglomerative effects of spatially orchestrated industry-academia-government interactions. The preceding chapter also established the conceptual case to focus on health sciences parks specifically as the best and most common examples of science park developments in China. The particular character of product development in health sciences was shown to necessitate the planed orchestration of corporate, academic and government interests in order to encourage spatial interaction in the pursuit of innovation. Planning health sciences parks to prompt this form of spatial interaction was identified as the essential first step in shaping the behaviours that are at the core of the agglomeration theory: it follows that innovation is dependent upon agglomeration and agglomeration is in turn dependent upon the kinds of interaction that occur within 'well-planned' health sciences parks. By contrast, less well-planned science parks may not produce the results that might be theoretically expected. This gives rise to the central question in this research: what are the ingredients of a well-planned health sciences park and how do science park inhabitants make location decisions?

This fundamental question coupled with the paucity of research on health sciences parks in China calls for an exploratory research design (Dulock, 1993). Exploratory research design requires a flexible approach as the subject matter under investigation is, by definition, not well understood. This chapter goes on to describe the methodological implications of this exploratory research design with regard to investigating the formation and development of health sciences parks in China. In this chapter, I outline the research design, methodology, and data collection methods employed to study health sciences parks. Our approach combines both qualitative research methods and case study-based research to explore the unique characteristics and success factors of health sciences parks. This chapter will also address the ethical considerations related to data collection, management, and reporting, and offer guidelines for interpreting the findings.

5.2 Testing the Theory on Science Parks

The previous chapters established the emergence of health sciences parks as a response to a consensus amongst a broad range of academic commentators that the agglomeration of cognate businesses and scientific research in one place provided a necessary spatial aspect to the development of innovation. However, it was also established in the previous chapters that little is actually known about the characteristics of science parks that are most attractive to footloose businesses and scientists. This has become an increasingly relevant question with the rapid and widespread development of many competing science parks. In short, with so many potential locations to choose from what makes some locations more or less attractive to businesses and scientific researchers? Furthermore, to what extent does these market preferences influence the planning of heath science parks?

From these general overarching questions, I can formulate a group of specific research questions that will define the limits of this study.

1. To what extent does the Triple Helix accurately account for the process by which health sciences parks have developed in China?
2. Has the state-orchestrated nature of health science park development in China contributed to any variations in how they have developed in contrast to the well-researched examples from Western settings?
3. What drives business decision making with regard to choosing a health sciences park? What variables are most important in determining where businesses choose to locate?
4. What drives scientist decision making with regard to choosing a health sciences park? What variables are most important in determining where businesses choose to locate?
5. To what extent do local decision makers consider the most important determinants of the location decisions made by businesses and scientists when implementing plans for the development of health sciences parks?
6. Do health sciences parks compete for some potential occupants? How do they compete? What incentives are used to attract desirable companies/scientists.

5.3 Qualitative Research Methods

Qualitative, quantitative and the combination of qualitative and quantitative methods are the three major approaches to research in the social science (Creswell, 2009). The research questions identified in the preceding section all relate directly to decision making and behaviour. This encompasses the decision making in the planning process that is fundamental to the design and delivery of health sciences parks and the locational choices of the businesses and scientists who come to occupy them. In order to explore these behavioural features of the planning process and the built environment outcomes that follow requires a qualitative research design.

The distinctive feature of qualitative research which distinguishes it from quantitative research has received a great deal of academic attention (Aspers & Corte, 2019). Exploratory research is normally considered qualitative in nature (George, 2021). With respect to this study the choice to use principally qualitative methods is driven by the nature of the research questions. Much of the literature on research methods makes the case that questions of human processes and behaviours are best suited to the qualitative suite of methods (Palinkas, et al., 2015). In qualitative research, it is required to examine assumptions and variations in inquiry strategies; the role of the researcher; and steps in data collection, analysis, and interpretation (Haq, 2014). The research questions here in this study are best handled through the traditional suite of qualitative methods: semi-structured interviews, documentary review, focus groups.

The full population of health sciences parks in China comprises over 2000 individual sites at different administrative levels (Huang, 2020), including 193 national-level health sciences parks (CCID & sinaMed, 2020). With a population of this size, it is not possible to conduct in depth exploratory research in all cases. For this reason, a sub-set of health sciences parks needs to be established that comprise the focus for this research. In order to select case studies a sampling method is required. Sampling is commonly used in qualitative research in order to identify meaningful case studies from which wider part-whole connections can be made. Concerns with sampling in qualitative research focus on discovering the scope and the nature of the universe to be sampled (Luborsky & Rubinstein, 1995). What is the underlying population for sampling? What is the reasonable sample size? How to select samples? It has been increasing rigorous in the qualitative research of making data and explanatory analysis more explicit (Denzin & Lincoln, 2005). The selected samples need to be representative and as unbiased as possible. It is always a challenge for research of this nature to arrive at a clear rationale for the identification of case studies from which research findings can be drawn that provide insights that are relevant for the broader phenomenon (Onwuegbuzie & Leech, 2007).

5.3.1 Sample size determination and sample selection

Chapter 4 highlights a stark contrast in the development of health science parks between China and the West. In Western countries, academic research in the sciences is concentrated at a select few universities, such as Stanford and Cambridge, which naturally attract talent and dictate the location of related activities. In contrast, China adopts an alternative approach by establishing science parks first and then encouraging the migration of science and industry to these designated areas. This strategy has led to the establishment of over 2,000 health science parks across China. Given this vast number, it is impractical to analyse every single park comprehensively. Therefore, to facilitate meaningful comparisons and understand the full spectrum of park types, it is necessary to employ a sampling principle that captures the diverse range of health science parks within China. This approach must account for variations including:

i. Established versus newer health sciences parks
ii. Growing versus static health sciences parks
iii. Those in prosperous regions versus those in developing regions

By examining each criterion in turn:

i. Established versus newer science parks

As identified in the previous chapter, China is home to well established health sciences parks that have now reached a mature status. However, the boom in health sciences parks in China means that there are many recently established parks. This raises a range of questions regarding the degree to which the new breed of parks learnt lessons from the originators and the manner in which the planning of health sciences parks has evolved. Without a full list of health sciences parks, a chronology of top 15 health sciences parks formation in China is summarized in this research based on a ranking list called '2021 Top 100 Bio-pharmaceutical Industrial Parks' (the "Ranking)". The Ranking was released in July 2021 with the joint efforts of a Chinese consulting firm and sinaMed, a media, based on a combined consideration of innovation, collaboration, green, open and sharing in light of various indicators from different dimensions for the purpose of evaluating the development level of 386 national-level parks (including 168 national-level HIDZs and 218 national-level ETDZs) (CCID & sinaMed, 2021). Although almost all the 386 national-level parks carry health sciences industry, but not all of them have a formal health sciences park inside. Figure 16 further pinpoint to health sciences parks with a chronology of 2021 top 15 health sciences parks formation in China based on the top 100 ranking list.

Figure 16: Chronology of 2021 top 15 health sciences parks formation in China

Year of launch	Name of Health Science Park	HIDZ/ETDZ	
		Name	Ranking
1996	Zhangjiang·China Drug Valley	Shanghai Zhangjiang HIDZ	3
1999	Lianyungang New Pharmaceutical Industrial Park	Lianyungang ETDZ	4
2000	Zhongguancun Life Science Park	Zhongguancun Technology Park	1
2005	Shijiazhuang National Biological Industrial Base	Shijiazhuang HIDZ	15
2006	Suzhou·BioBay	Suzhou Industrial Park	2
2015	Changsha Medical Health Industry Park	Changsha HIDZ	14
2007	Taizhou Pharmaceutical HIDZ	Taizhou Pharmaceutical HIDZ	10
2008	Wuhan BioLake	Wuhan Donghu HIDZ	5
2011	Beijing ETDZ Biomedical Park	Beijing ETDZ	7
2011	Guangzhou International Bio Island	Guangzhou HIDZ	11
2011	Nanjing Biotech and Pharmaceutical Valley	Nanjing ETDZ	13
2015	Shenzhen Biomedicine Innovation Industrial Park	Shenzhen HIDZ	8
2015	Xi'an Biomedical Cluster Base	Xi'an HIDZ	9
2016	Chengdu Tianfu Biotown	Chengdu HIDZ	6
2017	Tianjin Medicine & Medical Device Park	Tianjin ETDZ	12

Source: summarized by the author based on (CCID and sinaMed, 2021) and other public information.

As discussed in Chapter 3, 2010 was a watershed moment for the development of the health sciences industry in China. Since then, in addition to MNCs, local biotech and pharma companies has ushered in a period of rapid expansion. The needs and expectations on locations and space are even more diversified for local players comparing to MNCs. In response, more health sciences parks are established across vast China. As such, year 2010 is used as a demarcation line to distinguish a park as established from newer ones, i.e., parks launched prior to 2010 are deemed as established, while those launched after 2010 are called newer ones. Within these 2 sub-groups of parks, 1 sample of each is selected for case study. Zhangjiang China Pharmaceutical Valley, the first health sciences park in China is well-deserved to represent established parks. As the data of this research is up to year end of 2021, a park launched in the median year during 2010 to 2021 is selected to represent the newer parks group, that is either Shenzhen Biomedicine Innovation Industrial Park or Xi'an Biomedical Cluster Base.

ii. Growing versus static health sciences parks

The number of registered active enterprises might be a straightforward indicator of the agglomeration level of a park. “Active” here means an enterprise is under normal operation, rather than dormant, shutdown or in the process of liquidation. If there was a full list of health sciences parks in China in which the number of registered active enterprises is recorded for each park, it would be easy to establish the number of registered active enterprises as a benchmark for comparison. However, this pathway is obstructed by the fact that there is no such data publicly available. Alternatively, it is practical to build up a picture of the relative performance of health sciences parks through company specific data. This approach should provide us with more than a simple count of the registered active enterprises in a park as I can develop an understanding of the nature and quality of the enterprises in a park. What criteria could be established in order to make these kinds of assessment of parks’ economic vitality based upon the companies they accommodate?

A preliminary research exercise was undertaken in order to arrive at a typology to inform this selection criterion. This typology included scrutiny of public offering documents, prospectus for initial public offerings and annual reports of listing companies and stock price information, such as market capitalisation. Such information is verified by professional parties before open to public, e.g., financial statements included in such documents are audited/reviewed by certified public accountants, legal facts are verified by the applicant’s legal councils and if in an initial public offering (IPO), information is consented by underwriters and underwriters’ legal councils. Meanwhile, the compliance of presentation and discloser is subjected to the supervision from various regulators, stock exchanges, professional associations and industry associations. Therefore, such public information is comparatively reliable with other public sources. Mainland China, Hong Kong and U.S used to be the three major capital markets where Chinese health sciences companies choose to make their IPOs and listing their stocks. When working with financial data of this type it is essential to define a relevant time frame so that meaningful comparisons can be made. For the purpose of choosing case studies the year 2018 is chosen as the starting year as 2018 represents a milestone moment in the history of the health sciences industry’s entry to capital markets in China.

The introduction of Chapter 18A listing rules by the Hong Kong Stock Exchange (HKEx) in 2018 meant that newly defined “Biotech Companies” were eligible to be listed on the main board of HKEx (Hong Kong Stock Exchange, 2018) even if they were pre-revenue or preprofitmaking. The effects of this opening up of financial markets to biotech companies has been transformational and had a profound impact on the whole health sciences industry and its business value chain. Later in 2018 the Science and Technology Innovation Board ("STAR Market") of Shanghai Stock Exchange opened with a release of inclusive listing rules for pre-revenue or pre-profit-making biotech companies (Shanghai Stock Exchange, 2019). The listing rules of STAR Market are similar and comparable to Chapter 18A listing rules by HKEx. Aside from the more inclusive rules, the STAR Market has several features that differentiate it from the other stock exchanges in China, which support innovative enterprise and start-ups (EY China, 2020). Multiple capital market options in both mainland China and Hong Kong have been important in broadening the range of investors to encompass both domestic Chinese and international investors (GMA, 2020). The effects of these measures have been to encourage huge growth in the biotech sector and huge interest in the spaces they occupy. Therefore, number of IPOs on HKEx and mainland China during 2018 to 2021 are set as the benchmark of economic vitality. The assessment of science parks economic vitality is set out in below table Figure 17 and 18.

Figure 17: Number of IPOs of Top 15 Chinese Health Sciences Parks 2018-2022

Name of Health Science Park	No. of IPO (2018 - 2021)	HIDZ/ETDZ	
		Name	Ranking
Zhangjiang·China Drug Valley	16	Shanghai Zhangjiang HIDZ	3
Suzhou·BioBay	14	Suzhou Industrial Park	2
Zhongguancun Life Science Park	14	Zhongguancun Technology Park	1
Beijing ETDZ Biomedical Park	12	Beijing ETDZ	7
Shenzhen Biomedicine Innovation Industrial Park	11	Shenzhen HIDZ	8
Chengdu Tianfu Biotown	8	Chengdu HIDZ	6
Guangzhou International Bio Island	6	Guangzhou HIDZ	11
Nanjing Biotech and Pharmaceutical Valley	5	Nanjing ETDZ	13
Changsha Medical Health Industry Park	4	Changsha HIDZ	14
Wuhan BioLake	4	Wuhan Donghu HIDZ	5
Tianjin Medicine & Medical Device Park	4	Tianjin ETDZ	12
Taizhou Pharmaceutical HIDZ	3	Taizhou Pharmaceutical HIDZ	10
Lianyungang New Pharmaceutical Industrial Park	3	Lianyungang ETDZ	4
Shijiazhuang National Biological Industrial Base	1	Shijiazhuang HIDZ	15
Xi'an Biomedical Cluster Base	1	Xi'an HIDZ	9

Source: summarized by the researcher based on (CCID and sinaMed, 2021) and (Qianzhan.com, 2022).

The data set out in Figure 17 above provides an insight into the relative economic performance of health sciences parks. However, this alone does not provide a comprehensive understanding of the contextual circumstances within which each park operates. For example, the evidence of the cases presented to this point illustrates that the longest established and most successful health sciences parks were born in economically prosperous areas. The coincidence of these factors represents a real research dilemma as it may be that some of the most promising developments for the future are more recently established and/or in economically less prosperous areas: this does not mean that they are not successful but rather that their starting position is different. A scatterplot is a useful way of visualising this point that geography is an important aspect of a health sciences park's relative success. Figure 18 illustrate the number of listed health sciences companies in a park as the independent variable

(X) and the valuation of companies in parks as the dependent variable attribute (Y). Both X and Y are indicators of park agglomeration effect with the strongest agglomerations located in the upper right hand of the diagram.

Figure 18: Scatterplot of Agglomeration

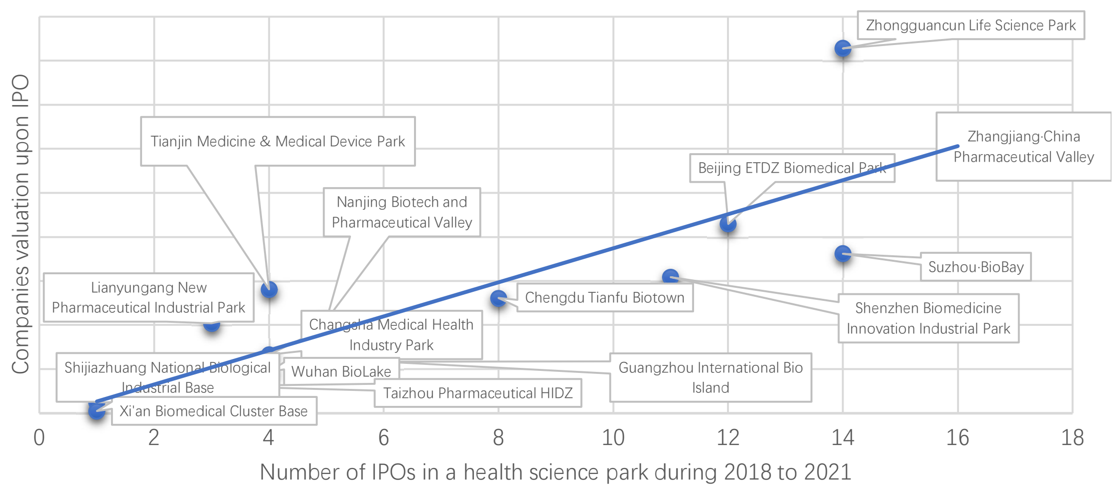


Figure 17 and 18 shows unsurprisingly that China's most well-known tier one cities, the national capital, Beijing, and the economic centre, Shanghai, have the most significant concentrations of highly performing health sciences parks in China. However, to focus only on these two geographic areas would omit the range of experiences from other parts of China where differences in approach to the implementation of health sciences parks may provide important lessons for others. This point regarding the significance of geography is extended in the next sections. It is also noted that Suzhou, a non-capital city of Jiangsu province, shows its strength and potential of BioBay; and Xi'an lags behind to bottom of the identified pool in terms of its economic vitality. As in "established versus newer science parks", Zhangjiang China Pharmaceutical Valley is located in tier one city Shanghai, to avoid focusing on tier one cities only, in this session, BioBay is selected as the sample to represent the growing park, and Xi'an is selected as the sample to represent static or less growing parks.

iii. Health sciences parks in prosperous regions versus those in developing regions

In all national contexts some areas are more economically prosperous than others. For example, the best-known science parks in the United States emerged in the already prosperous state of California. More recent science park developments in the USA have been introduced in some settings as a form of urban regeneration to support the development of less prosperous areas – for example, Mississippi. To some extent the relative performance of science parks set out in the preceding section is blind to the crucially important contextual variable of geography. It will, therefore, be essential to control for this criterion when drawing qualitative insights on the performance of health sciences parks in China – it would be wrong to conclude that established science parks in economically prosperous regions are simply 'doing better' than newer science parks in less economically prosperous places. As their starting positions are contexts are so variable it will be important to ensure that the research is sensitive to geography. Review the selected samples in the preceding session, the representations cover parks from east, west to south regions of China. A representative park in North China is in absence. ZLSP, part of Zhongguancun Science and Technology Park, Beijing which is ranked number 1 by (CCID & sinaMed, 2021) is worth being included as selected samples. Zhongguancun Science and Technology Park is China 's first national-level HIDZ, first national self-care innovation demonstration zone, and first national talent special zone. Zhongguancun Life Science Park is an important part of Zhongguancun Science and Technology Park. It is always encouraging to share success story for fellows to learn the experience and take-aways. Given these backgrounds thinking of the location factor, it is believed that ZLSP should be selected as the sample for study. In a summary, samples selected for further study are listed in Figure 19.

Figure 19: Table for the sample health sciences parks selected for further study

Typology	Selected samples	location region
Established park	Zhangjiang·China Drug Valley	East China
Newer park	Shenzhen Biomedicine Innovation Industrial Park	South China
Growing park	Suzhou·BioBay	East China
Static park	Xi'an Biomedical Cluster Base	West China
Outstanding park	Zhongguancun Life Science Park	North China

Source: author's own diagram

5.4 Case Study Based Research

A case study is a close observation and an in-depth study of a particular manifestation of a more general phenomenon. Case-study based research is also useful for testing whether a specific theory is actually applicable to phenomena in the real world (Yin, 2003). Case studies are helpful to explore and understand the behavioural conditions and complex issues through the actor's perspective (Zainal, 2007). It can be considered a robust research method. In this study, case studies are the applicable way of investigating the questions outlined above to narrow down China's health sciences park into easily researchable example(s). Classical case-study based research more inclined to adopt a single case through deep and comprehensive descriptions (Ridder, 2017), to elaborate insights, identify the relationship with existing theories or testing a theory (Gomm, Hammersley, & Foster, 2000), and sometimes even explicate unique contributions to theory (Fiss, 2009). A case is chosen often due to it is of interest (Stake, 2005), or because of inherent theoretical logics (Eisenhardt & Graebner, 2007). As explained in the previous session, a portfolio of cases (Ridder, 2017) makes more sense than a single case for this study because of the large landscape of the health sciences parks across vast China with the range of experiences. A portfolio of case studies is able to enhance the exploratory function (Ridder, 2017). Based on the identified portfolio, theoretical contributions of case-study based design can be better evaluated in terms of understanding and testing theories (Ridder, 2017).

In order to explore the behavioural features of the planning process and the built environment outcomes, how should the portfolio of cases be composed? Purposeful sampling is widely used in identification of case related to the phenomenon of interest. Samples are generally assumed to be selected purposefully to yield cases that are “information rich” (Patton, 2001). For the purpose of obtaining rich information, in addition to documentation reading and sites visiting of health sciences parks, the researcher will use the technique of interview for data gathering. Interview is not for data collection only but also to derive participants' perspectives and insights such as the ways the participants make sense out of their behaviours (Erickson, 1986). It requires to identify proper participants that are knowledgeable about or experienced with the research questions (Cresswell & Plano Clark, 2011). In addition to knowledge and experience, it is also very important that targeted participants are available and willing to participate, in an articulate and reflective manner (Bernard, 2011). It is a demanding process. Amongst different purposeful sampling methods, combining sampling, i.e., using the same samples identified in the previous session (Figure 19) may be more appropriate to the aims of this research. It is because that the identified 5 health sciences parks are “information rich” samples.

As a traditional case study method, it is important to gather empirical data through cases for which there is evidence of ‘success’ (Brinkerhoff, 2003). Three out of the five cases set out in Figure 19, ZLSP, BioBay and Zhangjiang China Pharmaceutical Valley are located in the top 3 HIDZs of China, respectively ranked by CCID and sinaMed (2021). They are generally regarded as China’s most mature health sciences parks. There is more readily available information regarding these 3 health sciences parks. These cases therefore serve as examples of what has been constructed to be ‘good practice’ that policy makers may wish to transfer to other parks. As previously discussed, Shenzhen Biomedicine Innovation Industrial Park is a good sample to represent a newer park of China located in developed region of China. Again, putting location coverage into the consideration, Xi'an Biomedical Cluster Base represents a park in western China. These five potential case studies are relatively information rich which has been suggested as an important consideration in case study selection (Patton, 2001; Palinkas, et al., 2015).

Data collection methods

Five health sciences parks are selected as case studies for this study as previously discussed. Semi-structured interviews with park management teams and occupants of these parks are the methods of data collection that will be used in this research. Semi-structured interviews are the traditional method of collecting data under a qualitative research paradigm (Kvale,1996) and are justified in this study on the basis that questions of behaviour, such as the factors that might influence health sciences park occupants’ location decisions may have cultural, social, personal and psychological aspects. Data of this character can only be accessed through semi-structured interviews.

The research employed a semi-structured interview approach, combining structured questions, observations, and open-ended queries to obtain comprehensive insights (Newton, 2010). Structured questions were utilized to elicit detailed and specific information, while open-ended questions encouraged participants to share their narratives and explain the reasoning behind their behaviours.

Information related to the creation, strategy, positioning, planning, policies, and other efforts of the parks was primarily gathered through interviews with local representatives, including local leaders, policymakers, and members of park management teams. The interview pool aimed to be diverse, encompassing a mix of these stakeholders; however, access constraints occasionally limited the range of participants. In total, 15 representatives from the parks were interviewed. Additionally, data and documents obtained during park visits and interviews were analysed and incorporated into the research.

To understand the needs and expectations of the demand side, interviews were conducted with representatives from companies located within the five selected parks. Most interviewees were company founders, although in a few cases, executive management members who were key decision-makers were interviewed. Out of 30 interviewees identified from 26 companies, 28 were successfully interviewed, while 2 could not be reached. In addition, 8 interviewees from support organizations were included, representing professional planners, university professors, private park owners and managers, financial advisors, venture capitalists, and head-hunters.

The interviews followed a semi-structured format, guided by a set of predetermined questions designed to gather specific information while allowing flexibility to explore emerging topics. When necessary, additional questions were posed to delve deeper into certain areas. Two types of interview guides were used: one with general questions applicable to all interviewees and another with more targeted questions tailored to specific participants. Of the 51 interviews conducted, 43 were on-site and face-to-face, while 8 were conducted via video or telephone. The interviews lasted between 30 minutes to an hour, and all were either recorded and transcribed or summarized with key points noted, depending on the interviewees' preferences.

The findings presented in this paper are derived from the data collected through these interviews, offering a comprehensive perspective on the various aspects of the health sciences parks.

5.5 Collecting, Managing and Reporting Data Ethically

In this qualitative research, semi-structured, in person interviews was established as the principal method by which data was collected. This is the method best suited to understanding human agency: the goals of the health sciences park planners and the businesspeople, scientists and government officials who populate the parks themselves.

When undertaking research of this nature it is crucial that ethics are given full and comprehensive consideration. Ethics is a vital component of qualitative interviewing. It not only relates to the execution of such interviews but will also strengthen the compliance of ethic requirements throughout the date collecting, managing and reporting, i.e., in this research more broadly. The search for facts and its unbiased reporting are fundamental for this study. But any unethical actions that are taken during data collection, would have a negative consequence on the validity of the research process, and subsequently have a negative impact on the reporting.

In this research, the sample size was determined according to the designed sampling method, and samples were drawn based on the pre-designed criteria. The process was not random but justified on the basis of typological selection. The interviews were conducted following a semi-structured format. An interview guide was used to collect the desired information but wherever it seemed important, additional questions were asked, or probing took place. In the interview preparation stage, the researcher has carefully understood the profile of the participants including how the participants look like. Before interview, the researcher made a double check to ensure that the participant is the exact person invited for interview, including checking the identity of the participants. Interviews were mostly conducted face to face. Due to inconvenience caused by Covid-19 pandemic, a few interviews were conducted through video. In a video interview, participants were required to present identity in front of the camara for the researcher to compare the photo in the identity with the participant sitting in front of the camera, making sure they are the same person. In addition to early communication with participants, the researcher informed all participants of the objectives of the research again before formal interview. An interview only happens with informed consent of participants. All interviews were conducted by the researcher herself, either conducted face to face or via video. Interviews audios are recorded and later transcribed. Source data, mainly including the audio recordings and transcriptions collected from interviews will be stored in the researcher's laptop and backed up in the researcher's removable storage disk. No data was stored in a public place or on a cloud-based server. All participants were provided with a clear, written guarantee that data resulting from semi-structured interviews would be anonymised.

5.6 Summary

The foregoing discussion clearly establishes a range of research questions and a programme of qualitative data collection across a defined typology of 5 health sciences parks in China as shown in Figure 19:

Case 1: 6.1 Zhangjiang: China's original health sciences park

Case study 1 is Zhangjiang China Pharmaceutical Valley (ZCPV), an established park located in Eastern China; the first health sciences park founded in China.

Case 2: 6.2 Shenzhen: China's new breed of health sciences park

Case study 2 is Shenzhen Biomedicine Innovation Industrial Park (SBIIP), a newer park located in Southern China, formed in 2015.

Case 3: 6.3 BioBay: A growing specimen

Case study 3 is Suzhou Biomedical Industrial Park (BioBay), an example of health sciences park in the economically most advanced part of China that has experienced rapid growth.

Case 4: 6.4 Xi'an: A health sciences park in incubation

Case study 4 is Xi'an Biomedical R&D Cluster Base, a large health science park located in Western China – a less well-developed area region of Chin.

Case 5: 6.5 Zhongguancun: Extending the life of a health sciences park

Case study 5 is Zhongguancun Life Science Park (ZLSP), a mature health sciences park located in Northern China, which was identified in the literature as an “outstanding” park following its inception in 2000 but which has subsequently slowed down.

The following chapter seeks to present empirical findings for these 5 case studies against the set of research questions defined in this chapter.

Chapter 6. An Empirical Investigation of Policy and Practice in China’s Health Sciences Parks

This chapter collates the empirical findings for the 5 case studies identified in the preceding chapter.

After examining five case studies, each embodying the unique circumstances and attributes illustrating a unique interplay of the key variables identified in the methodology, the chapter explores how the individual experiences of these five health sciences parks can be understood as emblematic of the issues that serve to define the development and longevity of health sciences parks in China.

6.1 Zhangjiang: China’s Original Health Sciences Park

6.1.1 Introduction

Zhangjiang China Pharmaceutical Valley (hereafter referred to as ZCPV), formally recognized as 张江中国药谷 in Chinese, is strategically located within the Zhangjiang Hi-tech Development Zone (HIDZ) in Shanghai's Pudong area. Established in 1996, ZCPV is known as China's first health sciences park and remains a leader in pharmaceutical and biotechnological innovation (Zhang & Wu, 2013; Zhang, 2015). Renowned for its dynamic and innovative ecosystem, ZCPV has garnered recognition from industry experts for its substantial contributions to China’s pharmaceutical R&D, earning high accolades (Sina Medical of Sina.com). The park's prominence makes it an ideal case study for exploring the strategic development of health sciences parks in China and assessing their impact on the sector.

Spanning an area of 3 km², the Zhangjiang China Pharmaceutical Valley (ZCPV) is strategically developed in two phases, with each phase covering 1.5 km². It occupies a central position in the Zhangjiang High-tech Park, at the heart of the Shanghai Zhangjiang High-tech Development Zone (HIDZ), established in July 1992 in Shanghai’s Pudong New Area. Adjacent to the Integrated Semiconductor Park and the Technology Innovation Centre of the HIDZ, ZCPV also lies in proximity to the Modern Medical Device Park, enhancing its integration within the industrial chain. The park is ideally located, bordered by Jinke Road to the north and south, facilitating excellent transportation connections and access to high-end talent. This prime location has been crucial in its development, aligning with China’s overarching goal to foster innovation across multiple sectors, especially in life sciences. This strategic placement not only supports ZCPV's growth but also contributes to its role as a key player in China’s push to become a leader in global health sciences and technology innovation.

The selection of ZCPV as the focus of this case study is predicated on its notable success and prominence within the health sciences industry. This research aims to explore the planning, development, and operational dynamics of ZCPV to identify the unique characteristics and key factors contributing to its distinguished status. Through an analysis of the park’s strategic planning and development processes, the study seeks to elucidate the elements that have driven ZCPV’s growth and to assess their broader implications for health sciences parks in China. The methodological approach will include conducting in-depth interviews and performing analytical reviews. This will focus on exploring the decision-making processes that influenced the park's establishment, its strategic positioning, and obtaining insights from the companies and scientific personnel based within the park. This chapter will critically analyse the initial planning stages, evaluate operational strategies, and investigate the evolutionary trajectory that has positioned ZCPV as a leading centre for life sciences research. The comprehensive analysis will cover infrastructural decisions, strategic partnerships, and policy interventions that have shaped Zhangjiang's development, providing insights into how these factors collectively contribute to the park's success. This objective examination aims to offer a thorough understanding of the dynamics at play in the development and sustained growth of health sciences parks in China.

6.1.2 Understanding the planning of Zhangjiang China Pharmaceutical Valley

Figure 20: Zhangjiang China Pharmaceutical Velley

Source: photo taken by the author at site in June 2024

The genesis of the Zhangjiang China Pharmaceutical Valley (ZCPV) is deeply rooted in a strategic vision to transform China's economic landscape by fostering knowledge-intensive industries. Officially approved in 1994, the establishment of ZCPV was a collaborative effort between key governmental bodies, including the Ministry of Science and Technology, the Ministry of Health and the State Food and Drug Administration, which are Central Government's functions, and the Shanghai Municipal People's Government (provincial government equivalent) (ZCPV, 2023). The Chinese Academy of Sciences joined this agreement in 1996, signifying the park's scientific and technological aspirations (ZCPV, 2023).

The establishment of ZCPV is regarded as a key milestone in the Zhangjiang Hi-Tech Development Zone's (HTDZ) development history, positioning the park as a significant player in China's biotechnology and pharmaceutical industry. As a critical component of the broader Zhangjiang HTDZ, ZCPV represents a strategic focus on the pharmaceutical and biotechnology industries within an area covering approximately 37 km² in the Pudong New Area, a district synonymous with China's rapid economic reform and innovation drive.

Zhangjiang HTDZ, covering an area of approximately 37 km² has been envisaged as a pioneering zone that merges science, technology, and industrial development, with a focus on sectors like high-technology, pharmaceuticals, and information technology. This collaborative framework was not merely an administrative formality but part of a broader strategic effort by Chinese planners and policymakers to pivot the economic focus towards higher value-added, knowledge-based industries.

> "The establishment of ZCPV was a strategic move to transition China’s economy towards knowledge-intensive sectors, making it a model for future developments in the health sciences parks across the country." (Interviewee 1A, 2023)

The park's development was strategically aimed at centralizing efforts to shift the regional economy towards high-tech and biotech sectors, leveraging the existing cluster of technology and multinational companies in Shanghai, thereby utilizing the city's robust local economy, access to a highly educated workforce, well-established infrastructure, and connectivity to global markets.

> "While there was an existing cluster of technology and pharmaceutical companies in Shanghai, the vision was much broader. We aimed to build a world-class health sciences park from scratch that could contribute to the growth of the national biopharmaceutical industry and become an engine of economic development." (Interviewee 1B, 2023)

The park was originally named Zhangjiang Biomedical Base, and was renamed in 2016 to "Zhangjiang China Pharmaceutical Valley" (ZCPV) with the six Chinese characters 张江中国药谷 prominently displayed at its site on Cailun Road, symbolizing a commitment to elevate its identity on the national and global pharmaceutical stage.

The renaming of the park is more than a narrative of strategic evolution; it reflects an intent to attract investment, nurture talent, and stimulate collaboration within the bio-pharmaceutical sector. This rebranding is underpinned by a recognition of Zhangjiang's established strengths as a bio-pharmaceutical hub, where a critical mass of research institutions, pharmaceutical enterprises, and the necessary infrastructure has already been amassed to support the industry's growth (Zhang, 2022). The aspiration for global leadership is evident in the park's ambition to align with renowned bio-tech clusters worldwide, supported by governmental policies that promote the bio-pharmaceutical industry as a catalyst for economic growth and innovation (Qin, 2023).

Economic development is a driving force behind the rebranding. The renaming is part of an overarching strategy to develop the area into a nexus for high-tech industries, thereby increasing its allure to investors and businesses alike (Wang & Liu, 2020). The integration of the innovation chain is a key component of Zhangjiang's development. The area has demonstrated its capacity to synergize R&D with manufacturing and commercialization, creating a robust ecosystem conducive to the bio-pharmaceutical industry's advancement (Zhang, 2022).

Figure 21: A view of ZCPV

Source: from a brochure of Zhangjiang HIDZ

The decision-making process that involved in the positioning, planning, and approval of the Zhangjiang China Pharmaceutical Valley are primarily governmental bodies at various levels due to the strategic importance and scale of the park, as well as professional management teams and relevant state-owned enterprises. At the highest level, Chinese Central Government played the decisive role in the conceptualization and approval for the park. On a more regional level, the Shanghai Municipal Government was also heavily involved in the planning and approval process. They would be the main governing body responsible for implementing and overseeing the project, considering the park's alignment with Shanghai's broader development plans and needs. The Shanghai Municipal Government recognized the strategic importance of fostering high-tech industries as a pivotal part of their economic growth and transformation plans.

The execution of the planning was undertaken by SOEs such as Shanghai Zhangjiang Biopharmaceutical Base Development Co., Ltd., which is responsible for the development and management of land plots and high-tech incubation facilities. The ZCPV Management Committee (ZCPV Committee) is tasked with the daily operations of ZCPV, ensuring the park's development aligns with the approved plans and strategic goals. The operational strategies of ZCPV have been underpinned by the implementation of strategic policies aimed at making the park an attractive destination for researchers and businesses. Competitive incentives, IP protection, and world-class infrastructure have been critical in creating a vibrant living and working environment.

Given the significance of the health sciences sector to the global economy and its potential to improve human health and wellbeing, supporting the establishment of the first health sciences park within the Zhangjiang HTDZ was an intuitive decision. Furthermore, as an integrated part of Zhangjiang HTDZ, the health sciences park could tap into the HTDZ's existing resources and infrastructure. This includes the established networks of tech companies and research institutions, access to a skilled talent pool, and the supportive policies and financial resources provided by local government authorities. The management of ZCPV involve a team designated by the Shanghai Municipal Government. This team would include professionals from various fields such as urban planning, business development, and technology. Their role would be to execute the approved plans, oversee daily operations, and make decisions pertaining to the park's ongoing management and future development. Furthermore, entities like the Zhangjiang Group, which is a state-owned enterprise tasked with developing and managing the Zhangjiang HTDZ, play an essential role in park planning and management. The diversity of stakeholders required an extensive coordination effort.

> "The multi-tiered planning and execution process, though complex, ensured that the park's development aligned with national goals while meeting local requirements." (Interviewee 1A, 2023)

The park's status as the originator of a model that was subsequently replicated in other parts of China was identified as an important aspect of understanding its development by many interviewees.

> "The success of the Zhangjiang China Pharmaceutical Valley is inextricably linked to its location. Its strategic placement in Shanghai not only provided an existing cluster of technological and pharmaceutical activities to build upon but also brought an unparalleled amalgamation of resources. The robust local economy, access to a highly educated workforce, well-established infrastructure, and connectivity to global markets have all contributed to transforming the park into a world-class hub for biotechnological innovation and commercialization. The park's strategic location undoubtedly plays a significant role in its overarching success." (Interviewee 1B, 2023)

When comparing Zhangjiang China Pharmaceutical Valley to other science parks, the primary distinguishing factor is its focus. Many science parks across the globe have a broader scope, accommodating businesses from various high-tech industries. However, Zhangjiang China Pharmaceutical Valley dedicated its resources to promote one specific industry, life sciences. This strategic decision gave the park a unique positioning and allowed it to cater to the needs of companies in the field more effectively. It set the stage for the creation of a community where companies could not only thrive individually but also benefit from the proximity of others in the same industry. This unique positioning played a crucial role in attracting talent. The park did not merely provide office space; it offered an environment tailored to the needs and aspirations of professionals in life sciences. This was confirmed by several interviewees from the park's management and human resources teams, who emphasized the park's commitment to creating an ecosystem conducive to research and innovation.

> "We made a conscious decision to concentrate on health sciences. And this focus allowed us to build an environment that specifically catered to the needs of the researchers, scientists, and entrepreneurs in the field. From providing the latest lab facilities to fostering collaborations and partnerships, we ensure that our park provides all the elements needed to nurture innovation in life sciences." (interviewee 1A, 2023)

Zhangjiang China Pharmaceutical Valley was designed not only as a research park but also as an incubator and commercialization centre, with an objective of attracting both domestic and international businesses and talents. The planning authorities implemented strategic policies to make it an attractive destination for researchers and businesses alike. These policies included competitive incentives, IP protection, world-class infrastructure, and the creation of a vibrant living and working environments.

The strategic positioning of Zhangjiang China Pharmaceutical Valley has rendered it attractive not just to local Chinese firms but also to international organizations, contributing to the park's broad reach. Given the global nature of scientific innovation, a cosmopolitan environment can be an asset, enabling the sharing of ideas and practices across different cultural contexts. In this sense, Zhangjiang China Pharmaceutical Valley’s global reach is not only beneficial for the park itself but also for the companies residing within it.

With numerous health sciences parks worldwide, competition is indeed a significant factor. To stay ahead, Zhangjiang China Pharmaceutical Valley had to ensure its value proposition remained attractive. This competitive positioning has influenced the design and planning of the park, with decisions being made to not only match but also outperform other parks.

Infrastructure-wise, Zhangjiang has consistently invested in maintaining top-tier facilities, including research labs and office spaces. In terms of offerings, the park has implemented various measures, such as establishing incubation centres and providing comprehensive business support services to enhance its attractiveness.

