HIDDEN SYNERGY: HONG KONG'S ROLE IN THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN CHINESE HIGHER EDUCATION

A PREPRINT

Yisu Zhou
Faculty of Education
University of Macau
Macao SAR, China
yisu.zhou@gmail.com

Yang Shen
Faculty of Education
University of Macau
Macao SAR, China
yc47113@connect.um.edu.mo

Xinyue Yao
Faculty of Education
University of Macau
Macao SAR, China
yc47103@connect.um.edu.mo

November 1, 2024

ABSTRACT

This paper examines the rapid growth of China's science and technology (S&T) sector within the broader context of higher education, focusing on the often-overlooked role of Hong Kong in this transformation. While conventional explanations emphasize China's relationship with the United States, this study argues that Hong Kong has played a crucial, yet underappreciated, role in advancing China's higher education and S&T capabilities. Despite its reputation as a finance-driven city, Hong Kong has developed a robust academic and scientific community that fostered close collaborations with mainland institutions. In the 1990s, as Hong Kong's research doctoral programs were gaining momentum, mainland students sought high-quality advanced training, and members of the overseas Chinese academic diaspora returned to join Hong Kong universities. This cross-border collaboration thrived despite cultural and ideological differences, combining the mainland's motivated talent pool with Hong Kong's free academic environment. Using a comprehensive dataset from the Web of Science, institutional archives, university leader biographies, and PhD dissertation records from Hong Kong's top universities, this paper provides both quantitative and qualitative analyses of the historical collaboration between Hong Kong and mainland China. The findings reveal that this relationship was evolutionary, initiated by forward-thinking educators long before formal mechanisms were in place, and was instrumental in China's rise to global prominence in higher education and S&T. By revisiting this underexplored dimension of China's educational development, this paper offers a new understanding of the forces behind the country's remarkable achievements in higher education and scientific research.

Keywords higher education development • science and technology • Hong Kong • mainland China • organizational learning

1 Introduction

How did China achieve such remarkable growth in science and technology over the past two decades? A common explanation points to the rapid expansion of its research university system, which produces an impressive number of graduates and research outputs (D. F. Simon and Cao 2009). Visitors to China often marvel at how modern and expansive these institutions have become (Rhoads et al. 2014). Notably, this transformation began in 1999 (Hayhoe and Zha 2005), and in just over two decades, the higher education system has grown to include 47 million students, with several Chinese universities now ranked among the world's top institutions. On the research front, China was once a relatively marginal player, but since 2000, its growth in research output has been nothing short of extraordinary (P. Zhou and Leydesdorff 2006). By 2018, China surpassed the United States as the leading producer of research papers, according to Web of Science data (Tollefson 2018). More importantly, it has excelled not only in quantity but also in

quality: China overtook the U.S. in producing top-cited scientific papers in 2019 (Wagner, Zhang, and Leydesdorff 2022).

The institutional growth is equally impressive. According to *Nature* magazine's institutional index, which tracks output in highly selective scientific journals, only four Chinese institutions ranked among the global top 30 in 2016. By 2024, that number had risen to 13, with 7 Chinese institutions ranked in the global top 10 (The Economist 2024). This rapid rise prompts an important question: How did China achieve such scientific and educational prominence in such a short period?

This paper seeks to provide a fresh historical analysis to address this puzzle. While conventional explanations often highlight the relationship between China and the United States (i.e. Crow (2022); Hao and Hua (2023)), we argue that a critical, yet overlooked, player in China's rise in science and technology is Hong Kong. This perspective brings to light an underappreciated dimension of China's higher education and S&T development.

At first glance, the suggestion that Hong Kong played a vital role in China's scientific rise might seem counterintuitive. Commentators such as Cornell's Eswar Prasad have argued that Hong Kong's traditional role as an intermediary—providing trade routes and capital market access to Chinese firms—is no longer crucial (Prasad 2019). In the context of modern finance and trade, Prasad suggests, China no longer needs Hong Kong's services. However, this analysis overlooks Hong Kong's continuing influence in the domains of higher education and S&T, where it has served as a key source of intellectual and scientific dynamism for China. Contrary to the belief that Hong Kong lacks scientific influence, the city has maintained robust and innovative ties with mainland China, particularly in S&T.

Despite its reputation as a finance-driven, business-oriented city, Hong Kong has quietly fostered a strong academic and scientific community, especially in collaboration with mainland institutions (Woo 2007). Although careers in science are not commonly aspired to in Hong Kong, and the city's scientific sector pales in comparison to its booming finance and legal industries, the region's universities have played a pivotal role in nurturing the development of China's S&T capacity.

Over the years, Hong Kong's scientific community has cultivated close ties with mainland counterparts, particularly in Guangdong, Jiangsu, Zhejiang, Shanghai, and Beijing. Hong Kong's relative autonomy, academic freedom, and generous support for research have made it an attractive hub for mainland students and scholars, creating a fertile ground for intellectual exchange and collaboration. This paper builds on Postiglione (2005)'s earlier claim of Hong Kong's bridging role between mainland China and Western academia, strengthening this argument with newer and more granular data

This paper argues that the historical collaboration between Hong Kong and mainland China has been a crucial, yet underappreciated, driver of China's higher education and scientific success. Existing accounts of China's educational rise often rely heavily on interviews or official statistics, but these explanations tend to overlook the long-term historical trends that have shaped both Hong Kong's and the mainland's educational landscapes. By focusing on the historical evolution of this cross-border academic relationship, we aim to provide a more comprehensive understanding of China's development in science and technology.

We propose that this historical process is evolutionary in nature, guided by forward-thinking educators who envisioned a mutually beneficial relationship long before formal mechanisms for collaboration were in place. Despite the absence of formal agreements for student mobility or funding mechanisms in the early stages, educational leaders from both Hong Kong and the mainland spearheaded a collaborative effort that has since flourished. This relationship emerged during a unique period in the 1990s, when Hong Kong's research doctoral programs were just beginning to gain momentum, mainland students were actively seeking high-quality opportunities for advanced training, and members of the overseas Chinese diaspora in S&T, who had established themselves in academia, chose to join Hong Kong universities, further nurturing the influx of talented students.

The collaboration between Hong Kong and mainland China succeeded despite ideological and cultural differences Shaw (2013). When Hong Kong's research programs gained momentum in the 1990s, even before the handover, they welcomed mainland students with open arms. This partnership created a dynamic network that combined the strengths of both regions: the mainland's steady supply of motivated and well-prepared young talent, and Hong Kong's free academic environment and generous scholarship, which allowed these students to thrive. The result was a mutually reinforcing system of academic exchange that contributed significantly to China's rapid rise in science and technology.

2 Literature Review and Theoretical framework

The development of the higher education sector has been the subject of extensive research, analyzed from a variety of perspectives. However, much of the scholarship falls into two broad camps: structuralist and culturalist approaches. While each offers valuable insights, both perspectives risk simplifying the complex dynamics at play in the evolution

of China's higher education system. Our theoretical departure seeks to go beyond these views by examining the role of organizational capacity and institutional agency, specifically how actors within China's universities engage in strategic decision-making, experimentation, and learning.

2.1 The Structuralist Perspective

The structuralist perspective emphasizes external, systemic forces that shape the actions and growth of universities. In the Chinese context, this framework highlights the influence of government directives, global competition, and institutional environments as key drivers behind the rapid development of the S&T sectors. Scholars like Rhoads et al. (2014) argue that Chinese universities were transformed through four simultaneous strategies: focusing on entrepreneurship, fostering international collaborations, recruiting overseas talent, and heavily investing in research capacity via initiatives like Projects 985 and 211.

From this perspective, Chinese universities appear as passive entities, responding to external pressures such as global competition or state-led initiatives. Programs like Project 985 are seen as critical to China's rise in global rankings, with state investment as the principal driver of growth. Similarly, the structuralist view emphasizes the role of internationalization, where Chinese universities formed joint-venture campuses, recruited foreign faculty, and built global partnerships in response to competitive pressures.

However, this narrative, while useful, presents a somewhat deterministic view of institutional development. It assumes a linear relationship between external pressures and institutional responses, overlooking the active role universities play in shaping their own trajectories. For instance, Jin and Horta (2018) show that even within the same university, different schools adopt diverse strategies for internationalization, reflecting internal negotiations and unique organizational cultures.

Thus, while the structuralist approach effectively highlights how Chinese universities responded to systemic pressures, it does not account for the internal dynamics and contradictions that complicate this narrative. Universities are not simply shaped by external forces but are sites of complex interactions among various stakeholders, each negotiating their own interests and goals. This becomes particularly evident when we consider the internal conflicts that emerged as managerial reforms clashed with traditional academic values (Wang and Jones 2021).