> "In the planning stages, we were acutely aware that we were competing in a global market. Therefore, the design of the park had to reflect this. We looked at successful parks around the world and then aimed to surpass them. Every decision, from the layout of the park to the services we offer, is made with the understanding that we must provide an environment that companies cannot find elsewhere." (Interviewee 1B, 2023)

In a competitive landscape, standing out is essential. The park's design, which promotes collaboration and offers top-tier facilities, has set Zhangjiang apart. However, the park isn't complacent. As competition grows, the park is consistently seeking ways to improve and innovate.

> "Competition is fierce. We've always understood that. That's why we designed the park to stand out. And that's why we're always seeking ways to improve and innovate. We want to offer the best, not just now, but in the future." (Interviewee 1C, 2023)

Successful science parks are those that create an environment that fosters innovation and business growth. Zhangjiang China Pharmaceutical Valley has achieved this through its careful planning and strategic focus on life sciences. However, continuous improvement is a defining factor of success. In terms of future development, the park could further encourage collaborations between companies and academic institutions, fostering a more seamless exchange of knowledge and research. This could involve creating shared research spaces or organizing regular academic-industry meetups. Moreover, expanding its focus to include adjacent areas like bioinformatics, precision medicine, or synthetic biology could also provide opportunities for growth. As the life sciences continue to evolve, staying abreast of these trends and being flexible to accommodate new industries will be vital for the park's continued success.

> "It has created a successful ecosystem here at Zhangjiang. We continually look for areas where we can develop and improve. Whether it's creating stronger links between industry and academia or expanding our focus to include emerging fields in life sciences, we are always striving to stay ahead." (Interviewee 1C, 2023)

Reflecting on the planning process, it's clear that several key factors set the stage for Zhangjiang's success. In the initial stages, a distinct vision steered the park's development, carefully curating an ecosystem that fosters life science innovation. This vision, along with a collaborative approach, has set Zhangjiang apart in the competitive landscape of science parks. The interviews conducted reveal that the decision makers behind the park's creation pursued a meticulous approach to planning. They envisaged a hub of life science innovation and took calculated steps to bring this vision to life.

> "We started with a vision, an ambition. From there, every decision was made purposefully, systematically. We knew where we wanted to go, and we charted a course to get there." (Interviewee 1A, 2023)

Since 1999, to accelerate the development of the health science industry, a series of policies and incentives were designed for the park, including financial arrangements, human resources support, project approvals, land development, incentives for overseas investment and the construction of cultural facilities. The park has attracted and nurtured a considerable number of well-known biomedical enterprises since then. For example, Roche, the global pharmaceutical company, developed its global R&D centre in Zhangjiang China Pharmaceutical Valley over the period 2004 to 2008. Furthermore, low development costs and a large patient population attracted some entrepreneurs in Zhangjiang to join the global pharmaceutical value chain by providing contract research organization (CRO) services. These companies primarily focused on pre-clinical development services, adopting an offshore outsourcing model, contributing to the development of the health sciences park.

Zhangjiang’s development was meticulously planned to unfold in phases, a strategy that allowed for gradual expansion and integration of new technologies and businesses. By 2023, the park had attracted nearly 300 innovative biomedicine firms, including global pharmaceutical giant Roche, which developed its global R&D centre there between 2004 and 2008.

> "The park's phased development was crucial in ensuring that each stage of growth was sustainable and in line with our overarching goals of fostering innovation and attracting international investment." (Interviewee 1C, 2023)

In summary, the establishment of ZCPV was strategically decided to transition China’s economy towards knowledge-intensive sectors, making it a model for future developments in the health sciences parks across the country. rebranding to "China Pharmaceutical Valley" is a deliberate step to solidify and project Zhangjiang's status as a preeminent centre for bio-pharmaceutical innovation. It encapsulates the area's developmental trajectory, existing capabilities, and forward-looking goals within the industry. This strategic planning and its positioning within the broader HTDZ are a testament to China's commitment to fostering high-tech industries, specifically biotechnology and pharmaceuticals, and its role in the economic transformation towards a knowledge-intensive economy within Triple Helix theory.

6.1.3 Understanding ZCPV's development using the Triple Helix model

The Triple Helix framework for progress pinpoints three essential components that are fundamental to fostering innovation: governmental initiatives, academic research endeavours, and entrepreneurial activities (Etzkowitz & Leydesdorff, 2000). This section aims to employ this conceptual model as a perspective from which to examine the evolution of ZCPV, scrutinizing the interplay and contributions of each of these key players in the innovation process. As discussed in the previous section, Zhangjiang government played the principal role in driving the development of the ZCPV during early years, while ZCPV Committee, as a government agency acted on behalf of the government, implemented its detailed planning and construction.

The growth of the park, however, can be viewed as a testament to the synergistic collaboration between government, academia, and industry. From policy incentives to infrastructural development and promoting a culture of innovation, the government's role was pivotal. On top of that, with solid business base, excellent universities and academic institutions, in its early days, ZCPV attracted a mix of companies that shared a common vision - harnessing the potential of the booming pharmaceutical and biotech industry in China. The corporate inhabitants primarily comprised pharmaceuticals MNCs, pharmaceutical contract research organizations ("CROs"), pioneering biotech and biotech start-ups, and small to mid-size enterprises that were enticed by the park's promise of a nurturing and innovative environment. Therefore, the growth of ZCPV, is a combined efforts contributed by the government, business and academy. The primary feature of ZCPV can be viewed as a testament to the synergistic collaboration between government, academia, and industry. The companies were characterized by their ambitious and innovative spirit. Many were led by scientists-turned-entrepreneurs who had deep domain expertise and were passionate about contributing to China's burgeoning biotech industry.

Zhangjiang, once a vast expanse of farmland, faced considerable scepticism when William E. Keeler, then General Manager of Roche China, expressed doubts in 1993 about the wisdom of establishing a health sciences base in such an unlikely location. However, the transformation that has since taken place is nothing short of remarkable. The government's role has been central to this metamorphosis, laying a solid foundation for Zhangjiang's development. By offering tax incentives, streamlining administrative processes, and fostering a conducive ecosystem for R&D, the government catalysed the area's transformation into a hub of innovation. Strategic initiatives, including the construction of advanced infrastructure, the provision of financial incentives, and the establishment of a regulatory environment favourable to innovation and business growth, were crucial in attracting investment and talent. These measures set the stage for Zhangjiang to thrive as a centre of scientific and technological advancement. Reflecting on the area's dramatic evolution, a former senior manager at Roche acknowledged the initial scepticism and praised the ambitious project.

> "The government's role has been pivotal in establishing Zhangjiang as a hub for innovation. The tax incentives, streamlined processes, and supportive ecosystem have been fundamental in transforming this once desolate farmland into a bustling centre of innovation, home to

> numerous pharmaceutical and biotech companies.” (Interviewee 1D, 2023)

The proximity of ZCPV to top-tier universities and research institutes has facilitated a continual influx of talent and academic collaborations, crucial for nurturing innovation. The park has strategically leveraged these relationships to enhance its research capabilities and attract high-calibre professionals.

In 2003, the Shanghai Institute of Materia Medica, Chinese Academy of Sciences, relocated from the Xuhui District Science Compound to Zhangjiang, occupying the best location right next to the subway station, which could be considered a reward for the pioneers. Later, the institute expanded with the construction of Phase 2 and Phase 3 within the same park. Recently, it has invested heavily in purchasing a plot of land on Newton Road, which may be used for student dormitories. In the same year, Shanghai University of Traditional Chinese Medicine moved to Zhangjiang, although it was split into two campuses by a light rail, the area was large enough for significant development. With "Pharmaceuticals" as a first-class discipline, it is poised for even greater growth. In 2008, the School of Pharmacy at Fudan University also moved to the Zhangjiang campus, located near the Shanghai University of Traditional Chinese Medicine. The addition of Shanghai Tech University, with its ample funding and space, has attracted numerous leaders in the pharmaceutical field, adding an important link to Zhangjiang's pharmaceutical industry chain.

> "The strategic placement of the park in close association with academic institutions ensures a steady flow of talent and innovative ideas, bolstering our R&D efforts," noted a park official (Interviewee 1A, 2023).

Attracting talent is a crucial element in the success of any science park. The location of ZCPV in Shanghai, coupled with its superior facilities and services, has allowed it to attract leading researchers and professionals from around the globe. The park also invests in talent development programs, ensuring a steady pipeline of skilled professionals for companies within the park.

> "One of the primary reasons people chose Zhangjiang was the talent. The park's location and its connections with leading academic institutions ensures companies have access to top-notch researchers. The talent development initiatives by the park also help to cultivate the skills we need in our teams." (interviewee 6I, 2023)

Evidence of this global reach is the presence of multinational corporations in the park. In our interviews, one Chief Executive Officer (CEO) of a European biotech firm that recently moved to Zhangjiang shared,

> "We wanted to be at the heart of innovation in life sciences, and Zhangjiang offered the right combination of infrastructure, academic connections, and an international environment that we needed to drive our research and business growth." (Interviewee 5H, 2023)

Another testimonial from a biotech start-up founder who moved his company from the US to Zhangjiang underlined the park’s far-reaching influence:

> "We initially thought about the travel and distance, but then we realized that the opportunities offered by Zhangjiang outweighed these considerations. The park's prestige and the promise of a vibrant research community made the decision a no-brainer." (Interviewee 1I, 2023)

To answer the question of what makes a successful science park, one must consider a multitude of factors. As the scientist from a listed company puts it,

> "It's not one, but a combination of things. Continuous investment in infrastructure, fostering a culture of innovation, nurturing talent, facilitating collaboration, and maintaining a dynamic, responsive management." (Interviewee 1D, 2023)

The founder of a pre-IPO company added,

> "A successful park is one that is not complacent. It should constantly evolve and adapt, keeping pace with the industry trends and changing needs of the companies." (Interviewee 1F, 2023)

ZCPV has attracted a diverse range of companies, from multinational pharmaceutical giants to biotech startups, fostering a rich ecosystem conducive to innovation and commercialization. The park's focus on life sciences has created a specialized environment that supports the specific needs of companies within this sector.

Responses to these questions revealed that, while varied in the specific details of what drew them to the park in the first place, there was clear continuity in the importance of the environment within the park with respect to encouraging the attraction and retention of businesses. For example, the founder of a biotechnology start-up provided compelling insights into the park's appeal.

> "Choosing Zhangjiang wasn't just a matter of logistical convenience; it was a strategic decision that aligned with our broader goals for growth and innovation," he shared. "The park is renowned for its robust life sciences ecosystem, and that was a massive draw for us. It's not just about the state-of-the-art laboratories or the cutting-edge research facilities. It's about the community of like-minded innovators, the pool of talent, and the support structures in place to aid our growth journey. Here, we're not working in isolation; we're part of a dynamic network that breathes life science." (Interviewee 1D, 2023)

For growing businesses, the support system of a park can be the difference between success and failure. The founder of the pre-IPO company reflects on her experience:

> "Setting up a business is challenging, especially in a highly regulated and complex industry like ours'. The administrative support from the park management, from business consultation to paperwork assistance, streamlined our processes and let us focus on our core functions. The environment, both physical and intangible, plays a huge role too. The shared facilities and resources, the quality of the infrastructure, the business-friendly policies, they all culminate in an environment that's conducive to growth." (Interviewee 1F, 2023)

A scientist from a listed company corroborates this view:

> "A good science park goes beyond providing office space. It creates an atmosphere that stimulates innovative thinking and encourages collaboration. It's hard to quantify, but you feel it in the air, in the interactions, in the buzzing energy that permeates Zhangjiang." (Interviewee 1D, 2023)

Further discussions with other founders echoed these sentiments. A serial entrepreneur with multiple successful ventures in the park, for instance, explained,

> “Zhangjiang is a crucible for innovation. The park’s reputation precedes itself, and there’s a reason for it. The culture of collaboration, access to funding, partnerships with research institutions, and the sheer energy of the place makes it an attractive proposition for any life science entrepreneur.” (Interviewee 1 F, 2023)

> "The decision was a confluence of several factors," a Chief Financial Officer (CFO) recalled. "But that's just part of the story," he continues, "The available talent pool here, primarily driven by proximity to esteemed educational and research institutions, makes it an ideal setting for a start-up like ours seeking skilled professionals. The network effect that comes from being part of this thriving cluster cannot be overstated." (Interviewee 1H, 2023)

Interviewee 1E, 2023 noted, "The park's extensive amenities, strategic location, and the network of high-tech companies made it an ideal location for our operations."

Thus, from the vantage point of its inhabitants, ZCVP's success hinges on its ability to provide an environment that fosters growth and innovation, its strategic location and infrastructure, its reputation as a centre of excellence. When asked if ZCVP needs to evolve to retain its attractiveness, an interviewee responded,

> "Continual evolution is crucial. As the industry evolves, so must we, by adapting our strategies to remain at the forefront of the pharmaceutical and biotech sectors" (Interviewee 6B, 2023)

As with any science park, the ultimate measure of success lies not only in its current status but also in its ability to adapt, evolve, and grow. Reflecting on the history and growth trajectory of Zhangjiang, our interviewees held the belief that the park is capable of reinventing itself to continually attract and retain talent. A research scientist who used to work for a major multinational and now in a pre-IPO biotech company noted,

> "Having worked in Zhangjiang for several years now, I've witnessed first-hand the transformation it has undergone. The management is proactive in anticipating the needs of its inhabitants and adapting accordingly. As a scientist, this dynamism is very encouraging."

One entrepreneur with a long-standing presence in the park opined,

> "Zhangjiang has consistently reinvented itself to remain at the forefront of innovation in life sciences. I've seen the park evolve from a nascent

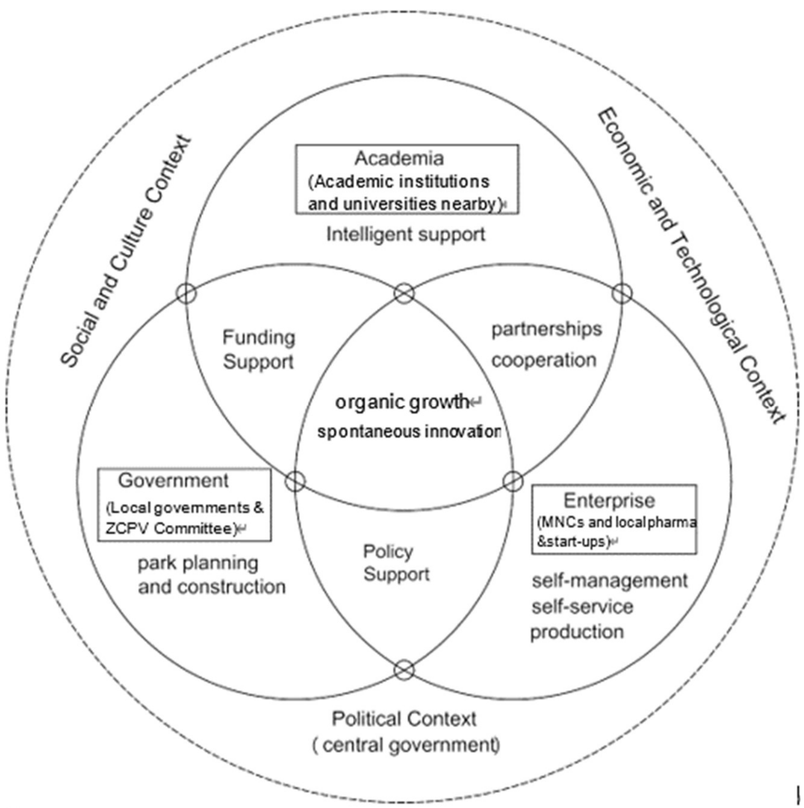
start-up hub to a mature ecosystem housing companies at various stages of growth. I believe this capacity to evolve is the defining factor for any successful science park."

Interviewee 1E added,

> "Zhangjiang has continually proved itself to be more than just a location for office space. It has a thriving ecosystem, fostering interactions among corporations, scientists, investors, and regulatory authorities. But what really sets it apart is its readiness to adapt to the evolving needs of this ecosystem." (Interviewee 1E, 2023)

In summary, the development of ZCPV stands as a testament to the effective application of the Triple Helix model, where government, academia, and industry contributions have converged into a synergistic relationship. This dynamic interaction has not only nurtured a vibrant ecosystem that is conducive to groundbreaking research and commercial success but has also established a standard for similar initiatives. The government's proactive engagement in developing infrastructure and formulating supportive policies, coupled with the rich intellectual contributions from academic institutions and the vigorous entrepreneurial activities within the industry, has cultivated an environment ripe for significant advancements in the life sciences sector. This collaborative approach has proven instrumental in driving innovation and economic growth within the region (Figure 22).

Figure 22: The Evolved Application of Triple Helix Model for ZCPV



Source: author's interpretation of Triple Helix

6.1.4 Future potential: synergistic collaborated ZCPV

Despite its success, ZCPV, like any thriving innovation hub, faces a myriad of challenges that could potentially impact its competitive edge in an industry characterized by rapid evolution and globalization. These challenges stem from both internal dynamics and external pressures, which necessitate continuous innovation and strategic adaptation. As ZCPV expands its reach, it must contend with established hubs in regions like the United States, Europe, and increasingly, emerging markets. The challenge lies in maintaining a competitive edge through innovation, cost efficiency, and quality, while navigating complex global market dynamics.

The pace of technological change is accelerating, with breakthroughs in areas like CRISPR gene editing, personalized medicine, and artificial intelligence transforming the industry. Maintaining and upgrading the park's infrastructure to meet the needs of cutting-edge R&D activities is a continual challenge. Efficient resource allocation to support both existing companies and new entrants is critical.

> "Keeping up with the rapid pace of technological advancements is a perpetual challenge. Our responsibility is to identify and attract cutting-edge innovative enterprises to our park and support their development, especially in their early days." (Interviewee 1A, 2023).

Securing sustained funding and investment is vital for the ongoing development of innovative projects. While ZCPV has attracted substantial investment, the volatility of global financial markets can impact the availability of capital. To address this, Zhangjiang and Shanghai have leveraged strategic partnerships between the government and private investors to establish health sciences industry-specific funds, fostering innovation. A prime example is the Shanghai Pudong Science and Technology Innovation Investment Fund, which focuses on sectors like biopharmaceuticals and AI.

> "The availability of investment funds can fluctuate with global economic conditions. We must ensure diverse and stable funding sources to support our long-term projects. " noted a CFO of a multinational corporation operating within ZCPV (Interviewee 1H, 2023).

While the Triple Helix model emphasizes the importance of collaboration among government, academia, and industry, effectively facilitating these interactions remains challenging. Ensuring seamless knowledge transfer and collaboration can be hindered by bureaucratic hurdles and differing organizational cultures.

> "Facilitating effective collaboration and knowledge transfer requires overcoming significant bureaucratic and cultural barriers. Creating a seamless collaborative environment is essential for innovation" (Interviewee 6H, 2023)

Navigating these challenges requires ZCPV to remain adaptable and forward-thinking. By continuously innovating, attracting top talent, securing stable funding, and fostering effective collaboration, the park's management continually seeks to innovate and adapt its strategies to meet these challenges effectively. Furthermore, the planning of ZCPV involved the integration of residential and commercial areas to offer a work-live balance for professionals. A resident could remark, "Living and working within the same park has given me a rewarding career and a great lifestyle." (Interviewee 6J, 2023)

It is good to learn during the interview that park inhabitants in general are optimistic about the park's future.

> "The park has immense potential to further develop in many ways, such as enhancing collaborative spaces, pushing for even more interdisciplinary cooperation, and driving greater adoption of emerging technologies. This evolution is necessary to keep attracting new talent and retain existing inhabitants." (Interviewee 1I, 2023)

Beyond the motivations for their initial location choice, the companies and scientists within the park provided us with comprehensive feedback on the park's environment, facilities, and support services. The overwhelming consensus revealed that the ecosystem within Zhangjiang is more than just a backdrop to their work; it's an integral component of their innovation journey. An executive at a multinational pharmaceutical company elaborated,

> "The facilities and services within Zhangjiang are second to none. Beyond just the cutting-edge infrastructure, there's a wealth of support available here. From research assistance to IP protection to funding, Zhangjiang has thought of it all. They've truly created an environment where we can focus on what we do best: innovate." (Interviewee 1F, 2023)

A similar perspective was shared by interviewee 6D:

> "As a scientist, Zhangjiang offers an environment that stimulates creativity and collaboration. The park has thoughtfully designed spaces to foster interaction, encourage knowledge sharing, and spark new ideas. It's not just the state-of-the-art laboratories, but also the public spaces, the amenities, and the overall design of the park that contribute to a stimulating work environment." (Interviewee 6D, 2023)

ZCPV's appeal extends far and wide, as reflected in the diverse geographical origins of the companies it hosts. Many companies and scientific talent, both domestic and international, relocate to the park, driven by its conducive research environment, state-of-the-art facilities, and the prospect of collaboration. An early-stage company founder, whose company hails from north China, recalls their decision-making process,

> "Distance was a significant consideration, but we focused on the long-term benefits. The move was about joining an ecosystem rich in resources and opportunities. While we considered parks closer to our original base, they lacked the holistic environment ZCPV offers. The decision was challenging, but the benefits clearly outweighed the costs." (Interviewee 5G, 2023)

> "The allure of Shanghai's cosmopolitan lifestyle, along with Zhangjiang's comprehensive facilities, were compelling reasons for me to relocate." (Interviewee 5F, 2023)

This relocation not only strengthens the park's scientific community but also elevates its status on the global health science map.

> "The presence of both start-ups and multinational corporations provides a spectrum of career growth opportunities. An employee could reflect, "The diversity of companies here at Zhangjiang allows for an exciting range of career paths, which was a big factor in my decision to join." (Interviewee 6I, 2023)

Of course, ZCPV has done many other things, such as introducing high-quality educational, medical, and residential resources to form a self-sustaining area. Drawing from the rich insights gathered through these interviews, it is clear that the success of ZCPV can be attributed to multiple factors. Not only has the park leveraged its location within a city recognized as a science and technology hub, but it has also capitalized on the vision and execution of its planning authorities. They created an environment that not only houses corporations and scientists but also nurtures their growth. The positive feedback from its inhabitants further strengthens the argument for ZCPV's successful planning. The park has succeeded in creating a conducive environment for life science companies, fuelling collaboration, encouraging innovation, and providing support services that allow companies to focus on their core work. The global reach of ZCPV, the diversity of its inhabitants, and the wide array of scientific and technological innovation that it fosters are testament to its success. These factors highlight the park's ability to attract and retain talent from across the globe, contributing to its vibrant and dynamic ecosystem. In conclusion, ZCPV represents an exemplary model of a successful science park. Its strategic planning, the ecosystem it fosters, and its adaptability to the changing needs of its inhabitants all contribute to its standing as a premier hub for life science innovation. It offers valuable lessons for future science parks in China and around the world, showing the importance of careful planning, fostering a supportive ecosystem, and maintaining a forward-thinking approach.

As ZCPV continues to evolve and adapt to new challenges, it remains a testament to the power of collaborative innovation and strategic planning within the framework of the Triple Helix model, underscoring its critical role in shaping the future of global health science industries.

6.1.5 Conclusion on Zhangjiang China Pharmaceutical Valley

In conclusion, this chapter has provided a comprehensive examination of Zhangjiang China Pharmaceutical Valley (ZCPV) as a pioneering case study of an established Chinese health sciences park. By delving into the park's planning process, its impact, and the perspectives of various stakeholders, we have gleaned valuable insights into its development history, unique characteristics, and key success factors through the lens of the Triple Helix theory.

ZCPV has emerged as a leading health sciences park in China, significantly contributing to the growth and advancement of the pharmaceutical and biotechnology industries. Its strategic location within the Zhangjiang Hi-Tech Development Zone (HIDZ) in Shanghai has been instrumental in attracting companies and scientific talent. The park's proximity to prominent research institutions, universities, and other science parks has fostered collaboration, knowledge sharing, and innovation.

The planning authorities and park managers demonstrated a forward-thinking approach in designing ZCPV. The park was envisioned not merely as physical infrastructure but as an ecosystem that encourages interaction and cross-pollination among industry players, research institutions, and entrepreneurs. This vision aligns closely with the Triple Helix theory, which underscores the importance of collaboration between academia, industry, and government in fostering innovation. The emphasis on state-of-the-art infrastructure, research facilities, and supportive services has created an environment conducive to scientific advancements and commercialization.

Interviews conducted with various stakeholders—including officials involved in establishing the park, the government agency operating it, and the businesses and scientists within it—have highlighted the key ingredients of ZCPV’s success. Companies are drawn to the park by the cluster effect, access to talents and a skilled workforce, collaboration opportunities, and its reputation as a centre of excellence. The availability of specialized services, incubation programs, and networking events further enhances the park's appeal. Scientists value the vibrant research community, access to cutting-edge technologies, and the opportunity to translate their research into practical applications.

ZCPV holds a unique status in China as the original health sciences park located in the country's principal economic centre. The park's establishment was a well-backed experiment at the beginning of China's economic rise, and its success is partly attributable to this early and strategic positioning. The mass urbanization of Shanghai over the past few decades has effectively integrated ZCPV into the broader urban geography of Shanghai, making it an almost seamless part of the metropolis.

Despite its success, ZCPV faces several challenges in maintaining its competitive edge in a rapidly evolving global industry. These include keeping pace with technological advancements, attracting and retaining top talent, navigating complex regulatory landscapes, securing sustained funding, and competing with other global biotech hubs. Addressing these challenges requires ZCPV to remain adaptable and forward-thinking, continuously innovating and improving its strategies.

Moreover, the unique success of ZCPV as the original health sciences park raises questions about the replicability of this state-led approach in other regions. The specific circumstances that contributed to ZCPV’s achievements—such as its strategic location, significant government backing, and timing during the early stages of China’s economic development—may not be easily replicated elsewhere. Future chapters will explore whether similar success can be achieved in other areas without these unique advantages.

In essence, ZCPV stands as a testament to the power of strategic planning, government support, and the effective implementation of the Triple Helix model, which emphasizes collaboration between government, academia, and industry. Its success story provides valuable lessons for the development of future health sciences parks in China and around the world. However, the need for continuous adaptation and innovation remains critical to sustaining its leadership in the global health sciences arena.

In summary, Zhangjiang China Pharmaceutical Valley exemplifies the successful integration of strategic vision, collaborative efforts, and robust infrastructural development. It highlights the potential for government-led initiatives to foster high-tech industry growth and the importance of creating an ecosystem that supports innovation and commercialization. As ZCPV continues to evolve, it must navigate its challenges and leverage its strengths to remain a beacon of biotechnological and pharmaceutical advancement.

6.2 Shenzhen: China’s New Breed of Health Sciences Park

6.2.1 Introduction

Shenzhen Biomedicine Innovation Industrial Park (henceforth, SBIIP), known as 深圳生物医药创新产业园 in Chinese, is located in Shenzhen and stands as a compelling case study of newer health sciences parks in China. SBIIP, initiated by the Shenzhen government, embodies the shift towards an innovation-driven economy with a particular focus on health sciences for Shenzhen. Although relatively new, SBIIP has rapidly emerged as a key player in the biomedicine sector, fostering a vibrant ecosystem of startups, research institutions, and established enterprises (Shenzhen China, 2021). The park's strategic blend of government initiation and subsequent industry-led growth sets it apart. Despite the city's initial lack of universities and research centres, it has countered this challenge through strategic collaborations with national and international educational institutions and robust talent development initiatives. These efforts are designed to bridge the gap in academic and research infrastructure, thus fostering a skilled workforce essential for sustained innovation and growth. This makes SBIIP an exemplary model for the new generation of health science parks in China.

SBIIP was opened in January 2015 covering floor area of 120,000 m^2, with a total industrial space of 293,000 m^2 (Shenzhen Pingshan District Government, 2023). The inception of SBIIP can be traced back to 2005 when Shenzhen was approved as one of China’s national bio-industry bases, which serves as an example of the national government’s plan to transition Shenzhen from a manufacturing-based economy to an innovation-driven one. As part of this strategy, efforts were made to expand the technological boom witnessed in Shenzhen into the domain of biomedicine. Shenzhen, the home of SBIIP, has made a name for itself on the global stage as a hub for technological innovation. Its status as a Special Economic Zone (SEZ), along with its geographical proximity to Hong Kong, underscores the strategic significance of SBIIP's location. SBIIP's establishment was a response to the growing global trend of biomedical research and the realization of the potential this sector held for the future. It represented a strategic decision to invest in the health sciences and leverage Shenzhen's burgeoning reputation as a technology hub to drive innovation in biomedicine. The SBIIP was set up with the aim of providing an innovation-friendly environment that fosters collaboration, knowledge sharing, and cross-pollination of ideas. Since its establishment, SBIIP has grown rapidly and is now home to a wide range of entities, from budding start-ups to multinational corporations. This diverse mix has facilitated a dynamic ecosystem that encourages collaboration and innovation. (Chen & Kenny, 2007)

On top of the sample selection methodology described in chapter 5, the selection of SBIIP as a case study for this research was motivated by a constellation of salient factors. First and foremost, the relatively recent establishment of SBIIP offers a fresh and contemporary perspective on China's evolving approach to planning, developing, and managing health sciences parks. The park embodies the nuances of China's current policies and strategic imperatives aimed at propelling innovation and technological progress in the realm of health sciences. Second, SBIIP's location within Shenzhen, a city that is internationally recognized for its technological prowess and enjoys strong governmental support, yields valuable insights into the role of the wider economic and policy environment in shaping the development trajectory of health sciences parks. Moreover, Shenzhen's unique position and status as a

SEZ of China offer a rich terrain for investigating the potential of these zones in catalysing innovation and growth in the sphere of biomedicine. Third, the wide diversity of entities housed within SBIIP, ranging from start-ups brimming with potential to multinational corporations with a global footprint, provides a panoramic view of the park's operations. This enables a comprehensive analysis of various facets of the park's functioning, from strategic planning and management to talent acquisition, retention, and development. SBIIP occupies a unique position at the intersection of innovation, industry, and healthcare. The strategic location of the park, its growth trajectory, and its approach towards fostering innovation provide an engaging context for this case study, aimed at understanding the current state and potential future directions of China's health sciences parks.

6.2.2 Understanding the planning of Shenzhen Biomedicine Innovation Industrial Park

The planning of the Shenzhen Biomedicine Innovation Industrial Park (SBIIP) epitomizes an integrated approach that combines government initiation with subsequent industry-led growth, specifically tailored to raise academia standing for cultivating innovation in biomedicine and biotechnology. Designed as both a physical space and an innovation ecosystem, the SBIIP is designed to cater to the needs of a diverse range of stakeholders, including academic institutions, startups, established companies, and government agencies. As such, it represents a synergy of research, development, and commercialization, backed by a comprehensive infrastructure and an enabling policy environment. The intricacies of this planning process deserve special attention. To develop a comprehensive view of the planning process, planners, officials, and other key parties involved were interviewed. These insights reveal the considerations and challenges faced in conceptualizing and executing the park's design.

SBIIP's ambition to nurture innovation by attracting top talent across various disciplines and providing the necessary resources for their creative pursuits is achieved through a unique dynamic between the government and the business sectors. The government sets up supportive policies and infrastructure to foster business growth and innovation, with SOEs leading initial investments, including the construction of the park and assuming associated risks. Once a robust foundational infrastructure is established, private businesses are encouraged to participate and gradually take the lead.

SBIIP is integral to a larger planned biomedical base with ample nearby land for expansion. This forward-thinking strategy positions SBIIP as a pioneer, providing private businesses such as real estate developers, property management companies, and industry players with sufficient physical and financial space to develop additional parks and facilities.

> "Shenzhen's model of governance and economic drive is unique contrast other places in China, characterized by a clear distinction between the roles of the government and the business sectors, which work in tandem to create an environment conducive to innovation and growth," said an expert in urban development and economic policy. (Interviewee 6A, 2023)

A park manager at the Shenzhen Biomedicine Innovation Industrial Park (SBIIP), who has previously served in the Pingshan government, has offered valuable insights into the park's development strategy. This individual's unique perspective, combining government experience with a deep understanding of the park's operations, underscores the significant role of SOEs in the initial phases of SBIIP's growth.

> "The SBIIP's development is a story of calculated risk and strategic growth, where state-owned enterprises have paved the way for a more competitive market landscape." (Interview 2B, 2023)

The SBIIP's strategic initiatives and operational models are designed to thrive in an atmosphere that values the principles of market competition for park supply. This feature, as a national level health sciences park in China, is distinctive, but is inextricably linked to the unique ethos of its host city, Shenzhen.

> "Shenzhen's enduring faith in market competition is the lifeblood of our park's success. It's this belief that propels us to continuously innovate and strive for excellence in everything we do." (Interviewee 2B, 2023)

To provide readers with a comprehensive understanding of the significance of the location, it is essential to delve into an introduction to the Shenzhen Special Economic Zone (SEZ). This context will elucidate the broader economic and strategic factors that underpin the development of SBIIP.

6.2.2.1 Shenzhen Special Economy Zone

A Special Economic Zone ("SEZ") is a designated geographical area within a country that has economic and other regulatory policies that are different from the rest of the country. These zones are typically established by governments to promote economic development and attract foreign investment. They often enjoy various concessions such as tax incentives, relaxed customs and import-export regulations, simplified business registration processes, and infrastructure support, making them more attractive for businesses (Vogel, 2011). The concept of SEZs has been around for decades, with countries such as the United States, Ireland, and Singapore establishing free trade zones as early as the 1960s (Engman, et al., 2007; Chen, 1995).

Special Economic Zones were introduced to China in the late 1970s as a policy instrument for economic reform and opening-up to foreign investment (Chen, 1995). In this context, Shenzhen, a small fishing village on the border with Hong Kong, was designated as the site for the first SEZ of China in 1980 (Naughton, 1997). The decision was influenced by its strategic location, proximity to Hong Kong, and the potential for economic integration with the neighbouring metropolis, or spillover. China has revolutionized the concept of SEZs and used them as a cornerstone of its economic development strategy. Shenzhen, in particular, transformed from a small fishing village to a bustling metropolis and a global hub for technology and innovation within a few decades.

> "SEZs, particularly the one in Shenzhen, have been pioneers in attracting foreign direct investment and promoting technology transfer." (Interviewee 6A, 2023).

The planning of Shenzhen's Special Economic Zone (SEZ) is a comprehensive process designed to foster economic growth and development through several key elements:

Policy Framework: Established with distinct economic policies, Shenzhen SEZ was designed to attract foreign investment, promote exports, and stimulate economic growth. These policies, including tax incentives, duty-free import and export, simplified customs procedures, and greater autonomy in economic decision-making, were experimental when introduced in 1980. At that time, under Deng Xiaoping's leadership, China was transitioning from a centrally planned system to a market-oriented economy. Shenzhen's strategic position as a gateway between mainland China and the outside world has been instrumental in its growth, facilitating the exchange of goods, services, technology, and ideas.

Zoning and Land Use: Initially covering approximately 328 km² and including four districts (Luohu, Futian, Nanshan, and Yantian), Shenzhen SEZ was strategically divided into zones dedicated to industrial, commercial, residential, and green spaces. The land use plan aimed to optimize land use, accommodate future expansion, and create a balanced and sustainable urban environment. Following significant achievements, the SEZ was expanded to cover the entire city of Shenzhen, spanning about 2,020 km². This expansion aimed to further promote economic development, attract investment, and foster innovation city-wide, extending the benefits of preferential policies and incentives.

Infrastructure Development: High-quality infrastructure is a cornerstone of SEZ planning. This includes transportation networks (roads, highways, ports, airports, and public transportation), utilities (water, electricity, and telecommunications), and social infrastructure (schools, hospitals, and recreational facilities). The goal is to provide robust and efficient infrastructure to support businesses and residents' needs. Planning also addresses social needs, including housing, education, healthcare, and cultural amenities. Environmental sustainability is a key focus, with measures to reduce pollution, conserve natural resources, and promote green technologies, evidenced by the development of green spaces, eco-friendly buildings, and sustainable transport options. These efforts aim to improve residents' quality of life, attract talent, and create a vibrant and inclusive community.

Diversification and Global Integration: Initially focused on manufacturing and export-oriented industries, the SEZ's planning has evolved to promote economic diversification, including services, finance, and technology. This diversification reduces reliance on a single sector and creates a more resilient and sustainable economy. The SEZ aims to integrate with the global economy, encouraging foreign investment, trade, and cooperation with international partners. Serving as a gateway between China and the world, Shenzhen SEZ facilitates economic and cultural exchanges. The choice of Shenzhen for the Shenzhen Biomedicine Innovation Industrial Park (SBIIP) aligns with the city's transformation into a knowledge-based economy, further reinforcing its role in global integration and innovation.

> "Shenzhen's SEZ has always been at the forefront of economic and technological innovation in China. Its business-friendly environment, combined with robust infrastructure and access to talent, made it an obvious choice for the development of SBIIP. The park is a testament to Shenzhen's commitment to remaining a global innovation hub." (Interviewee 2A, 2023).

In summary, the planning of Shenzhen's SEZ is a multifaceted process that involves a wide range of considerations. It seeks to create a dynamic and sustainable urban environment that fosters economic growth, innovation, and social development.

> "Shenzhen's SEZ offers the perfect blend of policy support, infrastructure, and access to capital that industries like biomedicine need. With its focus on fostering innovation, the SEZ provides Shenzhen Biomedicine Innovation Industrial Park (“SBIIP”) with the necessary tools to be at the cutting edge of biomedical advancements." (Interviewee 2B, 2023)

Located in Guangdong Province, the SEZ borders Hong Kong to the south, Dongguan to the north, and Huizhou to the northeast. Its geographical proximity to Hong Kong, a global financial and trading hub, played a pivotal role in Shenzhen's rapid development, which has allowed it to tap into the latter's global networks, driving its transformation into a major economic hub.

> "Shenzhen's remarkable growth story can be attributed, in large part, to its strategic location next to Hong Kong. The city has leveraged this proximity to attract capital, technology, and talent, fuelling its rapid economic development." (Interviewee 6K, 2023)

After years of development, Shenzhen became one of China's most economically dynamic cities. In 2000, the nominal GDP per capita for Shenzhen has reached about CNY 61,602 (approximately USD 7,425 based on an average exchange rate of 1 USD = 8.3 CNY for the year 2000), while the nominal GDP per capita were approximately CNY 7,129 (USD 860) for China, CNY 24,900 (USD 3,000) for Beijing and 36,100 (USD 4,350) for Shanghai. The city's strong economic performance and the presence of many successful companies contribute to the trend that Shenzhen's businesses often offer competitive if not highest salaries, benefits, and incentives to attract top talent.

In addition, the Shenzhen government has implemented housing subsidy programs to attract and retain talent. These subsidies help offset the high cost of living in the city and make it more attractive for professionals to move to Shenzhen. Shenzhen University (SZU), founded in 1983 in certain offered a wide range of graduates for the city. To take advantage of the city's economic dynamism, vibrant tech ecosystem, and supportive policies for innovation and entrepreneurship, universities took a strategic move to establish a presence there. In 2001, Peking University and Tsinghua University, the top 2 universities of China established graduate school in Shenzhen, respectively to contribute to Shenzhen's development as an innovation hub, and renowned Harbin Institute of Technology, Shenzhen was established in 2002 to support Shenzhen's development as a technology and manufacturing hub. In addition, Southern University of Science and Technology (SUSTech) was established in 2011 and has become a top-tier research university that focuses on science and engineering disciplines. These prominent universities have played a crucial role in supporting the city's further economic development and talent attraction.