2.2 The Culturalist Perspective

In contrast to the structuralist approach, the culturalist perspective emphasizes the importance of historical legacies and cultural traditions in shaping the development of China's higher education system. Scholars in this camp, such as Yang Rui, argue that Chinese universities have long prioritized serving national goals while pursuing global competitiveness in research and innovation (R. Yang 2022). From this viewpoint, the development of Chinese higher education reflects a blending of Western models with indigenous cultural values, particularly Confucian principles of education and statecraft.

While the culturalist perspective offers a compelling narrative of how Chinese universities integrate historical traditions with modern practices, it risks overlooking the material realities and global pressures that influence the development of science and technology sectors. For instance, while Yang Rui emphasizes cultural synthesis, this focus can obscure the real challenges Chinese universities face in building competitive S&T capacities in a highly unequal global landscape. Where, for example, does the foundational knowledge for disciplines like quantum physics, which have no cultural antecedents in Confucian tradition, originate?

Moreover, the culturalist argument, much like the *Tianxia* concept used by some later scholars (L. Yang, Marginson, and Xu 2024), tends to selectively highlight successes while ignoring the persistent inequalities and fragmentation within the global higher education system. While the blending of cultural traditions may contribute to the distinctiveness of Chinese universities, it does not fully explain how they navigate the global competition for resources, talent, and research collaborations.

Thus, while the culturalist perspective provides a valuable lens for understanding the historical and intellectual context of Chinese higher education, it too offers a limited view. The emphasis on cultural factors underplays the political, economic, and infrastructural challenges that are equally critical to the development of China's S&T sectors.

2.3 Evolutionary Institutionalism in Higher Education

This study applies evolutionary institutionalism to analyze the development of China's higher education sector, particularly in science and technology (S&T). Rooted in evolutionary economics, this approach views economic and institutional changes as dynamic, iterative processes characterized by continuous adaptation and experimentation. Evolutionary economists argue that such change cannot be fully understood without recognizing the roles of innovation, learning, and contingency in shaping long-term outcomes.

In this context, the development of Chinese higher education mirrors evolutionary principles of "variation and selection," where diverse strategies are continually tested, some institutions gain prominence, while others may stagnate. This dynamic leads to the gradual and adaptive emergence of more effective institutional structures and practices. Chinese universities and research institutions, through the mechanisms of trial and error, are adapting to both internal pressures (e.g., talent cultivation and resource allocation) and external demands (e.g., international competition and policy shifts) over time. This perspective highlights that outcomes of these efforts often deviate from initial plans, reflecting a common theme in evolutionary theory: unpredictability in achieving new organizational forms and practices.

Furthermore, evolutionary institutionalism stresses *institutional heterogeneity and selective adaptation*, capturing the reality that China's higher education landscape is neither monolithic nor uniformly successful. Instead, institutions vary in capacity, approach, and impact, a phenomenon intensified by local demands and regional conditions. For instance, while leading institutions like Peking University and Tsinghua University have successfully navigated global competition and innovation, others remain peripheral, reinforcing the evolutionary concept that only certain institutional forms thrive under specific conditions.

This framework also acknowledges the significant role of *institutional agency and feedback loops*, wherein universities act not merely as passive recipients of state-led reforms but as active participants in their developmental trajectories. Through these feedback loops, universities adjust to policy directives and market conditions by integrating or disregarding specific practices. Over time, these adaptive responses contribute to a complex, self-reinforcing ecosystem in which higher education institutions continuously evolve, sometimes creating entirely new pathways distinct from traditional or Western models.

In sum, by viewing China's higher education sector through the lens of evolutionary institutionalism, we can better understand its development as a dynamic, adaptive process that is deeply influenced by institutional diversity, selective adaptation, and the continual, often unpredictable, interplay of endogenous and exogenous factors.

2.4 China-Hong Kong Collaboration: A Case of evolutionary institutionalism

A key case of this evolutionary institutionalism the collaboration between mainland Chinese universities and those in Hong Kong. During the 1980s, as Chinese universities sought to modernize, they recognized Hong Kong's rapidly developing higher education sector as a potential model for collaboration. Hong Kong, with its more established infrastructure and international connections, became an essential partner in helping China build its S&T capacities. This collaboration involved the exchange of talent, resources, and knowledge, creating a virtuous cycle of "brain circulation" that benefitted both sides.

By the 2000s, this relationship had evolved into a well-established network of academic exchange, with Chinese universities sending their best students to Hong Kong for advanced training and research. Many of these students returned to China, bringing with them the expertise and international experience necessary to elevate China's higher education system. This dynamic illustrates how Chinese universities did not simply imitate Western models but adapted with new practices to suit their local contexts, demonstrating a capacity for organizational learning and innovation.

This paper argues that China's collaboration with Hong Kong offers a clear example of how institutional actors, through strategic partnerships and pragmatic learning, have played an active role in shaping the development of the country's S&T sectors. Moving beyond structuralist and culturalist explanations, this approach highlights the agency of universities as active participants in their own evolution.

In the following sections, we present our data and methods, followed by an analysis and discussion. This paper uses four data sources: bibliographic data from the Web of Science (WoS); PhD dissertation data from three universities in Hong Kong; biographies of university leaders; and university archives from these same universities. By combining these sources, we provide a comprehensive view of the science and technology sector's development within the Chinese higher education system.

3 Data and Method

3.1 Data collection

To systematically evaluate the role of Hong Kong, we collected a large-scale bibliographic dataset from multiple sources, including the Web of Science (WoS) and university libraries, along with textual data from different university archives. All data were preprocessed using `pandas 2.2.2` in `Python 3.10.15` and subsequently analyzed and visualized with `R 4.4.1`.

This study specifically utilizes bibliographic data from WoS to uncover the dynamics of scientific collaboration between Hong Kong and Mainland China. We focused on publications affiliated with the top three universities in Hong Kong: The University of Hong Kong (HKU), Chinese University of Hong Kong (CUHK), and Hong Kong University of Science and Technology (HKUST).

To ensure the relevance of our data to the S&T sector, we restricted our search to publications in SCI-E journals. Within this category, we selected five types of publications: articles, review articles, proceeding papers, letters, and early access articles[1]. This approach yielded a total of 203,393 results as of October 14, 2024.

We focused on several key aspects of the metadata collected from the Web of Science (WoS): basic publication information (title, author, year of publication, and disciplinary areas), citation information (times cited), geographic information (authors' affiliations), and sources of funding. This comprehensive dataset serves as the foundation for analyzing the collaboration dynamics between Hong Kong and Mainland China in the context of science and technology development.

Additionally, we collected PhD dissertation data from the library websites of HKU, CUHK, and HKUST. The dissertation data deepens our understanding of the scale of higher education and the academic output in Hong Kong before and after its connection with the mainland. The dataset includes dissertation titles, authors' names, their faculties, years of completion, and disciplinary categorizations.

Finally, to capture historical events with regard to three universities, we downloaded annual reports from the university archives. This large-scale qualitative data complements our quantitative findings, providing a richer context for each institution. We also include biographical data from key educational leaders. Together, these datasets create a comprehensive framework for analyzing the collaboration dynamics and developmental trends within the region's academic landscape.

3.2 Methodologies

All bibliographical data for our analysis was directly subsetted from the collected WoS metadata, except for geographic information, which was extracted from authors' addresses using text mining techniques.[2] We also exclude, from the dissertation dataset, works from non-S&T departments[3].

We calculated the number of publications by year to assess the research capacity of the selected institutions annually and compared publication counts across institutions. The dissertation dataset was utilized to compute the scale of PhD education, as a higher number of PhD students correlates with increased dissertation output. We also mapped the countries or regions of collaboration partners associated with the three selected universities in Hong Kong to examine changes in collaboration over time.

To understand the collaborative relationships between Hong Kong and mainland institutions, we sample 25 top-ranked institutions in Mainland China based on the Nature Index 2024. Beyond institution-to-institution level collaboration, we further calculated the collaboration between Hong Kong and Chinese mainland provinces by year, revealing the dynamics of collaboration between Hong Kong and different regions in China.

Table 1 lists the number of publications for the universities we selected.

[1]The initial analysis includes all five types of publications. We added two additional types to the three used by Wagner, Zhang, and Leydesdorff (2022): conference proceedings and early-access research papers. Since we are not studying citation counts but rather production volume, including these two types will not inflate our numbers and allows for a more inclusive view of research output.

[2]To process location and geographic information, author addresses from the Web of Science data were first divided according to their specific comma-separated format. Each address was split into multiple columns to capture details such as room number, street, city, and country or region. After segmenting the data, we applied a mapping chart to link each city to its corresponding province. For addresses containing typographical errors, we manually identified and corrected them by examining similarities in spelling or structure, ensuring greater accuracy in the dataset. Given our primary focus on collaboration between Hong Kong and Mainland China, we adhered to WoS's definition of inter-regional collaboration—where a paper with at least two authors from different regions indicates collaboration. This approach allowed us to narrow the dataset to include only publications involving researchers from both Hong Kong and Mainland China, highlighting the collaborative dynamics between these regions.

[3]To classify the dissertations into Science and Technology (S&T) and non-S&T categories, we primarily used the faculty affiliation of each dissertation. This approach aligns with established institutional norms, where faculties such as engineering, computer science, and physical sciences are associated with S&T fields, while faculties like Chinese, arts, humanities, and social sciences fall under non-S&T. In cases of ambiguity, particularly with recent interdisciplinary programs, we cross-referenced departmental charters and institutional directories to ensure accurate classification. Additionally, we adhered to the UNESCO nomenclature (see #tbl-nomenclature-st and #tbl-nomenclature-non-st in Appendix A) for fields of science and technology(UNESCO 1988), further validating our faculty-based classification. For departments that straddled both categories, we conducted a manual review of the universities' archives to avoid misclassification, ensuring a rigorous and systematic approach to distinguishing between S&T and non-S&T fields.

Table 1: Number of publications for the selected 28 universities

Affiliation	Location	Number of Publications
The University of Hong Kong	Hong Kong	87,592
Chinese University of Hong Kong	Hong Kong	72,959
Hong Kong University of Science and Technology	Hong Kong	42,842
Sun Yat-sen University	Southern China	141,227
Southern University of Science and Technology	Southern China	28,977
South China University of Technology	Southern China	75,758
Shenzhen University	Southern China	47,476
University of Science and Technology of China	Eastern & Central China	123,321
Zhejiang University	Eastern & Central China	211,933
Nanjing University	Eastern & Central China	114,586
Shanghai Jiao Tong University	Eastern & Central China	204,505
Fudan University	Eastern & Central China	144,022
Huazhong University of Science and Technology	Eastern & Central China	130,823
Wuhan University	Eastern & Central China	101,026
Xiamen University	Eastern & Central China	62,671
Central South University	Eastern & Central China	119,587
University of Chinese Academy of Science	Northern China	259,903
Peking University	Northern China	177,071
Tsinghua University	Northern China	179,901
Nankai University	Northern China	62,008
Shandong University	Northern China	120,719
Jilin University	Northern China	108,973
Harbin Institute of Technology	Northern China	108,557
Zhengzhou University	Northern China	76,916
Chinese Academy of Science	Northern China	941,180
Sichuan University	Western China	135,254
Xi'an Jiaotong University	Western China	114,352
Lanzhou University	Western China	59,131

In summary, this study employs a comprehensive dataset derived from bibliographic records, PhD dissertations, biographical data, and annual reports to explore the collaboration dynamics between Hong Kong and Mainland China in the S&T sector. By analyzing bibliographic and dissertation data, alongside targeted qualitative data from university archives, we assess publication trends, research capacity, and collaborative patterns over time. Our methodological approach highlights the active role of academic institutions in Hong Kong and Mainland China, providing a new understanding of their evolving relationships within the context of China's rapid development of S&T sector in higher education system. In the following section, we present our analysis based on the aforementioned data.

4 Analysis

4.1 Collaborations in Science and Technology between Hong Kong and Chinese mainland

4.1.1 Key Collaboration Locations for Mainland Universities

How important is Hong Kong to mainland China's research landscape? The answer is clear from the WoS data, which covers the most comprehensive records from 1980 to the present. Collaboration between regions is significant. The United States remains by far the most crucial S&T partner for mainland Chinese institutions, as shown by the grey line with the steepest upward trajectory in the figures below. This pattern holds for each mainland institution we examined. Overall, China-U.S. collaboration accounts for 8.84%, rising to 21.07% among highly cited papers. Hong Kong ranks as the third most significant collaborator, contributing 2.15%, just after China-Great Britain collaborations.[4]

The data becomes more revealing from an institutional perspective. As shown in Figure 1, Figure 2, and Figure 3, the U.S. is the top collaborator for three of China's most decorated research institutions: the Chinese Academy of Sciences, Shanghai Jiaotong University, and Sun Yat-sen University. This pattern holds across the 25-institution sample.

[4]Due to the complex methods employed by the WoS to determine the location of each paper, including whether they are affiliated with Hong Kong, we cannot provide an accurate count within the time constraints. The percentage presented here is an estimate based on the collaboration rates between HKU, CUHK, and HKUST and their mainland counterparts, derived from the data we collected from WoS.

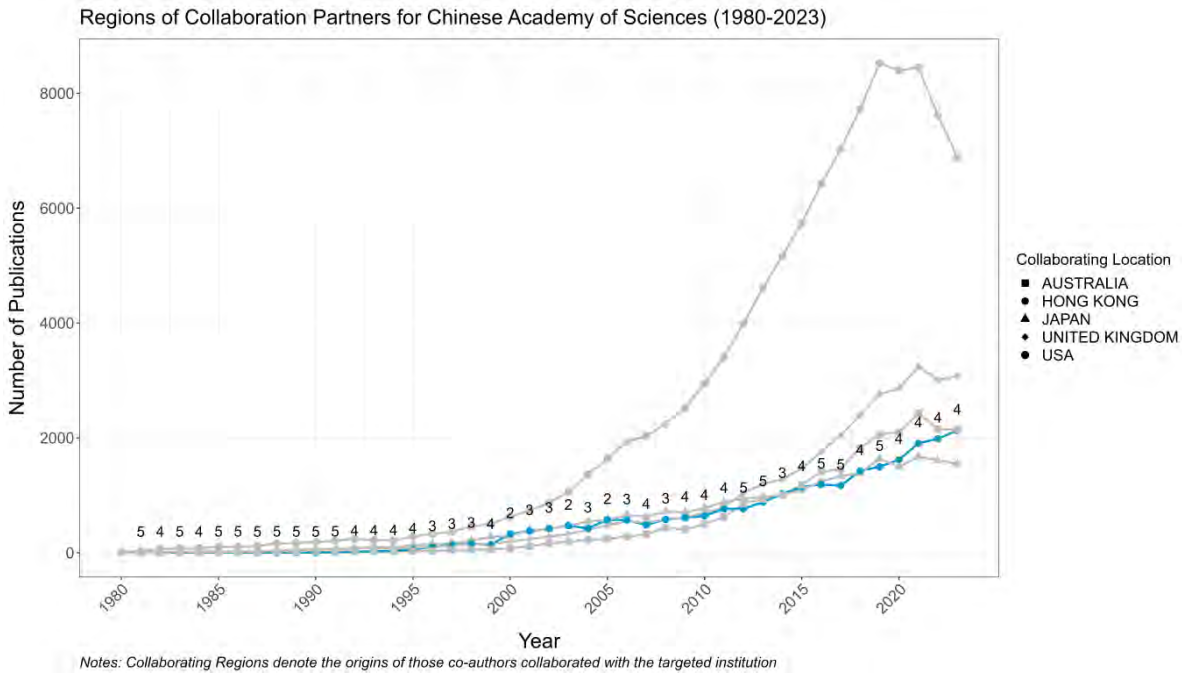

Figure 1: Regions of collaboration partners for Chinese Academy of Sciences (1980-2023)

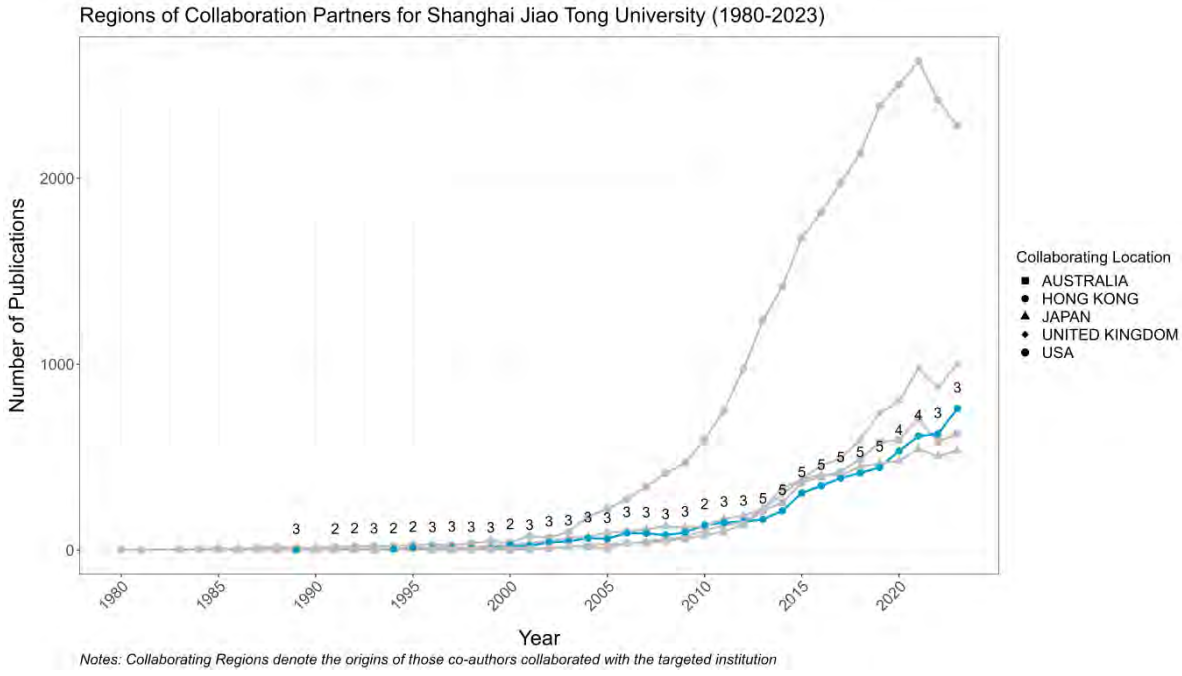

Figure 2: Regions of collaboration partners for Shanghai Jiao Tong University (1980-2023)