The success of Shenzhen SEZ has made it a model for other economic zones in China and around the world. As a testament to success, Shenzhen SEZ model has been replicated and expanded to other parts of China, including Hainan Province and the development of economic and technological development zones (“ETDZ”) and high-tech industrial development zones (“HIDZ”) which we have mentioned in 4.1.1 of this research, and also free trade zones, export-processing zones (Zeng, 2010) and science parks which are more specific and small areas within those zones.

However, health science industry has its own unique characteristics， whether does Shenzhen SEZ’s experience still work?

> “Shenzhen was approved as one of the national bio-industry bases, yet its development has stagnated. As of this year, the bio-industry in Shenzhen holds a very minimal share in the city's total industrial output value, marking a small proportion in the overall industrial landscape." (Interviewee 2A, 2023)

6.2.2.2 Shenzhen Biomedicine Innovation Industrial Park

The choice of location for the Shenzhen Biomedicine Innovation Industrial Park (“SBIIP”) was influenced by a variety of factors. Shenzhen SEC's established reputation as a burgeoning hub for technology and innovation, its excellent connectivity to major domestic and international destinations, and its proximity to world-class universities and research institutions made it an ideal choice. The city's robust infrastructure, including state-of-the-art research facilities, high-tech industrial parks, and a network of support services, provided a solid foundation for establishing a dedicated biomedical park. Shenzhen attracts a diverse and highly skilled workforce, including researchers, scientists, engineers, and entrepreneurs, making it a natural choice for a biomedicine base. Overall, Shenzhen's strategic location, economic growth, availability of resources, government support, infrastructure, track record in technology and innovation, and talent pool made it an attractive location for establishing biomedicine bases.

The establishment of the SBIIP aligns with the strategic goals of the Shenzhen SEZ further evidences this strategy, which is designed to nurture innovation and entrepreneurship in the biomedical field. SBIIP is part of the broader Shenzhen SEZ ecosystem, enjoys the benefits of favourable policies, relaxed regulations, and financial incentives. SBIIP helps diversify the economy by promoting the growth of the biomedicine industry, which is characterized by high-value-added activities and strong potential for innovation, which have been critical in attracting biomedicine companies, researchers, and investors.

> “Initially aiming to establish a biomedical presence in Nanshan, Shenzhen’s efforts were unfruitful. In 2009, Pingshan volunteered to host the national biopharmaceutical park. Approved by the Shenzhen Municipal Government, the Pingshan Management Committee embarked on the project. In 2011, a subsidiary of Shenzhen Investment Holding Co., Ltd. (the largest SOE in Shenzhen) acquired the project, completing SBIIP in 2015.” (Interviewee 2A, 2023)

Interviewee 2B added on as followings:

> “Pingshan is situated in the most north-eastern corner of Shenzhen, a remote location. This remote location played a role. There was an intention to induce Sanofi to Shenzhen in 2007 but necessitating a remote location for vaccine production. Pingshan well fitted in. With the aspiration to spearhead industrial evolution with Sanofi at the forefront, Pingshan designated it as a park as a strategic complement to this industrial infusion. That’s how the volunteered request raised by Pingshan to host SBIIP in 2009 came.” (Interviewee 2B, 2023)

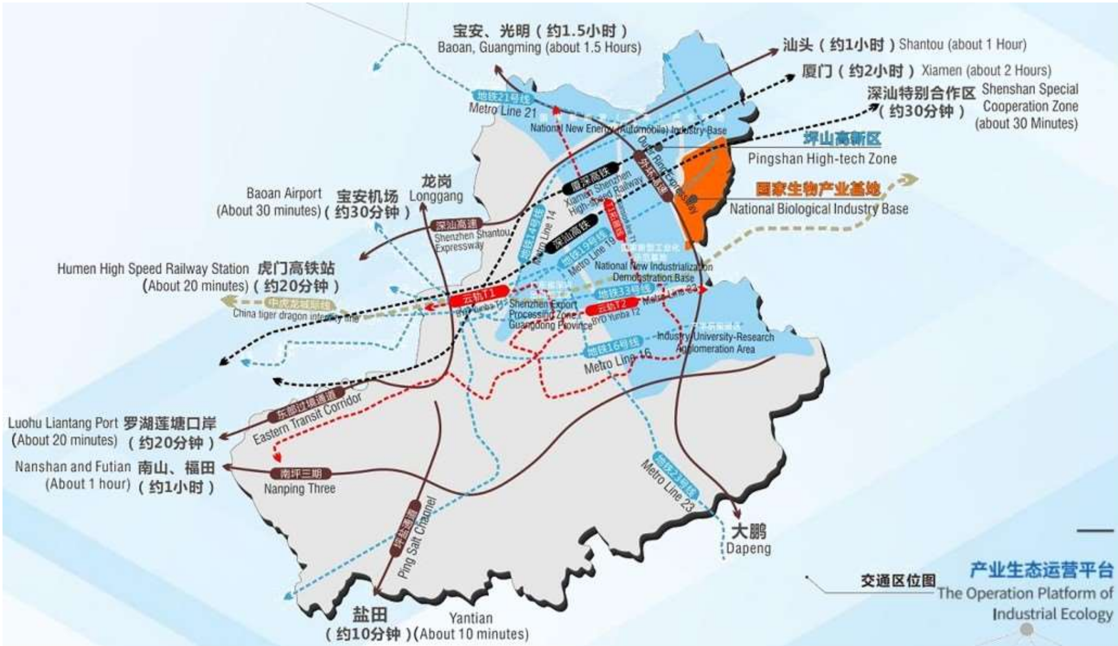
Setting up the SBIIP in Pingshan could be part of a broader strategy to diversify Shenzhen's economic base and promote balanced development across its various districts. A map of Shenzhen (Figure 23) may tell more.

Figure 23: The map of Shenzhen with 12 districts

Source: English translation added based on the map picture downloaded from Baidu picture (public)

The geographic location of Pingshan presented initial challenges to the development of SBIIP, as the area's remoteness made it unappealing to both businesses and real estate developers. In such circumstances, SOEs emerged as crucial players, shouldering the initial investment. Pingshan has seen significant investment in infrastructure, including transportation networks. After years of development, Pingshan has a solid infrastructure, including roads, utilities, and public facilities. As one of the newer districts in Shenzhen, Pingshan provides ample space for development and future expansion, and its location within the city offers a mix of advantages that make it a prime candidate for hosting a major biomedicine industrial park. The cost of land and facilities in a newer development area like Pingshan is also lower than in an already established hub. This could make Pingshan a more cost-effective choice for the development of the SBIIP. Located in the north-eastern part of Shenzhen, Pingshan is well-connected to key transportation networks. It is close to the Shenzhen Bao'an International Airport, Shenzhen North Railway Station, and major highways, making it easily accessible for domestic and international visitors. SBIIP is located at the intersection of Jinxiu East Road and Luhui Road, northeast Pingshan within the planning range of Metro Line 19. The park is near the Pingshan High-Speed Rail Station and is connected to Shenshan Expressway, Nanping Expressway, Xiashen Expressway, Xinhengping Highway. Additionally, the Nanping Expressway Phase III, Pingyan Passage, and Outer Ring Expressway will further shorten the distance between Pingshan and the city centre. The Xiamen-Shenzhen High-Speed Rail has been opened, with 12 pairs of express trains running directly to Shenzhen North Station daily. Metro Lines 3, 12, 14, 16, and 19 are designed in promoting rapid industry aggregation and development, smooth industrial resource circulation, and facilitating business growth.

Figure 24: The transportation map of the SBIIP



Source: provided by SBIIP

While mature districts of Shenzhen are already known as a tech and innovation hub, the establishment of the SBIIP in Pingshan could help create a new cluster of biomedicine companies and institutions in the district, fostering a more diverse innovation ecosystem in Shenzhen.

> “The park's strategic location was a conscious decision. Its proximity to Pingshan High-Speed Rail Station and connections to key transport networks like the Nanping Expressway and Outer Ring Expressway make it highly accessible. This ensures the seamless flow of goods, resources, and talents necessary for the park's success." (Interviewee 2A, 2023)

The SBIIP was planned to division into "one core," "one corridor," and "four sub-zones" reflects a commitment to enabling a flexible and functional space for a variety of stakeholders. The "core" hosts research institutions and high-tech companies, fostering an atmosphere of intellectual exchange. The "corridor" integrates research and industrial clusters, ensuring that innovations can be quickly translated into marketable products. The "four sub-zones" cater to different sectors of the biomedicine industry, promoting specialization and innovation. The park's planning has been largely oriented towards attracting talent from various regions. Policies facilitating talent mobility, competitive compensation, affordable housing, high living standards, and access to quality education and healthcare have been instrumental in attracting and retaining a skilled workforce.

> “The planning of the park was a multi-dimensional process, considering infrastructure, transport connectivity, environment, and fostering innovation. The park is not only a symbol of Shenzhen's technological advancement but also a commitment to developing a

> sustainable and inclusive economy. But all is about talent." (Interviewee 2A, 2023)

Shenzhen municipal government believe in market competition and regard SOEs as instrumental in fostering agglomeration. As highlighted in the interview, the Shenzhen municipal government is committed to prevent the domination of a single SOE by actively encouraging private businesses to participate in the competition once cluster effect formed.

> “We as a SOE led the demonstration role in the early development phase of SBIIP, in the way of identifying market needs and establishing a site that met the special requirements of the particular industry.” (Interviewee 2B, 2003)

Since 2015, SBIIP has become capable of accommodating enterprises, concentrating small and micro enterprises in the park through space leasing. Meanwhile, the Pingshan government introduced medium and large enterprises by rendering land-use-right nearby for construction and production. The consolidation of small and micro enterprises in the SBIIP, in tandem with other surrounding medium and large enterprises nearby contributed to a notable clustering effect in the area. In January 2017, Pingshan officially became an administrative district and formal statistics started since then. The growth of bio-enterprises in Pingshan, from 216 in 2017 to 1009 in 2022, is a testament to the burgeoning industrial milieu, further augmented by the addition of five new parks by private entities in response to the observed agglomeration effect. These additional parks, while in competition with SBIIP, have contributed to a richer, more diversified, and supportive environment for various biotech and medical devices enterprises, enhancing the overall attractiveness and functionality of the SBIIP.

The nature of SBIIP as a leasing business necessitates a close integration with the local industrial landscape, leveraging Shenzhen's strengths in medical devices, especially electronics and diagnostic reagents (Allen, 2020). Unlike the expansion model of BioBay in Suzhou, BIIP aids in finding nearby land for expanding companies, ensuring they remain within the broader Pingshan national bio-industry bases rather than confined to a specific park.

Since its inception, SBIIP has established various investment funds, including some industry guidance funds, primarily investing in the park. This strategic focus is gradually transitioning towards more market-oriented investments. Highlighting this, at the end of 2022, the Mayor of Shenzhen announced the establishment of the initial biotechnology industry fund, amounting to CNY10 billion, strategically positioned in Pingshan. This move underlines the city’s commitment to leveraging the Shenzhen city biotechnology industry fund as a pivotal tool to attract substantial large-scale enterprises to the Pingshan.

Even with all demonstrating efforts, attracting talent poses a significant challenge for SBIIP, as the clustering of universities and research institutes in Shenzhen falls short compared to cities like Guangzhou and Shanghai, while Pingshan is even more remote in Shenzhen. Despite the ability to headhunt high-level executives, the emphasis is placed on the critical role of vocational and technical institutions in training essential technical staff and laboratory personnel for company operations. This highlights the segmented operational approach of certain advanced companies, which position their R&D centres in cities like Shanghai or Beijing, utilizing the Shenzhen park predominantly for reception and recruitment purposes.

The SBIIP model is integrating governmental support, SOEs' demonstrating leading role and private investment to establish a robust biomedical ecosystem. The model hinges on an initial collaboration between government and SOE to establish the essential infrastructure, overcoming the challenge of its remote location of the larger existing cluster for the purpose of spearheading and supporting the growth of private enterprises within the larger clusters.

6.2.3 Understanding SBIIP's development using the Triple Helix model

The Triple Helix model of development posits that government, university-based research, and industry are the three critical ingredients for innovation (Etzkowitz & Leydesdorff, 2000). This framework provides a lens through which to examine the strategic development of the SBIIP. Similar to the development strategy of the Zhangjiang Life Science Park (ZLSP), SBIIP's growth has been significantly influenced by government-led initiatives, with the Shenzhen Municipal Government playing a pivotal role in the park's inception. The SBIIP Management Committee, acting as a governmental agency, has meticulously planned and executed the park's construction to align with the broader economic and technological goals of the region.

However, the success of SBIIP is not solely attributable to regional governance. Its strategic location within the Shenzhen Special Economic Zone (SEZ), a hub of thriving industry clusters, has been a significant asset. Shenzhen, as the vanguard of China's reform and opening-up policy, has pioneered economic system reforms and technological innovation, consistently implementing progressive policies that foster a dynamic environment conducive to entrepreneurship and technological breakthroughs (Vogel, 2011). Shenzhen's context of free-market competition and an open-minded, innovative government that emphasizes enabling rather than substantive management has provided a fertile ground for SBIIP's development.

SBIIP is designed as a blend of government-initiated development followed by industry-led growth. This unique approach leverages the strengths of both public and private sectors. Initially, the government's role in providing the necessary infrastructure and policy support was crucial in establishing a solid foundation. Once this foundation was in place, the government receded, allowing market forces to drive the park's development. This balance between public sector involvement and private sector innovation has created a dynamic and competitive environment conducive to sustained growth and innovation. This model is particularly noteworthy given the city's initial lack of a robust academic environment.

Despite this, SBIIP has effectively addressed the challenge by strategically bridging the gap in academic and research infrastructure. This approach has been crucial in nurturing a skilled workforce essential for driving sustained innovation and growth within the park. Leveraging government planning and the capabilities of SOEs, SBIIP embodies all three elements of the Triple Helix model: government, academia, and industry. Once the foundational infrastructure was established through SOEs, the government shall strategically recede, allowing for the organic development of the surrounding area. This transition facilitated the growth of private businesses and fostered a vibrant private economy, which is vital for the park's dynamic ecosystem.

The government's role has been instrumental in providing the initial impetus and creating an enabling environment. The commendable business environment in Shenzhen and the strategic role of the SBIIP government have been widely recognized for their contributions to the park’s thriving ecosystem. Shenzhen's pro-business environment is often lauded for its conduciveness to innovation and entrepreneurship, a sentiment echoed by various stakeholders and experts in the field.

> "Shenzhen's government has demonstrated a strong commitment to fostering a business-friendly environment, which is evident in the robust support systems and policies in place for enterprises within SBIIP". （Interviewee 6C, 2023）

As explained by interviewee 2A and 2B, the strategic inception of SBIIP by the government laid a groundwork, catalysing industry-led advancement and highlighting the synergy between governmental direction and market dynamics. With a pivot towards empowering private enterprises, the park has leveraged its infrastructure and governmental initiatives to enhance convenience and accessibility. This shift has cultivated a dynamic landscape, propelling the prosperity of private businesses and bolstering the park’s economic vigour and innovative edge. Interviewee 6A remarked, underscoring the park’s success in harmonizing public and private sector efforts to drive economic and technological progress:

> "SBIIP exemplifies strategic government involvement working in harmony with market mechanisms, thereby creating a fertile ground for innovation and private sector growth. What is particularly encouraging is the government's ability to step back at the right moment, allowing private players to take the lead." (Interviewee 6A, 2023)

Supportive policies and financial incentives offered at SBIIP were cited as important motivating factors by several interviewees. Interviewee 2C shared,

> “We are attracted to the preferential leasing rate offered by SBIIP, including office space and talent apartment. The park has connected us with investors and facilitated partnerships with other companies, helping us grow and expand our market reach." (Interviewee 2C, 2023)

The influence of government incentives and favourable policies in the decision-making process is further highlighted by another testimonial:

> "The government incentives and favourable policies at the SBIIP played a significant role in our decision to locate here. The tax incentives and subsidies granted by the government were definitely factors that influenced our decision to locate at the SBIIP." (Interviewee 2H, 2023)

The open-mindedness of the Shenzhen government has made the region accessible to a wide range of educational institutions, from emerging to well-established ones. This inclusivity has been pivotal in the strategic planning and establishment of the SBIIP. The proximity to research institutions and universities is a critical factor influencing companies' decisions to locate at SBIIP. Shenzhen’s strategic efforts to attract renowned universities to establish branches and campuses within the city have significantly contributed to the development of an academic base. Institutions such as Peking University, Tsinghua University, and Harbin Institute of Technology have established campuses in Shenzhen, providing a steady stream of qualified graduates. These universities not only supply a talent pool for the industry but also engage in collaborative research projects with businesses, fostering a culture of innovation. This synergy between academia and industry is fundamental to the Triple Helix model, enhancing the park's innovation ecosystem. As one interviewee noted,

> "The establishment of university branches in Shenzhen has been instrumental in cultivating a local talent pool that meets the demands of our industry. The close-knit relationship between these educational institutions and SBIIP has facilitated a symbiotic relationship where academia feeds directly into the workforce, supporting our development." (Interviewee, 2E).

Moreover, the collaboration between universities and businesses in Shenzhen has led to the creation of joint research centres and innovation labs, which drive technological advancements and commercialization of research. This interaction is crucial for maintaining a competitive edge in the biomedicine and biotechnology sectors. The Shenzhen government’s initiatives, such as providing funding for joint research projects and creating innovation hubs, have further strengthened these collaborations. This support has enabled universities to align their research agendas with industry needs, ensuring that the outcomes are both academically rigorous and commercially viable.

In addition to fostering academic-industrial collaboration, the government has also implemented policies to attract top-tier global academic institutions. For example, partnerships with renowned international universities to establish joint programs and campuses in Shenzhen have expanded the city’s educational landscape and enhanced its global competitiveness (Vogel, 2011). The Chinese University of Hong Kong even opened a campus in Shenzhen since 2014 (Chinese University of Hong Kong Shenzhen, 2024).

This concerted effort to build a robust academic infrastructure has been a cornerstone of SBIIP’s development strategy. The close relationship between academia and industry, facilitated by proactive government policies, has been crucial in cultivating a skilled workforce and fostering innovation.

From the perspective of the business helix within the Triple Helix model, Shenzhen's commercial environment is thriving and is particularly noted for its ability to attract and foster industry leaders. The city's vibrant business atmosphere is characterized by a strong entrepreneurial spirit, a pro-business government, and a strategic location that facilitates international trade and investment. This environment has proven to be a significant draw for both startups and established industry giants, leading to a clustering effect where industry leaders in various sectors converge. The aggregation of technology industry leaders in Shenzhen creates a synergistic effect that stimulates innovation, fosters collaboration, and enhances the city's competitiveness on a global scale. Some interviewees believe similar success will happen in the health sciences industry.

> "Shenzhen's track record of nurturing industry leaders like Huawei, Tencent, and BYD inspires confidence in its potential to shape frontrunners in the health sciences sector, with BGI (a leading genomic sequencing and analysis company headquartered in Shenzhen) as a prime example." (Interviewee 3A, 2023)

Several other interviewees echoed that the strategic direction of SBIIP, set against the vibrant backdrop of Shenzhen's business landscape, reinforces their belief in the park's ability to cultivate market-leading enterprises. Opportunities for collaboration with other companies, researchers, and institutions are essential for innovation. A business development executive of a listed company, shared,

> "Our extensive network of mentors, peers, and friends within Shenzhen, coupled with the city's skilled workforce, fundamentally guided our choice to establish our company at SBIIP. The park's reputation as an innovation cluster with a collaborative ethos was a compelling factor in this strategic decision. " (Interviewee 2D, 2023)

The park's location and ease of access to transportation and other amenities also come into consideration. A founder of an early-stage biotech company, stated,

> "The SBIIP's location within the Shenzhen Special Economic Zone, along with its proximity to major universities and research institutions, ensures access to a pool of highly skilled professionals. " (Interviewee 2G)

The COO of a start-up genetic engineering company, concurred, stating,

> "The strategic location of the SBIIP, with its proximity to major transportation hubs and amenities, made it an ideal choice for us." (Interviewee 2E)

Companies and scientists may evaluate science parks based on the availability and quality of services and amenities, the park's reputation and track record, and the potential for collaboration and innovation.

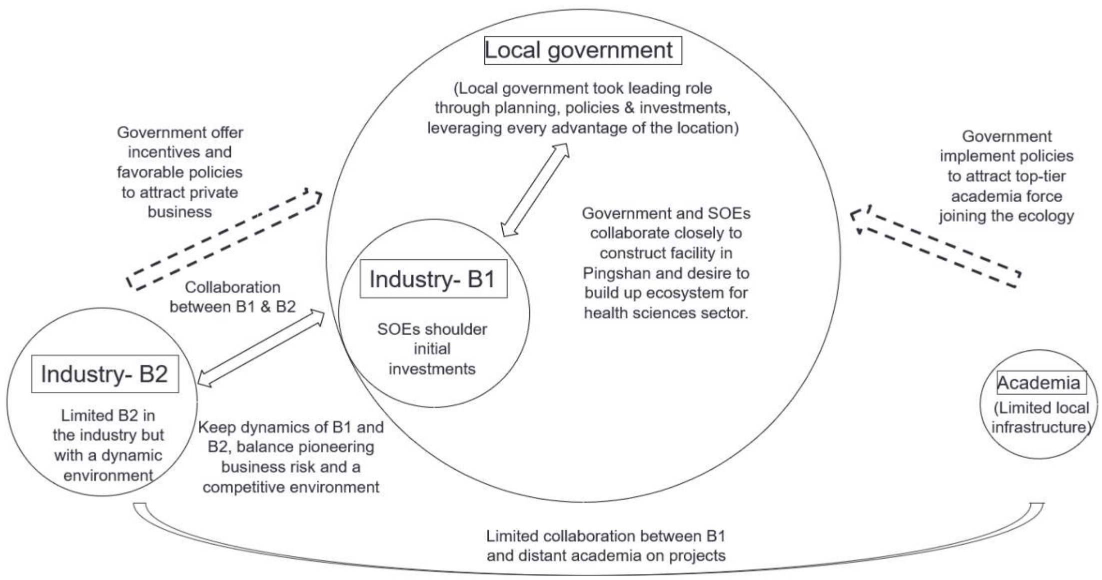
> "The SBIIP's dedicated support services, especially in training us with IP and other regulatory filing matters, have been invaluable for us as a start-up.” (Interviewee 2E)

In a summary, companies and scientific talents evaluate the services and environment provided at a science park based on a combination of factors, including infrastructure, networking opportunities, support services, talent pool, innovation ecosystem, government incentives, and location. The testimonies of the interviewees at the SBIIP underscore the importance of these factors in influencing their decision to locate at the park.

> "The decision to establish our operations at SBIIP was influenced by the park's strategic location and the comprehensive support it offers. The investor's recommendation, coupled with the existing collaborations between the investor and the Pingshan local government, made SBIIP an attractive choice for us.” (Interviewee 2C, 2023)

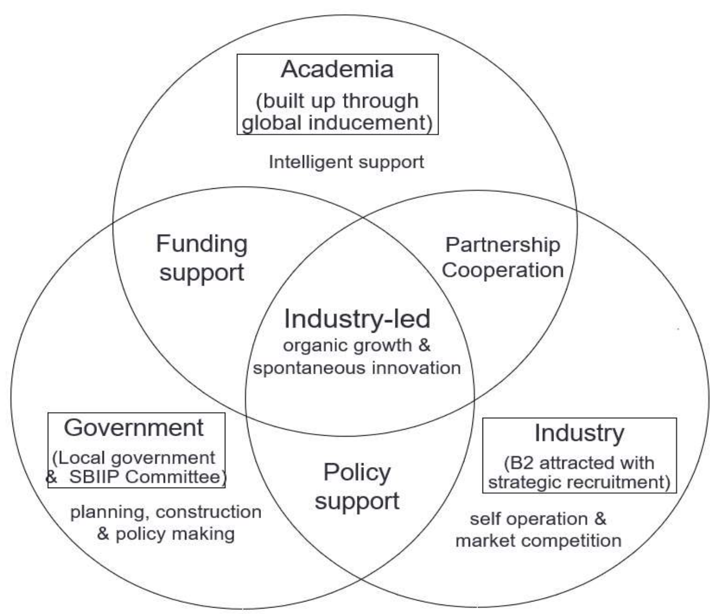
The development of SBIIP through the Triple Helix model demonstrates the significant role of government, academia, and industry in fostering an innovation-driven ecosystem. The Shenzhen Municipal Government's strategic planning and initial investments have laid a robust foundation, while the gradual shift to industry-led growth has fostered a dynamic and competitive environment. Despite initial challenges, such as the lack of a robust academic infrastructure, SBIIP has effectively bridged this gap through strategic collaborations and the development of local talent. The integration of supportive government policies, a thriving business environment, and proximity to leading universities has created a conducive environment for sustained innovation and growth. As a new bread, SBIIP serves as a model for other health science parks in China, illustrating how the strategic blend of government initiation and subsequent industry-led growth can drive economic and technological progress in the biomedicine and biotechnology sectors.

Figure 25: The Original Ecology of Triple Helix in SBIIP – government initiated



Source: author's interpretation of Triple Helix

Figure 26: The Evolved Application of Triple Helix in SBIIP – industry led



Source: author's interpretation of Triple Helix

6.2.4 Diverse reach and academia helix challenges in the development of SBIIP

Building on the Triple Helix model discussed in the previous section, it is essential to explore the diverse reach and academia helix challenges faced by the SBIIP. Understanding the geographic origins of the companies and scientists located at SBIIP reveals the park's extensive and varied appeal, while also highlighting some inherent challenges, particularly in cultivating a robust academic environment.

The reach of the SBIIP can be assessed by understanding the geographic origins of the companies and scientists located there. Interviews may reveal whether the SBIIP attracts businesses and talent from local, regional, or international markets. Some companies may have considered alternative science parks, either within China or internationally, before deciding to locate at the SBIIP. The comparative advantages of the SBIIP over other parks may be highlighted through the interview responses.

For instance, a CEO of a medical device start-up that originated in Beijing, shared his company’s journey:

> "We were initially based in Beijing, but we decided to relocate to the SBIIP due to its strategic location and the opportunities it presented for collaboration and growth. We did consider other science parks in Shanghai and Suzhou, but the comprehensive support and facilities offered by the SBIIP, and also the cluster of medical devices here made it our top choice." (Interviewee 2E)

Another interviewee commented on the company’s decision to establish operations at the SBIIP:

> “We have a laboratory in the States. While thinking of further elaborate our research and move it into Investigational New Drug (IND), we evaluated multiple science parks across Asia. The SBIIP's strong reputation for fostering innovation, broad fund-raising channels, as well as the access to talents with reasonable costs, played a decisive role in our choice." (Interviewee 2F)

Based on conversation with the park manager and interviewees on the park inhabitants, In general, the reach of the SBIIP is broad and diverse, attracting companies and scientific talents from different regions, both within China and internationally. Shenzhen's strong GDP growth, competitive salaries, benefits, and incentives is pivotal and SBIIP's strategic location, strong innovation ecosystem, and supportive government policies have all played a role in its ability to attract companies from various parts of the world. The testimonies from the interviewees underscore the factors that influenced their decision to establish operations at the SBIIP, highlighting the park's competitive advantage in attracting global talent and companies.

When asked what makes for a successful science park, interviewees share their perspectives on the critical success factors for a science park hinges on several factors including location, infrastructure, support services, opportunities for collaboration, and a conducive environment for innovation and growth. The SBIIP has strived to provide these elements to attract companies and scientific talents.

> "A successful science park should offer top-notch facilities, provide access to funding, and create an environment that fosters collaboration and innovation. SBIIP has done well in providing these factors, and it's one of the reasons we chose to locate here." (Interviewee 2E)

Regarding the evolution needed to retain companies, responses varied. A business development executive from a pharmaceutical listed company expressed concerns:

> "As the biotech industry evolves, the park needs to keep up with the latest trends and technologies. We would like to see more investment in infrastructure and the introduction of new services that cater to the changing needs of the industry." (Interviewee 2D).

Another interviewee shared a similar view:

> "The park needs to continuously innovate and adapt to the changing landscape of the biotech industry. It should focus on attracting top talent, fostering collaboration, and providing access to the latest research and technologies." (Interviewee 2C)

Despite the proactive measures taken by Shenzhen's municipal government to attract renowned universities and foster a collaborative model of development, there remains a significant challenge in cultivating high-end talent in the health sciences sector. The city's universities, majority relatively young, have primarily focused on undergraduate education. This focus, coupled with the fact that even prestigious Chinese universities only began to establish graduate schools in Shenzhen in the early 2000s, has resulted in a skilled workforce that, while accessible, may not fully meet the demands for cutting-edge expertise in specialized fields such as biology, pharmacology, and chemistry.

> "Shenzhen's universities are at a critical juncture where they must balance the rapid development of industry partnerships with the need to cultivate a deep and independent academic environment. The challenge is to create a fertile ground for innovation that can sustain the city's ambition to become a hub for health sciences, without compromising the integrity and freedom of academic research." noted a professor of health sciences industry expert (Interviewee 6L, 2023).

This statement underscores the dual challenge faced by Shenzhen's universities: to create a compelling academic environment that can nurture top-tier talent while maintaining a competitive edge in the national and global race for academic excellence. It also highlights the necessity for these institutions to evolve their research infrastructure and academic programs to produce graduates who can contribute significantly to the innovation and advancement of the health sciences sector.

The Shenzhen municipal government's efforts to attract top-tier talent, exemplified by the recruitment of Professor Nieng Yan from the University of Princeton, highlight the city's commitment to enhancing its academic standing within the Triple Helix model (Shenzhen Municipal Government, 2022). Professor Yan, a renowned biophysicist known for her groundbreaking research on membrane proteins and ion channels, serves as the Founding President of the Shenzhen Medical Academy of Research (established in 2021, expected to open in 2025) and Director of Shenzhen Bay Laboratory (established in 2019). Her work has significantly advanced the understanding of cross-membrane transport, and she was honoured with the 2024 "L'Oréal-UNESCO For Women in Science International Award" (L'Oréal-UNESCO, 2024). While the collaborative model has driven Shenzhen's academic progress, it is crucial to balance this with efforts to strengthen internal capacities and promote independent research for sustainable growth and the cultivation of leading expertise.

The diverse reach and challenges in academia helix of SBIIP highlight both the park's extensive appeal and the obstacles it faces in developing a robust academic environment. SBIIP attracts companies and scientific talents from various regions, leveraging its strategic location, strong innovation ecosystem, and supportive government policies. However, despite these strengths, Shenzhen must address significant challenges in academia helix to sustain its growth and innovation in the health sciences sector. Balancing rapid industry partnership development with deep academic cultivation is crucial. By reinforcing internal capacities and fostering independent research, SBIIP can maintain its competitive edge and continue to thrive as a leading health science park.

6.2.5 Conclusion on Case Shenzhen Biomedicine Innovation Industrial Park

This case study exemplifies a government-orchestrated approach, blending government initiation, industry-led growth, and synthetic academic collaboration to foster innovation and technological advancement in the biomedicine sector. The strategic location, supportive government policies, and vibrant innovation ecosystem have all played crucial roles in attracting global companies and scientific talent to the park. As a new breed of health sciences park in China, SBIIP provides a unique view of the practical application of the Triple Helix model.

The initial establishment of SBIIP in Pingshan, Shenzhen, was strategically chosen for its proximity to the Shenzhen Special Economic Zone (SEZ), which offers a favourable economic environment for foreign investment and technological advancements. Shenzhen's location near Hong Kong has facilitated international collaborations. The Chinese central government selected Shenzhen for SBIIP due to its economic vibrancy and technological progress. Local government support through funding, incentives, and policies, along with the encouragement of university campuses and research institutions, making efforts to create a fertile ground for health sciences advancements. SBIIP's strategic location and strong innovation ecosystem have attracted companies and scientific talents from various regions, both within China and internationally. The park's ability to provide comprehensive support, including funding, talent acquisition, and collaboration opportunities, has positioned it as a competitive destination for global biomedicine companies.

After laying the foundational infrastructure and implementing policy support, the government assigned SOEs to play a critical role in the park's initial phase. This involvement provided a demonstration effect that encouraged private investment an, taking the investment risks, participation, facilitating the shift from government-led to market-driven development. This industry-led growth model enabled SBIIP to adapt to the evolving needs of the biomedicine sector by fostering a dynamic and competitive environment.

Despite initial challenges related to the lack of a robust academic environment, SBIIP has effectively bridged this gap through strategic collaborations with renowned universities and research institutions. The establishment of university branches and joint research centres in Shenzhen has been instrumental in cultivating a skilled workforce and fostering innovation, resulting in The park's reach extends both nationally and internationally, attracting companies from within China and other countries. However, SBIIP faces challenges in attracting high-end talent and fostering a deep academic environment. The relatively young universities in Shenzhen need to balance rapid industry partnership development with cultivating a robust academic infrastructure. Addressing these challenges requires continued investment in educational institutions, enhancing research capabilities, and promoting independent research.

The case of Shenzhen Biomedicine Innovation Industrial Park (SBIIP) demonstrates that a government-orchestrated approach to establishing science parks, underpinned by the Triple Helix model, can result in innovation and industrial growth. SBIIP's success underscores the importance of strategic planning, comprehensive support systems, and a dynamic approach to fostering innovation. However, the sustainability of this model hinges on continuous adaptation and improvement. Ensuring the development of a robust academic environment, attracting top-tier talent, and maintaining a competitive edge in the global market are crucial for the long-term success of SBIIP. By addressing its challenges and leveraging its strengths, SBIIP has the potential to serve as a model for other health science parks in China and beyond. However, the park's unique position in Shenzhen and the specific advantages provided by its location necessitate a cautious evaluation. Despite its promising start, SBIIP is still a young park and requires more time to fully demonstrate its effectiveness and long-term viability.

In conclusion, SBIIP represents a new breed of health science parks in China, showcasing the potential of the Triple Helix model in driving economic and technological progress. The strategic blend of government initiation, industry-led growth, and even artificial synthetic academic collaboration has positioned SBIIP as a key player in the global biomedicine sector, offering valuable insights for the development of future science parks. As China continues to transition towards an innovation-driven economy, the lessons learned from SBIIP's development will be instrumental in shaping the country's approach to fostering innovation and growth in the health sciences industry.

6.3 BioBay: A growing specimen

6.3.1 Introduction

Suzhou Biomedical Industrial Park, 苏州生物医药产业园 in Chinese, commonly known as BioBay, is located within the Suzhou Industrial Park (SIP), a national-level High Technology Industrial Development Zone (HIDZ) in East China. Positioned in the economically dynamic Yangtze River Delta urban agglomeration, BioBay plays a crucial role in China's rapidly expanding biomedical sector (EqualOcean, 2021; Wu & Sun, 2023). The park has garnered widespread acclaim for its rapid development and significant contributions to the national biomedical industry, underscoring its importance within both regional and national biotechnology landscapes (Sina Medical, 2021; Wan, Sun, & Hao, 2022). As such, BioBay exemplifies China's broader ambitions to establish itself as a global leader in biotechnology and pharmaceuticals, reflecting the nation's efforts to enhance its international standing in life sciences. The development of BioBay offers a valuable case study for examining the strategic planning, early implementation, and evolution of China's biomedical industry, highlighting its impact on the national and global stages (Zhavoronkov, 2022).

Construction of BioBay began in 2006, with Phase I officially opening in June 2007, spanning 680,000 m². Initially designed to cultivate and incubate early-stage biomedical projects and commercialize health science research, BioBay's early progress was gradual, further hampered by the 2008 financial crisis, which complicated funding for local innovation and start-ups. However, by May 2015, Zone A of Phase II was opened, focusing on novel antibodies, cell therapy, and biomedical industrialization. Phase II became fully operational with the opening of Zones B and C by May 2020, covering 290,000 m². The success of local biotechnology innovations within BioBay fuelled the development of additional phases, each with a distinct focus. Phase III, comprising IIIa, IIIb, and IIIc, with an emphasis on gene therapies and RNA therapy, expanded by 480,000 m², with IIIa and IIIb opening in 2021 and 2022, respectively, while IIIc remains under construction. Phases IV through VIII are in various stages of design, construction, and partial use. By July 2024, BioBay had expanded to 2.60 km², housing over 620 biomedicine and medical device enterprises (BioBay, 2024).

The selection of BioBay as a focal case study for this research was driven by several critical factors, most notably its reputation as a rapidly emerging biotechnology hub. Established with the strategic intent of cultivating and incubating early-stage biomedical projects and commercializing health science research, BioBay represents a key node in China's broader health science landscape. Its strategic location allows it to capture industrial spillover from the nearby Zhangjiang China Pharmaceutical Valley (ZCPV), effectively mitigating challenges such as limited space availability and the high costs of rent and labour associated with ZCPV. BioBay's pioneering role in the biotechnology industry is further highlighted by its innovative operational models and strategic advancements, which have consistently set benchmarks within the sector. This case study offers valuable insights into BioBay's contributions to the regional and national health science industry, reflecting China's broader strategy to foster innovation and maintain a competitive edge in the global biotechnology market.

6.3.2 Understanding the planning of BioBay

The establishment of BioBay represents a significant milestone in China's broader effort to foster innovation and growth within the biomedical industry. Rooted in the successful model of the Suzhou Industrial Park (SIP), BioBay builds upon the foundational experiences and lessons learned from SIP to create a specialized hub focused on health sciences.

SIP itself is a product of Sino-Singapore collaboration, initiated after China's paramount leader, Deng Xiaoping's 1992 proposal to leverage Singapore's development expertise to bolster China's economic growth. This proposal, supported by Singapore's then-Senior Minister Lee Kuan Yew, led to the formal establishment of SIP in 1994, marking a pivotal moment in China's broader reform and opening-up policy (Suzhou Municipal Local Chronicles Compilation Committee Office, 2022). SIP, as a China’s national-level Economic and Technological Development Zone (ETDZ) encompassing 278 square kilometres, with 80 square kilometres designated as the China-Singapore Cooperation Zone. The SIP Administration Committee (SIPAC), established with the approval of China's National Council, oversees governance, including policymaking, planning, and supporting policy implementation within the park. This governance is further reinforced by the China-Singapore Joint Steering Council, which is co-chaired by senior officials from both nations. This structure ensures that SIP benefits from Singapore’s advanced management practices while adhering to international standards (SIPAC, 2024). The operational management of SIP is entrusted to the Sino-Singapore Group, a joint venture funded by consortia from both countries. This entity, known as SIP Manager, is responsible for the park's construction, development, and comprehensive management services, including financial investments. The relationship between SIPAC and SIP Manager is carefully designed to maintain the operational independence of the management entity, allowing it to function effectively as a business while leading the park's development (SIPAC, 2024).

The collaborative model in SIP effectively separates government oversight from business management, contributing significantly to its economic and social achievements. This strategic collaboration, marked by clear short and long-term goals, has positioned SIP as a benchmark for international cooperation and industrial development in China. Its success has driven local economic growth and supported China's broader objectives of industrial modernization and global engagement. Notably, the Ministry of Commerce ranked SIP as the top development zone in China for eight consecutive years (2016-2023) based on its comprehensive development level (SIPAC, 2024; Zhang, 2021).