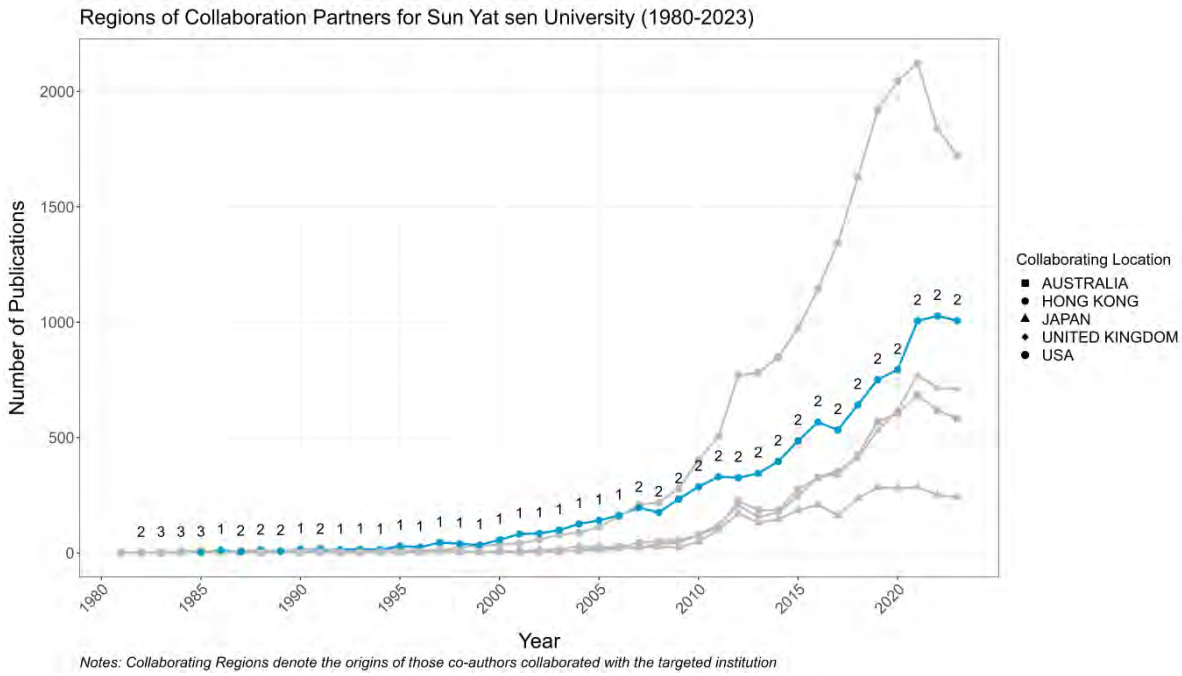

Figure 3: Regions of collaboration partners for Sun Yat-sen University (1980-2023)

A closer analysis reveals that Hong Kong has emerged as a key collaborator for many of China's top institutions, consistently ranking among their top three partners over time. For universities in Guangdong—such as *Sun Yat-sen University*, *Shenzhen University*, *Southern University of Science and Technology*, and *South China University of Technology*—Hong Kong is typically the first or second most frequent collaborator. This partnership was especially strong from 1995 to 2015. For institutions outside Guangdong, Hong Kong generally ranks between second and fourth, depending on the year.

However, the collaborative relationship between Hong Kong and mainland institutions varies significantly. Two main patterns stand out: spatial proximity and temporal trends.

In terms of spatial proximity, institutions closer to Hong Kong (particularly those in Guangdong) have higher collaboration frequencies. This frequency tends to decrease as geographical distance from Hong Kong increases. Yet, despite the distance, major centers like Beijing and Shanghai maintain strong collaborative links with Hong Kong.

As shown in Figure 3, from 1990 to 2010, Hong Kong was the second most frequent collaborator for *Sun Yat-sen University*. For more distant institutions, such as Zhengzhou University, Wuhan University, and Lanzhou University—each recognized for their strength in S&T—Hong Kong ranks as the third or fourth most frequent partner. This trend underscores the influence of physical distance on collaboration intensity.

For temporal trends, Hong Kong's prominence in S&T collaboration has varied over time. Prior to 1995, collaboration with mainland institutions was minimal. The mid-1990s marked a turning point, with Hong Kong soon rising to number 2 or 3 as a collaborative partner for most institutions in our sample. This pattern persisted into the mid-2010s when Hong Kong's relative rank declined, not due to reduced collaboration, but because mainland China's partnerships with other regional players sharply increased.

4.1.2 Key Collaboration Locations for Hong Kong Universities

Building on the previous analysis, a key question arises: is the partnership between Hong Kong and mainland institutions unidimensional? Specifically, do mainland institutions mainly play a supporting role in their scientific collaborations with Hong Kong, or do they hold a more central, reciprocal position?

The answer is that this partnership is far from unidimensional. For Hong Kong universities, collaboration with mainland institutions is not only reciprocal but, in many cases, primary. Mainland universities have become some of the top contributors to Hong Kong's research output, forming a cornerstone of Hong Kong's international collaborations. As illustrated in Figure 5, Figure 6, and Figure 7, which show the top international collaborators for the University of Hong Kong, the Chinese University of Hong Kong, and the Hong Kong University of Science and Technology respec-

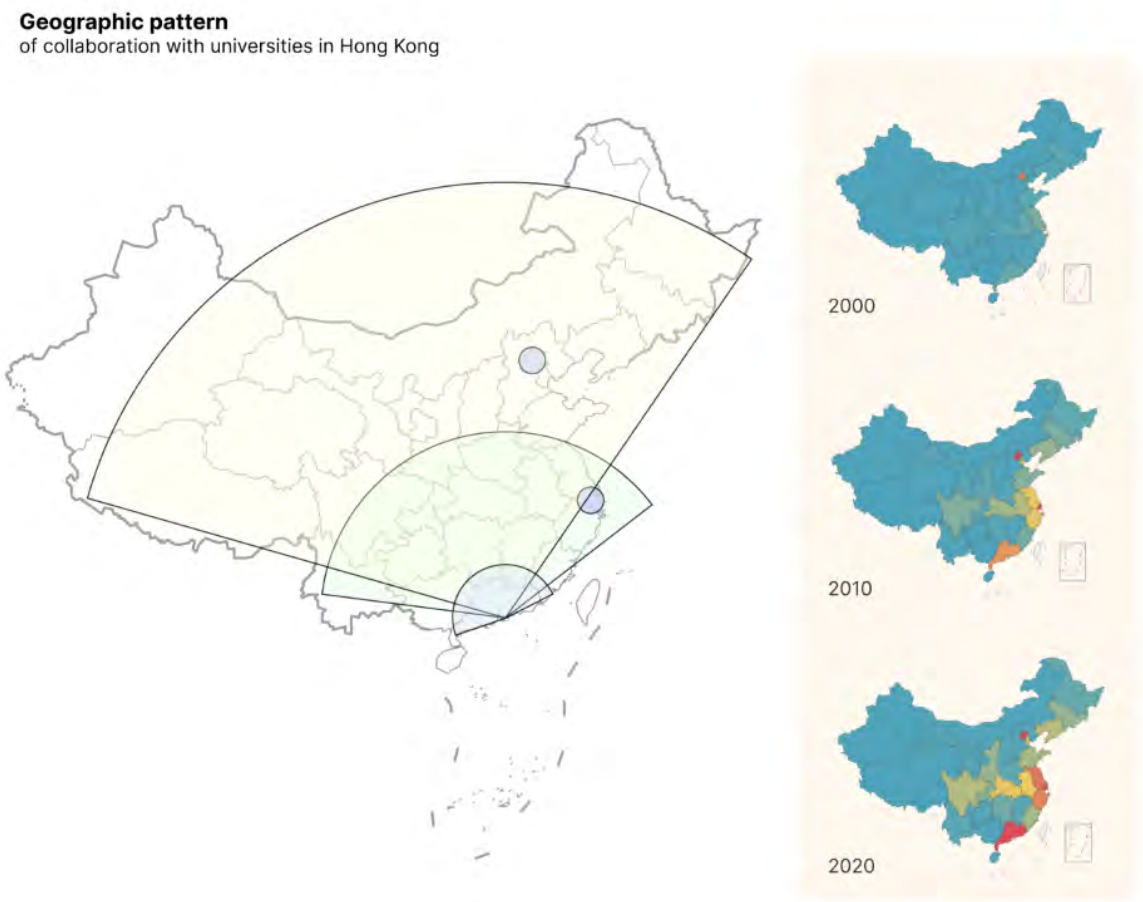

Figure 4: Geographic pattern of collaboration with universities in Hong Kong

tively, mainland institutions have replaced traditionally dominant regions to become Hong Kong's most significant research collaborators. This shift began in the mid to late-1990s (CUHK: 1997, HKU: 1995, HKUST: 1998) and has remained consistent, reflecting the depth and continuity of this cross-border academic relationship.

For Hong Kong's universities, the shift toward mainland partnerships underscores a growing interdependence, where mainland collaborations are essential for maintaining Hong Kong's position in the global academic landscape. While Hong Kong universities engage in collaborations worldwide, it is the connection with mainland institutions that drives much of their scientific progress. In this way, mainland universities have replaced traditionally competitive regions like the United States and Europe by providing a steady stream of research partnerships along with a shared cultural and linguistic foundation that enables smoother and more extensive collaboration.

In contrast, mainland universities see Hong Kong as a valuable but supplementary partner within a broader network of international collaborations, particularly with the U.S. While mainland institutions consider Hong Kong important for advancing scientific research and expanding S&T initiatives, the relationship does not hold the same central role it does for Hong Kong universities. This difference highlights a unique asymmetry: mainland universities have a diverse array of international collaborators, while Hong Kong universities increasingly depend on mainland institutions as their "lifeline" in research partnerships. This dynamic bolsters Hong Kong's academic ecosystem and provides mainland universities with a high-quality, regional partner.

This asymmetry reflects a larger regional trend, where Hong Kong's universities leverage their autonomy, resources, international reputation, and proximity to mainland institutions to create a unique collaborative synergy. Across the Shenzhen River, the academic relationship extends beyond formal agreements or joint projects; it has become foundational for Hong Kong universities' research agendas and strategic development. Thus, while mainland institutions

engage on a global scale, Hong Kong universities find in mainland China an irreplaceable collaborator, making the partnership integral to their growth in the global higher education and research arenas.

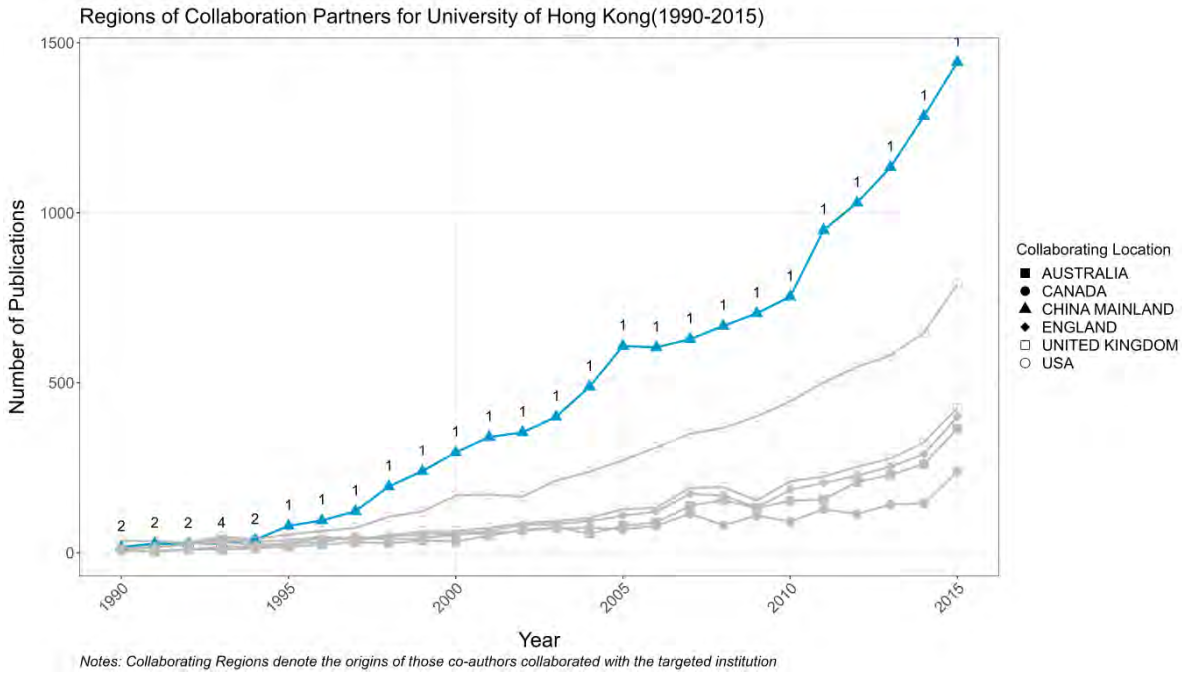

Figure 5: Regions of collaboration partners for Univeristy of Hong Kong (1990-2015)

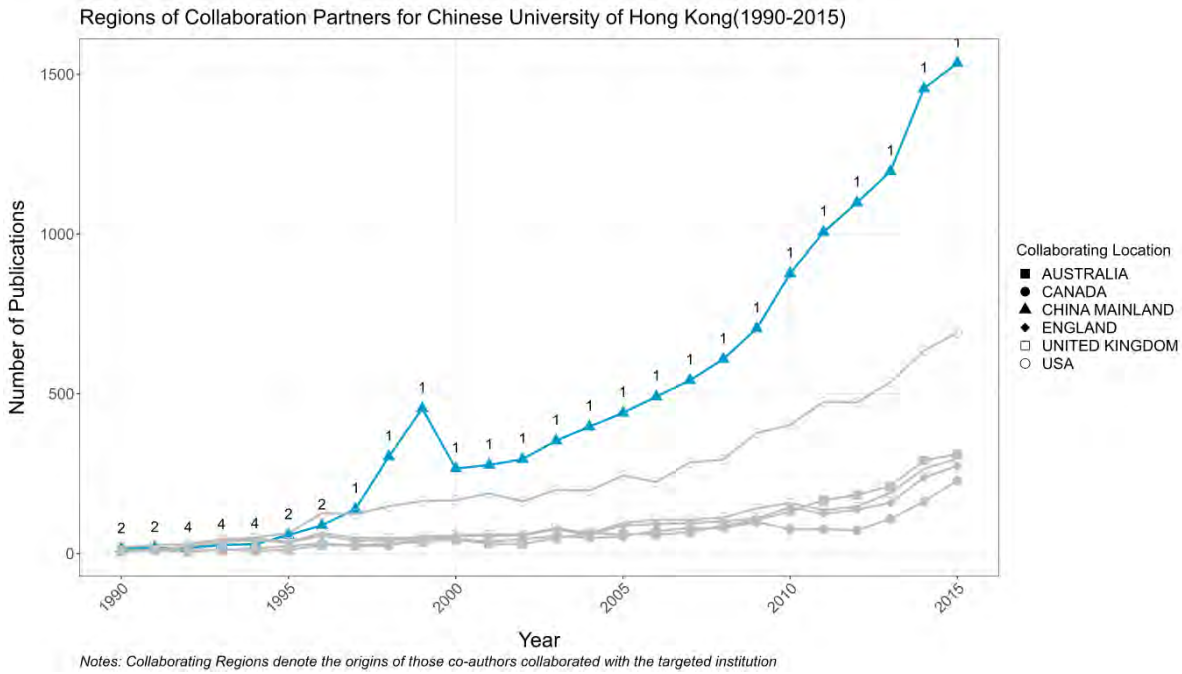

Figure 6: Regions of collaboration partners for Chinese University of Hong Kong (1990-2015)

4.1.3 Major Collaborative Subject Areas between Hong Kong and Mainland China

It is essential to note that universities in Hong Kong are not merely passive participants in collaborations with mainland institutions; they exhibit a high degree of *strategic agency* in selecting and developing their areas of expertise. This section highlights the key subject areas where Hong Kong and mainland China collaborated frequently between 1990