SIP has been meticulously designed with a forward-looking approach to urban planning, emphasizing high standards in both infrastructure and environmental integration. Central to this development is the integration of urban functions within a cohesive layout that blends industry and residential life. The park is organized with a central business district surrounding Jinji Lake, which serves as the urban centre, while the broader 80 square kilometres of the Sino-Singapore Cooperation Zone are divided into four distinct functional areas: commerce, science and innovation, leisure and vacation, and high-end manufacturing and international trade zones. The park's urban design prioritizes a robust underground infrastructure, including a comprehensive rainwater collection and drainage system, which is critical in managing the environmental impact of urbanization. Additionally, SIP's urban road network and public transport systems have been intricately planned to connect seamlessly with the surrounding highways, high-speed railways, and intercity rail transit, enhancing both internal mobility and regional connectivity. These efforts reflect a sophisticated blend of Singaporean planning principles adapted to the Chinese context, demonstrating SIP's role as a model for urban growth in China, as discussed in several studies focusing on the park's development (Lin, 2019; Melnick, 2019).

Figure 27: BioBay

Source: Photo provided by BioBay.

Building upon the foundational experiences of Suzhou Industrial Park (SIP), BioBay represents an evolution tailored specifically to the growing health sciences sector. This development exemplifies the proactive and innovative approach of the Suzhou government, SIPAC, and the SIP Manager, who are deeply committed to nurturing emerging industries, particularly in health sciences.

Drawing on SIP’s successful planning concepts, BioBay was conceived within the Dushu Lake Science & Innovation Zone, a strategically planned area of 51.85 square kilometres. This zone was meticulously designed to foster high-level industry-university-research collaborations. This zone, located on the east bank of Dushu Lake, emphasizes cutting-edge sectors such as biotechnology, artificial intelligence, nanotechnology applications, and the digital economy, and is home to an expected population of 400,000. BioBay benefits from Suzhou's highly developed transportation network, which includes expressways, railways, and proximity to key international airports, ensuring seamless connectivity with major cities across China and globally. Conveniently located just 20 minutes from Shanghai by high-speed railway, Suzhou enjoys a highly developed and extensive network of expressways, railways, waterways, and air routes that seamlessly connect it to major cities across China and globally. This strategic positioning is further enhanced by proximity to key transportation hubs, such as Sunan Shuofang International Airport, located just 47 kilometres away and accessible within 40 minutes by car, and Shanghai Hongqiao International Airport, only 80 kilometres distant, with a quick 20-minute train ride to SIP. The ease of access to Shanghai Pudong International Airport, 120 kilometres away, which can be reached in approximately 90 minutes by car, further enhances BioBay's global connectivity (BioBay, 2024). This strategic location and comprehensive transportation infrastructure enhance BioBay’s attractiveness as a hub for biotechnology and life sciences companies, supported by the robust infrastructure and continuous enhancements initiated by SIPAC. Figure 28 illustrates the overall landscape of BioBay and its transportation connectivity.

Figure 28: BioBay Overall Landscape

Source: downloaded from BioBay.com.cn

As Interviewee 3C describes:

> “The success of BioBay can be attributed to the deep historical roots and unique geographical advantages of Suzhou, which have provided a solid foundation for its rapid development.” (Interviewee 3C, 2023)

With its inherent advantages, Suzhou Industrial Park Bioindustry Development Co., Ltd., was established in 2005 as a direct affiliate of the SIP Administrative Committee (SIPAC). This entity, known as the BioBay Manager, was tasked with overseeing the development, construction, investment attraction, and overall operation of BioBay. From its inception, the BioBay Manager has been strategically operated as a market-oriented enterprise, reflecting SIP’s broader strategy of aligning public sector initiatives with market mechanisms. This market-driven approach has empowered the company to make decisions based on market dynamics, a crucial factor in ensuring the park's sustainable growth and long-term success. Interviewee 3B remarked,

> "Our commitment from the beginning was to operate under market principles, making informed decisions that align with the dynamics of the market. This strategy has been instrumental in maintaining BioBay's competitive edge and fostering long-term development." (Interviewee 3B, 2023)

The construction of BioBay commenced in March 2006, drawing on the successful planning concepts and experiences of SIP. The park was strategically designed to create an environment conducive to research and innovation while simultaneously providing a comfortable living space. This emphasis on a harmonious natural environment, scientific rigor, and carefully managed construction reflects the forward-thinking ethos that has been central to the project’s development. As one interviewee aptly noted,

> "The top-level design of park planning, management, and operation mechanisms is critical. We learned a great deal from SIP, which itself

> drew heavily from Singapore's experiences, both in government and business practices." (Interviewee 3A, 2023)

This insight highlights the deliberate and informed approach that has guided BioBay's development, ensuring it not only follows in SIP's footsteps but also advances its legacy in new and impactful ways.

BioBay's phased development strategy has been pivotal to its growth. This strategy integrates several key components: strategic positioning, differentiation, ecosystem building, and capital availability. The development model is based on a dual approach that combines top-down strategic direction with the flexibility to adapt to shifting market demands and ground-level realities. By focusing on differentiation, BioBay has successfully carved out a unique niche in the biotechnology sector, emphasizing the nurturing of startups, fostering original research, and attracting top-tier talent (BioBay, 2022). This strategic choice has allowed BioBay to avoid direct competition with more established bio-pharma hubs like (ZCPV in Shanghai, thereby creating a distinctive identity within the industry. Phase I of BioBay, which spans an area of 800 square kilometres, was officially inaugurated in June 2007, marking the beginning of its journey as a key player in biotechnology.

Ecosystem building has been central to BioBay's phased development, with a strong emphasis on creating a comprehensive service network that supports businesses at every stage of their growth. This network includes specialized departments that offer full-process and all-round support services, alongside incubators tailored to various sectors of biomedicine. To attract and retain top talent, BioBay offers a range of preferential policies, including relocation allowances, entrepreneur subsidies, and academic rewards. The park also provides customized services for individuals and enterprises considering relocation, thereby enhancing its appeal to highly skilled professionals.

> "We used 'spider' to describe our all-rounded talent services. BioBay is the centre of the spider, and the functional service platforms are its 'legs'." (Interviewee 3C, 2023)

This metaphor highlights the park's interconnected support system, with each "leg" representing a critical service platform.

These efforts are complemented by BioBay's extensive support systems, which include facilities for medicine analysis and testing, corporate registration assistance, and human resources services that cover training, recruitment, and even personal needs such as housing and children's education. For instance, the public technology platform offers lab facilities for medicine analysis and testing, available to enterprises within BioBay either for free or on a rental basis, ensuring that startups have access to the necessary resources. The settlement assistance platform handles tasks such as corporate registration, laboratory setup, and certificate applications on behalf of companies, while also offering personal services like talent settlement, spouse employment, children's education, and housing support. Meanwhile, the human resources platform provides corporate training, internship assistance, post-doctoral station establishment, and recruitment services, further solidifying BioBay's role as a comprehensive support hub.

Interviewee 3A and 3C also emphasized how service vision was integrated into the park's planning. Recognizing the international backgrounds of many professionals in the biotechnology and life sciences sectors, BioBay introduced the ‘Overseas Chinese Academy of Chiway Suzhou,’ the first school in China tailored for Chinese children seeking an international K-12 education without leaving the country. This initiative complements the already established Singapore International School and Dulwich International College within the park. Additionally, in response to the high priority that talents place on housing, the park developed talent apartments, offering them at preferential rates for sale or rent.

> "We do not only attract talents but also intend to raise talents. We need to think as the talents do. The clustering of talent is critical to the development of the biotechnology industry." (Interviewee 3C, 2023)

Despite these efforts, BioBay faced significant challenges in its early stages, particularly in attracting enterprises to settle within the park. The lack of an established biotechnology industry in Suzhou and the absence of prominent academic institutions specializing in the field made it difficult to convince companies to move there. This initial struggle highlighted the complexities of establishing a new industry cluster from the ground up, even with substantial resources at hand. Interviewee 3A reflected,

> “Despite the perfect facilities and ample space we provided, convincing biotechnology or life science companies to settle in Suzhou back then was exceedingly difficult.” (Interviewee 3A, 2023)

This quote captures the frustration and disappointment that marked the project's early days, particularly among the leadership of SIPAC and BioBay Manager, who were acutely aware of the gap between their ambitions and the reality they faced. The initial struggle highlighted the complexities of establishing a new industry cluster from the ground up, even with substantial resources at hand.

In summary, BioBay's development model is a testament to the strategic vision and planning initiated at the highest levels of China's leadership, while embracing a market-driven methodology deeply rooted in the successful model of SIP. Conceived as part of China’s broader ambition to lead in global biotechnology, BioBay was meticulously planned in phases, each aligning with national and regional industrial policies. This phased approach allowed BioBay to differentiate itself by focusing on the incubation of startups and the nurturing of original research, which has been critical to its success.

6.5.3 Understanding BioBay’s development using the Triple Helix model

The Triple Helix model, conceptualized by Etzkowitz and Leydesdorff, serves as a framework for understanding the dynamic interactions between government, industry, and academia, which are pivotal for fostering innovation in knowledge-based economies. BioBay's development exemplifies this model, particularly as it embodies a distinctive fusion of top-down strategic intent and bottom-up market-driven execution.

The establishment of BioBay within the SIP is a testament to the Chinese government's strategic approach to economic development, particularly in leveraging existing park infrastructure and successful park planning and operation model. BioBay's development reflects a nuanced and balanced approach where government oversight is strategically combined with market-driven execution. This synergy has been pivotal in distinguishing

BioBay from other biotechnology hubs in China. The SIPAC, which played a key role in BioBay's establishment, brings a unique perspective rooted in its experience with international standards, particularly from its collaboration with Singapore. This experience has allowed SIPAC to create a conducive environment for innovation by providing essential infrastructure, favourable policies, financial incentives, and platforms that encourage industry-academia collaboration. This supportive ecosystem has been instrumental in fostering the growth of bio-pharmaceutical enterprises within BioBay.

What sets BioBay apart is its hybrid model that successfully integrates government support with market dynamics. Rather than tilt heavily towards either government intervention or market liberalization, BioBay exemplifies a balanced approach. The government's strategic oversight, facilitated by SIPAC, does not stifle market-driven growth but rather nurtures it, enabling BioBay to become a pivotal player in China's biomedical sector.

> “Our collaboration with Singapore has been pivotal in the development of BioBay. By integrating the best practices from the Suzhou Industrial Park (SIP) with our aspirations in the biomedical sector, we have aimed, from the outset, to cultivate a unique ecosystem. This ecosystem not only supports the growth of individual companies but also drives the advancement of the entire biotechnology industry in China.” (Interviewee 3A, 2023)

When comparing national-level health sciences parks in China, Shenzhen Biomedicine Innovation Industrial Park (SBIIP) and BioBay in Suzhou stand out as significant players, each with a strong emphasis on market competition but embodying unique development strategies reflective of their regional contexts. SBIIP's development was initially government-driven, with state initiatives laying a strong foundation that eventually allowed the private sector to lead in innovation and commercialization. This sequential development model emphasizes a clear transition from government-led to industry-driven growth, illustrating the distinct phases of development where each sector's role is clearly defined and influential. On the other hand, BioBay's development, under the oversight of SIPAC, represents a more integrated and collaborative approach. From its inception, BioBay has been a model of synergy between government initiatives and market forces, where government and market forces work in tandem to foster a conducive environment for innovation. This balanced approach, where government intervention is carefully aligned with market dynamics, is particularly effective given the maturity and extensive experience of SIPAC in managing such complex projects. These complementary strategies highlight the diverse paths that different regions in China take towards innovation goal. As interviewee 6F stated,

> “While the SBIIP delineates a clear sequence of primarily attribution of government and industry roles at different stages of development, BioBay exemplifies an integrated model where ongoing collaboration between these sectors fosters sustained long-term growth. Despite their differing approaches, both strategies highlight the critical importance of government involvement in promoting innovation and driving regional development.” (Interviewee 6F, 2023)

The success of BioBay is also a result of the government's strategic vision, influenced by the forward-thinking policies of leaders like Deng Xiaoping, who emphasized economic reform and openness to global markets (Vogel, 2011). This vision was further refined and implemented with insights from Lee Kuan Yew (Allison, Blackwill, & Wyne 2013), who played a key role in shaping SIP to foster innovation and economic development. The strategic positioning of BioBay within the SIP reflects this broader ambition to make China a leader in biotechnology and life sciences, recognizing that innovation is crucial for sustained economic growth.

> "The integration of international advice with local strategic vision has been a defining feature of China's rapid advancement in high-tech industries, where hubs like BioBay serve as key nodes in the nation's ambitious drive towards becoming a global leader in biotechnology." (Interviewee 6B, 2023)

In a summary, the government's role in BioBay has been to blend oversight with market-driven execution, leveraging existing infrastructure and successful models from international collaborations, particularly with Singapore. This approach has created a balanced environment where government support nurtures market growth rather than stifling it. SIPAC's experience with international standards, has provided essential infrastructure, favourable policies, and financial incentives, fostering a conducive ecosystem for innovation. This hybrid model of government support integrated with market dynamics has been pivotal in distinguishing BioBay from many other health sciences parks across China.

Whilst all efforts made by government, BioBay faced significant challenges in its early stages, particularly in attracting enterprises to settle within the park. Although strategically positioned near the established ZCPV and benefiting from the strong reputation of SIP, BioBay struggled due to the absence of a pre-existing pharmaceutical and biotechnology industry cluster in Suzhou. At the time, SIP was primarily dominated by the electronic information and machinery manufacturing industries, which left BioBay without a robust local foundation in life sciences to leverage and build upon. An interviewee closely involved with BioBay's early development remarked,

> "We were trying to create something entirely new in an environment that was not yet familiar with or geared towards biotechnology. Convincing enterprises to invest in the park back in 2007 was a significant challenge, especially when there were only two buildings—a concept rather than a tangible reality. The absence of a local life sciences ecosystem made the initial phase particularly difficult, but we remained steadfast in our commitment to our vision." (Interviewee 3A, 2023)

The transformation of BioBay into the thriving biotechnology hub it is today was a gradual process marked by significant challenges. Following the opening of Phase I, the 2008 global financial crisis severely hampered funding for local innovation and startups, making it more difficult to attract enterprises to the park. However, BioBay's strategic location, just 100 kilometres from the ZCPV in Shanghai, provided a critical advantage. The proximity to ZCPV allowed BioBay to tap into the well-established pharmaceutical ecosystem of Shanghai, benefiting from the spillover of resources and expertise (ACS, 2008). Additionally, China's accession to the WTO in 2001 encouraged MNCs to establish a presence in China, with many setting up R&D centres in ZCPV. The presence of major pharmaceutical companies like GSK and Sumitomo Dainippon Pharma, which had already established manufacturing sites in the Suzhou Industrial Park (SIP) by the early 2000s, laid the foundational infrastructure that would later support BioBay's growth. Johnson & Johnson's decision to establish an R&D centre in ZCPV in 2005, followed by a manufacturing site in BioBay in 2006, further solidified this relationship. Increased investment by MNCs enhanced the Yangtze River Delta region's attractiveness for biotechnology and other health sciences enterprises. While these early sites were primarily focused on manufacturing, which limited their capacity for innovation, their presence played a crucial role in laying the groundwork for BioBay's subsequent evolution into a hub of innovation and growth. The confluence of factors of strategic location, spillover benefits from ZCPV, and the foundational infrastructure provided by early MNCs, enabled BioBay to overcome early difficulties. As interviewee 3D shared,

> "The initial years were challenging, but our strategic location and early investments by MNCs created a fertile ground for growth. The spillover effects from Zhangjiang, combined with the proactive efforts of the SIP, enabled BioBay to eventually overcome this difficult period." (Interviewee 3D, 2023)

Notwithstanding significant challenges in its early years, BioBay remained committed to its vision of becoming a premier incubation centre for innovation. In the aftermath of the financial crisis, while order volumes in many industries have declined, the biopharmaceutical sector has not only maintained steady demand but has seen an increase. This trend has further reinforced BioBay's commitment to the development of the particular industry. This steadfastness attracted startups and independent firms dedicated to cutting-edge R&D. BioBay's strategy diverged from conventional park promotion and enterprise recruitment methods by focusing on building comprehensive cooperation platforms designed to attract a diverse pool of talent. This approach has been pivotal in creating a complete industrial chain within the biotechnology sector.

Central to BioBay's success is its meticulous approach to selecting target enterprises. This process is driven by a comprehensive analysis of the industry value chain, a deep understanding of leading scientists and their research priorities, forward-looking insights into industry development trends, and a keen awareness of regulatory frameworks and market demands. BioBay systematically examines existing startups across China to assess their development stages and potential needs, enabling the identification of enterprises that are well-suited to the park's resources and environment.

An illustrative example of BioBay's proactive approach is recounted by a founder who relocated his firm from ZCPV to BioBay in 2007. Facing rising land prices and limited availability in Zhangjiang, the founder was approached by the BioBay promotion team, who offered a compelling introduction to BioBay, addressing the firm's critical needs. The team's thorough understanding of the firm's situation and their persistent outreach ultimately convinced the founder to relocate, resulting in a mutually beneficial outcome that provided significant financial support and recognition.

> "In addition to addressing my company's urgent needs, I was honoured to be recognized as a leading talent at BioBay, which came with substantial financial support. I was particularly impressed by the BioBay team's thorough preparation; they were well-acquainted with

> every enterprise in Zhangjiang, and I realized I was one of their carefully selected targets. Ultimately, this led to a win-win situation for both my company and BioBay." – by a founder in BioBay (Xinhua Daily, 2022)

The above quotation highlights the strategic and proactive efforts of BioBay's promotion team in successfully attracting enterprises to the park. When questioned about whether BioBay studies every existing company in Zhangjiang, the interviewees from BioBay responded with a smile but chose not to answer directly. However, the methods and outcomes suggest a well-informed approach, indicating that BioBay's team conducts thorough research on potential targets. This understanding reflects their broader strategy of carefully selecting enterprises that align with BioBay's industrial focus and long-term vision.

BioBay's proactive engagement with scientists and scientific associations, both domestically and internationally, has significantly enhanced its chances of success. By understanding the entrepreneurial ambitions of these scientists and aligning them with the park's industrial focus, BioBay has effectively attracted and nurtured innovative enterprises. This strategy is supported by the expertise of BioBay's promotion teams, who possess a deep understanding of the particular industry. Their industry knowledge allows them to engage meaningfully with entrepreneurs, accurately identify their needs, and provide tailored support. In turn, this interaction enriches BioBay's assets by keeping the team updated with the latest industry insights.

A testament to the effectiveness of BioBay's approach comes from a scientist who, while exploring potential locations in China for establishing a pilot plant in 2009, was immediately impressed by the professionalism of the BioBay promotion team.

> “The team not only communicated fluently in English but also presented their offerings with a high level of expertise and sophistication. The Suzhou government, along with the BioBay Administration Committee, demonstrated a broad and forward-thinking vision, fully supporting the management's efforts. The BioBay staff consistently adhered to international standards, showcasing their commitment to professionalism.” (Interviewee 3E, 2023)

This testimonial highlights the effectiveness of BioBay's strategic approach, emphasizing the park's commitment to providing an internationally competitive environment that supports innovation and growth in the biopharmaceutical sector.

BioBay's approach goes beyond merely identifying potential enterprises and entrepreneurs; it actively connects with the capital market to secure essential financial backing, establishes public R&D platforms, and guides enterprises in applying for various subsidies. One of the key aspects of BioBay's strategy is its robust financial support system, which is designed to attract top talent and innovative firms. As recounted by Interviewee 3E, BioBay provided substantial incentives to relocate and establish their company in the park.

> “BioBay provided me with a comprehensive support package for my relocation, which included housing subsidies, reduced rent, low-interest loans, and start-up funds. Shortly after our move, BioBay's venture capital fund invested approximately USD 1 million in my firm.

> This funding was crucial for us during the early stages of development." (Interviewee 3E, 2023)

This testimony highlights the effectiveness of BioBay's integrated financial incentives to both entrepreneur and enterprise, attracting a continuous influx of top-tier talent and pioneering enterprises. From its inception, BioBay recognized the importance of creating a synergistic relationship between capital investment and industrial growth. By becoming a limited partner in several venture capital funds, BioBay has effectively aligned itself with top industry players, including renowned funds like Lilly Asia Ventures (Liu, 2011). This strategic partnership has been instrumental in attracting substantial investment to the park and its resident enterprises. Rather than rushing into development, BioBay has taken a thoughtful and deliberate approach, deeply studying the biotechnology industry to ensure that its growth is sustainable and future oriented. This methodical planning has resonated with investors who share BioBay's long-term vision. Interviewee 6E expressed this alignment of values and strategy by stating,

> "It is essential to continue fostering a capital ecosystem where industry and investment mutually reinforce each other. Since its inception, BioBay has evolved alongside investment institutions, creating a synergistic relationship. We pay close attention to enterprises within BioBay because, like us, they are committed to investing in the future. Their deep industry knowledge and strategic planning inspire confidence, encouraging our continued support of BioBay enterprises." (Interviewee 6E, 2023)

This narrative highlights how BioBay's financial strategy complements its industrial development, creating a robust ecosystem where innovation is nurtured and sustained by well-aligned capital support. The integration of strategic financial planning with industrial focus has been crucial in establishing BioBay as a leader in the biotechnology sector, ensuring that both the park and its enterprises continue to thrive. By carefully selecting and supporting enterprises that align with future industry trends, BioBay has created a fertile ground for innovation and growth, which in turn attracts more investment.

BioBay's public technology platform is integral to supporting startups by offering access to advanced laboratory facilities and equipment at no cost. This model substantially reduces the financial burden on emerging enterprises, allowing them to save significantly on fixed asset investments. For startups, where cash flow is often a critical concern, this support enables companies to allocate their limited resources more effectively toward research, development, and growth. Beyond cost savings, the platform grants startups access to state-of-the-art technology that might otherwise be beyond their reach. By utilizing these shared labs, companies can conduct essential experiments and focus on innovation without the financial strain of purchasing expensive equipment. This support is particularly crucial during the early stages when efficient resource allocation can determine a company's success. Interviewee 3F highlighted this benefit,

> "For start-ups like ours, BioBay's public technology platform is incredibly valuable. It offers advanced labs and facilities at no cost, allowing us to save significantly on fixed asset investments. We only pay for materials and ingredients when conducting experiments, which

> is crucial for preserving cash in the early stages. We truly appreciate this model." (Interviewee 3F, 2023)

By offering such a supportive infrastructure, BioBay helps level the playing field, allowing new companies to focus on what truly matters—developing cutting-edge biotechnological solutions. It is just one example of how BioBay fosters an environment where innovation can thrive. This support doesn't stop at the initial stages. As these startups grow, BioBay continues to provide consistent and tailored services, ensuring that even the smallest enterprises receive the resources they need to scale. The success of this approach is evident in the number of innovative firms that have emerged from BioBay, many of which have gone on to become industry leaders in medical R&D. These companies, once fledgling startups, have grown into listed companies that now lead the biotechnology and biopharmaceutical industry in China. This growth is further reflected in the trend of existing companies and newcomers expanding their manufacturing capacities within BioBay, a clear indication of the thriving business environment and the continued growth of its inhabitants.

"No matter how small the enterprise is, we provide consistent services" (Interviewee 3C, 2023). This philosophy of unwavering support has not only helped nurture early-stage companies but also contributed to the broader growth and success of BioBay as a leading biotechnology hub.

In a summary, BioBay strategically attracts and nurtures innovative enterprises by engaging proactively with scientists, startups, and multinational corporations. This approach is supported by thorough industry analysis, targeted recruitment, and strong financial incentives, including venture capital investments and public R&D platforms. BioBay's business strategy fosters a comprehensive industrial chain within biotechnology, providing consistent support to enterprises of all sizes. Through these comprehensive measures, BioBay has successfully attracted a group of potential start-ups, injecting continuous vitality into the prosperity of the park and the development of the biotechnology and biopharmaceutical industry. The nurturing environment has enabled many startups to grow into industry leaders, contributing significantly to BioBay's overall success and growth.

While BioBay has excelled in fostering business and industrial growth, the integration of academia remains a critical component of its long-term success. Innovation is not able to exist alone without the support from well-known universities or first-class laboratories – this a proven global experience in biotechnology industry. However, when BioBay began construction in 2006, Suzhou's academic landscape was relatively underdeveloped. Suzhou University was the only academic institution in the city at the time. Despite the city's economic strength, the limited number and quality of universities were seen as a significant shortcoming, or "shortboard", in Suzhou's development strategy. Recognizing this gap, the local government has actively sought to bolster the city's academic infrastructure, understanding that a strong academic presence is essential for cultivating the talent and research needed to sustain BioBay's growth. This effort to strengthen academia in Suzhou is not just about increasing the number of universities, but also about enhancing the quality of education and research to match the city's economic ambitions.

A pivotal moment occurred with the visit of Nobel laureate James Watson in 2006 (Nobel Prize,1962). Watson, who, along with Francis Crick, famously unveiled the double helix structure of DNA, thereby opening the door to molecular genetics (Watson & Crick, 1953), made a significant impact on the development of Suzhou's biotechnology industry during this visit (Chi, 2010). Although Suzhou was not originally included in Watson's travel plans, concerted efforts by local officials ensured that he visited the city, which proved to be a turning point for the region's biotechnology ambitions. During his presentation at Jinji Lake Hotel, Watson shared his extensive academic experience and the evolution of biological sciences, particularly highlighting the rise of the biotechnology industry in the United States since the 1980s. He also discussed the rich history and culture of Cold Spring Harbor Laboratory, a leading institution in biomedical research and education, which has been home to eight Nobel Prize winners, including Watson himself. The insights and inspiration from Watson's speech left a lasting impression on the leaders of SIP, catalysing further action to bolster the park's biotechnology industry (Chi, 2010). Subsequent to Watson's visit, a delegation from SIP travelled to the United States to visit Cold Spring Harbor Laboratory. This visit led to the landmark decision in October 2006 to establish the only Asian branch of Cold Spring Harbor Laboratory in Suzhou (Jiang, 2010), beating out other major cities such as Tokyo, Seoul, and Singapore (Zhou, 2022). This decision was instrumental in solidifying the biotechnology industry as a key pillar of the park's economic strategy. Consequently, the name BioBay was formally adopted in December 2006, replacing the initial name, Suzhou Bio-Nanotechnology Park, and marking a significant new phase in the park's development.

> "James Watson's presentation in Suzhou in 2006 was instrumental in positioning the Park as what is now known as BioBay. His endorsement, combined with the decision by Cold Spring Harbor Laboratory to set up its Asia branch in Suzhou, provided a powerful validation of BioBay's potential. This strategic alignment not only enhanced the park's credibility but also served as a critical factor in attracting enterprises. Watson's trust and support have become a cornerstone of BioBay's development, helping to shape its trajectory as a hub in the biotechnology sector." (Interviewee 3C, 2023)

In the same year, the collaboration agreement with Cold Spring Harbour Laboratory was signed and James Watson was appointed as the Chief Scientific Consult of BioBay. The launch of Cold Spring Harbour Laboratory Asian Conference Centre in 2010 significantly broadened Suzhou’s perspective on the global biotechnology industry. This collaboration has created vital linkages between BioBay and the world’s leading scientists, offering a platform where academia and industry can exchange knowledge, share industry insights, and expand professional networks. Since the inaugural conference, Suzhou has attracted a substantial influx of visitors from around the globe, enhancing its reputation as a hub for biotechnology.

Recognizing the critical role of academia within the Triple Helix model, Suzhou has strategically leveraged the influence of Cold Spring Harbor Laboratory to address its previous academic shortfalls by establishing and expanding universities and research institutes. A significant milestone in this effort was the establishment of the Suzhou Campus of Renmin University of China in 2007, which marked the beginning of a concerted push to enhance the city's academic capabilities. This initiative gained momentum with the creation of the Yangtze River Delta Research Institute and the Taicang Campus of Northwestern Polytechnical University in 2018, significantly strengthening Suzhou’s position as a hub for higher education and research. The city's academic landscape was further enriched in 2019 when Nanjing University decided to open a new campus in Suzhou, adding to the city's growing reputation for academic excellence. This commitment to developing a vibrant academic environment continued with the collaboration between Suzhou and Southeast University in 2021, leading to the establishment of the Suzhou Campus of Southeast University. These initiatives collectively underscore Suzhou's dedication to fostering a robust academic infrastructure that complements its industrial ecosystem.

Moreover, Suzhou's engagement with globally renowned universities, such as the University of Oxford, the University of California, Los Angeles, the National University of Singapore, Monash University, and the University of Liverpool, highlights its dedication to fostering international academic partnerships. These collaborations not only enhance Suzhou's academic reputation but also attract top-tier talent from around the world.

Meanwhile BioBay actively collaborates with international organizations to draw global experts and professionals to Suzhou, often start on a project basis, with the aim of encouraging them to relocate more permanently. However, retaining these talents as long-term entrepreneurs and residents within the park requires considerable effort. This challenge underscores the importance of not only attracting top-tier talent but also creating an environment in which they can thrive and feel integrated into the community.

By May of 2023, Suzhou has established partnerships with over 200 domestic and international universities and research institutes. This has resulted in the creation of more than 160 innovation platforms that effectively integrate industry, academia, and research. The success of these initiatives is evident in the implementation of over 20,000 cooperative projects, showcasing Suzhou's robust ecosystem for innovation and research development. (Suzhou Announcements, 2023)

Suzhou's proactive strategy of collaborating with renowned universities and institutions has effectively addressed the city's initial academic shortcomings by sharing resources and expertise. This approach has been instrumental in cultivating a robust talent pool, which in turn fuels the city's sustainable development. This strategy mirrors that of Shenzhen, another city that has prioritized academic and technological advancement. Both cities, once lacking in strong academic infrastructures, have progressively built ecosystems that support their ambitions in the biosciences, reflecting a shared commitment to integrating academic excellence with industrial growth. Frequently compared to Shenzhen in terms of academic development, Suzhou has made significant strides in integrating both domestic and international academic resources to strengthen its position in health sciences. A key achievement in this regard is the establishment of the Cold Spring Harbor Laboratory Asian Branch and the Cold Spring Harbor Laboratory Asian Conference Centre in Suzhou. These institutions have significantly elevated Suzhou's academic standing, particularly in the biotechnology sector, setting a high standard that Shenzhen now aspires to emulate.

The recruitment of Professor Nieng Yan from Princeton University in 2022 to lead the Shenzhen Medical Academy of Research and the Shenzhen Bay Laboratory underscores Shenzhen's determined efforts to elevate its academic resources. However, this strategic move comes 16 years after Suzhou set a similar precedent in its commitment to bolstering academic excellence to support its ambitions in health science industry. Suzhou's early recognition of the critical role that top-tier academic talent plays in driving innovation and economic growth highlights its forward-thinking approach. This proactive strategy laid the foundation for what has become a deeply integrated ecosystem of academia, industry, and government in Suzhou, setting a standard that other cities are now following to enhance their own competitive edge in the global knowledge economy.

Recognizing the importance of academia in its long-term success, BioBay and the Suzhou government have worked diligently to address the city's initial academic shortcomings. However, as BioBay continued to evolve, it became clear that another significant obstacle in biotechnology development was the lack of clinical resources. Without robust clinical research facilities and effective partnerships with hospitals, biotech enterprises faced considerable challenges in advancing their medicine development efforts. To overcome this hurdle, BioBay took decisive action in 2021 by partnering with pharmaceutical research institutions in Shanghai and the Suzhou Institute of Materia Medica to establish the Suzhou Clinical Research Service Platform. This platform was a strategic initiative aimed at bridging the gap between BioBay enterprises and public hospitals. Through the creation of a comprehensive database, the platform precisely matches the specific needs of BioBay enterprises with appropriate hospitals, fostering multi-level, in-depth cooperation. This initiative not only provides biotech companies with essential clinical resources but also actively promotes the collaboration necessary for the successful development and testing of new pharmaceuticals. Reflecting on the impact of this initiative, Interviewee 3G remarked,

> “The creation of the Suzhou Clinical Research Service Platform has been a game-changer for us. It’s connected us, biotech firms with public hospitals in ways that simply weren’t possible before. This collaboration has been key in moving our clinical trials forward and accelerating the development of new therapies." (Interviewee 3G, 2023)

Building on its commitment to integrating academia, industry, and government, a hallmark of the Triple Helix model, BioBay has not only overcome its initial academic limitations and the lack of biotechnology agglomeration but has also cultivated a thriving innovation ecosystem. This ecosystem, strengthened by strategic partnerships and initiatives, has attracted top-tier knowledge and expertise from across China and the globe. As a result, BioBay has become a dynamic environment where innovation flourishes, and entrepreneurs can easily network, exchange ideas, and launch new ventures. For many entrepreneurs, the presence of such a robust ecosystem was a decisive factor in choosing BioBay as the location for their new enterprises. During interviews, several entrepreneurs with experience in the Bay Area or Boston in the United States expressed that Suzhou evoked a similar atmosphere, reminiscent of Boston's vibrant biotech scene and the innovative spirit of a bay area. These sentiments affirm the success of Suzhou's ecological environment and innovation ecosystem. Interviewee 3H stated,

> “Suzhou has successfully created an ecosystem through the introduction of the Cold Spring Harbor Asian Conference Centre. The speakers invited by Cold Spring Harbor to BioBay are among the world's top scientists, bringing the latest innovative technologies. With this ecosystem, we meet people and inspire new innovations. This is something that other cities in China don’t have. That’s why I chose BioBay to establish my firm " (Interviewee 3H, 2023)

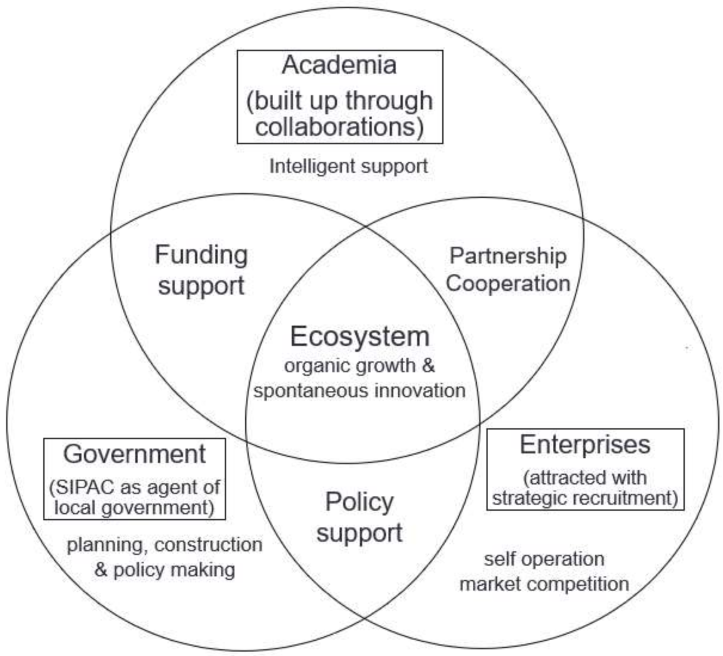
For many returnees, the decision to establish a venture in China is influenced by more than just the business environment. Personal factors such as housing, education, and overall lifestyle play a significant role in their choices. In this context, a "returnee" refers to a Chinese professional who has spent considerable time studying or working abroad, typically in Western countries like the United States, and has returned to China to pursue new opportunities. These returnees often bring valuable international experience and expertise, contributing significantly to China's burgeoning innovation and entrepreneurial sectors. Suzhou, with its close proximity to Shanghai, offers a unique blend of modern conveniences and historical charm, all at a lower cost of living compared to major cities like Beijing or Shanghai. This balance allows families to enjoy a higher quality of life without sacrificing professional opportunities. BioBay has further enhanced this appeal by providing comprehensive support to entrepreneurs, helping them navigate the various challenges associated with relocating and settling in a new environment. This sentiment is echoed by Interviewee 3I, who shared their experience:

> "As a returnee accustomed to the Bay Area lifestyle, I prioritized both the entrepreneurial environment and quality of life when deciding to return to China. Suzhou was the ideal choice—close to Shanghai, blending old and modern elements, and offering a better quality of life without the high costs of Beijing or Shanghai. The BioBay staff were exceptionally helpful, ensuring a smooth and pleasant relocation" (Interviewee 3I, 2023).

Through thoughtful analysis, it can be concluded that BioBay's development is a compelling example of the Triple Helix model in action, where the integration of government, industry, and academia has gradually evolved into a cohesive and synergistic system. Initially, BioBay faced significant challenges, including deficiencies in both academic infrastructure and business resources—two critical elements of the Triple Helix model. Despite these limitations, BioBay successfully overcame these obstacles by leveraging strong government support, its strategic location near Shanghai, and the infusion of international expertise and best practices. The strategic integration of academic advancements, particularly through partnerships with prestigious institutions like Cold Spring Harbor Laboratory, has significantly strengthened BioBay's innovation ecosystem. This ecosystem has not only become a hub for cutting-edge R&D but has also emerged as a highly attractive destination for global talent and returnees. BioBay's development illustrates how, despite inherent challenges, a balanced and collaborative approach can drive growth and innovation in a knowledge-based economy.

After years of dedicated development, BioBay's implementation of the Triple Helix model bears a strong resemblance to those in Western contexts, as shown in Figure 29, demonstrating its success in creating a synergistic environment where innovation thrives.

Figure 29: Application of the Triple Helix Model in BioBay's success



Source: author's interpretation based on Triple Helix

6.3.4 Securing a legacy beyond emulation

As BioBay continues to solidify its reputation as one of leading health sciences parks in China, the challenge now shifts from achieving success to maintaining and securing a lasting legacy. While the park's accomplishments have set a benchmark for other cities, sparking interest and imitation from regions like Shenzhen, Chengdu, Xi'an, and Qingdao, the true test lies in how BioBay can sustain its leadership in an increasingly competitive landscape. The saying, "imitation is the sincerest form of flattery," highlights the recognition BioBay has garnered, but it also underscores the need for continuous innovation to stay ahead of its followers. As others look to replicate its model, BioBay must not only refine its strategies but also focus on preserving the core values and unique strengths that distinguish it from its competitors. The path forward requires a commitment to adaptation and evolution, ensuring that BioBay remains a step ahead, securing a legacy that goes beyond mere emulation.

In recent years, the investment landscape in China's health sciences industry has undergone a significant transformation. While investment funds once predominantly flowed from the United States, there is now a growing reliance on Chinese state-owned capital and local industry guidance funds, which have increasingly become the primary drivers in the market. This shift was due to less attraction of the industry resulted from combined reasons. It has made securing external financing more challenging, particularly for companies facing financial constraints. For many firms, state-owned capital is now one of the few available sources of funding. However, this financing often comes with substantial conditions.

One of the most common stipulations imposed by state-owned investors is the requirement for companies to relocate their operations, all or partially to the investor's locality. For businesses that have been rooted in a specific region for years, such a move can be a difficult decision. It may involve leaving behind established networks, resources, and communities that have been integral to their growth. The choice between remaining in a familiar environment without the necessary financial backing and relocating to secure funding is complex and often painful for entrepreneurs.