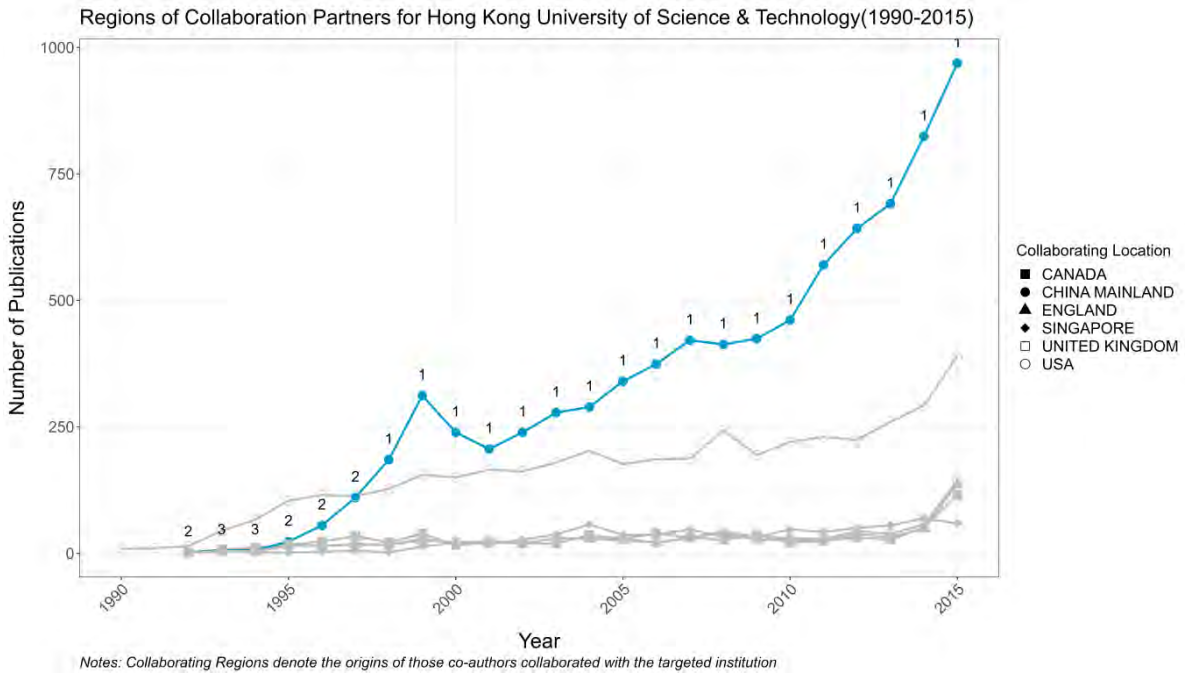

Figure 7: Regions of collaboration partners for Hong Kong Univerity of Science and Technology (1990-2015)

and 2015, a period when Hong Kong became an indispensable international partner for Chinese scientific advancement. We identify the top subject areas with high publication output and frequent collaborations for three leading Hong Kong universities.

Figure 9, Figure 8 and Figure 10 display the top 1st disciplines collaborated with mainland with the number of publication descending from top to bottom. As shown in those figures, three universities share strengths in several subject areas, notably *electrical & electronic engineering*, *oncology*, and *biochemistry & molecular biology*. HKU and HKUST also excel in *applied physics* and *materials science*. While CUHK distinguishes itself with additional strengths in *pharmacology & pharmacy* and *computer science*, reflecting a broader range of expertise. The distinct collaborating subject areas between Hong Kong and mainland display the disciplinary heterogeneity and further reveal the flexible collaborative strategy characteristic by with *strategic agency* adopted by higher education institutions in Chinese mainland.

Focusing further on these collaborations, we identify specific "advantage" disciplines, featured by both significant publications and high-frequent collaboration with mainland, for each university. Based on collaboration frequency and publication impact, HKU and HKUST both show an advantage in *electrical & electronic engineering*, *applied physics*, and *multidisciplinary materials science*. Meanwhile, CUHK excels in *electrical & electronic engineering*, *biochemistry & molecular biology*, and *artificial intelligence in computer science*. These selected subject areas exhibit notable growth, evidenced by publication counts and citation impact metrics, demonstrating these disciplines' significant role in attracting mainland scholars to establish robust academic networks with Hong Kong.

The following figures display the development trends in these disciplines at each university from 1990 to 2015, as seen in Figure 11, Figure 12, and Figure 13. The increasing publication numbers and high citation impact in these fields underscore their prominent status and growing expertise, which have effectively drawn mainland collaboration to Hong Kong's highly specialized institutions.

Overall, the evolution of these highly collaborative and productive disciplines reveals a dynamic pattern that extends beyond passive cooperation. The evidence suggests that Hong Kong's specialized strengths have acted as a "pull factor" for Chinese mainland institutions, prompting them to pursue deeper collaboration with Hong Kong's established research hubs. This collaboration has allowed Hong Kong to play an active role in shaping the mainland's S&T development, particularly in these advanced fields.

In conclusion, the evolving partnership between Hong Kong and mainland China warrants further exploration to understand the underlying drivers. A longitudinal analysis of collaboration intensity reveals that from 1990 to 2015, Hong Kong emerged as a critical partner, with several key subject areas—*engineering*, *physics*, *biochemistry & molec-*

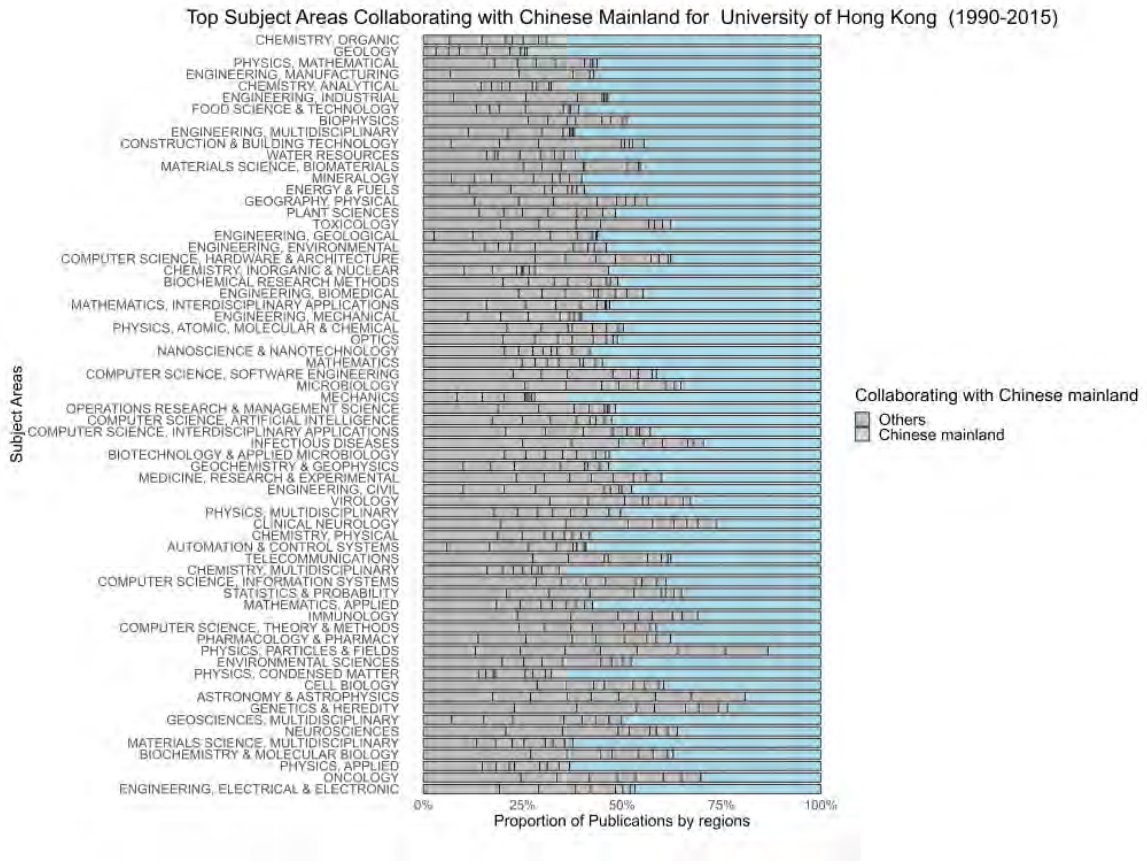

Figure 8: Top subject areas collaborating with mainland China for the University of Hong Kong (1990-2015)

ular biology, *materials science*, and *computer science*—anchoring this collaboration. While current data illustrate the breadth of these partnerships, further empirical investigation will be necessary to unravel how these cooperative models have been shaped by evolutionary and professional dynamics.

4.2 Explanation from an Evolutionary Perspective: The Longitudinal Development of Science and Technology in Hong Kong

Up to this point, we have demonstrated that research collaboration between Hong Kong and mainland China is both reciprocal and significant—second only to the Sino-U.S. relationship in terms of importance for China's S&T growth. This collaboration varies across geographic regions and shifts over time, revealing a complex, evolving pattern. But a key question remains: why does this pattern exist? To address this, we offer three explanations: (1) the role of key individuals who served as crucial points of contact, (2) the timing of developmental changes in Hong Kong's S&T sector, and (3) the strategic location of Hong Kong as a bridge for mainland China's scientific development.