> "We've been in BioBay for years, but recent slower growth has made us difficult to secure investment from BioBay. Now only fund back up by state-owned investors are interested with string of relocating to their locality. "(Interviewee 3J)

This narrative highlights the increasing pressure on BioBay to adapt to these evolving conditions in the investment landscape. While BioBay's investment fund has traditionally been a key advantage, widely adopted among science parks, the increasing emphasis on cash flow has altered the dynamics. As enterprises, particularly those facing financial constraints, prioritize immediate financial support, BioBay's mature ecosystem may no longer serve as its sole competitive edge. This change has intensified competition among science parks. The importance of financial backing and investment opportunities has become paramount as parks strive to attract and retain businesses in this evolving environment. BioBay must now navigate these challenges while continuing to offer an environment that supports innovation and growth, ensuring that it remains a competitive and attractive destination for biotechnology companies despite the changing dynamics of capital investment.

As the biotechnology and biomedical sectors in China increasingly turn their attention to global markets, the challenges and opportunities of expanding internationally are becoming more pronounced. Centralized procurement and national negotiations policies in China have significantly compressed the value of innovative medicines, prompting companies to seek out developed overseas markets to maintain their corporate interests and valuations. Among the various methods for international expansion, "licensing out" overseas rights has become a prevalent approach. This involves companies authorizing all or part of the rights for the development, clinical advancement, and commercialization of their products in foreign markets to international companies, in exchange for economic benefits.

In these global collaboration arrangements, the focus naturally shifts to product innovation, the effectiveness of trial methods and design, and the credibility of data, key factors for both negotiating parties. For companies aiming to expand abroad, a deep understanding of the destination country's laws, regulations, data requirements, and business customs is crucial. A science park like BioBay that can successfully foster a platform to connect and support companies in their international ventures significantly enhances its market position. By helping companies build credibility and achieve success in global markets, BioBay can establish a sustainable model of excellence.

BioBay is particularly well-positioned to leverage its existing connections and infrastructure to assist companies in navigating the complexities of overseas expansion. This support not only benefits the companies but also elevates BioBay's reputation as a mature and internationally recognized hub for biotechnology. By effectively guiding companies through the challenges of global markets, BioBay can secure a lasting legacy in the global biotechnology landscape, solidifying its place as a leader in the industry. This approach not only strengthens BioBay’s market position but also contributes to its enduring impact on the global biotech sector.

In summary, transitioning from initial success to securing a lasting legacy presents several key challenges for BioBay. To navigate an evolving financial landscape, BioBay must remain agile and innovative, particularly as economic conditions fluctuate and funding environments change. Maintaining a culture of innovation is crucial as global competition intensifies and other regions seek to replicate BioBay's achievements. This challenge is amplified by the need to continuously develop and sustain a robust ecosystem that not only supports but also drives the ongoing growth of the biotechnology and pharmaceutical industry.

Securing a lasting legacy involves cultivating unique strengths that set BioBay apart from other innovation hubs. This means fostering an environment that consistently attracts top-tier talent and enterprises while producing groundbreaking innovations that impact the global biotech and pharmaceutical sectors. Additionally, BioBay must ensure that its growth is sustainable, balancing rapid expansion with the need to preserve the quality and depth of its ecosystem. These efforts are essential for BioBay to solidify its position as a leader in the global biopharmaceutical industry, ensuring its influence endures well beyond its current successes.

6.3.5 Conclusion

The case study of BioBay offers a compelling example of how a well-coordinated and strategic approach can overcome inherent challenges and drive sustained industrial success in the biotechnology sector. It provides valuable insights into the crucial roles of strategic planning, government support, and market-driven execution in fostering innovation, particularly when coupled with academic collaboration. BioBay's transformation from a nascent park to a leading hub in China's biomedical landscape underscores the power of integrated planning, strategic partnerships, and a robust ecosystem. This ecosystem harmonizes government oversight, market dynamics, and academic interaction, demonstrating the importance of creating a balanced environment where government involvement nurtures, rather than stifles, market growth.

From its inception, BioBay faced significant hurdles, including a lack of local academic infrastructure and the absence of a pre-existing biotechnology industry in Suzhou. However, these challenges were met with a visionary approach that leveraged the strengths of the SIP model, adapting it to the specific needs of the biotechnology and life sciences sector. The Suzhou government and SIPAC played pivotal roles in this process, demonstrating a deep commitment to nurturing emerging industries through proactive governance and strategic infrastructure development.

One of the critical success factors for BioBay was its ability to attract and retain top-tier talent and enterprises by offering a comprehensive support system. This included financial incentives, access to state-of-the-art research facilities, and a conducive living environment. BioBay's emphasis on ecosystem building, particularly its focus on differentiation and the nurturing of original research, allowed it to carve out a unique niche in the competitive biotechnology landscape.

The integration of the Triple Helix model—government, industry, and academia—was central to BioBay's success. The park's strategic collaborations with renowned institutions like Cold Spring Harbor Laboratory and its proactive engagement with international academic and industry partners created a fertile ground for innovation. This model not only addressed the initial academic and industrial gaps but also positioned BioBay as a hub of cutting-edge R&D, attracting global attention and investment.

BioBay's phased development strategy, grounded in a deep understanding of industry trends and market demands, further reinforced its success. By adopting a flexible yet strategic approach, BioBay was able to adapt to shifting economic conditions and continue its growth trajectory even in the face of external challenges, such as the 2008 financial crisis. This adaptability, combined with a clear vision and strong leadership, ensured that BioBay remained a step ahead of its competitors, both domestically and internationally.

As BioBay looks to the future, the challenge will be to maintain its leadership position in an increasingly competitive and rapidly evolving global landscape. The shift in the investment environment, with a growing reliance on state-owned capital, underscores the need for BioBay to continue innovating and refining its strategies. By expanding its focus to support companies in their international ventures and leveraging its existing infrastructure to foster global partnerships, BioBay can secure a lasting legacy in the global biotechnology arena.

In conclusion, the story of BioBay is one of resilience, strategic foresight, and the successful integration of diverse elements into a cohesive and thriving industrial ecosystem. It exemplifies how a well-coordinated approach, rooted in a deep understanding of local and global dynamics, can overcome initial challenges and drive sustained success. As BioBay continues to evolve, its legacy will not only be measured by its past achievements but also by its ability to remain a leader in innovation, setting new benchmarks for the global biotechnology industry.

6.4 Xi’an: A Health Sciences Park in Incubation

6.4.1 Introduction

The Xi'an High-tech Zone Biomedical R&D Cluster Base (XBCB), known in Chinese as 西安高新生物医药产业研发聚集基地, is strategically located in Xi'an, the capital of Shaanxi Province. Recognized as a critical centre for scientific research, education, and industry in western China, Xi'an has actively pursued the development of strategic emerging industries. Since 2016, under a government-led initiative, the city has focused on fostering industrial agglomeration and the creation of industrial clusters valued at hundreds of billions of yuan in sectors such as semiconductors, intelligent terminals, biomedicine, aerospace, and energy-efficient and new energy vehicles (Xi’an Government, 2016). Since 2021, the focus has intensified with biomedicine identified as one of the six pillar industries underpinning the regional development strategies of Xi'an and Shaanxi Province. The establishment of XBCB is a direct result of these strategic efforts (Xi’an Government, 2021). Located in a region renowned for its capabilities in intelligent manufacturing and technological innovation, XBCB was designed to act as a catalyst for innovation, collaboration, and economic growth within the health sciences sector. This initiative aligns with the broader goals of enhancing regional competitiveness and integrating into the global innovation network.

XBCB stands as a nascent health sciences park, poising at a critical juncture. Expected to be a significant endeavour in China's strategic vision for healthcare innovation, XBCB was envisaged as a catalyst for innovation, collaboration, and economic expansion within the health science sector in Xi 'an. Situated in a region rich in history and technology, it has the potential to harness local educational and manufacturing strengths to evolve into a hub suitable for the biomedical industry. The park embodies a fusion of ambitious vision and untapped opportunities, particularly in the realm of large pharmaceutical enterprises. From the perspective of the development foundation and planning of the biopharmaceutical industry in Xi 'an, a whole industrial chain map of the biopharmaceutical industry covering upstream R&D, midstream production and circulation, and downstream application has been initially formed, which is based on chemical medicine, traditional Chinese medicine, biological medicine, and medical device industries. The development pattern of the biomedicine industry with XBCB as the main carrier has the conditions for the development of the biomedicine industry with complete industrial categories, rich botanical medicine resources, profound talents and leading biotechnology.

However, XBCB's journey from a promising innovation hub to what is now referred to as a "static park" offers an insightful case study to understand the Triple Helix model in China. The role of the government and universities in the expansion of XBCB is a topic worthy of discussion. A number of renowned universities in Xi'an have amassed formidable scientific research capabilities and have provided ample support for the development of the pharmaceutical industry. Despite this, The practice in Xi 'an shows the diversity and complexity of regional governments' policy support for the pharmaceutical industry in different regions of China. The underlying attitude of local governments prevents XBCB from completing the transformation from a small enterprise group to the large-scale high-quality enterprise aggregation of managing and sustaining specialised industrial clusters. This section explores the origin and evolution of XBCB, analyses the three key factors influencing the park's dynamics based on the theory of Triple Helix, and attempts to reveal the variable of Triple Helix through a discussion of local government's role and intent in this case.

6.4.2 Understanding the planning of Xi'an High tech Zone Biomedical R&D Cluster Base

XBCB's plan represents the local government's determination to develop the pharmaceutical industry. The base was planned as a part of the larger Caotang Science and Technology Industrial Base, a large-scale comprehensive industrial park containing electronic information, biopharmaceutical, advanced manufacturing industry, that was planned with the goal of building a world-class industrial park. The planning of XBCB is mainly divided into two phases and four sections. The first phase comprises section A and B. Section A is located in the north of the base, covering an area of about 0.33 square kilometres, and mainly used for the construction of pharmaceutical manufacturing and R&D enterprises. Section B is located in the south of the site and covers an area of about 0.27 square kilometres and mainly used for the construction of biomedical R&D and innovation institutions. There are obvious differences between the two sections A and B in terms of infrastructure construction, but both are to promote the development and innovation capacity of the biomedical industry.

With the progress of the construction of the base, the second phase of the project has been started since 2023. The second phase of the base is divided into sections C and D. located in the east of the site covering an area of about 0.4 square kilometres, Section C is mainly used for the construction of integrated service platform for R&D, production and sales of pharmaceutical enterprises. Section D is located in the west of the site, covering an area of about 0.47 square kilometres, and used for the construction of high-tech business incubators and science and technology parks. The construction of the two sections C and D aims to provide more complete industrial chain and innovative services, and further strengthen the function and influence of the base.

It is worth mentioning that the division of the base is not limited to the above four sections, but also involves the division of supporting facilities and functional areas. For example, the base has different functional areas such as office area, R&D area, and industrialization area to meet the needs of different enterprises. In addition, the base is also equipped with living facilities, health care facilities and transportation facilities to provide convenience for personnel working and living in the base. Through reasonable division, the base has promoted the development of the biomedical industry, attracted more pharmaceutical enterprises and innovative institutions to settle in, and enhanced the industrial agglomeration effect and scientific and technological innovation capability of the base.

In general, the division of XBCB is carried out according to different use needs and planning layout. Through reasonable division, the base can promote the development of the biomedical industry, attract more pharmaceutical enterprises and innovation institutions to settle in, and enhance the industrial agglomeration effect and scientific and technological innovation ability of the base. At the same time, the base also emphasizes the construction of supporting facilities and functional areas to provide convenient working and living conditions for personnel in the base. It is believed that in the future development, XBCB will become an important centre of the bio-pharmaceutical industry in Northwest China and even the whole country.

The first phase XBCB, as an integrated base, with a floor space of approximately 0.134 square kilometres and a constructed area of around 0.176 square kilometres completed in the end of 2019, has been meticulously planned as a multi-functional hub. It integrates research, development, production, and sales functions through its infrastructure, comprising 27 standard factory buildings and auxiliary service facilities, highlighting the strategic intent to establish a comprehensive and integrated biomedical R&D cluster.

Ms. 4A, an official of XBCB shared,

> "The XBCB represents a critical juncture in our region's economic and scientific advancement. It is designed not just an industrial park but a strategic initiative that aligns with national priorities in healthcare innovation. Here, we're not just building infrastructure but also cultivating an ecosystem that synergizes research, industry, and entrepreneurial spirit." (Interviewee 4A, 2023)

Central to the planning process was the integration of Xi'an’s historical strengths in education and technology with new investments in biomedical research and infrastructure. Planners envisioned a park that not only facilitated R&D but also encouraged commercialisation and industry-academia collaboration. "Our goal was to create an ecosystem where innovation in biomedicine could thrive, supported by robust academia-industry linkages," noted a key architect of the project.

The strategic blueprint for XBCB was marked by several ambitious targets. These included the attraction of top-tier biomedical companies, the establishment of state-of-the-art research facilities, and the creation of an environment conducive to startups and spin-offs from university research. A government official highlighted the scope of these ambitions: "We aimed to develop a world-class infrastructure that could support a wide range of activities, from basic research to high-tech manufacturing in the biomedical field."

Figure 30: XBCB Landscape

Source: from a brochure of XBCB.

6.4.3 Understanding XBCB using the Triple Helix model

XBCB's evolution, when viewed through the lens of the Triple Helix theory – which emphasises the collaborative interplay between government, academia, and industry – reveals potential imbalances. The theory provides a framework for understanding the critical interactions and alignments necessary among these three sectors for fostering a vibrant, innovative ecosystem. In XBCB's case, this theory helps highlight areas of disconnect, whether in policy implementation, academia-industry collaboration, or the strategic alignment of government initiatives with the park's operational realities. This case study not only highlights the challenges in fostering sustainable innovation ecosystems within specialised industrial clusters but also underscores the importance of adaptive, collaborative approaches in cluster management. XBCB's experience offers valuable lessons on the necessity of a coordinated, responsive interplay among the key institutional sectors. Effective collaboration, strategic alignment, and adaptive management are pivotal in driving the success of high-tech industrial parks.

Xi 'an government continues to introduce policy measures to accelerate the development of biomedical industry. The government has issued a number of policies and measures for industrial development, such as the Action Plan for the Development of Xi 'an Biomedical Industry Cluster, to encourage domestic cutting-edge medical enterprises to build factories in Xi 'an. The Xi 'an Innovation Funding with a scale of 10 billion CNY has also been established to attract more social capital and financial institutions to invest in the medical industry, through market-oriented operation, and accelerate the development of the biomedical industry. Although the development of the biomedical industry has begun to take shape and has certain advantages, there is still a big gap between the biomedical industry in Shaanxi and the same industry in the country. According to the data of the China High-tech Industry Statistical Yearbook (2019), the scale of Shaanxi's pharmaceutical manufacturing industry only accounts for 2.71% of the same industry in the country, which is less than 1/5 of Jiangsu Province, which has a developed pharmaceutical economy.

Since 2013, the Xi'an High-Tech Zone has been methodically enhancing its capabilities to support biomedical industry. The Development Center of the Xi'an High-Tech Zone Venture Park, in partnership with the Xi'an High-Tech Zone Biomedical Park, has been instrumental in advancing XBCB. This initiative is strategically designed to bolster the regional biomedical R&D sector, emphasising the cultivation of engineering technology centres with R&D prowess, and the establishment of shared laboratories for foundational research applications. The project's objective is to integrate industrial resources to create a functional, pragmatic, and professional biomedical service ecosystem. It is particularly focused on nurturing an environment conducive to innovation and entrepreneurship, with an emphasis on the advancement of novel pharmaceuticals, medical devices, high-value plant extractions, and the wider biomedical industry. The Caotang Science and Technology Industrial Park, a key component of the Xi'an High-Tech Zone, has witnessed notable industrial advancements, marked by the swift completion of several pivotal projects. This indicates a phase of dynamic construction and concurrent development across various sectors.

> "The dynamics of Xi'an's biomedical industry are shaped by key players like Xi'an Janssen and a network of its suppliers and support units crucial for the park's operation. Notably, there is a resilient base of the medical device sector anchored by Northwestern Polytechnical

> University, benefits from Xi'an's solid manufacturing background." (Interviewee 4B, 2023)

Xi 'an's university cluster is the main thrust of the investment boom in XBCB. From 2016 to 2020, the new pharmaceutical product number in the province only accounted for 0.88% of the national total, far lower than the national average. Provincial leaders and department-level leaders serve as the "chain leader", forming a "chain one special class" and "chain one line" system, promoting the development of key industrial chains such as biomedicine, and enhancing the market competitiveness of key industries such as biomedicine in our province. From 2019 to 2022, the number of patents in China has ranked first in the world for three years, but compared with developed countries in Europe and the United States, which have a research conversion rate of about 40%, China's research conversion rate is less than 10%, and the realisation of industrialisation is less than 5%. Xi 'an is very strong in scientific research with Xi 'an Jiaotong University, Northwestern Polytechnical University, Xidian University, Northwest University, Xi 'an Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences (Xi 'an Institute of Optics and Mechanics). For some investors, entrepreneurial projects led by well-known scholars have their own attraction, scientific research results and sufficient funding endorsement, which can save a lot of learning costs and screening costs. At the same time, the scientific research projects here are mostly at the forefront of basic research, and if these results can be translated, the upper limit that can be reached later is often higher than the projects that are conceived in the market. Here the main introduction of Xi'an Jiaotong University, Northwest University, and the Chinese Academy of Sciences Xi'an Institute of Optics and Fine Mechanics specific situation.

Xi 'an Jiaotong University is one of the most famous universities in Shaanxi Province and even the whole northwest China. Since 2021, Xi 'an Jiaotong University has established more than 150 scientific and technological enterprises in Xi'an, many of which are high-tech projects in frontier fields such as brain computer, chemiluminescence, laser, and new molecules. They have established a full-time science and technology broker team of 57 people, while helping the market to connect the scientific and technological resources of universities, aiming at the scientific and technological achievements that are intended to be transformed and have market prospects, helping researchers to connect with relevant enterprises and sales channels to promote transformation; On the one hand, we can understand the demand of the market and the dynamics of industrial development, so that the results can be accurately connected with the demand. Under a number of measures, Xi 'an Jiaotong University has gradually formed a system built around industrial chain research, investment promotion and promoting the transformation of scientific and technological achievements. The boundary between innovation and industry has been broken, and more than 100 results have benefited.

Different from Xi 'an Jiaotong University, Northwest University focuses on "adapting to local conditions" in the transformation of scientific research. In 2019, the school started the exploration of customised transformation plans, and created a series of new models of "achievement transformation +". In order to attract enterprises to invest small and early, the school adopted the result transformation model of "license + phased incubation + transfer". For example, in the project of "anti-pollution filtration membrane and oily sewage separation and purification", the research team established a new company in cooperation with enterprises, and the school implemented the transformation with a license of 12 million yuan.

The conversion funds will be invested by the enterprise in stages, and the team will use most of the funds for further pilot test and industrialisation expansion. The school will transfer the results to the enterprise for free at a certain stage, and disperse the risks of the enterprise. For projects focusing on R&D such as "early breast cancer diagnostic reagents", Northwestern University completed the conversion of 9.3 million yuan in the form of "empowerment + cash". After the result team pays the cost compensation to the school in accordance with the proposed conversion amount, the school grants the ownership to the team and makes the conversion by itself, with the purpose of overcoming the company's operating risks arising from the high R&D investment in the early stage. Judging from today's results, Northwestern's performance is equally remarkable. The founder of Juzi Biology is the dean of the Biomedical Research Institute of Northwestern University, and the company's main "recombinant collagen" is transformed from its scientific research results 20 years ago, and is now the leader on the collagen track.

Another typical case comes from Xi 'an Institute of Optics and Machinery, the pioneer of the "Xiguang Model". As the fastest institution of scientific research transformation in Xi 'an, Xi 'an Institute of Optics and Machinery has completed the incubation of more than 400 enterprises in XBCB, forming three cutting-edge technology industrial clusters of photon manufacturing, photon information and biophoton. In the view of Xi 'an Optical Machinery Institute, the traditional results transformation model is often to have results first, and then find applications. The natural mission of research institutes is to attach more importance to research and ignore transformation. This also makes there is a disconnect and separation between scientific research and industry, and even the emergence of major funded scientific research projects, and the phenomenon of falling into the industry is only a small market scene. In order to solve this problem, Xi 'an Light Machinery Institute put forward the concept of "demolishing the wall and opening the office". On the one hand, the achievements are encouraged to "go out", and on the other hand, more talented people are encouraged to "come in". "Going out" is not only the opening of high-quality scientific and technological resources such as scientific research results, instruments and equipment, and experimental environments, but also the full release of scientific research results, encouraging scientific research results to "go out", and effectively combining the technical achievements that may be consigned to the shelf in the original "wall" with the market. The "coming in" is to introduce excellent resources outside the wall, move enterprises into the institute, and rely on the platform of Xi 'an Optical Machinery Institute to play its strengths. In addition, "de-administration" also plays an important role in the process from results to enterprises. Xi 'an Institute of Optics and Machinery has always adhered to the incubation concept of "institute participation, not holding, incubating enterprises but not running enterprises", and has released the maximum vitality by encouraging enterprises to develop mixed ownership.

In general, universities and the scientific research transformation system established by universities effectively eliminate the information asymmetry between in XBCB enterprises and investors by standardising the process of scientific research transformation. The accumulation of scientific research results of universities themselves endorses cutting-edge scientific and technological projects, so that they can be sold at high quality prices. It's a win-win-win deal. While universities and investors complete value creation, local governments also benefit from the pooling of resources.

XBCB has made great efforts to develop enterprises of the bio-pharmaceutical industry. In recent years, the bio-pharmaceutical industry in the park has made a series of achievements in talent reserve, platform construction, industrial agglomeration, innovation environment and other aspects, which has the conditions for industrial development. Xi 'an has geographical advantages in the development of biomedicine industry. Xi 'an is close to Qinling Mountain, known as the "natural plant gene bank", which contains 3000 kinds of high-quality Chinese medicine resources, and Shangluo, the base of Chinese medicinal materials. Xi 'an is rich in medical resources, the Fourth Military Medical University, the School of Medicine of Jiaotong University and other institutions provide 1,200 medical graduates every year, and the Fourth Medical University alone has seven national research laboratories engaged in medical and pharmaceutical research. Xi 'an High-tech Zone has a good support service system and industrial foundation for the development of biomedical industry. With a state-level biomedical incubator, the park has a strong industrial foundation, with more than 400 large-scale well-known pharmaceutical companies such as Janssen, Buchang and Lijun. In 2013, the Johnson & Johnson supply chain production base project was settled in Xi 'an High-tech Zone, which attracted a number of multinational pharmaceutical companies and R&D institutions, and promoted the large-scale development of the biological industry. Xi 'an High-tech Development Zone can accelerate the formation of Xi 'an biomedical industry cluster and promote the adjustment of Xi 'an industrial structure by improving the innovation ability of biomedicine.

The number of hospitals and pharmaceutical enterprises in XBCB has maintained continuous growth in the past years. By the end of 2022, there are 4,120 bio-pharmaceutical related enterprises in XBCB with 2 top 100 industrial enterprises, 26 GMP certified enterprises, and 9 listed enterprises among them. The output value of biomedicine has exceeded 20 billion yuan, and the industrial scale has exceeded 70 billion yuan, ranking in the forefront of high-tech zones in central and western countries. The pharmaceutical industry cluster in Xi 'an also forms a complementary relationship with hospitals in Xi 'an. On the one hand, there are a total of 81 tertiary hospitals in Shaanxi Province (by the end of 2022), 55 of which are located Xi 'an, and such industrial assemble strengthen the concentration of medical resources in Shaanxi.

These hospitals have become the main force of scientific research while treating patients as industrial entrepreneurs. Xijing Hospital of Air Force Military Medical University and the First Affiliated Hospital of Xi 'an Jiaotong University are outstanding in terms of the number of projects approved by the national research funding National Natural Science Fund, with 82 and 67 projects respectively, ranking second and third among western hospitals. The existence of high-quality hospitals brings together the clinical trials of major new medicines in China, and provides continuous and strong support for the development of the pharmaceutical industry in Xi 'an.

XBCB is the development area with the largest number of innovative biomedical industry enterprises and the most complete innovative services. In 2019, 31% of the enterprises accounted for 42% of the output value share, and there is a trend of further gathering, which may change the industrial pattern of Xi 'an's biomedical industry dominated by traditional Chinese medicine. In 2023, a total of 438 enterprises were selected as the listed "reserve army" in Shaanxi, 43 from the medical field, forming a network biomedical industry with Xi 'an as the core and the surrounding urban areas as the fulcrum, collaborating with the province's strength to break through the life science.

XBCB is the development area with the largest number of biomedical industry enterprises and the most complete innovative services in Shaanxi Province. By strengthening the innovation project carrying capacity of hospitals, universities and research institutes as the source of innovation, Xi 'an High-tech Zone gives full play to the advantages of the industrial chain resource system with complete innovation factors such as industrial investment, regulatory regulations, market circulation, industry leading enterprises and technology transfer institutions, and promotes the high-quality development of the biomedical industry. Focusing on the R&D of new medicines, XBCB has brought together the backbone leading enterprises such as Xintong Pharmaceutical, Micott and Buchang Pharmaceutical. In terms of medical device R&D, it has gathered key enterprises such as Konto Medical, Dimension Biology, and Blue Pole Medical, especially in the fields of cardiac treatment medical devices and 3D printing medical devices.

In terms of high-end medical devices, since 2023, the 30W and 200W blue laser surgical system developed by Blue Ji Medical, the "SLM matching thoracolumbar artificial vertebra" developed by Dimension Biology, and the "hydrophobic acrylic aspherical intraocular lens" independently developed by Eye Dele have been approved by the State Food and Drug Administration of the Class III medical devices. Inject new momentum into the development of biomedicine industry in high-tech zones. In order to further stimulate the vitality of various innovative elements, XBCB actively explores the form of platform integration to enable the high-quality development of the biomedical industry. At the same time, by improving the interaction mechanism between universities, research institutes and research-oriented hospitals, it provides a basis for the demonstration of maturity and clinical practicability of technological innovation, and promotes the transformation and application of technology.

As early as 2002, XBCB upgraded business incubation to industrial cultivation, and participated in the establishment of a number of professional incubators of biomedicine. As one of the three key projects in the construction of Caotang Science and Technology industry base of Xi 'an High-tech Zone, XBCB has formed a perfect nurturing hardware environment to meet the needs of biomedical R&D, pilot test, production, sales and other links.

> "The project has signed to settle nearly 20 scientific and technological achievements transformation projects, medical devices and pharmaceutical intermediates IVD and other fields to reach the international and domestic leading level, a number of technologies to break foreign technology monopoly, 2025 is expected to exceed 3 billion yuan of total output value of the park." (Interviewee 4B, 2023)

6.4.4 A park in incubation

The initial concept behind XBCB was aligned with China's broader ambition to establish a leading position in the global health science industry. The cluster was designed to serve as a dynamic nexus for R&D, attracting an amalgamation of leading enterprises, start-ups, and research institutions. With Xi'an's historic significance and emerging status as a centre for technological innovation, XBCB appeared to have all the prerequisites for success. Anticipated benefits included leveraging the city's rich talent pool, advanced infrastructure, and supportive governmental policies. However, the unfolding reality of XBCB diverged significantly from these aspirations. Despite a promising start, the park gradually succumbed to a developmental inertia, characterised by limited innovation, subpar commercialisation of research, and lacklustre collaboration among its entities, which makes XBCB known as a "static park".

Despite the strong foundational elements, the XBCB has not fully realised its potential. The park seems to be underperforming in terms of becoming a prominent hub for biomedical innovation and development. Interviewee 4C, a former government official of Xi'an High tech Zone now a venture capitalist reflected,

> "While we built state-of-the-art facilities, perhaps we underestimated the complexity of integrating these into a live, pulsating network of innovation." (Interviewee 4C, 2023)

Indeed, the reality of XBCB, highlighted by its comprehensive infrastructure and ambitious investment of CNY 800 million, reveals a stark contrast between the idealised planning and the operational outcomes. This shift from its envisioned trajectory warrants a critical analysis of both surface-level challenges and deeper systemic and operational issues.

First, the effect of industrial agglomeration in XBCB is not obvious. Most of the biomedical enterprises in Xi 'an are SMEs with limited financing channels. Although there are many key enterprises in XBCB, there is still a "small" and "low" industrial pattern. "Small" means that the enterprise organization is mainly small and medium-sized. Most enterprises still lack the internal motivation of technological innovation, fail to highlight the advantages of small business innovation and entrepreneurial strength, and it is difficult to become the dominant force in controlling the flow and allocation of innovation factors, and their competitiveness is not strong, resulting in the gradual decline of the current industrial benefits. "Low" refers to the low level of enterprises and industries, from the perspective of industry categories, although there are many high-tech enterprises in biomedicine, there are not many enterprises in line with the identification of high-tech industrial enterprises in the West, and most enterprises are production and processing enterprises, low grade, short product chain, and a large number of weak enterprises "adhere" in the low-end link of the value chain. In addition to shareholder investment, most of the capital sources of enterprises rely on bank loans, and private capital is less involved, resulting in the main funds of enterprises into the sales link, reduce R&D funds, breakthrough innovative products are few, weak competitiveness, and many can only produce low-level repetitive products to survive.

The business correlation between enterprises in the region is weak. The SMEs adhere to the packaging, marketing and small manufacturing in the lower end of the industrial chain, and the operation and management are independent, and the marketization and industrialization of enterprise R&D results are difficult. Low industrial correlation and short industrial chain. In the first and second phase of West High-tech, many enterprises chose to settle down in the industrial park under the motivation of preferential policies at the early stage. Preferential policies were the main factors attracting enterprises to settle down at that time, but not many chose to settle down because of the agglomeration of related industries. This shows that the degree of industrial agglomeration in the current phase one and two is not high, and most enterprises are in a state of "lone combat", which is only a simple concentration in the scope of industrial land, and has not formed industrial agglomeration benefits, "form and God do not gather". Lack of supporting industries. In the fierce market competition environment, professional market analysis and marketing agencies have become important factors affecting the development of enterprises. The success of "Silicon Valley" lies in having a large number of high-level technical support enterprises: such as business intermediaries, legal consulting, accounting and tax firms; And a third of the region's venture capital firms. Through field research, it is found that professional supporting services, market analysis and marketing agencies are relatively lacking in the second phase. The effect of various incubators on technological innovation of enterprises within the research scope is not significant, and the strength of incubated enterprises needs to be improved. It is found that the number and scale of productive service enterprises providing service intermediaries and consulting services for the development of high and new technology are relatively small in the first and second phase. Venture capital firms are even rarer. It is difficult to provide relevant service support to ensure the innovation and development of enterprises and industries.

Large-scale financing gives enterprises the opportunity to grow, but also brings some noise. Many technology companies have not yet reached the standard of technology or ability, but because of capital support or support, they will survive longer, and truly excellent companies will be subjected to more competitive pressure. If such enterprises can survive after three years of operation, they usually establish reliable technical barriers, explore the real market demand, and eventually become the backbone of the development of Xi 'an biopharmaceutical pharmaceutical industry. A key aspect contributing to XBCB's status as a static park is the possible misalignment of its strategic objectives with the rapidly evolving global health science market. This mismatch may stem from an overestimation of the effectiveness of governmental policies and incentives intended to nurture a conducive environment for innovation and collaboration. Moreover, the nature and extent of interaction among the park's constituents, essential for fostering knowledge exchange and synergistic growth, seem to have fallen short of expectations. Delving deeper into XBCB's journey, it becomes imperative to scrutinise the park's management strategies, the adaptability of its infrastructure to technological shifts, the quality of collaboration and networking opportunities available, and the effectiveness of support mechanisms for both start-ups and established enterprises. These dimensions collectively paint a comprehensive picture of the park's operational dynamics and strategic missteps.

Second, although XBCB's biotechnology research team is large, but the innovation technology and strength are not powerful. There are still more traditional medicines, less innovative medicines, more generic medicines, with independent IP rights of exclusive medicines and other problems. Looking at the listing reserve army table, Chinese medicine and Chinese medicine raw materials occupy a large share, and the development of innovative medicines is still in the bud. Although the site selection of the first phase of the West high-tech fully takes into account the utilization of surrounding scientific research resources, in fact, the proportion of university staff in the first phase of entrepreneurship is not high. There are few cooperative experimental projects between universities and enterprises, and the campus land planned in the first and second phase of Western Technology University is also more sold; In addition, the South Second Ring Road makes the dense area of colleges and universities form spatial isolation from the first and second periods, and communication is not convenient. There are differences in the concerns of universities and enterprises, universities pay attention to scientific research results, and are not enthusiastic about product realization and transformation. Enterprises are less enthusiastic about investment projects. There is a lack of an effective "industry-university-research" coordination mechanism to bridge these gaps.

Third, Industrial functions are separated from other urban areas and functions. Present situation the industrial land use is extensive, and the output benefit is low. If the average land output reflects the production efficiency per unit area of the industrial park, and the average land profit and tax reflects the income from the unit land of the industrial park, then the average land output and average land profit and tax in the study range are lower than the average of the whole west high-tech land, and the development intensity per unit area of land is low, the average plot ratio of industrial land is about 0.8, and the degree of intensification is not high. The space landscape of the park is simple, and the public activity space is relatively short. The large-scale distribution of plant-based enterprises divides the layout space, which brings obstacles to the connection between industrial development and urban life, both of which restrict the exchange activities of technical personnel to a certain extent. The function of living consumption in industrial agglomeration area is weak. It is not conducive to the development of work and life of employees in the district. From the investigation of daily activities of employees, it can be found that the supporting functions of the park fail to meet the needs of employees' daily activities, especially the general consumption needs in the short distance and short time between work. Apartments and other supporting residential functions are lacking, employment and consumer groups mostly live in the periphery of the area, and the commuting time forms peak traffic pressure in the area.

Finally, XBCB lacks cultural environment for business growth. A corporate culture that encourages risk-taking entrepreneurship and promotes informal communication is weak. Learning from the experience of Silicon Valley, the success of the park also lies in the characteristics of Silicon Valley culture such as competition, cooperation and win-win and emphasis on informal communication. The innovation of high-tech industry is highly uncertain, and its success depends on the collection and processing of various information and data and the rapid integration of various resources to a considerable extent. The rapid diffusion of information and technology caused by the high turnover rate of employees and the informal communication network linked by various relationships obviously contributes to this rapid integration. Although the new government of the West High School regularly prepares for academic exchange and research conferences, there is a lack of space for informal exchanges between enterprises and employees. Single channel communication is not enough to meet the actual needs of corporate cultural exchange and technology spillover.

In discussion of the reasons behind, a professional park manager, founding partner of a Biotech Real Estate company, Mr. 6F commented:

> "Despite my personal connection to Xi'an and my work experience there, the XBCB hasn't fully met its potential. I attribute this to various factors, with government being a significant one. My engagements and interactions suggest that the mindset of Xi'an's governmental might not

> be ideally structured to effectively support and grow the biomedical industry." (Interviewee 6F, 2023)

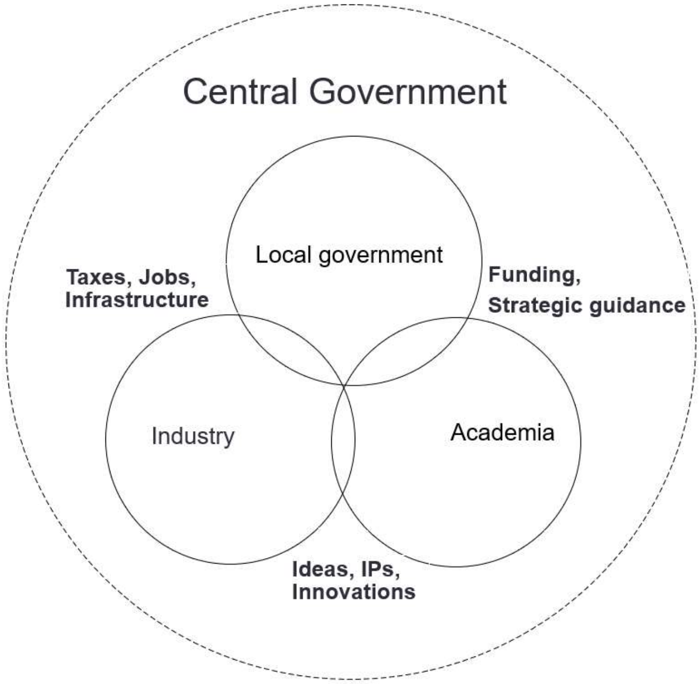
Bridging the above high-level quotations to a detailed discussion on the planning of XBRCB, we encounter a pivotal question: How effectively did the planning process align with the broader goals of fostering an innovation-driven biomedical industry in Xi'an? While personal connections and experiences in Xi'an suggest a deep-seated potential, they also reveal critical gaps, particularly in the governmental framework's ability to nurture this sector. This insight leads us to probe deeper into the planning phase of XBCB, specifically examining the roles and interactions of the Triple Helix components - government, academia, and industry. This theory, emphasising the interplay between government, academia, and industry, serves as a crucial framework for understanding innovation ecosystems. In the case of XBCB, are academia and industry inherent strengths, and is the governmental role a point of contention?

As the interviews suggest, while the planning was grounded in high aspirations, certain critical elements may not have been given due weight. For instance, the importance of fostering a flexible and adaptive management structure capable of responding to the rapidly changing landscape of biomedical science was often overshadowed by the focus on infrastructure and physical capacity building. "In hindsight, we perhaps concentrated more on the tangible aspects of the park, like buildings and labs, and less on the intangible dynamics that drive innovation." reflected interviewee 4B.

Furthermore, the planners initially underestimated the challenges of integrating the park into the broader economic and social fabric of Xi'an and the region. As one interviewee remarked, "Creating a seamless interface between the park and the city's existing economic ecosystem was more complex than we initially anticipated. It wasn't just about building a park; it was about embedding it into a larger network of innovation and commerce."

In summary, the planning of XBCB was marked by high hopes and strategic ambitions, aiming to position Xi'an as a pivotal player in the global biomedical field. While the blueprint reflected a comprehensive approach to building a state-of-the-art R&D hub, interviews with key stakeholders reveal that certain critical aspects, particularly those concerning management adaptability and economic integration, were not adequately addressed. This high-level overview of the planning phase sets the stage for a deeper dive into the specifics of these challenges and how they have shaped the current state of the XBCB.