4.2.1 Points of Contact

The collaboration between Hong Kong and mainland China in S&T has been greatly influenced by key individuals who facilitated connections. On the mainland side, ever since the mid-1970s—before the end of the Cultural Revolution—Chinese scientists began welcoming international visitors (Suttmeier 1980). Following the Nixon Shock in 1971, prominent overseas Chinese scientists, such as Nobel laureate Yang Chen-Ning, visited China, discovering both a damaged scientific infrastructure and a generation of Chinese S&T talents eager to learn (J. Yang 2016).

These renowned scientists, many of whom had established themselves abroad, became conduits for collaboration, eagerly creating channels to assist Chinese scientists and providing valuable *feedback loops* between mainland institutions and overseas counterparts. Through their efforts, knowledge and practices circulated in both directions, enhancing the capacity of Chinese institutions while keeping them connected to global scientific advancements.

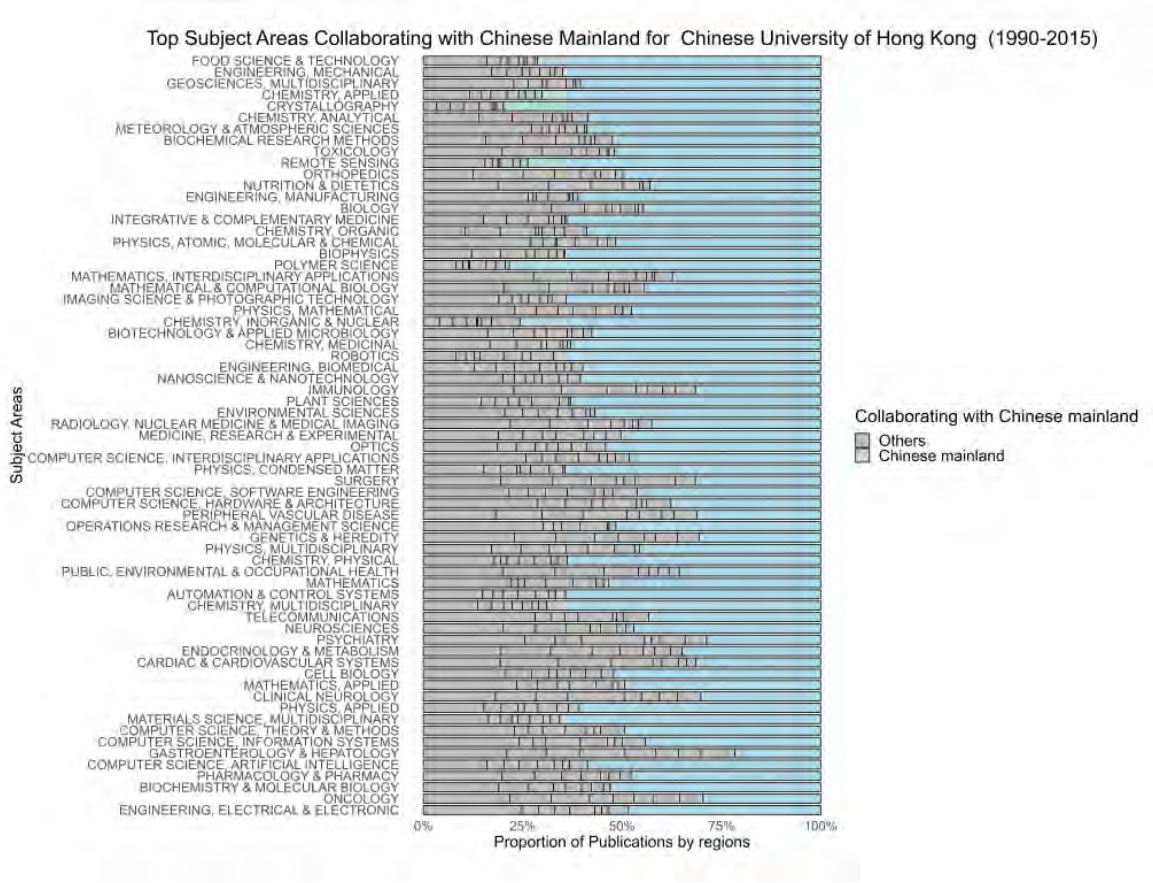

Figure 9: Top subject areas collaborating with mainland China for the Chinese University of Hong Kong (1990-2015)

A prime example is Chinese Nobel laureate Lee Tsung-Dao's China-U.S. Physics Examination and Application (CUSPEA) program, established following his visit to China. In collaboration with top mainland institutions such as CAS, PKU, and Tsinghua, CUSPEA sent over 900 Chinese physics students to U.S. universities between 1979 and 1989 (Shen and Zhao 2001), playing a critical role in fostering early international exposure for Chinese researchers.

At the time, formal mechanisms for such exchanges were lacking, as the China Scholarship Council would only be established in 1996. Consequently, points of contact relied heavily on personal connections and institutional ties (i.e. Shaw (2013, 145)). In addition to Lee's initiative, many overseas Chinese scientists were individually approached by mainland institutions. Figures like physicist Woo Chia-Wei (later the founding president of HKUST) and plant biologist Kung Shain-dow (later Dean of Science at HKUST) regularly hosted Chinese visitors (2007, 35; 2000, 110). This relatively small circle of prominent overseas Chinese scientists (Ch'i 2014) —many of whom were politically inclined to support mainland China (Shaw 2013) —became pivotal facilitators of exchange.

Among these figures, Woo Chia-Wei stands out. Woo's first visit to the PRC was in 1978, during a four-month sabbatical when he visited Fudan University and the Chinese Academy of Sciences (CAS) (Woo 2007). Then a faculty member at Northwestern University, Woo arranged for Chinese physicists to visit his institution, fostering early ties. Although Woo moved to become President of San Francisco State University (SFSU), his eventual return to Hong Kong as the founding president of HKUST (1991-2001) rekindled his mainland connections. In his second year as president, Woo led HKUST's management team on a visit to the mainland (Ch'i 2014, 226), initiating a series of bilateral exchanges and collaborations that solidified ties.

HKUST was not alone in reaching out to mainland China. Yang Chen-Ning joined CUHK as a Distinguished Professor in 1986, and Fields Medalist Yau Shing-Tung followed in 1993 Yau and Nadis (2019). Both scholars attracted mainland students and further solidified academic ties. On the mainland side, institutions like CAS, Zhejiang University, and Fudan University also played pivotal roles. CAS President Zhou Guangzhao, for instance, was awarded an honorary doctorate by CUHK in 1991 and served on HKUST's Presidential Advisory Board as the sole representative from the mainland The Hong Kong University of Science and Technology (1992).

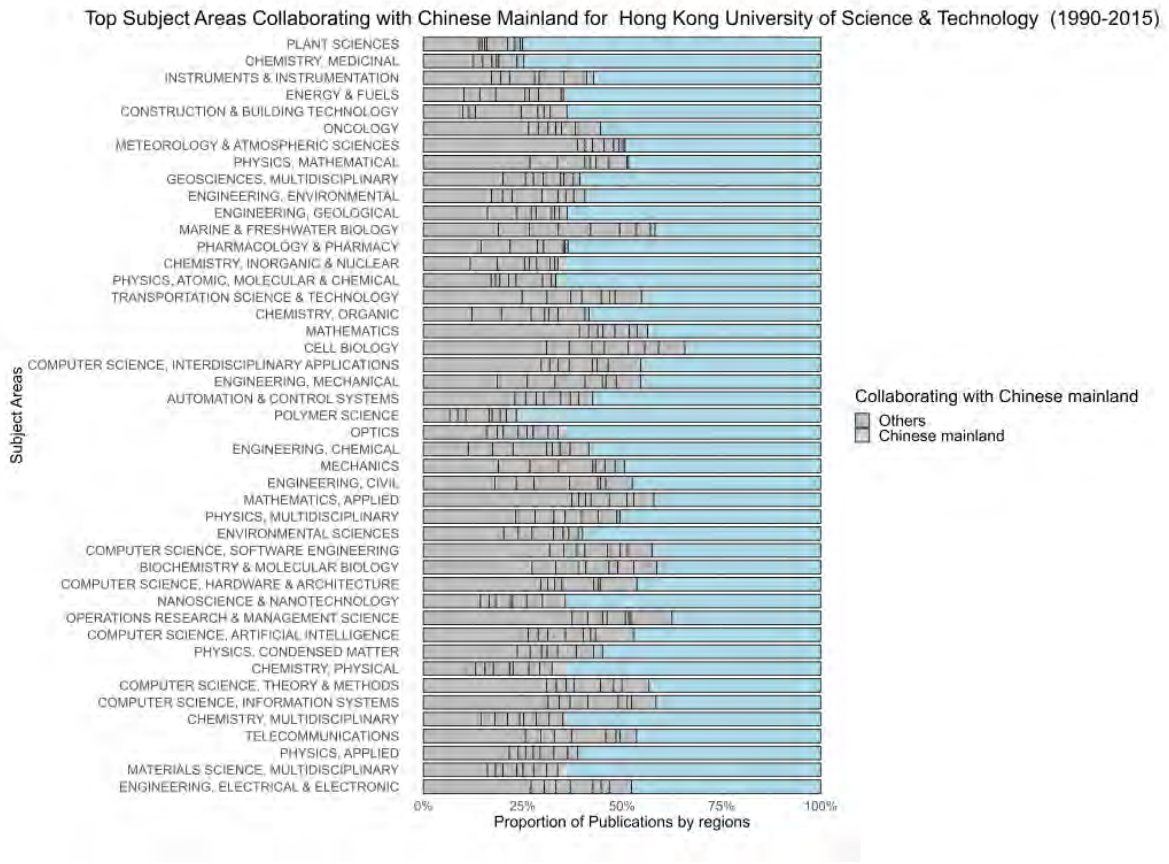

Figure 10: Top subject areas collaborating with mainland China for Hong Kong University of Science and Technology (1990-2015)