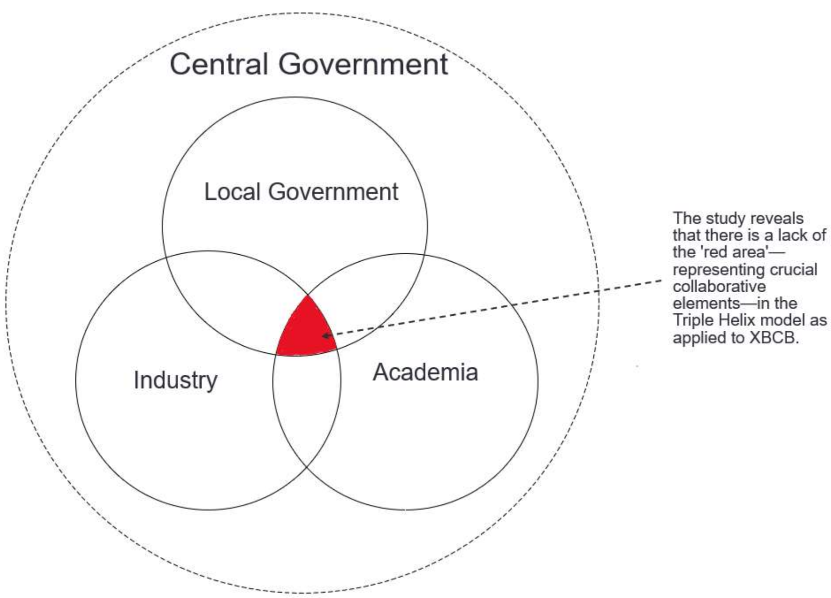
Figure 31: Application of the Triple Helix in XBCB



Source: author's interpretation of Triple Helix

Compared to the Balanced Interaction Model shown in Figure 2 as stated in Chapter 2, XBCB lacks the red area that signifies a fully integrated, balanced interaction—highlighting the essential collaboration between government, industry, and academia. This absence indicates a gap in cohesive engagement among these sectors, which is critical for fostering robust innovation and sustainable development (Figure 32).

Figure 32: Challenges in Triple Helix Application in XBCB



Source: Abstracted from Figure 2 – Balanced Interaction Model, which is author's interpretation of Triple Helix.

6.4.5 Conclusion on Case XBCB

The government's financial policies and attitudes towards small bio-pharmaceutical businesses have a great impact on the development of XBCB. The key enterprises in the biomedical industry chain cannot independently establish their own supply chain finance system due to the scale of enterprises and their own talent team structure. Considering that the construction of long-term operation mechanism of supply chain finance involves government departments, chain owner enterprises, chain affiliated enterprises, financial institutions, guarantee institutions and platform service institutions, it is proposed to adopt a working mechanism of "government promotion, platform service, multi-party cooperation and market operation". The industrial chain work class can take various forms to organize financial institutions, service platforms and biopharmaceutical chain master enterprises for effective docking, improve the awareness of biopharmaceutical chain master enterprises on the importance of establishing a long-term operation mechanism of supply chain finance, and play a leading role in the long-term operation mechanism of supply chain financial services.

The transformation of XBCB from a burgeoning innovation centre to a static park provides critical insights into the intricacies of developing and maintaining specialised industrial clusters. Unlike other industries, the threshold of biomedicine is relatively high, the industry supervision and regulations are stricter, and a lot of human, material and financial resources need to be invested before the product is launched, and many startup companies often find it difficult to obtain sufficient funds and resources to complete pre-clinical R&D and obtain the next stage of investment, let alone go to the stage of product clinical trials. These insights underscore the importance of dynamic and collaborative strategies that align with the evolving needs of the industry and the global market. The lessons drawn from XBCB are instrumental for future endeavours in establishing and managing high-tech industrial parks, emphasising the need for a holistic, integrative approach that encompasses government, academia, and industry in a harmonious and synergistic manner.

6.5 Zhongguancun: Extending the Life of a Health Sciences Park

6.5.1 Introduction

Zhongguancun Life Science Park (henceforth, ZLSP), 中关村生命科学园 in Chinese, is situated in Beijing and is widely regarded as China's most successful health science park (Jia, 2019). Indeed, ZLSP was ranked as China's number-one park by CCID (China Centre for Information Industry Development) and SinaMed (Sina Medical of Sina.com) in 2021. It is this role as the health sciences park most commonly identified as an exemplar for others that ZLSP functions in this analysis as a case study of national and international significance. In this respect, ZLSP is emblematic of China's broader aspirations to establish itself as a global leader in the domain of life sciences. These contextual factors present a compelling case for an in-depth study of how ZLSP was planned, its early implementation, and how it has evolved over time.

ZLSP is comparatively large among Chinese life science parks. It is located at the Technology Innovation Corridor on Beiqing Road, commonly known as the "Golden Cross", connecting Haidian District and Changping District. ZLSP, covering a total area of 7.2 km², surpasses BioBay (3.48 km²), ZCPV (3 km²), SBIIP (1.23km²), XBCB (1.34 km²), and Guangzhou International Bio Island (1.83 km²) in size. Focusing on life sciences, biotechnology and biomedical research, ZLSP is deeply rooted in the broader vision of the Zhongguancun Science and Technology Park, often dubbed the "Silicon Valley of China", where the Chinese national government has aimed to bolster innovation across multiple sectors (Zhang, et al., 2016), including life sciences. Benefiting from the large space in Changping District, the park was planned as a large-scale development designed to unfold in three phases (Zhang & Guan, 2023). In the first two phases, the park's essential built environment was established across an area of 2.5 km² comprising approximately1,368,000 m² of floor space. The third phase, an expansion area of 4.7 km², started the planning in 2017 and is being developed at the time of writing. The total floor area of the park for this phase is about 3,600,000 m², with industry-specific spaces taking up around 1,000,000 m² (Cao, 2021).

The choice of ZLSP as a focal case study for this research was influenced by several pertinent factors, not least the park's reputation as a highly successful park of national and international significance. The creation of ZLSP was deemed a response to the ever-evolving global landscape of biotechnology research and an acknowledgement that the park would provide the Chinese economy with exposure to this high growth sector of the global economy. ZLSP's establishment within the context of Beijing's status as the nation's capital presents a unique vantage point to understand China's overarching strategy in nurturing, directing, and managing health sciences parks as the territorial counterpart to an economic growth strategy focused on this sector.

6.5.2 Understanding the planning of Zhongguancun Life Science Park

ZLSP was born out of Zhongguancun Science and Technology Park (Z-Park), a government-planned industrial park. The predecessor of Z-Park was Beijing New Technology Industry Development Experimental Zone, which was established in 1988 as one of the first science parks and first national innovation demonstration centres in China (Lyu, et al., 2017). On 5th June 1999, The State Council of China issued the *Reply on Issues Related to the*

Construction of Zhongguancun Science and Technology Park, agreeing the opinions of the Beijing Municipal Government and the Ministry of Science and Technology on accelerating the construction of Zhongguancun Science and Technology Park. On 10th August 1999, the Beijing Municipal government decided to change the name of the Beijing New Technology Industry Development Pilot Zone Operation and Management Committee to Zhongguancun Science and Technology Park Management Committee (Z-Park Committee). Z-Park Committee in essence is a government agency to implement planning and to construct the entire park. In the same month, the National Technology Innovation Conference issued the Decision of the Central Committee of the Communist Party of China and The State Council on Strengthening Technological Innovation, Developing High Technology and Realising Industrialization, which declared that China will comprehensively optimise the distribution of scientific and technological forces and form a system and mechanism conducive to technological innovation (most.gov.cn, 2002). Z-Park is regarded as the Beijing New Technology Industry development pilot Zone and China's first national high-tech industrial development zone to be explored and experimented with.

From its inception, a clear focus on life sciences for the park predominated at the local government. In April 2000, the Beijing Municipal Government and the Ministry of Science and Technology jointly signed the Cooperation Agreement on the Industrialization of the Achievements of High-tech R&D Plan to promote the transfer, transformation and industrialisation of national high-tech projects in the capital. These projects included ZLSP, Beijing Laboratory Animal Research Center, national high-tech green material development centre construction, and 12 other advanced and basic projects first shortlisted. Z-Park Committee was responsible for the project of ZLSP, a new component of Z-park. Interviewee 5A remarked,

> "The Z-Park committee's proficiency in establishing and managing industrial parks, although they might not have had a historical inclination towards the biotechnology/biopharmaceutical sector, made them the best candidates to undertake this venture. The biotechnology/ biopharmaceutical sector became a broader vision of the Zhongguancun Science and Technology Park. And that's also how the name Zhongguancun Life Science Park came." (Interviewee 5A, 2023)

Z-Park Committee's forte managing more general industrial parks was identified by some, such as Interviewee 5A as a significant advantage in securing the role of managing ZLSP. However, other interviewees were not convinced that the experience of running 'mainstream' industrial parks made Z-Park Committee better placed than others to manage ZLSP. For example, Interviewee 6B, a senior industry expert commented: "Z-Park Committee's credentials in park management are solid, but the life science sector is not just another park. It's a nuanced field that requires specialised understanding." (Interviewee 6B, 2023)

At the time of its creation, ZLSP was described as a response to the evolving global landscape of biotechnology research and a strategic attempt to provide space for the industry to become established in China. The origins of ZLSP as a planned space to accommodate this industry can be found in the examples of the 1960s and 1970s when the concept of biomedical industrial parks emerged in the United States. Prior to the construction of ZLSP the Beijing Municipal Planning Institute and Beike Construction (the construction company that ultimately delivered ZLSP) had been to the United States for multiple times, investigating the most well-known cities in the biomedical industry of the United States such as Boston, New York, the Silicon Valley area and Maryland as well as other science and technology parks. After that, on 12th June 2000, a specific work meeting for the construction of ZLSP was organised by Beijing Municipality, China Bioengineering Development Center, Zhongguancun Administrative Committee of Beijing Municipal Planning Commission, the Municipal Science and Technology Commission, and Beike Construction. The meeting decided that the planning and design scheme of ZLSP should be open to international bidding (Landscape Monogatari, 2000).

The planning and design of this world-class life science park was completed at breakneck speed. The work meeting requested that all bid evaluation work should be completed by the end of September 2000, and the following planning and design scheme must be completed in one month. Designers were encouraged to ensure that the construction of the park reached was consistent with established international standards, reflects a “people-oriented” planning and design concept and also provided comprehensive facilities, resources and a suitable environment for life science research, development and pilot tests. Professional incubators, large medical service institutions, young talent apartments and other facilities and support services should be available (ZLSP, 2020). The proposal submitted by Beijing Turen Landscape Planning and Design Institute won the bid. The plan regarded ZLSP as a “life cell” for planning and design and puts forward new concepts of high-tech park planning and design, such as the construction of a sustainable wetland environment, the integration of functional buildings and environment, the design of circulation network and the construction of park boundaries (Xiao, 2006). On November 25, 2000, the construction of ZLSP started.

Figure 33: ZLSP Landscape

Source: photo taken in the ZLSP.

Despite the government-driven character of ZLSP's planning and design, the park's development evolved to include aspects of organic growth combined with strategic organisation. Rather than developing tailor-made policies that catered specifically to meet requirements unique to biotechnology/biopharmaceutical operations, generic guidelines applicable across Beijing and Zhongguancun were adopted. The administration appeared to be more hands-off regarding the park's management. Interviewee 5A, a former official of Z-Park who was involved in the early planning of ZLSP, shared:

> "In the initial stages, many of our planning endeavours might not have significantly influenced the historical formation of ZLSP. We were more focused on restricting land and providing basic amenities." (Interviewee 5A, 2023)

This statement underscores the fact that while there were overarching visions for the park, the detailed intricacies of its development were reactive rather than proactive. This foundational stage laid the groundwork for what ZLSP aimed to represent – a blend of top-tier research facilities, innovation centres, and industrial hubs.

However, a new plan later reinforced the association between ZLSP and its surroundings, anchoring ZLSP in a more ambitious development project in Beijing. The park was approved as the "National Biological Industry Base" in October 2006 by the National Development and Reform Commission of China. The commission granted the park the identity of a 'national-level science park'. In 2009 Changping District embarked on an ambitious journey to shape what would become Beijing's Future Science City, a testament to the district's commitment to forward-looking urban and technological development (Future Science City Group, 2021). The strategic development of Beijing's Future Science City has been a multifaceted endeavour. It has focused on cultivating a landscape for technological innovation and constructing and refining a comprehensive programme of infrastructure delivery to underpin this growth. A professional planner elaborated on this holistic vision:

> "There has been an impressive commitment to infrastructure. From essential medical facilities and schools to supporting stadiums and waterfront parks, highways to subways, talent apartments, and high-end hotels, Future Science City has been envisioned as a self-sufficient enclave. They were building a city within a city, where one can find the vibrancy of urban life alongside the serenity of natural spaces, the efficiency of modern transportation alongside the comfort of upscale living." (Interviewee 6A, 2023)

As an existing cluster of the broader urban ecosystem, benefits are imperative for ZLSP from the seamless interconnection with the Future Science City. The shared infrastructure and intellectual synergy have created a mutually reinforcing relationship that has amplified the strengths of each. It has turned the area into a magnet for talent, innovation, and investment, underpinning the region's status as an innovation hub.

The new city planning contributed to ZLSP's evolution. In 2018, Beijing underwent an urban reconfiguration by establishing four central hubs, one designated as the International Science and Technology Innovation Center. To achieve this, the city harnessed the synergies of three cities and one district, known as "Three Cities, One District". These include The Future Science City in Changping District, Zhongguancun Science City in Haidian District, Huairou

Science City in Huairou District, and the Beijing Economic-Technological Development Area in Yizhuang District. A closer examination of Changping District reveals that the Future Science City has a spatial structure characterised by “Two Valleys and One Campus” (Beijing Government, 2023). Specifically, the western section of Future Science City is ZLSP, regarded as “Life Valley”, with a primary focus on life sciences and its immediate surroundings. In contrast, the eastern section, separated by an ecological park between, is referred to as “Energy Valley”. Together with a higher education campus located in the north of ZLSP gives rise to the vital characteristic of the Future Science City, “Two Valleys and One Campus” (Figure 34). The planned area of Future Science City covers an extensive 179.6 km², highlighting the project’s scale and ambition.

Figure 34: Map of Future Science City

Source: An arrow and English translation is added based on the map provided by ZLSP.

Within this intricate network of Future Science City, ZLSP plays an integral role in Beijing’s strategy to establish itself as an international innovation centre. A good example of the comprehensive planning of the park and the surrounding area is the “One Campus” development, the higher education facility within the Future Science City. This development stands as an excellent example of how the facilities that comprise the essential functions of ZLSP have been augmented with a wider set of public facilities to support the location (and relocation) of companies and talent to the area. The scope of the plan goes beyond the functionality of ZLSP as a space of industrial innovation; it aims to create stable neighbourhoods that could sustain the long-term residency of the companies, academic institutions and employees that are essential for ZLSP’s success. This aspect of the broader park planning strategy was identified as important to the long-term viability of ZLSP by Interviewee 6A, a professional planner, elucidates,

> “One Campus is to build a public infrastructure that is versatile and multifunctional, with an emphasis on mixed-use development that can

provide a diverse range of services. Future Life Science City did well. The planning is about future-proofing the community ensuring the necessary space and facilities for emergency response to disasters and public health events. The investment in educational resources, addressing any shortcomings in regional basic education to ensure that the community does not just live, and work well but also learns and thrives. This holistic approach reflects a comprehensive understanding of urban living, where the infrastructure serves as the backbone supporting the social and cultural fabric of the community." (Interviewee 6A, 2023)

In summary, ZLSP as a national project, was conceived by the central and local state and dawned initially from the inspiration of science parks developed in the USA. The subsequent development of the park also benefited from the local overall development planning and industrial layout. ZLSP's construction was implemented by the Beijing Municipal Committee and Government to implement a plan set out in the State Council's document 'Reply on Accelerating the Construction of Z-Park', aiming to develop the capital's knowledge economy, adjust the industrial structure of Beijing, and enhance the ability of independent innovation. Over two-decades of evolution, ZLSP has developed into an international high-tech park that integrates the R&D of life sciences, enterprise nurturing, mid-test and production, bio-technology project issuance, result appraisal and international exchange.

6.5.3 Understanding ZLSP's development using the Triple Helix model

The Triple Helix model of development identifies three critical ingredients as a precursor to innovation: government, university-based research activity and business (Etzkowitz & Leydesdorff, 2000). Exploring these three perspectives, this section attempts to use this theory as a lens through which to consider the development of ZLSP. As discussed in the previous section, much of the development of ZLSP was government led.: The Beijing Municipal Government was instrumental in the creation of the park, while the Z-Park Committee, as a government agency acted on behalf of the government, implemented its detailed planning and construction.

The growth of ZLSP, however, is not only subject to the regional authority. The primary feature of ZLSP is its geographical advantage, located in the seat of China's central government. As China's political, cultural, and educational centre, Beijing provides ZLSP with a context rich with China's most important state and academic institutions. Academic theories of industrial agglomeration informed the government-led planning of ZLSP. In candidly reflecting on ZLSP's competitive stance, Interviewee 5B acknowledged its strengths and weaknesses.

"Located in Beijing, ZLSP holds differentiated advantages over other domestic parks, particularly in centralised high-level approval authorities (regulatory bodies) that other locations cannot match. Moreover, with over half of China's top-tier hospitals are located here. Proximity to these institutions and experts is crucial for this particular industry. Standing out in core competitiveness, yet it grapples with challenges, notably the prohibitive cost of land and rental space due

> to Beijing's premium on real estate. This makes establishing even a small laboratory or start-up costly." (Interviewee 5B, 2023)

Interviewee 5F, the co-founder of an early-stage synthetic biology company, a Beijing native and Tsinghua University alumnus, also stated,

> "Our extensive network of mentors, peers, and friends within Beijing, coupled with the city's skilled workforce, fundamentally guided our choice to establish our company at ZLSP. The park's reputation as an innovation cluster with a collaborative ethos was a compelling factor in this strategic decision." (Interviewee 5F, 2023)

The government-led planning distinguishes ZLSP with biomedicine and health as its leading industries in the capital city. Ms. 5B notes the advantage of natural agglomeration in Haidian due to the legacy of Zhongguancun, which has evolved to include biomedical industries, albeit to a lesser extent than other sectors.

> "We (ZLSP) house a multitude of R&D institutions, while Daxing Yizhuang leans towards manufacturing. We monitor and nurture enterprises from the research phase to help plan their industrialisation journey. Our innovation corridor is designed to anchor the outcomes, to prevent them from drifting away." (Interviewee 5A, 2023)

Haidian's focus on information services and less emphasis on medical investment contrasts with Changping, where biomedical, branded medicine and health industries are prioritised, with ZLSP leading the charge as the district's flagship industry. ZLSP differentiates itself through its focus on innovation and research.

Phased planning is an essential reason for the park's success. This phase was envisioned to complement the infrastructure established in the earlier phases and expand ZLSP's capabilities by incorporating specialised industry zones to further catalyse research, development, and commercialisation efforts in life sciences.

> "The phased development approach was strategic. Starting with a robust foundation in phases one and two and then significantly expanding in phase three allowed us to ensure quality, manage resources efficiently, and adapt to the evolving needs of the life science industry. Furthermore, the significant allocation for industry-specific spaces in the third phase underscores ZLSP's commitment to bridging the gap between research and commercialisation, ensuring that breakthroughs achieved within the park's confines have a clear pathway to the market." (Interviewee 5A, 2023)

Government-led infrastructure construction has provided a solid foundation for the development of the industrial park. Changping District is harnessing the ZLSP as its nucleus, with the G6 and G7 expressways as its backbone, two Metro lines, and the future Line 17 connecting both Beijing airports. Additionally, a large commercial complex embedded with high-end hotels, conference and exhibition centre is being constructed in the park, along with high-quality primary schools providing educational support to systematically deploy a series of industry demonstration, acceleration, and conversion bases, forging a Life Valley innovation corridor across the entire region. By 2026, at least 200 hectares of land will be further allocated for the health industry. In 2022, the municipal committee and government imparted a new functional positioning to ZLSP, mandating the acceleration of the development of a globally leading “Life Valley” and establishing it as the “core explosion point” for Beijing’s pharmaceutical and healthcare industry.

Academic institutions have also played a vital role in the development of ZLSP. Researchers from nearby universities began pouring into the industrial park on their own initiative since its creation. In 2000, Zhongguancun gathered 68 institutions of higher learning at all levels, represented by Peking University and Tsinghua University, with 300,000 students (Landscape Monogatari, 2000). There were 213 scientific research institutions at all levels and of various types defined by the Institute of Chinese Academy of Sciences. The number of academicians in the two institutes (Peking University and Tsinghua University) accounted for 36% of the total academicians in China, and thousands of high-level scientific research achievements radiated across the country were produced yearly. A group of top R&D institutions, such as the National Institute of Biological Sciences, Chinese Institute for Brain Research, and National Center for Protein Science, have now settled in Zhongguancun Life Science Park. A total of 10 national engineering centres, key laboratories, and 16 R&D centres at provincial and ministerial levels have been built. A group of top scientists, including but not limited to Xie Xiaoliang, Wang Xiaodong, Shi Yigong, and Shao Feng, and more than 300 high-level talents are brought together. Mr. 5E highlighted the founder’s scientific credentials and network as pivotal to the company’s early growth and talent acquisition, affirming that:

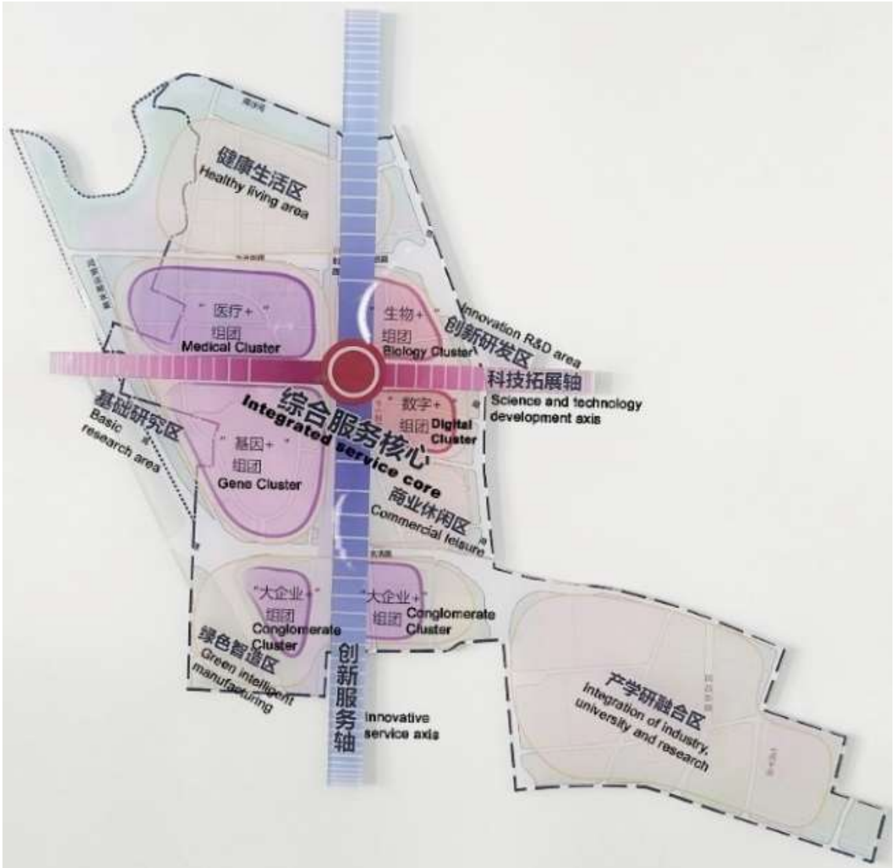
> “The founder’s distinguished reputation was instrumental in swiftly mobilising a skilled workforce, thereby endorsing the strategic localisation within the innovation-centric ecosystem of ZLSP.” (Interviewee 5E, 2023).

An unforeseen attraction gradually emerged within the organic growth of ZLSP in the first two phases. The park soon became a melting pot for the younger generation. A significant number hailed from China’s premier educational institutions – Tsinghua University, Beijing University, the Chinese Academy of Sciences and more. Beyond these new park inhabitants there was also a seasoned cohort that provided a blend of experience and youth. Interviewee 6C gave this phenomenon clear articulation: “You’d find professors from medical institutions and experts who’ve returned after stints at global pharmaceutical giants. The mix of youthful exuberance and seasoned expertise created a unique ecosystem.” (Interviewee 6C, 2023) Interviewee 5D, a biotech researcher who established their presence in the early days of the park, also expressed,

> “It was akin to witnessing a beehive take shape. Every corner you turn, there’s an energy. It’s almost infectious. And it’s not just the infrastructure or the amenities. It’s the people. Even though there seemed to be a lack of guidance, a natural order began to emerge. This is the natural advantage of being close to Beijing’s Haidian District.” (Interviewee 5D, 2023)

The presence and convergence of entrepreneurs, researchers, and professionals brought an aura of innovation and a hunger for breakthroughs, giving rise to an organic industrial agglomeration.

Figure 35: Landscape of ZLSP



Source: photo taken in the ZLSP

Since its inception, ZLSP has grown dramatically, accommodating a range of entities from small-scale, nascent start-ups to some of the largest transnational corporations in the biotech sector. The park has more than 600 innovation-oriented pharmaceutical enterprises on different scales. Well-known innovative pharmaceutical enterprises at home and abroad have settled here, including Novo Nordisk, BeiGene, InnoCare, Sironax, Huahui Health, Grit Science, Singlomics, Pyrotech Therapeutic, etc. In terms of production and circulation, it has attracted enterprises engaged in producing and circulating important medicines and medical devices at home and abroad, such as New Era Health Industry Group, Yangtze River Pharmaceutical Group, Wantai BioPharm and Takara Biomed. In terms of clinical applications, medical resources equipped with more than 3,000 sickbeds have been made available, including Peking University International Hospital, Peking University Sixth Hospital, Changbo International Research Hospital, Beijing Hope Thyroid Hospital, Peking University Rehabilitation Hospital, etc., providing rich clinical resources for R&D of innovative medicines and medical devices made by enterprises settling in the park.

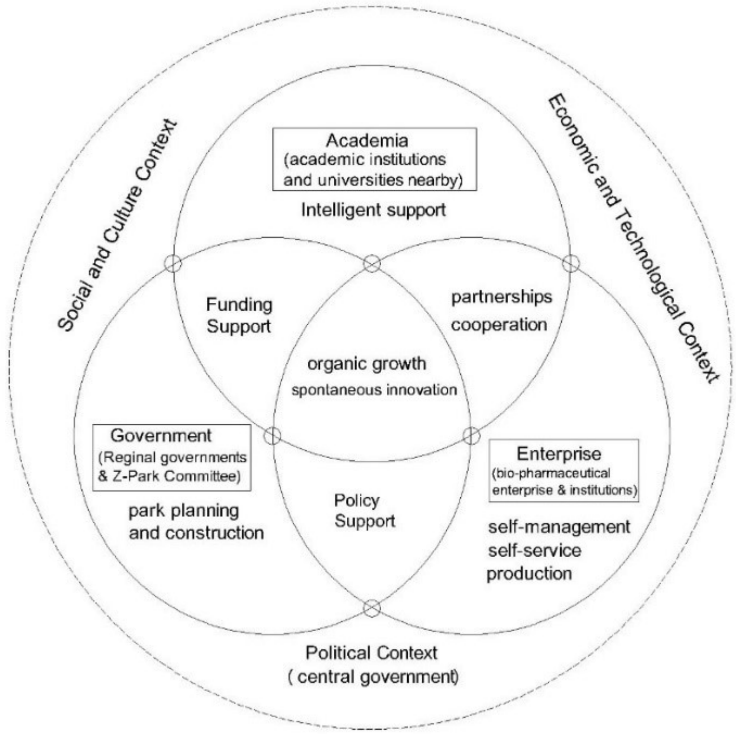
ZLSP adopted a mixed approach in its planning to attract enterprises on different scales. The blended approach presented at ZLSP emerged organically rather than explicitly planned. These varied enterprises have provided ZLSP with a specific character that differentiates it from other science parks. There is often a recruitment strategy that is reflected in the physical nature of the parks: those parks that seek to encourage the location or re-location of large-scale trans-national operations are generally qualitatively different with respect to infrastructure and facilities compared to those that seek to provide small-scale, accessible space for start-ups.

The rational planning by the government and the academic support from the universities have greatly strengthened ZLSP's capacity to continually grow the number of enterprises choosing to locate on the park. From the vantage point of corporations, the experience of operating within ZLSP is multifaceted. On one hand, companies operating in ZLSP benefit from Beijing's concentration of regulatory bodies, which could potentially streamline the often-onerous approval processes. In a discourse regarding the locational determinants for a biopharmaceutical venture, Interviewee 5E, the former Vice President of a notable public biopharmaceutical entity, provided context for their establishment within ZLSP. He noted,

> "The choice of ZLSP as our operational base was underpinned by its pre-existing concentration of life science research firms and the region's academic capital, particularly our founders' ties to the Chinese Academy of Sciences and Beijing Institute of Life Sciences." (Interviewee 5E, 2023).

Through analysis, it can be concluded that the three critical ingredients for innovation of the Triple Helix model: government, university-based research activity and business achieved a dynamic balance in the case of ZLSP. The government provided planning and policy support and integrated the park with the development of the whole city. Universities and research institutions offered indispensable intellectual support and research strength for industrial innovation. Finally, companies attracted to the park by this environment have grown in the relatively liberal environment and by virtue of their proximity to administrative and social resources (Figure 36). From this perspective there is no doubt that ZLSP serves as a very good example of how the three components of the Triple Helix can come together to result in innovation.

Figure 36: Application of the Triple Helix Model in ZLSP's success



Source: interpretated by the author based on Triple Helix

6.5.4 An Uncertain Future: the Government-managed ZLSP

For over 20 years the model outlined in the previous section has operated resulting in unchecked growth and urban agglomeration in ZLSP. However, in 2020, the governmental role in ZLSP, started to go beyond planning and construction. The establishment of the ZLSP Administrative Committee, an agency on behalf of the city government, marked a pivotal shift in the park's trajectory. It was a strategic move to centralise resources, streamline policies and public management services to the ZLSP Administrative Committee, and bolster the park's industry focus to reveal a more coherent development path and uncover a wealth of research potential. The establishment of this new agency marked the beginning of the government's administrative intervention in managing the park. This marked a shift from the state's previously crucial role as the planning and delivery agency of the park whilst allowing the park inhabitants a degree of autonomy and freedom to one of more day-to-day control. Such administrative intervention brings an uncertain future to the ZLSP.

A set of changes began to take place. The park's development, industrial services, and property management, which were spontaneously operated by private companies in the park, were assigned to respective state-owned enterprises. Additionally, market-oriented third-party professional teams were brought in to support operations and services, enhancing the park's market efficiency, professionalism, and international standards. It is not possible to objectively disentangle the organic agglomeration effects from the work of the administrative committee. Nevertheless, the result shows that a dense network of hidden scientific talent has emerged, growing from 80 establishments in 2020 to approximately 880 recognised entities by

September 2023, as stated by the documents provided by the park during the interview. This strategic consolidation under the ZLSP Administrative Committee has profoundly shaped the park's development, emphasising a government-managed approach to fostering innovation.

The third phase of ZLSP planned in 2017 has also started to be realised under the guidance of the ZLSP Administrative Committee. The third phase, an expansion area of 4.7 km² compared to 2.5 km² of the first and second phases, is currently under expedited construction. The building scale for this phase is about 3,130 km², with industry-specific spaces taking up around 1,100 km²s. This phase was envisioned to complement the infrastructure established in the earlier phases and expand ZLSP's capabilities by incorporating specialised industry zones to further catalyse research, development, and commercialisation efforts in life sciences.

In light of the insights gathered from the research, questions arise about the ZLSP Administrative Committee's influence on the park's dynamic environment. Specifically, there is a clear question over a potential shift from the organic growth of the park's beginnings to a later phase of structured development under the Administrative Committee. These considerations led to consultations with park inhabitants and the solicitation of expert opinions on the committee's impact. The analysis seeks to critically assess the balance between the committee's contributions to infrastructure and governance and the implications of its regulatory focus. This discourse aims to navigate the dichotomy between high-level strategic planning and the granular realities of park life, evaluating how the committee's actions affect the park's innovation and enterprise. A corporate executive might argue that while administrative efficiency is a boon, it comes with the territory's high operational costs, raising the question of whether the efficiency gains offset the financial burden.

Post-establishment of the ZLSP Administrative Committee, inhabitants have acknowledged infrastructural enhancements and the imposition of order as pivotal to reaching international standards. "These upgrades have been fundamental in aligning us with global benchmarks." (Interviewee 5B and 5E, 2023). Yet, the new structure has elicited critical scrutiny, particularly from entrepreneurial stakeholders concerned about the potential dampening of the park's innovative spirit. Interviewee 6C noted, "The tension between stringent administration and innovation is tangible." (Interviewee 6C, 2023) The shift towards administrative uniformity has prompted debate among smaller entities fearing a one-size-fits-all model. Interviewee 6D, a returnee scientist entrepreneur who ultimately chose not to establish his business in ZLSP, contended,

> "Initial engagement with ZLSP revealed a governance approach prioritising management over facilitative services, a stance that potentially hinders start-up ventures in contrast to the more enabling climates of the Yangtze and Pearl River Deltas." (Interviewee 6D, 2023)

This administrative rigor, despite enhancing the park's reputation, may inadvertently place nascent enterprises at a disadvantage.

Moreover, according to a policy analyst, the committee's orientation towards larger enterprises poses risks of homogenisation within the ecosystem, potentially suppressing entrepreneurial diversity. Resource allocation towards ventures led by renowned scientists also invites scrutiny regarding the marginalisation of lesser-known talents. Interviewee 6E, a venture capitalist, remarked:

> "Investments in ZLSP have disproportionately favoured established scientists, potentially leading to overcapitalisation in certain innovation tracks at the expense of emerging scholars whose funding needs remain unmet. The misalignment between available funds and clinical necessities has historically resulted in the inefficient utilisation of financial, talent, and medical resources, thereby stifling novel innovation." (Interviewee 6E, 2023)

In light of these reflections, it is apparent that the committee's influence has been both beneficial and restrictive. The correlation between ZLSP's shift from organic to structured development and its vitality can be encapsulated by contrasting perspectives within the park. Interviewee 5D and Interviewee 5E, who have been in the park since the early days, reminisced, "The park's early organic growth fostered a hotbed of innovation, where start-ups thrived on the agility and informality of the ecosystem." (Interviewee 5D and 5E, 2023) Yet, as a park official pointed out, "The introduction of the Administrative Committee's structured framework was aimed at propelling ZLSP towards a global competitive stature, with an emphasis on sustainable, scalable development." (Interviewee 5B, 2023)

However, this new structure has not been universally welcomed. Interviewee 6D, a research scientist and entrepreneur who ultimately chose not to establish his business in ZLSP, argued that, "There's concern that in our stride towards organisation and order, we might lose the spontaneous combustion that ignites ground-breaking innovation." (Interviewee 6D, 2023). This sentiment underscores the delicate balance between the need for structured growth and the preservation of an innovative culture. Interviewee 6E, a venture capitalist, observed,

> "The park's pivot towards attracting established enterprises has inevitably altered its entrepreneurial landscape. While it may elevate the park's profile, it's imperative to consider whether this shift might inadvertently marginalise the smaller innovators who are often the lifeblood of technological advancement." (Interviewee 6E, 2023)

Reflecting on the future, Interviewee 6E suggested, "To maintain its dynamism, ZLSP must strike a balance, perhaps through a hybrid model that retains the park's original entrepreneurial spirit while incorporating the benefits of structured development." (Interviewee 6E, 2023)

ZLSP Administrative Committee is a specific administrative body that strengthens the administrative intervention of the government in ZLSP. The attitudes towards the committee from inhabitants illustrate the complex relationship between ZLSP's developmental strategy and vibrancy, highlighting the need for a nuanced approach to foster. It epitomises the paradoxical nature of health science parks navigating between the organic innovation that spurs initial growth and the structured development that ensures sustainability.

Another factor contributing to the uncertain future of ZLSP is the rise of other parks. In recent years, the limitations of ZLSP have gradually been realised, while the advantages of alternative science parks have drawn more attention. Addressing operational dynamics, Interviewee 6B, senior industry expertise, former Healthcare Head of an international investment bank, and now CFO of a biotech company, commented,

> "Beijing's role as the Capital city of China can occasionally precipitate disruption to normal business operations at ZLSP, resulting in uncertain delivery timetable. Such uncertainty, including logistical, supply chain and production challenges, may prolong normal business cycles." (Interviewee 6B, 2023)

Ms. 5A and Ms. 5B acknowledge the limitations: "We can't contain all industry expansion within ZLSP. As businesses grow, their operations span across Beijing, nationwide, even globally." (Interviewee 5A and 5B, 2023) This introspective assessment from the interviewees provides a nuanced perspective on ZLSP's position within the competitive landscape of Beijing's various industrial parks, emphasising its unique selling points while also acknowledging areas where it faces challenges.

When exploring expansion options, Interviewee 5F assessed sites within the Yangtze River Delta and Shenzhen, which are renowned for their business-friendly environment.

> "After thorough deliberation, we opted to relocate our headquarters to Shanghai, aligning with our commercialisation strategy, while maintaining our Beijing site as a dedicated R&D centre, leveraging the local research talent and resources." (Interviewee 5F, 2023)

Interviewee 5G, provided a comprehensive rationale behind their strategic re-location, focusing on the interplay of financial funding, cost considerations, and talent availability. "In navigating the shift from R&D to commercial production, the direct access to Yangtze River Delta's financial resources necessitated a reassessment of our operational base." (Interviewee 5G, 2023)

The financial ecosystem in the Yangtze River Delta and Pearl River Delta regions were a catalyst for change, prompting a critical evaluation of the long-term sustainability of remaining in Beijing, given its cost structure. The financial strategies employed by the Yangtze River Delta offered immediate fiscal relief and served as a foundation for future scalability. Bridging this point to the advantages of Jiangsu, Interviewee 5G added,

> "This financing support was instrumental for us in acquiring land-use rights in Jiangsu province at advantageous rates. It starkly contrasts our situation in Beijing, where the high costs present significant barriers to growth for smaller enterprises like us." (Interviewee 5G, 2023)

Further elucidating on the talent dynamics, Interviewee 5G stated, "While Beijing boasts a wealth of R&D talent, its industrial workforce does not meet the demands of production-oriented growth." (Interviewee 5G, 2023) He highlighted the comparative advantage of the Yangtze River Delta, where research experts and a skilled technical workforce create an environment conducive to the full spectrum of business development, from innovation to market delivery. Interviewee 5H, a European returnee entrepreneur, articulated the significance of initial start-up funding.

> "Securing initial financial support is pivotal for the viability and feasibility of my business. My company's foundational capital was procured from a couple of Shanghai-based venture capital funds, a determining factor in situating the business in Shanghai's dynamic

> economic environment, despite the convenience of my residence adjacent to ZLSP." (Interviewee 5H, 2023)

Reflecting on regional financial dynamics, Interviewee 5H observed,

> "ZLSP's fiscal framework, largely dependent on Changping District's allocations, does not exhibit the dynamism characteristic of the financial ecosystems within the Yangtze River Delta's parks, such as Zhangjiang and BioBay," stated the CFO. "The venture capital environment within ZLSP, tethered to the district's financial strategies, does not parallel the robustness of the Yangtze River Delta's private equity sector. This disparity in investment opportunities, compounded by the Delta region's more attractive financial incentives, may steer early-stage companies toward these economically favourable locales." (Interviewee 5H, 2023)

Interviewee 5H further reflected on his observation:

> "Throughout the fundraising process, I perceived a greater receptivity towards innovation in Shanghai. The dynamism of its funding ecosystem, coupled with the supportive services from governmental and park authorities, fosters an environment considerably more conducive to entrepreneurial ventures. Additionally, the city's openness to scientists and researchers significantly contributes to its appeal as an innovation hub." (Interviewee 5H,2023)

On the talent ecosystem, which significantly impacts the industrial capabilities, Interviewee 5E, the former Vice President of a notable public biopharmaceutical entity, remarked,

> "While Beijing is replete with R&D expertise, it lacks the industrial workforce critical for scaling innovations into commercial production, a need that is readily met in the manufacturing-rich regions like Yangtze and Pearl River Deltas. We set up our large production site in Guangzhou, where the maturation of industrialisation is evident through the comprehensive integration of upstream and downstream infrastructure and sufficient well-trained technical workforce, which markedly optimises production costs and efficiency relative to Beijing." (Interviewee 5E, 2023)

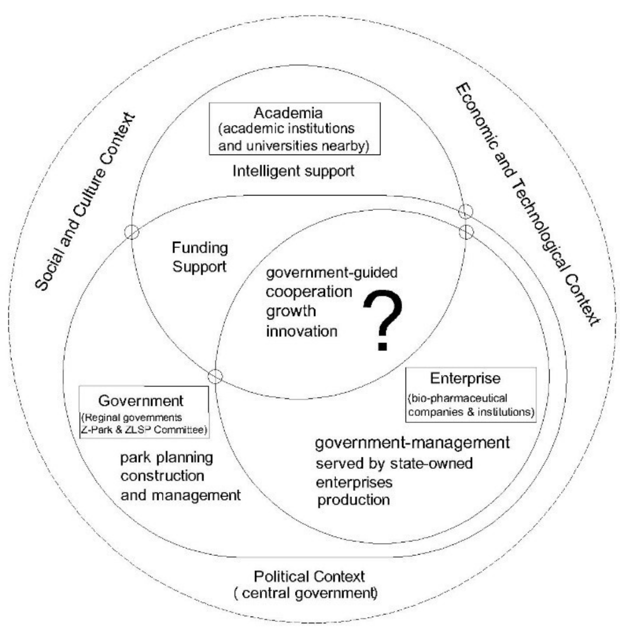
The proximity to national regulatory agencies has historically conferred a strategic advantage to Beijing's parks, facilitating direct communication for compliance and approvals. However, delegating certain regulatory functions to provincial levels has diminished this benefit as regional health science industries have become more self-sufficient. "The establishment of local regulatory bodies has bridged the competitive gap once dominated by Beijing," a health science professional noted. (Interviewee 5H,2023) In the Yangtze River Delta, for instance, the Shanghai Center for Medical Evaluation and Inspection, located in Zhangjiang's China Pharmaceutical Valley, and the presence of the Jiangsu Medical Products Administration in BioBay exemplify the trend of regional hubs enhancing their regulatory frameworks. "This evolution in the regulatory landscape is a significant factor in the diminished appeal of ZLSP for new ventures, despite the convenience of my nearby residence," the professional concluded. (Interviewee 5H,2023)

Within Beijing's constellation of science parks, Interviewee 6C, managing partner of a venture capitalist, deems that ZLSP contends with ample competition, particularly from cost-effective alternatives like Yizhuang, strategically positioning itself as an affordable biomedical industry base.

> "The land and operational costs discrepancy between ZLSP and its counterparts like Yizhuang and even Tongzhou is significant. Furthermore, the abundance of resources channelled towards well-established academicians in ZLSP, Changping inflates valuations, potentially neglecting emerging entrepreneurs with promising innovations. This dynamic may shift the focus of venture capital towards more financially accessible parks, where the proximity to prestigious institutions does not eclipse innovation potential." (Interviewee 6C, 2023)

The narrative and quotes that emerge from the voices of the inhabitants of ZLSP and external professionals paint a paradoxical picture of a health sciences park caught between past success and future uncertainty. Summarising the experiences of park inhabitants and professionals reveals a complex portrait of a park in transition. The administrative changes introduced have undeniably streamlined operations and attracted significant players, yet there's an undercurrent of concern about maintaining the park's foundational entrepreneurial energy. This trend is particularly evident in the context of the advantages of other parks. Such tension spotlights ZLSP's current challenge: fostering a balanced ecosystem where fledgling both start-ups and state-owned firms can thrive. It stands as a testament to the delicate interplay between nurturing innovation and imposing order, a dynamic that will shape the park's trajectory as it continues to evolve within the Triple Helix model (Figure 37).

Figure 37: The Evolved Application of Triple Helix Model Since the Establishment of ZLSP Administrative Committee



Source: author's interpretation based on Triple Helix

6.5.5 Conclusion

This chapter has illustrated the ambitious vision behind ZLSP. However, it is also clear that, even with all the advantages of its location in the national capital, the park's evolution has been complex. The chapter has provided a detailed account of the operational realities of initiating and developing a park of ZLSP's status over a period of two decades.

The ZLSP case study showcases the evolving nature of the Triple Helix model, where the balance between the three helices—university, industry, and government—is crucial to sustaining an ecosystem's innovative capacity. The planning of ZLSP has shown a concerted effort towards creating a world-class science park, marked by significant infrastructural investments and the construction of living facilities. Located in Beijing, ZLSP has a strategic advantage over other domestic parks in China. Researchers from nearby universities provided the park with intellectual support and sustained the park's initial innovative impetus. Rational planning and academic support have attracted various enterprises and institutions to settle down at the park and finally made it a blend of top-tier research facilities, innovation centres, and industrial hubs.

The creation of the ZLSP Administrative Committee in 2020 marked a transition in the strategic management of the park from one focussed on organic growth with different-sized enterprises (which means a solid balance between government planning, university support, and enterprise initiative) to the government-managed assembly of State-owned and large enterprises. The committee showed a concerted effort towards creating a world-class science park, marked by significant infrastructural investments and a drive towards a more top-down regulated framework. While these developments have streamlined processes and raised the park's international profile, they have also prompted a dialogue on their appropriateness for sustaining its innovativeness.

From the business perspective, the park's proximity to regulatory bodies, academic institutions and clinical and hospital resources has been a considerable advantage. However, challenges such as high operational costs, the preferential treatment of larger enterprises, and a perceived imbalance in resource allocation have emerged. Moreover, competition within Beijing and other regions of China has also brought challenges to the park. These factors contribute to a growing sentiment that while ZLSP has made strides in infrastructure, it must recalibrate its approach to better serve its diverse community of innovators.

ZLSP, as a paradoxical park, is underscored by its shift from an academia-driven model of the Triple Helix, characterised by spontaneous innovation and organic growth, to a government-led model of the Triple Helix, signalling a more structural approach to development. This shift has brought about a new set of dynamics; where once the interplay of academia and industry dominated, now the hand of governance steers the helm. The indications of this evolution are multifaceted: while the administrative committee has introduced a level of predictability and order, there is an ongoing debate about whether this has come at the cost of the park's dynamic and entrepreneurial character. The accurate measure of its value lies in the successes it enables and the barriers it presents, painting a complex picture of opportunity and challenge.

ZLSP can be regarded as a specific illustration of the Triple Helix model in practice. ZLSP's growth trajectory, especially the shift in dynamics post-2020 with the establishment of the park Administrative Committee, provides a tangible representation of the Triple Helix theory's practical application and its fluid interactions over time. The before-and-after scenario presented by ZLSP offers a unique test ground to study how the dynamics of the Triple Helix model can change over time, especially with the introduction of new governing structures. This case is valuable for understanding adaptability and resilience in innovation ecosystems. The park's journey, especially around the pivotal year of 2020, provides a rich backdrop against which the dynamics of university-industry-government collaboration can be critically examined, further enriching the discourse around the Triple Helix theory.

Chapter 7. Analysis on the Case Studies

The previous chapter provided a thorough analysis of the five case studies health science parks in China. Taken together the five case studies illustrate the flexibility of the 'health sciences parks' concept and terminology – a very wide variety of experiences are captured under what is superficially the same territorial approach. This variation extends to the character of the activities that take place at the parks, from R&D to manufacturing, through to their physical size and their relationship with the metropolitan areas of which they are a part. The breadth of experiences summarised in Chapter 6 provides an insight into the diverging character of the parks themselves attributable to a wide variety of factors such as the length of time they have been in operation and the economic maturity of their respective locations. This diverse selection encompasses both well-established and nascent parks, highlighting the varying stages of growth and challenges they encounter. Furthermore, the parks, situated in regions with disparate economic statuses, offer a broad spectrum of insights into the interaction between regional economic health and the success of science parks.

Section 6.1 to 6.5 of this chapter unpack this full range of experiences using the Triple Helix Theory as an explanatory device. This portion of the thesis dissects these varied experiences to understand how the interplay between government, academia, and industry shapes each park's evolution, which can be summarised as below.

The approach taken enables a nuanced understanding of how each park navigates its unique challenges and leverages its strengths, influenced by the roles and contributions of each helix component.

The aim of this section is to synthesize the continuity and contrast across the case studies, drawing out common themes and distinctive features. This comparative analysis is structured around the research questions established in Chapter 4.7, ensuring a cohesive link between empirical observations and the broader research objectives. Using these questions to structure this section provides a clear point of connection between the empirical findings presented in the previous sections and the overarching research aims and objectives that provided the study with its focus.

#1 What are the unique characteristics and success factors of Chinese health sciences parks, and how do they differ from those of health sciences parks in other countries?

Each of the five selected health sciences parks in China - Zhangjiang, Shenzhen, BioBay, Xi'an, and Zhongguancun - exhibit distinct characteristics, strengths, and challenges, shaped by unique drivers and contexts. It reflects the complexity in practical application of the Triple Helix model.

Case 1: 6.1 Zhangjiang: China's original health sciences park – balanced strong interaction Triple Helix model

Zhangjiang stands as a testament to China's pioneering efforts in the realm of health science parks, which is a vivid example where the synergistic interplay of academia, industry, and government fosters a thriving hub of innovation and economic development. The park is distinguished by its emphasis on fostering a seamless continuum from research to commercialization. This is achieved through a well-structured framework that supports and encourages the rapid translation of scientific discoveries into market-ready products and services. The balanced approach collaboration among academia, industry, and government with a well-thought-out design is critical to the park's success.

Case 2: 6.2 Shenzhen (SBIIP): China's new breed of health sciences park – shifting from government driven to industry led Triple Helix approach

Shenzhen exemplifies the new generation of health science parks in China, symbolizing the nation's transition towards an innovation-driven economy, with a strong focus on genomics and biotechnology. Initiated through a top-down approach by the Shenzhen government, the park now thrives on a hands-off policy, encouraging organic, industry-led growth. Despite the city's initial shortage of universities and research centres, Shenzhen counters this through strategic collaborations and talent development initiatives, bridging the gap in academic and research infrastructure, and fostering a skilled workforce for sustained innovation and growth.

Case 3: 6.3 BioBay: A growing specimen – active government involvement with market-oriented Triple Helix approach

BioBay represents a prime example of the advantageous spillover effects arising from its close proximity to Shanghai. It has carved out a unique niche in the biotech sector by providing manufacturing sites for companies based in Zhangjiang while simultaneously distinguishing itself through its commitment to nurturing biotech startups and early-stage research firms. The park's operation and management model are particularly noteworthy, blending active government involvement with a market-oriented approach. This synergistic combination has endowed BioBay with a distinctive dynamism, driving not only rapid and stable growth but also significantly enhancing its overall appeal.

Case 4: 6.4 Xi'an (XBCB): A health sciences park in incubation – moderate interactions Triple Helix model

Xi'an stands as a nascent health sciences park, poising at a critical juncture. Situated in a region rich in history and technology, it has the potential to harness local educational and manufacturing strengths to evolve into a hub suitable for the biomedical industry. The park embodies a fusion of ambitious vision and untapped opportunities, particularly in the realm of large pharmaceutical enterprises. However, a shift in the existing government mindset and approach is necessary, which is different from a focus on large technology devices to a more dynamic, adaptable biomedical sector.

Case 5: 6.5 Zhongguancun (ZLSP): Extending the life of a health sciences park – shifting from organic growth to a structured government led Triple Helix model

Zhongguancun (ZLSP) stands out for its strategic transition from organic growth to a structured development model, driven by the establishment of the Administrative Committee. Initially thriving on a university-led Triple Helix model that fostered spontaneous innovation, its evolution into a government-led framework has brought infrastructural enhancements and more strategic development. However, this shift has also raised concerns about maintaining its entrepreneurial spirit and equitable support for smaller startups. The park's unique characteristic lies in its ongoing effort to balance rigorous management with the nurturing of a vibrant innovation ecosystem, making it a paradoxical yet dynamic player in China's health science landscape.

These unique characteristics and variations from one to another, not only reflect the diverse approaches to developing health sciences parks in China but also illustrate the practical application of the Triple Helix model, where the roles of academia, industry, and government differ in weight and impact across each park. This diversity reveals several common characteristics and success factors, providing a deeper understanding of what sets Chinese health sciences parks apart from their international counterparts.

Large scale and scope

The scale and scope of Chinese health sciences parks are perhaps their most striking features. These parks are not only vast in terms of physical dimensions but also in the breadth of activities they encompass.

Figure 38: Size of health science parks selected for case studies

Short name	Full name of the case studies	Floor space
Zhangjiang, ZCPV	Zhangjiang China Drug Valley	3 km²
Shenzhen, SBIIP	Shenzhen Biomedicine Innovation Industrial Park	1.23 km²
BioBay	Suzhou·BioBay	2.6 km²
Xi'an, XBCB	Xi'an Biomedical Cluster Base	1.34 km²
ZLSP	Zhongguancun Life Science Park	7.2 km²

Source: author's own diagram.

The five Chinese health science parks examined are notable for their substantial physical size (as stated in Figure 38), which reflects their extensive capacity to support diverse operations. These parks are characterized by their large land areas, which are specifically designed to accommodate the broad range of activities associated with health sciences. For comparison, Manchester Science Park and Cambridge Science Park, though not exclusively focused on health sciences, illustrate different scales of park development. Manchester Science Park spans approximately 2.27 square kilometres, providing a significant amount of space for a variety of science and technology companies. In contrast, Cambridge Science Park covers a smaller area of 3,716 square meters but serves a wide range of science and technology sectors. Moreover, in these Chinese parks, the construction area often significantly exceeds the floor area, a trend common where tall, multi-functional buildings are favoured. This architectural choice not only optimizes the use of space but also aligns with the need for vertical integration of diverse activities. In these parks, thoughtful design is evident in the construction, which is tailored to meet the specific requirements of various sectors within the health sciences field. The expansive area allows for a wide range of facilities, from extensive research laboratories and academic institutions to large-scale manufacturing units and commercial spaces. This design philosophy facilitates the creation of comprehensive ecosystems that support the entire spectrum of activities in the health sciences, from basic research to advanced commercialization. The substantial physical footprint of these parks reflects considerable investment and strategic planning, ensuring they can cater to the diverse needs of the health sciences sector. However, the grand scale of Chinese parks brings its own set of challenges. Managing these vast, multi-dimensional spaces requires substantial resources and meticulous coordination. The risk of bureaucratic complexity and inefficiency is a notable concern, as it can potentially slow down decision-making processes and stifle innovation.

Such a comprehensive approach sets Chinese health science parks apart from many global counterparts, where the development of life science parks often adopts a more segmented and evolutionary model. Typically, Western parks start as research-focused centres linked to academic institutions, gradually adding commercial and manufacturing elements. This phased development contrasts with the integration at early planning seen in Chinese parks, where various components coexist from the outset.

The immediate and integrated environment offered by Chinese parks enhances the scope of services and opportunities available, it also necessitates adept strategic planning and management to mitigate risks associated with large-scale operations. In these parks, government involvement is often more pronounced with the aim to ensure that the scale and scope of these parks translate into a competitive advantage. However, balancing this with the agility and innovation driven by industry and academia is crucial. This interaction in such a large-scale environment can either foster a vibrant, collaborative atmosphere or lead to challenges in alignment and agility.

Observations such as this help shed light on the strategies employed to maintain efficient operations, encourage innovation, and balance the interests and inputs of academia, industry, and government within the Triple Helix framework. Such insights would be invaluable in understanding how these parks navigate their unique set of challenges and opportunities.

Strong government involvement

The development of China's health sciences parks, as highlighted in the case studies, is closely tied to the significant role of government. This state-led model is characterized by direct funding, policy incentives, infrastructural support, extending from the parks' inception to their ongoing expansion and operations. Such enduring government involvement underscores its commitment to integrating these parks into the nation's broader economic and scientific goals. However, this government-centric approach presents challenges, necessitating a balance between adhering to state directives and adapting to market dynamics. This is crucial for fostering an environment that supports private enterprise and international collaboration, thereby ensuring the parks' long-term sustainability and global competitiveness. Different parks exhibit varying governance styles. For instance, Shenzhen (SBIIP) has evolved towards a more market-driven approach after the early-stage development driven by the Shenzhen government, while in contrast, Zhongguancun is shifting from an organic growth to operation under the supervision of a traditional Administrative Committee, indicating a governance structure shaped significantly by government policies and strategies. These variations reflect an ongoing adaptation process, essential for aligning the interest and involvement of the central and local government.

The directive nature and substantial level of government involvement to the five parks selected as cases illustrates a stark contrast to the facilitative role played by governments that is often observed in Western contexts. This significant government support has been providing parks with advanced infrastructure and state-of-the-art facilities essential for fostering innovation, and have achieved good results in certain parks like Zhangjiang, BioBay and Zhongguancun.

However, this model of government dependency, while beneficial in establishment and sometimes catalysing initial growth, implicating challenges for the parks' long-term sustainability and adaptability. A heavy reliance on state funding could make these parks susceptible to the vagaries of political and economic shifts. Such a dependency might limit their ability to respond agilely to changing market demands or scientific advancements. Furthermore, the predominantly top-down approach in these parks could inadvertently suppress grassroots innovation. By prioritizing state and government directed goals, there is a risk of overshadowing initiatives that are market-driven or originate from academic research. This could potentially stifle the creative and exploratory spirit that is often crucial for ground-breaking discoveries in the biotechnology field.

Intentional creation of ecosystems

The intentional creation of ecosystems in Chinese health science parks represents a significant departure from the more organic evolution typically observed in Western counterparts – the setting from and under which the Triple Helix Theory was developed. This difference reflects a broader strategic intent and underscores a key aspect of China's approach to fostering innovation in the health sciences sector.

In the Chinese context, as demonstrated in the above case studies, the ecosystem's development is meticulously planned and executed. This approach is characterized by a synergistic collaboration among academia, industry, and government, conforming to the Triple Helix model. The Chinese strategy is not to leave the establishment of such ecosystems to the spontaneous convergence of various elements but to actively construct them through deliberate government initiatives, policy incentives, and substantial investments. Key features of these parks, including incubation centres, technology transfer offices, and collaborative research programs, are strategically deployed. These facilities are not mere physical infrastructures; they are integral to fostering a milieu where academic research seamlessly intertwines with industrial applications and market-oriented pursuits. The strategic location of these parks, often near urban centres or academic institutions, further strengthens their potential for innovation and collaboration. Zhongguancun, for example, leverages its proximity to Beijing's universities to enhance its collaborative dynamics. However, in areas such as Suzhou and Shenzhen, where initial academic and clinical resources were sparse, efforts to construct ecosystems involve attracting top-tier academic institutions and industry leaders. For instance, the invitation of Cold Spring Harbour Laboratory to Suzhou and the integration of major companies like Sanofi into SBIIP in Shenzhen are tactical moves to create a robust and dynamic environment conducive to biotechnological advancement. These initiatives demonstrate a conscious effort to compensate for any inherent resource limitations and to elevate the parks' profiles as innovation hubs.

In contrast, health science parks in Western countries typically evolve through a more organic process, driven predominantly by academic institutions. These ecosystems often materialize around universities or research institutions, progressively drawing in industry partners for the commercialization of research. Government involvement in these settings tends to be facilitative, providing a supportive backdrop rather than dictating the course of development. This bottom-up approach allows for a natural alignment of interests among various stakeholders, fostering a collaborative spirit that contributes to the ecosystem's resilience and adaptability. However, this model may not immediately provide the integrated and comprehensive environment that is a hallmark of the Chinese approach. The gradual evolution can mean slower integration of research, industry, and government elements, potentially delaying the full realization of an innovation ecosystem's potential.

Comparing these models, Chinese health science parks stand out with their ambitious scale and the proactive integration of research, industry, and government from the outset. This structured approach aligns with China's broader objectives in science and technology, aiming for rapid establishment and scalability of innovation ecosystems.

However, this top-down method faces its own set of challenges. It might limit the organic growth and flexibility that are characteristic of more spontaneously evolved ecosystems, as seen in Western models. The orchestrated development can also be susceptible to policy shifts or economic changes, which might affect the sustainability and adaptability of these parks.

The challenge for Chinese health science parks lies in balancing this orchestrated development with the flexibility and creativity found in organically evolved ecosystems. Ensuring that the structured, top-down approach does not stifle innovation requires a nuanced understanding of the dynamic interplay between the park's constituents.

In Western parks, the natural evolution of ecosystems, driven by the needs and initiatives of academia and industry, contributes to a resilient and adaptable innovation environment. This model, while slower to integrate various elements, offers a sustainable approach to ecosystem development, often resulting in deeply rooted collaborations and a strong sense of community among stakeholders.

In summary, the approach to ecosystem creation in Chinese health science parks, characterized by strategic planning and government intervention, stands in contrast to the more organic development seen in Western countries. While each model has its strengths and challenges, the Chinese approach is particularly notable for its rapid scalability and comprehensive integration, marking a distinct contribution to the global discourse on health science parks.

#2 How has the design of health science parks evolved? How the designers/planners seek to ensure that the science parks they create lead to collaboration and innovation?

The evolution of health science parks in China, exemplified by the five case studies, represents a significant facet in understanding the dynamics of innovation ecosystems. These parks have transitioned from rudimentary clusters of research facilities into sophisticated ecosystems that merge research, commercial, and communal spaces. This transformation reflects a broader shift in design philosophy, emphasizing the integration of various functions within a conducive environment for innovation. Early designs were primarily focused on providing state-of-the-art laboratories, office spaces and (or) manufacturing sites depending on the respective park’s positioning. However, recent trends indicate a shift towards creating integrated environments where innovation is not only facilitated by the physical infrastructure but also by the social, residential and communal aspects of the parks. The evolution of health science parks in China, particularly the five selected cases represent a significant facet in understanding the dynamics of innovation ecosystems. This analysis critically examines how these parks' designs have evolved to foster collaboration and innovation, assessing the extent to which the Triple Helix Model explains their development.

Early Designs and Evolution

Historically, the design of health science parks in China mirrored Western prototypes, prioritizing state-of-the-art facilities and infrastructure conducive to scientific research. However, as these parks matured, their design philosophy evolved to incorporate elements tailored to local needs and contexts. This evolution can be seen in two primary dimensions: spatial organization and functional diversification.

Spatially, early designs were characterized by rigid, compartmentalized structures that segregated different activities. Over time, there was a shift towards more integrated layouts. For instance, in parks like BioBay, there is an emphasis on creating communal spaces that facilitate informal interactions among researchers, entrepreneurs, and students. Such spaces are critical in fostering an environment where unplanned 'collision' moments can spark innovative ideas.

Functionally, the parks have evolved from being rudimentary solely research-focused to becoming multifaceted hubs incorporating business incubation, residential areas, and recreational facilities. This transition acknowledges that innovation thrives in environments that support not just the professional but also the personal lives of those working within them. For example, the Shenzhen Biomedicine Innovation Industrial Park integrates living and recreational spaces within its campus, recognizing the importance of work-life balance in driving creativity and productivity.

Fostering Collaboration and Innovation

Regardless of the results, the design and planning of the parks considered in this research have been strategically focused on promoting collaboration and innovation. Central to this has been the creation of ecosystems that facilitate interaction among various stakeholders in the health sciences field. Although the level of achievements varies from good results to unsatisfactory, some common aspects of practice can be identified:

- Proximity and Accessibility: By situating companies, research institutes, and ancillary services in close proximity, these parks reduce physical and logistical barriers to collaboration. For instance, Zhongguancun Life Sciences Park is strategically located near major universities and research centres, easing the flow of ideas and resources.

- Flexible Infrastructure: The parks often feature adaptable infrastructures that can accommodate the rapidly changing needs of the health sciences sector. This includes modular lab spaces and shared facilities that can be easily reconfigured as new technologies and research areas emerge.

- Incubation and Acceleration Programs: Programs designed to nurture start-ups and young companies are commonplace in these parks. By offering not only funding but also mentorship and networking opportunities, they help bridge the gap between academic research and marketable products.

Critical Reflections

It is critical to note that the varying degrees of ‘success’ experienced by each of the pars considered in this research cannot be attributed to design and planning alone. The broader socio-economic and political context plays a crucial role. Additionally, while the Triple Helix model provides a valuable framework for understanding the interplay between academia, industry, and government, it may oversimplify the complex dynamics at play. The model must be adapted to local contexts and needs, ensuring a balanced and equitable contribution from each stakeholder. Cultural factors, market demand, global trends and prevailing mindset around the location also significantly influence the evolution of these parks. For instance, the growing global emphasis on sustainability and environmental responsibility is pushing parks towards greener designs and operations.

In summary, the evolution of health science parks in China is marked by a shift from traditional research facilities to integrated ecosystems fostering collaboration and innovation. The application of the Triple Helix model, while beneficial, requires careful implementation to ensure balanced and equitable development. As these parks continue to grow and adapt to changing global and local dynamics, their ability to innovate and contribute to regional economic growth will remain a key indicator of their success. Balancing the rapid development with the need for sustainable and inclusive growth will be essential for these parks to maintain their position as vital centres of innovation and economic activity. However, the application of the Triple Helix Model is nuanced and varies across different contexts. Understanding and addressing the challenges inherent in this model is essential for the continued success and evolution of these vital innovation ecosystems.

#3 What attracts talent to science parks in a country such as China where there are so many options? How do science parks compete for talent? How do they incentivize location and relocation?

In the rapidly evolving economic landscape of China, characterized by a multitude of options for researchers and skilled professionals, science parks have carved out a niche as prime destinations for talent. Understanding what attracts talent to these parks, how they compete for this talent, and the incentives offered for relocation reveals a complex interplay of factors that align with various academic theories and practical considerations. The insights gleaned from the above five case studies based on interviews with a diverse array of stakeholders – ranging from park administrators and entrepreneurs to researchers and industry experts – reveal a multifaceted approach to talent acquisition and retention—provide a comprehensive view of the strategies employed to attract and retain top talent. These strategies are not only crucial in drawing high-calibre professionals but also play a pivotal role in shaping the parks' developmental trajectories and their ability to compete on both national and global stages. The factors identified from these case studies underscore the complex interplay of factors that drive talent movement within the unique ecosystem of Chinese science parks.

From a theoretical standpoint, the attractiveness of these science parks to talent can be largely explained through the lenses of knowledge spillover and agglomeration theories. The knowledge spillover theory posits that areas with high concentrations of innovative activities and institutions naturally foster an environment where knowledge, skills, and innovations permeate beyond their initial confines. Chinese science parks epitomize the creation of such environment, where proximity to research institutions and technology companies creates fertile ground for knowledge exchange. Professionals are drawn to these parks not merely for employment but for the vibrant intellectual milieu they offer, which is conducive to learning and innovation.

Agglomeration theory further explains the appeal of these parks, where the geographical concentration of firms and industries leads to operational efficiencies and innovation. The clustering of diverse organizations within a confined space reduces barriers to information flow and fosters a collaborative culture. For professionals, this means access to a plethora of opportunities for collaboration, networking, and career advancement, all within a single geographic locale.

Practically, these theories manifest in several key strategies employed by Chinese science parks. First, the provision of state-of-the-art facilities and infrastructure is a major draw. Parks like Zhangjiang and Zhongguancun (ZLSP) are equipped with advanced laboratories and research centres, offering an environment where cutting-edge research can be conducted. This infrastructure is not only about physical spaces but also includes access to the latest technologies and resources, essential for driving innovation. Second, the strategic collaborations and partnerships that these parks establish play a crucial role in attracting talent. Collaborations spanning academia, industry, and government illustrates the intention of creating ecosystems that offer diverse opportunities for professional growth. The intention to integrate the interaction between the three ingredients of the Triple Helix model is evident in these parks and the result instrumentally impact in their success level of attracting and retaining talent. Third, the parks' focus on competitive compensation and career advancement prospects is another significant factor. Recognizing the value of skilled professionals, some health sciences parks offer attractive incentive and additional benefits in addition to the packages offered by their employers, making them competitive locations. Additionally, the potential for career growth within these innovation-driven environments is a major attraction for professionals seeking to advance their careers.

In terms of competing for talent, Chinese science parks employ a range of strategies. Central to their approach is the establishment of a distinct brand identity, positioning themselves as leading centres for specific R&D fields. This approach extends beyond reputation, grounded in substantial investments in targeted infrastructure, research facilities, and collaborative networks. For instance, Zhangjiang is acclaimed for its robust industry collaboration, whereas Zhongguancun stands out as a focal point for academic engagement. This targeted branding not only draws professionals seeking challenging, innovative work but also fosters a cycle of investment, partnerships, and talent attraction. As these parks evolve, their established brands reinforce their status as premier destinations for scientific and technological talent in China.

In the realm of incentivizing relocation, science parks adopt a multi-pronged strategy to attract top talent and businesses. Primarily, these parks offer financial incentives and subsidies, which can range from tax breaks and reduced rent for laboratory and office spaces to grants and funding opportunities for research projects. Such financial benefits reduce the initial economic burden for new businesses and professionals relocating to the park, making the transition financially viable and attractive. Additionally, science parks often provide comprehensive location and relocation assistance. This support can encompass a range of services, from help in finding housing to assistance with the logistics of moving. For international professionals, this may also include language and cultural integration programs. By easing the relocation process, science parks make the prospect of moving less daunting, especially for individuals and businesses relocating from other regions or countries. Another key aspect is the development of a supportive ecosystem that extends beyond professional needs. This includes establishing a quality living environment within or near the park, offering amenities like shopping centres, schools, healthcare facilities, and recreational areas. By creating a community that caters to the everyday needs and lifestyle preferences of individuals and their families, science parks make the location more appealing for long-term settlement. Lastly but not least, science parks actively promote networking and collaborative opportunities. They organize events, workshops, and seminars that not only foster professional development but also enable new arrivals to integrate into the community. This focus on building a vibrant, interactive community helps in creating a sense of belonging and encourages professionals and businesses to commit to the location as a long-term base for their work and life.

The case studies of the five science parks reveal several general lessons about what makes talent move and stay in these ecosystems. A conducive environment for innovation, collaborative opportunities, and comprehensive support systems emerges as key factors. These factors align well with the theoretical frameworks mentioned earlier, confirming the relevance of knowledge spillover and agglomeration theories in the context of talent attraction in Chinese science parks. However, these factors also highlight some differences from Western models, where the development of science parks is often more organic and linked closely with academic institutions. In China, the government's more directive role in the development and operation of these parks presents both advantages and challenges. While it enables rapid establishment and resource allocation, it can sometimes lead to a top-down approach that may not always be as conducive to spontaneous innovation as the more organic models seen in the West. In practice, Chinese science parks have had to adapt to ensure that their structured, government-led approach does not impede innovation. Efforts to foster a culture of creativity and entrepreneurship within these parks are critical in this regard. This includes providing spaces for networking and collaboration, encouraging risk-taking and experimentation, and facilitating connections between park residents and the wider global research community. Moreover, as these parks evolve, there is an increasing recognition of the need to balance the government's role with market forces and academic freedom. This balance is crucial for sustaining an environment where innovation can flourish and where talent feels motivated and valued.

In conclusion, attracting talent to Chinese science parks involves a multifaceted strategy that combines theoretical understanding with practical approaches. The integration of state-of-the-art facilities, strategic collaborations, competitive compensation, and a supportive living environment aligns with the knowledge spillover and agglomeration theories, explaining the parks' appeal to top talent. The adaptation and balancing of these strategies to ensure a dynamic and innovative ecosystem are essential for these parks to continue thriving in the competitive landscape of China.

#4 What is the impact of Chinese health sciences parks on regional innovation and economic development, and how do they contribute to fostering collaboration and knowledge exchange?

The impact of Chinese health science parks on regional innovation and economic development is a subject of considerable importance, marked by both notable successes and challenges. The development of these parks has been instrumental in fostering collaboration, knowledge exchange, and economic growth within their respective regions. However, the extent of their impact and the factors contributing to their success or limitations vary, reflecting a complex interplay of regional dynamics, strategic planning, and execution.

Health science parks in China, as exemplified in the above case studies have emerged as significant catalysts in regional innovation landscapes. Functioning as epicentres for scientific research, these parks have been instrumental in drawing substantial investment towards the development of state-of-the-art technologies and pharmaceutical innovations. Their strategic approach to co-locating research, development, and commercialization activities within specific geographic confines has yielded dynamic ecosystems, conducive to accelerated advancements in the health sciences sector. The core of these parks' effectiveness lies in their ability to aggregate critical resources – sophisticated facilities, a skilled workforce, and a cluster of high-calibre companies and institutions. This aggregation has tangibly amplified innovation outputs, as evidenced by increases in patent filings, research publications, and the emergence of novel medical technologies and pharmaceutical products. Furthermore, these parks have been pivotal in attracting both domestic and international investment, thereby reinforcing local economies and fostering high-value employment opportunities.

Beyond direct economic contributions, these science parks have also stimulated the growth of ancillary industries. The presence of supply chains, service providers, and startups in parks like Zhongguancun and Zhangjiang has not only generated direct employment but also induced secondary economic activities across sectors such as hospitality, real estate, and supply chain services. The ripple effect of these parks extends to the broader regional economy, enhancing job creation and fostering economic diversification. In cases like Zhongguancun, often likened to China's Silicon Valley, this impact has been profound, significantly influencing Beijing's technological and economic metamorphosis.

The concentration of talent and resources within these parks has also created fertile grounds for collaboration and knowledge exchange. Proximity to universities, research institutions, and a plethora of industrial partners has spurred a collaborative ethos, pivotal for the transfer of knowledge and technological innovation. This collaborative environment, bolstered by the parks' strategic locations, has been instrumental in driving regional economic growth, transforming host cities into hubs of innovation and attracting further investments.

In summary, Chinese health science parks, through their strategic aggregation of resources and facilitation of collaborative environments, have significantly impacted regional innovation and economic development. Their ability to attract investment, stimulate ancillary industries, and foster a culture of innovation has transformed them into key drivers of economic diversification and growth in their respective regions. However, the challenge remains to sustain this momentum and ensure these ecosystems continue to evolve and adapt in response to changing global and domestic dynamics in health sciences and technology.

One of the key successes of these science parks has been their ability to foster collaboration and knowledge exchange among various stakeholders. Through strategic partnerships and alliances, they have encouraged interactions between academia, industry, and government, embodying the Triple Helix model of innovation. This collaboration has led to the development of new technologies and solutions, particularly in the biotech and pharmaceutical sectors, contributing to the parks' and regions' innovative capacity. The parks also provide platforms for startups and established companies to engage in collaborative projects, driving both technological advancement and commercialization. Incubation centres and accelerators within these parks offer support services, mentorship, and funding, nurturing an environment conducive to the growth of new ventures. These initiatives have been instrumental in bridging the gap between research and market, leading to the development of products and services that address societal needs and contribute to regional economic prosperity.

The economic growth of cities and regions hosting these science parks has been significantly influenced by their presence. Parks like Zhangjiang Pharmaceutical Valley have not only bolstered Shanghai's position in the pharmaceutical industry but also attracted a wide array of ancillary businesses, contributing to the region's overall economic health. Similarly, the establishment of SBIIP has been a key factor in Shenzhen's emergence as a leading city in biomedicine and biotechnology. However, the success of these parks in stimulating economic growth has not been uniform across all regions. Factors such as geographic location, existing industrial base, and the level of government support have played crucial roles in determining the extent of their impact. In some cases, parks located in less developed regions or those with limited access to resources and talent have struggled to achieve the same level of success as their more favourably situated counterparts.

Interviews with park administrators, researchers, and industry professionals reveal that the most significant factors contributing to the success of these parks include strategic location, government support, and the quality of infrastructure and services provided. These factors align with agglomeration theory, which emphasizes the benefits of geographic concentration of industries and services, and the Triple Helix model, highlighting the importance of collaboration between academia, industry, and government. However, interviews also underscore the challenges faced by these parks, such as bureaucratic hurdles, difficulty in maintaining a balance between government directives and market needs, and the risk of overdependence on government funding. These challenges reflect a deviation from the idealized models of innovation ecosystems, where flexibility, organic growth, and market-driven dynamics are key. In practice, while these parks have been catalysts for regional economic growth and innovation, their effectiveness has been tempered by these challenges. The need for a more balanced approach, integrating government support with market dynamics and fostering an environment conducive to organic growth and innovation, is crucial for their sustained success.

In conclusion, Chinese health science parks have had a significant impact on regional innovation and economic development, contributing to the transformation of cities into high-tech hubs and fostering collaborative ecosystems for knowledge exchange. Their success has been influenced by a range of factors, including strategic location, government support, and infrastructure quality. However, challenges such as bureaucratic inefficiencies and the need for a more balanced approach to innovation ecosystem development highlight the complexity of these initiatives. As these parks continue to evolve, addressing these challenges will be key to maximizing their potential and ensuring their continued contribution to regional economic growth and innovation.

Conclusion

The study of Chinese health science parks, as exemplified by the cases considered in this research, provides a nuanced understanding of their evolution, unique characteristics, the factors that attract talent to these parks, and their impact on regional innovation and economic development. These parks offer a comprehensive view of the role these parks play in the broader context of China's economic and scientific landscape. Analysing these aspects provides insights into how these parks align with the Triple Helix model of innovation and their overall success and challenges.

The design of Chinese health science parks has evolved significantly, shifting from basic research-focused facilities to complex ecosystems that integrate research, commercial, and communal spaces. Initially modelled after Western prototypes, these parks have adapted to local needs, resulting in a more integrated approach. This evolution encompasses both spatial organization and functional diversification, with a focus on fostering collaborative environments. For example, parks like BioBay emphasize communal spaces, encouraging interactions among diverse stakeholders. Functionally, these parks have expanded to include business incubation, residential areas, and recreational facilities, recognizing the holistic needs of innovation ecosystems. The Triple Helix model, emphasizing collaboration between academia, industry, and government, is a useful framework for understanding this evolution. In the Chinese context, this model is evident in the strategic collaborations and partnerships fostered within these parks. However, the extent to which this model is applied varies, with some parks showing a more pronounced government role, influencing the dynamics of collaboration and innovation.

Chinese health science parks have several unique characteristics compared to their international counterparts. Their large scale and the government's willingness to provide financial incentives are notable differences. These parks often feature vast, purpose-built facilities, reflecting the government's commitment to fostering innovation hubs. This scale enables a comprehensive range of activities, from advanced research to commercialization, within a single location.

The intentional creation of ecosystems in Chinese health science parks represents a significant departure from the more organic evolution typically observed in Western counterparts. This difference reflects a broader strategic intent and underscores a key aspect of China's approach to fostering innovation in the health sciences sector. This includes factors include their strategic locations, often near major urban centres or academic institutions, state-of-the-art infrastructure, and a strong focus on fostering collaborative ecosystems. However, this heavy reliance on government support and top-down planning can also pose challenges, potentially limiting flexibility and responsiveness to market dynamics.

Attracting talent in a competitive landscape like China involves a multifaceted approach. Chinese health science parks offer state-of-the-art facilities, collaborative environments, competitive compensation, and comprehensive support services. The parks' brand identities as centres of excellence in specific fields also play a crucial role in attracting top-tier professionals. Furthermore, parks like Zhongguancun and Zhangjiang have established themselves as hubs for specific research areas, enhancing their appeal to professionals interested in those fields.

The impact of these parks on regional innovation and economic development is significant. They have catalysed local economies, attracted domestic and international investments, and stimulated the growth of ancillary industries. The concentration of talent and resources within these parks has been pivotal in driving regional economic growth and transforming host cities into innovation hotspots.

Chinese health science parks, while confirming some predictions of the Triple Helix Theory, also present unique models influenced by local contexts and needs. Their evolution from basic research facilities to integrated innovation ecosystems highlights their role in China's broader economic and scientific ambitions. While these parks have been successful in fostering innovation, attracting talent, and stimulating economic growth, they also face challenges related to their heavy reliance on government support and the need for greater flexibility. Balancing the benefits of structured development with the dynamism of organic growth remains a key challenge. In summary, these parks are defining features of China's approach to scientific innovation and economic development, embodying both the successes and challenges of this ambitious endeavour. The implementation of the Triple Helix model in China showcases the the modles' adaptabilty to bridge the gap between the international best practices to unique socio-economic needs in countries like China.

Chapter 8. Implications for Policy and Practice: Lessons Learned from the Development of Health Sciences Parks

The growth of health sciences parks across China has been a significant phenomenon, mirroring the country's rapid economic growth. However, as this research shows, this expansion has reached a juncture where the quality of the parks should become a more prominent consideration for policy makers rather than the continuing proliferation of the parks themselves. With so many health science parks now in operation in China it could be argued that the country has reached a saturation point where new developments effectively dilutes the concept and potentially results in an undifferentiated approach where health sciences parks are replicated in a formulaic way. Against this backdrop, the Triple Helix model of innovation—emphasizing the collaborative interplay between academia, industry, and government—emerges as a critical framework for rethinking the future of health science parks. This model advocates for a synergistic approach to innovation, where each ingredient plays a pivotal role in fostering a conducive environment for research, development, and commercialization.

Strategic differentiation and competitive positioning are essential in health science park development in China. Over two decades of development reveals the importance of a strategic vision that transcends physical infrastructure, focusing on leveraging local strengths and meeting both global and local needs. Interviews with stakeholders from various sectors highlight the risk of merely constructing ecosystems without strategic foundations. Differentiation is key to avoiding redundancy and ensuring each park uniquely addresses market demands. Furthermore, this chapter explores the imperative for an urgent transformation towards differentiation and competitive advantage. The sustainability of health science parks hinges on their ability to adapt and evolve in response to the changing landscape of innovation and technology. This entails a deep understanding of the Triple Helix model's application in varying contexts and recognizing the strategic value of ecosystem creation as part of the broader innovation system. The empirical evidence and case study analysis provide a rich narrative on the necessity of aligning park development strategies with the intricate balance of contributions from academia, industry, and government.

By articulating a forward-looking perspective that emphasizes strategic planning, differentiation, and high-quality development, this chapter aims to contribute to the discourse on optimizing the role and impact of health science parks in China's innovation ecosystem. It positions these parks as more than just physical spaces; they are vibrant hubs of creativity and innovation that play a critical role in the country's economic diversification and technological advancement. Through a comprehensive analysis of empirical evidence and reflective insights from the field, this chapter lays a foundational roadmap for policy making and health science park practice, aiming to navigate the complexities of health science park development in an era of both opportunities and challenges. It underscores the need for a strategic reorientation that prioritizes quality, specialization, and sustainable growth, ensuring that China's health science parks continue to be pivotal in the global innovation landscape.

8.1 Navigating the Crossroads: Strategic Reorientation towards Qualitative Growth in China's Health Science Parks

As this research has shown, the huge growth of health science parks across China has been a notable phenomenon, reflecting the nation’s rapid economic advancement and commitment to innovation. Over the past two and a half decades, these parks have played a pivotal role in China's health science industry ascension. However, the rapid expansion has led to challenges, including duplication of facilities and a lack of differentiation, which can dilute regional competitiveness (Teng et al., 2020). Addressing these issues is crucial as the sector moves towards optimizing its growth and enhancing its global influence in health sciences. The exponential growth of these parks has now reached a critical juncture, necessitating a shift from prioritizing scale and quantity to emphasizing quality and strategic differentiation – the factors shown in this research to be essential determinants of where leading scientists and businesspeople in the sector wish to be located. This saturation raises pivotal questions regarding the overarching strategy of health science parks and the effectiveness of their differentiation within the broader ecosystem of innovation. The scenario underscores the need for a recalibrated approach, focusing on enhancing the intrinsic value and impact of individual parks rather than expanding their number.

Strategic differentiation and competitive positioning become paramount in this context. The lessons learned from the past over two decades of health science park development in China highlight the need for a clear strategic vision that goes beyond the mere physical infrastructure of parks. Stakeholders must leverage local strengths and address inherent challenges to create parks that are not only unique in their specialization but also aligned with both global trends and local needs. An overemphasis on artificially constructing ecosystems without this strategic underpinning has been identified as a significant pitfall. Insights from interviews with a diverse range of stakeholders, including industry experts, government officials, financial investors, entrepreneurs and researchers, underscore the importance of differentiation. This approach is crucial for avoiding redundancy, ensuring that each park can carve out a niche that responds effectively to the dynamics of the global and local markets.

The Triple Helix model of innovation, which fosters a conducive environment for research, development, and commercialization, advocates for a balanced approach where each component—government, academia, and industry—plays a pivotal role (Etzkowitz & Leydesdorff, 2000). In the context of China's political and economic framework, the Triple Helix model's application is uniquely shaped by the dominant role of the government in the development and operation of science parks. The government's dominant role, while pivotal in the rapid establishment and operational scale-up of these parks, now requires recalibration to foster a more balanced innovation ecosystem. This recalibration involves rethinking the direct role of government in innovation processes, positing a scenario where the interaction between industry and academia becomes the primary driver of innovation, without side lining the essential supportive and regulatory role of the government. This perspective underscores a need for a recalibrated approach where, despite the government's overarching presence, the dynamics between industry and academia are not only preserved but also emphasized as critical drivers of innovation (Wang & Zhu, 2018). Such an approach suggests that even within a system characterized by strong governmental control, the essence of the Triple Helix model can be maintained by fostering a conducive environment for industry and academia to collaborate effectively, thereby fuelling innovation (Zhuang & Wu, 2013).

In navigating China's transition from quantity to quality, the strategic positioning of the government within the Triple Helix framework emerges as crucial. Rather than acting as the sole architect of innovation, the government's role evolves towards creating an enabling environment where academia and industry can collaborate more freely and effectively (Zhuang & Wu, 2013). This approach is evident in the evolving landscapes of parks like Zhangjiang China Pharmaceutical Valley ("ZCPV") and Shenzhen Biomedicine Innovation Industrial Park (SBIIP), where private sector management of health science parks introduces a dynamic blend of market-driven innovation and strategic government support. The success stories from these parks highlight the potential of flexible governance structures in stimulating sustainable park development, showcasing the benefits of combining government oversight with private sector efficiency and innovation.

The challenge and opportunity lie in balancing this triadic relationship in a manner that leverages the government's capacity to set strategic directions and provide support while ensuring that the dynamism, creativity, and entrepreneurial spirit of the private sector and academic institutions are not stifled. In this context, the government's role transitions from a direct innovator to a facilitator of innovation, ensuring that the collaborative potential between industry and academia is maximized within the strategic frameworks and policies it establishes. Effective collaboration between government and private entities, clear communication, mutual trust, and alignment of objectives are imperative for the success of this balanced governance approach. Moreover, a robust framework for accountability and performance evaluation is essential to maintain the commitment of all stakeholders to the parks' long-term success. However, the opportunities presented by this transition are vast, offering a pathway to enhance the operational efficiency, innovation capacity, and global competitiveness of China's health science parks. This adaptation of the Triple Helix model in China underscores the importance of re-evaluating traditional roles within innovation ecosystems, especially in political and economic contexts where the government plays a dominant role. It calls for a strategic approach that fosters an environment conducive to innovation, where each helix—industry, academia, and government—contributes optimally towards the collective goal of sustainable economic development and technological advancement.

As China stands at a crossroads in the development of its health science parks, the imperative for a strategic shift towards quality and differentiation is clear. Leveraging the Triple Helix model as a guiding framework, this transition requires a nuanced understanding of the government's role, advocating for a governance model that fosters a vibrant innovation ecosystem. By balancing the strengths of government planning and support with the innovation potential of the private sector and academic institutions, China's health science parks are poised to thrive as competitive innovation clusters. This balanced approach not only contributes to the nation's broader economic and innovation goals but also positions China's health science parks as key players in the global innovation landscape.

8.2 Implications for Policy Making

8.2.1 Evolution of Policymaking in China's Science Parks

Initially, China's science park policies focused on creating basic infrastructural frameworks to attract foreign investment and technology transfer, aligning with the broader economic reform and opening-up policies of the late 20th century (Liu, et al., 2011). Over time, these policies evolved to support high-tech industries explicitly, recognizing the crucial role of R&D activities in driving sustainable economic growth (Liu, et al., 2011). This shift saw the integration of R&D activities within the parks, facilitated by targeted government funding, tax incentives, and streamlined administrative procedures designed to nurture innovation ecosystems. The government's strategic emphasis on cultivating high-tech sectors, such as biotechnology, information technology, and renewable energy, reflects a deliberate policy shift towards leveraging science parks as catalysts for China's transition from a manufacturing-based economy to one led by innovation and high-tech industries. This evolution underscores the dynamic nature of policy development in response to global technological trends and the domestic imperative for economic transformation and competitiveness.

Accordingly, it is pivotal to consider the transition from prioritizing rapid expansion to emphasizing qualitative improvement within China's science parks. This shift necessitates policies that not only foster innovation but also ensure its sustainability, technology transfer, and the commercialization of research. The evolution toward quality over quantity is driven by the recognition that long-term economic growth and global competitiveness are increasingly dependent on the ability to innovate and commercialize new technologies. Thus, policies must be designed to nurture a conducive innovation ecosystem, where collaboration between academia, industry, and government is streamlined, and incentives for R&D are aligned with national development goals. This approach underscores the importance of nurturing an environment where technological advancements can be effectively translated into market-ready solutions, thereby contributing to the broader socio-economic objectives.

8.2.2 Key Policy Areas for Transition

To effectively support China's shift towards prioritizing quality and innovation within its extensive network of science parks, a sophisticated, multi-tiered policy framework is essential. This framework necessitates a clear delineation between national, regional, and park-specific objectives, tailoring strategies to meet the diverse needs of enterprises across the spectrum. National strategies should articulate overarching goals for innovation and sustainable growth, serving as a blueprint for regional and park-level initiatives. Regional policies, in turn, must capitalize on localized strengths, tailoring strategies to regional industrial capabilities and needs. At the science park level, policies should be meticulously designed to offer customized support, including financial incentives and regulatory guidance, directly addressing the unique requirements of resident companies. This granular approach ensures that policies are not only coherent and aligned across different governance levels but also flexible enough to adapt to the specific contexts and ambitions of individual science parks, thereby fostering an environment conducive to innovation and sustainable economic development.

The development of health science parks necessitates policies specifically designed to navigate the sector's distinct challenges and opportunities. This includes a strong emphasis on protecting IP at national level to encourage innovation without the fear of infringement. It's pivotal that policies for the development of health science parks are predicated upon comprehensive background analysis and strategic industry planning. Regionally, these policies need to adapt to leverage local industrial strengths and market demands, guided by strategic planning. At the individual park level, a detailed approach is necessary to foster a nurturing ecosystem. This involves a meticulous assessment of local market demands and the identification of industrial strengths to ensure that policy initiatives are both relevant and supportive of the region's economic landscape. Financial incentives are critical to fuel the initial stages of R&D, which are inherently resource-intensive in the health sciences. Fostering a nurturing ecosystem with robust funding, R&D incentives, and streamlined collaboration across academia, industry, and government is key. Additionally, implementing policies that offer mentorship, improve quality of life, will attract innovative enterprises and talents. Such strategic alignment is crucial for fostering an ecosystem where innovation thrives, directly contributing to the growth and sustainability of health science parks. This approach underscores the necessity of integrating empirical data and forward-thinking strategies in policy formulation to meet the specific needs of the local context effectively. Such a nuanced policy approach is key to nurturing environments that drive high-tech advancements and SME growth, ensuring China's health science parks remain at the forefront of global innovation and sustainable development.

Amid economic challenges, the private equity fund industry, particularly in major economies including the U.S., Europe, and China, is entering a new development phase, crucial for revitalizing the real economy. In 2023, global capital markets saw growth, driven by financial innovation, trade shifts, and post-pandemic recovery. In China, private equity funds have significantly contributed to industrial upgrading, innovation capital formation, and SME development. The shift towards government-guided "fund groups" marks a strategic approach to balance financial returns with industrial growth, highlighting the evolving landscape of investment promotion and industrial transformation. These government-guided funds, supported by diverse funding sources including local financial investments and contributions from significant national agencies, aim to leverage capital for regional industrial development. The evolving strategy indicates a nuanced balance between financial returns and industrial growth, reflecting a complex landscape of investment promotion and industrial transformation.

The prominence of local government funds in the venture capital and IPO sectors, particularly within health science parks, highlights a strategic shift in the financial ecosystem. In recent years, there has been a noticeable scarcity of market-driven funds, prompting a greater reliance on government-backed financial support. This transition enables a more selective and strategic approach to supporting new ventures, aligning closely with broader goals for innovation and economic development. With government backing, there is an opportunity for more targeted policymaking, creating environments that foster technological advancement and economic growth. Moving forward, policies are expected to evolve to further emphasize support for ventures that align with local economic and innovation strategies. This will ensure that resources are efficiently allocated, promoting sustainable development and long-term success for health science parks. These changes underscore the importance of understanding the intricate relationship between financial investment and industrial growth, guiding a more strategic and evidence-based approach to policymaking that supports the objectives of health science parks.

It is imperative that future policymaking for health science parks must be rooted in adaptability and responsiveness to technological changes, integrating the Triple Helix theory to foster innovation through collaboration among academia, industry, and government. This approach should prioritize policies that are inherently adaptable, capable of evolving alongside technological advancements, and foster international collaboration. Such an approach not only facilitates the exchange of ideas and technologies but also contributes to the global competitiveness of health science parks. This dynamic policy landscape encourages continuous learning and adaptation, essential for navigating the complexities of the health sciences sector. By leveraging the Triple Helix framework, policies can facilitate a synergistic interaction that enhances the innovation capacities of health science parks, ensuring they remain at the forefront of scientific and technological breakthroughs. Applying the Triple Helix theory in future policymaking for health science parks involves fostering a collaborative environment where academia, industry, and government work together to support innovation. This model promotes a dynamic ecosystem where shared knowledge and resources accelerate innovation and commercialization. By integrating the strengths of the sector, such policies aim to accelerate the commercialization of scientific discoveries, enhances the parks' innovation capacities, and ensures their competitiveness on a global scale. This approach necessitates clear communication channels, mutual objectives, and shared benefits to sustain effective collaboration and innovation.

In conclusion, the evolution of policymaking in China's science parks reflects a strategic shift towards emphasizing quality and innovation. By fostering environments that encourage the integration of innovation networks, attract high-calibre talent, and support the development of a dynamic community of innovators, China is positioning its science parks as key drivers of its broader innovation agenda. This strategic and quality-focused approach is pivotal for ensuring the continued success and global competitiveness of China's science parks in the ever-evolving landscape of global innovation.

8.3 Lessons Learned for Practice

Transitioning from policy implications to practical applications marks a pivotal phase in the evolution of science parks. This shift from conceptual frameworks to actionable strategies is crucial for operational effectiveness. The insights derived from case studies offer valuable guidance for this transition, highlighting the necessity of translating strategic policies into tangible practices. This approach ensures that health science parks not only benefit from theoretical policy support but also realize practical enhancements in park management, innovation fostering, and economic growth stimulation.

In the landscape of health science parks, the journey from initial isolation of enterprises within these parks to their evolution into collaborative ecosystems marks a critical transition. This transformation, influenced by a blend of national and local policies dedicated to nurturing the health science sector, underscores the importance of transitioning from policy implications to practical applications. Specifically, policies designed to enhance innovation—such as the creation of incubation centres providing mentorship and financial support to startups—have been instrumental in operationalizing these strategic visions. Similarly, policies aimed at economic growth, through mechanisms like industry-academic partnerships for commercializing research, directly link strategic objectives with tangible outcomes in park management, innovation, and economic development. Despite the uniform guidance of national policies, the developmental outcomes of parks vary as illustrated by the cases studies in Chapter 6, highlighting the impact of policy operationalization.

Transforming strategic policies into operational practices within health science parks involves a systematic approach to apply theoretic frameworks and implement policy guidelines. This includes assessing the effectiveness of these policies in promoting innovation, transiting directives into practical, measurable actions, evaluating their impact on park management and economic growth, and identifying areas where theoretical intentions diverge from practical outcomes. A framework for bridging the gap between policy and practice might involve iterative feedback loops, stakeholder engagement, and adaptive management strategies, all supported by empirical research and theoretical models relevant to the field of science park development and management. This process typically includes defining clear objectives, translating high-level strategic goals into specific, actionable initiatives, establishing implementation timelines, allocating resources effectively, and setting up mechanisms for monitoring and evaluation. The mechanics also entail fostering collaborations among academia, industry, and government to leverage their collective strengths, promoting innovation, and addressing the specific needs of health science enterprises. Through this approach, policies are transformed from strategic visions into concrete practices that enhance park management, stimulate innovation, and contribute to economic development.

The necessity for differentiation among the multitude of parks in China has become a paramount concern (Forward, 2019). This differentiation is critical in attracting investment, supporting infrastructure development, and promoting urban harmony. As parks mature, focusing on key industries and core enterprises, they enter a rapid development phase centred on production, evolving from a singular focus to multifunctional relationships that encourage intra-park interaction and mutual transactions among enterprises. Innovation, becoming the central tenet, transforms parks into comprehensive zones that meld economic and social functions, cultivating a community-oriented industrial environment. This progression from isolated operations to a vibrant, multifunctional ecosystem not only optimizes business environments but also emphasizes educational and collaborative opportunities, fostering a culture of creativity and innovation.

Interviewee 6B's insights on the role of local governments in China's science park development further illuminate this evolution, highlighting their significant involvement in policy formulation and the structuring of incentives. These government-guided efforts, aiming to leverage capital for regional industrial development through direct funding and professional asset management, facilitate a coordinated approach to regulatory and financing services, enhancing the efficiency and selectivity of parks like Shenzhen via industry and market led in guiding companies through this complex process.

Drawing from the insights of the cases studied in Chapter 6, this discussion transitions from general operational practices to specific practice findings within health science parks. It underscores the importance of tailoring park development strategies, from architectural innovations to marketing tactics, all aimed at meeting the unique demands of the health sciences sector. By focusing on differentiated development patterns, nuanced business strategies, and targeted industry positioning, these case studies offer a comprehensive view on enhancing operational efficiency and fostering innovation in health science parks.

Park development pattern differentiation

In the evolving landscape of China's park development, a shift towards diversified and strategic development patterns is increasingly evident. The adoption of phased, mixed-use, and industry-specific development strategies has proven pivotal in addressing the diverse needs of tenants and integrating seamlessly with broader community objectives. Emerging parks are pioneering novel approaches in their development strategies, with the "partial sale, partial self-holding" model exemplifying this trend towards distinctive operational differentiation.

BioBay's successful implementation of a phased development strategy illustrates the practical benefits of this approach, highlighting how adaptability to the specifics of each project can foster sustainable growth and innovation within the park. This method allows for incremental expansion, ensuring that infrastructure and services evolve in tandem with the emerging needs of startups and established enterprises alike (Feldman & Audretsch, 1999). By segmenting development into distinct phases, parks can remain responsive to market and technological shifts.

The "partial sale, partial self-holding" model, as exemplified by the Shenzhen Biomedicine Innovation Industrial Park (SBIIP), reflects a trend towards operational differentiation, balancing government involvement with market-driven innovation (Zhuang & Wu, 2013; Tan, 2006). By mitigating the traditionally heavy governmental role, this approach allows industry dynamics to drive growth organically, aligning with the Triple Helix theory's emphasis on collaborative growth (Etzkowitz & Leydesdorff, 2000).

The transition from a 'single-state development model' to mixed-use configurations signifies a transformative approach in urban planning, catering to the complex needs of today's society and economy. Traditionally, urban spaces were delineated into singular functionalities—industrial, residential, or commercial—each operating in isolation. This compartmentalization, while simplistic, increasingly proves inadequate against the backdrop of today's complex socio-economic landscape (Howard, 1898; Hall, 2014). The adoption of mixed-use development, especially within the precincts of science parks, embodies a holistic approach; it seamlessly integrates R&D facilities, production sites, and living quarters. This integrative model not only caters to the dynamic needs of modern enterprises but also fosters a symbiotic environment where innovation thrives amidst a blend of work, life, and recreation. By transcending traditional boundaries, such a model encapsulates a forward-thinking blueprint for urban development, championing versatility and sustainability. This shift acknowledges the multifaceted requirements of today's businesses, responds to the complex needs of contemporary enterprises. However, it also presents legal and practical challenges, especially in jurisdictions like China where land use permissions are strictly regulated and cannot be altered arbitrarily. This adaptive model, while enhancing the functionality and appeal of science parks, necessitates careful navigation of the complexities of policy and regulatory frameworks, heavily reliant on local government support and attitudes.

In the landscape of science park development, the utilization of diverse development patterns stands as a critical strategy, particularly in navigating the challenges of unfamiliar or oversupplied markets. The emphasis on strategic pre-development planning—leveraging competitive advantages, aligning with government initiatives, and considering the maturity of the surrounding area—underscores the importance of differentiation. This approach ensures that parks can not only adapt to but also thrive in their unique environments, fostering innovation and growth in alignment with broader economic and policy objectives (Cooke, 2001).

Business strategy differentiation

To optimize the business strategies for health science parks, a structured approach is pivotal. Initially, the focus should be on fostering innovation through incubation programs that offer startups specialized facilities, mentorship, and crucial resources. Simultaneously, building academic-industry partnerships can significantly promote collaborative research and facilitate the commercialization of innovative solutions. Furthermore, ensuring venture capital access is essential for providing the necessary financial backing to emerging companies within the park. These strategies collectively aim to balance immediate financial returns against the goal of achieving long-term sustainability, addressing the substantial initial investments required. Implementing these strategies, mindful of the park's competitive environment, nurtures a dynamic ecosystem. This fosters growth for health and life sciences ventures, driving innovation and expansion (Löfsten & Lindelöf, 2005).

Differentiating business strategies in health science parks requires an in-depth understanding of market dynamics that are specific to the health and life sciences sector. This entails recognizing the unique needs of startups and established companies within the sector, such as specialized facilities, apace scale, regulatory compliance, and access to funding and partnerships. Tailoring strategies to these needs, while also considering the competitive landscape, allows parks to attract and retain tenants effectively. It involves balancing the park's value offerings against those of competing parks and aligning them with the evolving demands of the health sciences industry. For instance, BioBay in the Yangtze River Delta employs strategic preferential terms to secure early-stage tenancy, strategically positioning itself without competing directly with Shanghai Zhangjiang. In addition to deals to enterprises and personal assistance in relocation, family employment and etcetera, it has one step ahead including planning for manufacturing sites, capturing spillover benefits from Zhangjiang due to cost advantages. Conversely, in less competitive location like Zhongguancun, the park leverages its unique location advantages—proximity to elite universities and regulatory bodies—to justify higher pricing strategies. This balance ensures the park meets both market standards and tenant expectations, showcasing strategic adaptability to the competitive landscape and enhancing the park's overall value proposition.

The strategic differentiation in business practices within health science parks is critical for their success, emphasizing adaptability and market sensitivity. By customizing strategies to meet specific market challenges, these parks can effectively attract and retain tenants, ensuring financial health and promoting an innovative and growth-oriented environment. This approach requires a keen understanding of market trends and the agility to adapt to the fast-paced evolution of the health and life sciences sector. Such adaptability, combined with strategic positioning based on unique advantages, is essential for fostering a thriving ecosystem that supports innovation and contributes to the sector's advancement.

Segmented industry positioning differentiation

In health science parks, strategic segmentation into industries such as biotechnology, pharmaceuticals, medical devices, and digital health is vital for addressing their specific development, regulatory, and market needs. Differentiation within these segments allows parks to tailor their support and infrastructure, enhancing their appeal to both startups and established entities. This tailored approach acknowledges the unique challenges each segmented sector faces, from regulatory compliance to innovation cycles, ensuring that the park's resources are optimally aligned with the requirements and growth trajectories of resident companies, thereby fostering a conducive environment for sector-specific innovation and expansion (United Nations Industrial Development Organization, 2021).

To optimize the strategic positioning of segmented industries within health science parks, a nuanced approach that addresses the distinct requirements and opportunities across sectors such as biotechnology, pharmaceuticals, medical devices, and digital health is essential. This involves not only equipping the parks with specialized infrastructure tailored to each segment—like labs for biotech research and environmental control systems for chemical manufacturing—but also implementing targeted incubation programs for emerging digital health startups. This differentiation extends to specialized requirements even within each segmented sector, such as the distinct infrastructure needed for cell and gene therapies versus small molecule pharmaceuticals or the specific environments conducive to antibody product development, including specialized labs and early discovery facilities with animal housing. Furthermore, aligning with the specific regulatory frameworks and market needs of these sectors enhances the park's capacity to foster innovation and attract investment. An integral part of this strategy includes leveraging the park's location to connect tenants with the right talent pool, whether it's R&D-focused academics from nearby universities or technical staff from local technical colleges for manufacturing. By fostering strategic partnerships with academia and industry and emphasizing regulatory compliance alongside infrastructure and community development, parks can create a vibrant ecosystem that accelerates the growth and advancement of the health sciences sector.

In synthesizing a conclusive perspective on health science parks, it's clear that the strategic differentiation and tailored positioning of segmented industries—spanning biotechnology, pharmaceuticals, medical devices, and digital health—are essential for their thriving success.

These parks enhance their appeal by aligning their unique capabilities with the specific demands of each sector, thereby driving innovation and sectoral growth. The effective use of specialized infrastructure, alongside strategic partnerships and incubation programs, underpins a dynamic ecosystem that nurtures health sciences development. Crucially, leveraging unique strengths, such as local academic and technical talent, not only adds significant value for tenants but also cements the parks' roles as pivotal enablers within the health and life sciences ecosystem. This multifaceted approach ensures that health science parks remain at the forefront of contributing to the advancement and expansion of the sector, embodying key hubs of innovation and growth.

Operating services Differentiation

In recent years, the range and quality of services offered by health science parks have become one of the decisive factors for enterprises when selecting a location. Despite many parks claiming to offer comprehensive services and platforms, research indicates that many are still in the nascent stages of truly understanding and meeting the nuanced needs of tenant companies and tenants (Ratinho & Henriques, 2010). The integration of generic services such as business support, financial advisories, legal, and human resource functions often fall short of providing the substantial aid that enterprises genuinely require (McAdam & McAdam, 2006).

Effective service differentiation in health science parks must hinge on addressing the real and pressing needs of tenant businesses. It focuses on directly meeting the specific needs of tenant businesses, going beyond generic offerings to provide targeted support. Critical financial support mechanisms, such as facilitating access to capital or providing financial relief, can be a lifeline for companies facing liquidity challenges. For instance, for companies facing financial challenges, parks could facilitate access to emergency funds or introduce financial services that offer lower interest rates. Additionally, parks could assist startups in securing market orders by leveraging their network to connect tenants with potential clients. Moreover, offering specialized services such as assistance in navigating policy declarations, talent recruitment, and resource networking can significantly impact the success of SMEs within the park. Assistance in talent recruitment and resource networking further exemplifies how parks can offer meaningful support beyond the basic provision of space. These examples illustrate a move towards creating a more supportive and practical ecosystem for businesses at every stage of their development. Incorporating services that address personal and professional needs of talents is also vital for health science parks. Services like assistance with Chinese Hukou relocation, family employment support, and guidance on children’s education and talent housing can significantly enhance the park's attractiveness to top talents and professionals. Tailoring these services not only aids in recruiting high-level talent but also in retaining them by ensuring their transition and life in the park are seamless and supported. This holistic approach to service provision reflects a deep understanding of the challenges faced by talents moving to new areas for work, making the park a more compelling choice for both domestic and international experts. The interviews underscored that the early service provisions by BioBay notably exemplified effective support for tenant enterprises, setting a distinguished precedent in the sector.

Ultimately, the value of a health science park to its tenants transcends the physical infrastructure, resting significantly on the ability to offer targeted, impactful services that address the specific challenges and opportunities faced by resident companies and talents. By evolving to provide such bespoke assistance, parks not only enhance their appeal to potential tenants but also contribute to the broader ecosystem of innovation and growth within the health sciences sector.

Architectural and Design Differentiation

In the development of health science parks, the thoughtful integration of architectural and design elements is crucial for creating spaces that cater effectively to the diverse operational needs of resident companies. Embracing innovative design features, such as varied household ratios and morphological matching, enhances not only the functionality but also the aesthetic appeal of these parks. This strategic focus on design diversity serves as a cornerstone for building competitive advantages, enabling the accommodation of businesses across a broad spectrum of sizes and types, and promoting an environment ripe for innovation and collaboration (Milburn, 2003).

Implementing differentiated design strategies in health science parks involves creating a range of space configurations to support the diverse lifecycle stages of tenant companies. From compact incubator spaces designed for burgeoning startups to expansive offices tailored for well-established enterprises, these strategic spatial arrangements facilitate seamless growth transitions. Morphological matching extends this concept by aligning the design and layout of facilities with the operational workflows of tenant companies, enhancing efficiency and fostering a strong sense of community. The Cambridge Science Park serves as prime example of parks that successfully implement differentiated design strategies, featuring an array of lab spaces, collaborative zones, and tailored office solutions. Similarly, BioBay has adopted this practice, enhanced its offering and earned recognition for its adaptability and support for businesses at various stages of growth. These parks have reported increased tenant satisfaction and desirability, attributing success to their ability to meet specific needs while cultivating a collaborative ecosystem.

The aesthetic standards of today's parks set a high benchmark for architectural design, especially in mixed-use developments where the interplay between distinct functional areas and landmark structures creates an environment of contrast and harmony (Saxenian, 1996). This is vividly embodied by the by Pingshan where Shenzhen Biomedicine Innovation Industrial Park (SBIIP) located. Leveraging the unique natural features, including Shenzhen’s sole waterfall, city-embedded mountains, and riverside views, Pingshan harmoniously integrates these elements with its iconic theatre designed, crafting a setting that is both tranquil and vibrant for SBIIP. Such architectural distinction not only carves a strong identity for SBIIP but also catalyses innovation through thoughtfully designed communal spaces that encourage interaction. The park's commitment to modern, aesthetically appealing facilities, leveraging natural light and green spaces, significantly enhances talent attraction and investment, while fostering productivity and satisfaction among its occupants.

The significance of strategic differentiation in architectural design is paramount in fostering a vibrant, dynamic health science park. By creating an ecosystem conducive to business growth, these design choices contribute significantly to the park's appeal. Continuous innovation in park design, responsive to evolving tenant needs and market demands, is crucial for maintaining a competitive edge and ensuring the park's long-term viability and success. The implications for science park practice involve balancing innovative development strategies with the constraints of existing legal and policy environments, underscoring the need for flexible and forward-thinking approaches to park development and management.

Marketing differentiation

Marketing differentiation in health science parks involves emphasizing unique features and advantages. This strategy showcases a park's connection to academic institutions, access to capital, and a supportive innovation ecosystem. Focused marketing can highlight the park's regulatory benefits, preferential policies, incentives, and specialized services, effectively communicating the value it offers to the health sciences community. Through such tailored marketing efforts, parks can distinctly position themselves, appealing directly to the needs and aspirations of prospective tenants and investors (Barney, 1991).

In the competitive landscape of health science parks in China, strategic marketing differentiation plays a crucial role in defining a park's appeal and operational success. This approach is not just about highlighting the physical attributes, or the range of services offered; it's about crafting a compelling narrative that resonates with the aspirations and needs of potential tenants and partners—be it startups, established enterprises, or academic institutions. It not only highlights a park's robust connections to academic institutions and capital access but also its supportive ecosystem for innovation. The application of this marketing differentiation is exemplified by the distinct strategies employed by leading science parks in China. Zhangjiang China Pharmaceutical Valley, for instance, benefits from its strategic location within the Zhangjiang Hi-Tech Park, creating a dynamic R&D and startup ecosystem. BioBay utilizes the Suzhou Industrial Park’s unique Sino-Singapore management model to offer an attractive business environment and comprehensive services. Similarly, the Biomedicine Innovation Industrial Park in Shenzhen leverages the city's culture of innovation, coupled with policies that expedite research commercialization. Zhongguancun Life Science Park capitalizes on its proximity to regulatory bodies and top universities, enhancing its competitive edge. The implications of these differentiated marketing strategies for park practice are significant. By effectively communicating a health science park’s unique attribute and aligning with the specific needs and aspirations of targeted tenants and investors, parks can enhance their competitive positioning within the industry. This requires a nuanced understanding of the park's value proposition and the ability to convey this effectively to a diverse audience. Emphasizing a park’s strategic advantages, from infrastructure to ecosystem support, is key to attracting high-calibre tenants and fostering a vibrant community that supports both innovation and quality of life. In practice, these insights suggest that health science parks must continually innovate their marketing approaches to reflect their unique strengths and the evolving needs of the health sciences sector. In crafting marketing strategies for health science parks in China, it's essential to adopt a viewpoint that resonates with the needs and aspirations of potential occupants, diverging from merely echoing local government objectives (Lyu, et al., 2017).

In conclusion, the practice of marketing differentiation in health science parks is a dynamic and multifaceted challenge that requires a deep understanding of the target audience, a clear articulation of the park's unique value proposition, and a strategic approach to communication and engagement. By effectively differentiating themselves, parks can not only attract but also retain a diverse and vibrant community of tenants, thereby ensuring their long-term success and contribution to the broader health and life sciences ecosystem. This strategic marketing approach, when aligned with the park's operational strategies and broader economic objectives, can significantly enhance the park's competitive edge, drive innovation, and foster sustainable growth within the health sciences sector.

The exploration of health science park practices in China, underscored by case studies, reveals a critical emphasis on differentiation as a foundational pillar for success in an increasingly competitive landscape. Through strategic diversification in development patterns, astute business strategies, precise segmentation of industries, innovative operating services, and targeted marketing efforts, parks can distinctly position themselves to meet the nuanced demands of their tenants and the broader industry. This comprehensive approach not only caters to the specific needs of startups and established enterprises within the health and life sciences sector but also fosters a conducive environment for innovation, collaboration, and growth. The lessons learned and strategies employed, from leveraging unique architectural designs to tailoring services and infrastructure, illuminate the path forward for health science parks. By embracing these differentiated practices, parks can enhance their appeal, drive innovation, and contribute significantly to the sector's advancement, thereby ensuring their relevance, competitiveness, and sustainability in the dynamic landscape of health science innovation.

Chapter 9. Conclusion

In Western discourse, China is often associated with centralized governance and substantial government control. Consequently, national-level health sciences parks in China might be perceived as products of extensive government intervention, potentially dampening innovation or disrupting the balance within the Triple Helix model, which emphasizes the synergistic collaboration of academia, industry, and government. However, a comprehensive examination of China's health sciences parks reveals a more nuanced reality. The preceding chapters have meticulously analysed these parks' development, operational dynamics, and strategic significance within the Chinese context. This concluding chapter synthesizes the key findings from this research, discusses their implications for policy and practice, and offers recommendations for future research. It highlights the evolving interplay between government, industry, and academia in driving innovation and growth within health sciences parks, revealing the complexities and adaptations that characterize the Chinese model of innovation.

9.1 Synthesis of Key Findings

Health sciences parks have emerged as pivotal ecosystems for fostering innovation, facilitating knowledge transfer, and driving economic development within the health sciences sector. The case studies presented in Chapter 6 showcase a range of models, from well-established to emerging parks, and from various regions of China, including both developed and developing areas. These case studies highlight the diverse approaches and challenges faced by these parks, underscoring the importance of strategic planning, government support, and the collaborative efforts of academia, industry, and government within the Triple Helix framework. The application of the Triple Helix model—integrating academia, industry, and government—varies significantly across these parks, shaped by regional economic conditions, levels of industry development, and local industrial chains. Additionally, the historical and academic strengths of local universities and student demographics contribute to these variations. Crucially, the vision and governance capabilities of local governments, along with their receptiveness to economic and political reforms, play a pivotal role in shaping the implementation of central policies and the overall success of health sciences parks.

9.2 Implications for Policy and Practice

The evolution of policymaking in China's science parks has progressed from a focus on basic infrastructure and foreign investment attraction to a more nuanced emphasis on nurturing high-tech industries and innovation. This shift highlights the continued relevance of the Triple Helix model, which underpins the development of science parks even in government-led contexts like China. Notable examples, such as the Shenzhen Biomedicine Innovation Industrial Park (SBIIP) and BioBay, demonstrate how effective government involvement can enhance the Triple Helix model, overcoming challenges such as limited business clustering and academic strength. Key to achieving successful outcomes are several factors. First, a clear strategic vision and sustained government support are vital, including policies that promote R&D investment, offer incentives for startups, and facilitate cross-sector collaboration.

Second, health sciences parks must adapt to rapidly evolving technologies and market demands, requiring flexible regulatory frameworks, continuous learning, and innovative management practices. Lastly, fostering a culture of collaboration and knowledge sharing through networking events, joint projects, and shared facilities is essential. Future policies should integrate the Triple Helix model, emphasizing the collaborative efforts of academia, industry, and government to cultivate a dynamic and globally competitive innovation ecosystem.

9.3 Directions for Future Research

While this research has shed light on the significant role of health sciences parks in innovation ecosystems, there are several avenues for future research. Further studies could explore the long-term impacts of these parks on regional economic development, healthcare outcomes, and global health innovation. Comparative studies between health sciences parks in different countries could provide deeper insights into the factors contributing to their success or failure. Additionally, research into the environmental sustainability of health sciences parks and their role in promoting green technologies in the health sector would be valuable. Additionally, the current qualitative research framework presents an opportunity for expansion into quantitative analyses. Future studies could employ and refine existing methodologies such as DEA-Malmquist index to develop the innovation efficiency matrix alongside comprehensive quantitative models for evaluating the success of parks. This quantitative approach would enable a more detailed and measurable understanding of the factors contributing to the efficiency and effectiveness of health sciences parks, providing a robust foundation for comparative analysis and policy development.

9.4 Final Thoughts

Health sciences parks stand at the intersection of science, industry, and policy, playing a pivotal role in advancing health innovation and economic development. The experiences of China's health sciences parks, as detailed in this study, offer both inspiration and cautionary tales for the development of similar parks worldwide. As the global health landscape continues to evolve, the lessons learned from these parks will be invaluable for shaping the future of innovation in the health sciences sector. In conclusion, health sciences parks are not just physical spaces but ecosystems that require strategic nurturing, dynamic leadership, and a collaborative spirit to thrive and contribute to the broader goals of societal health and economic prosperity.

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