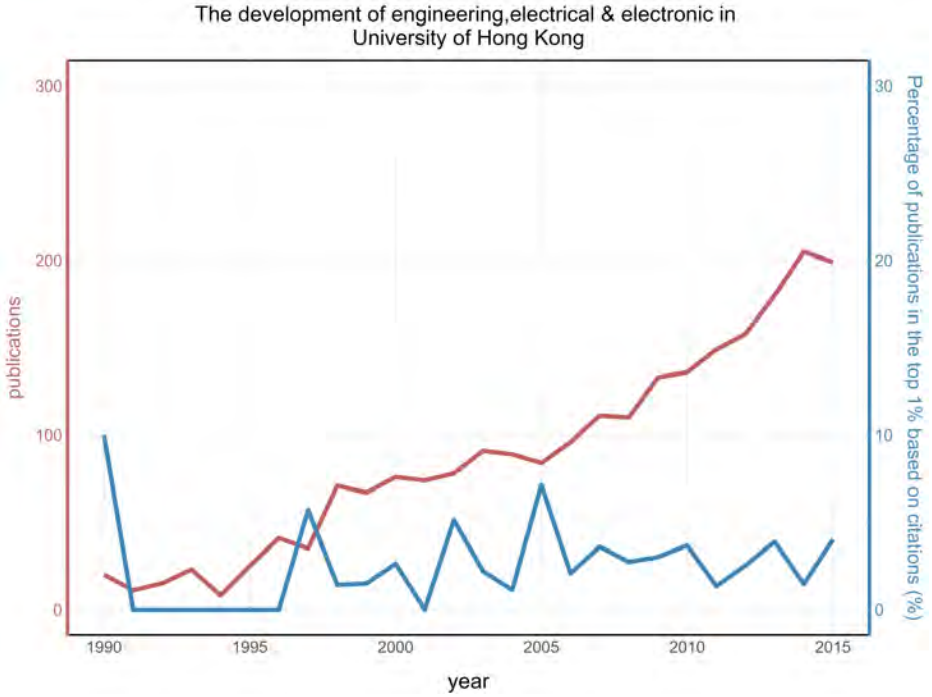

Figure 11: Development of electrical & electronic engineering at the University of Hong Kong

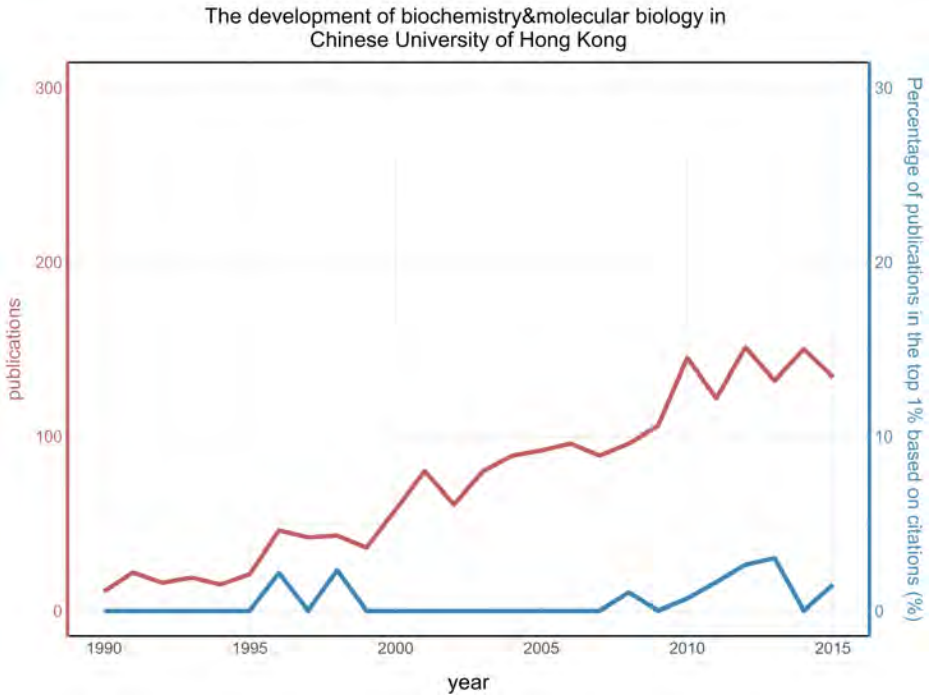

Figure 12: Development of biochemistry & molecular biology at the Chinese University of Hong Kong

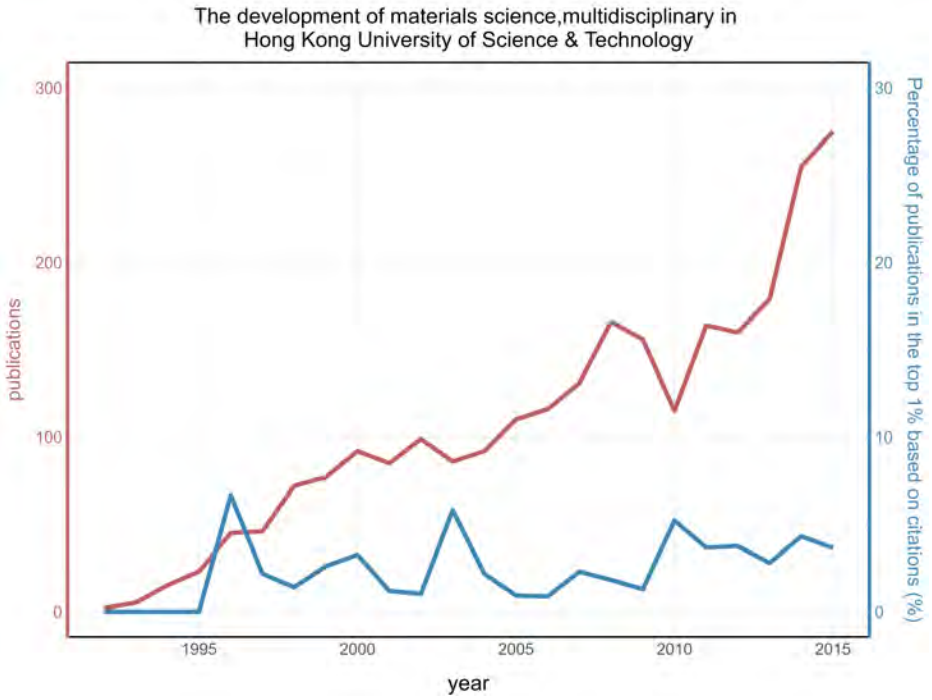

Figure 13: Development of materials science at Hong Kong University of Science & Technology

4.2.2 Temporal Characteristics

To understand why Hong Kong became a prime collaborator for mainland China in the late 1990s, it is essential to examine the evolution of Hong Kong's higher education landscape. As illustrated in Figure 14, Hong Kong universities functioned primarily as teaching institutions with limited research activity until the mid-1990s. The figure shows the trend in PhD dissertations in S&T fields across four representative Hong Kong universities, revealing a surge in the number of eligible PhD students starting in 1994, which continued to grow steadily until 2020. This upward trend in PhD dissertations demonstrates not only the expansion of Hong Kong's research programs but also its emergence as a regional education hub, particularly attractive to students from nearby regions, including mainland China.

This shift toward research-focused education in Hong Kong was not only reflected in publication output but also in the increasing numbers of research-trained PhD graduates. Physicist Chih-Yung Chien noted in his autobiography that when he became the founding Dean of Science at HKUST, a survey of HKU and CUHK showed that only 5% of students were enrolled in research PhD programs (Chien 2024). By setting an ambitious target of 30% for research enrollment, HKUST signaled a transformative shift in Hong Kong's academic landscape. This shift coincided with a substantial intake of mainland students beginning in 1995, creating a collaborative exchange that went beyond a simple transfer of knowledge. Instead, it fostered a process of *iterative learning*, where both Hong Kong and mainland China's academic ecosystems grew richer and more interconnected through this dynamic exchange.

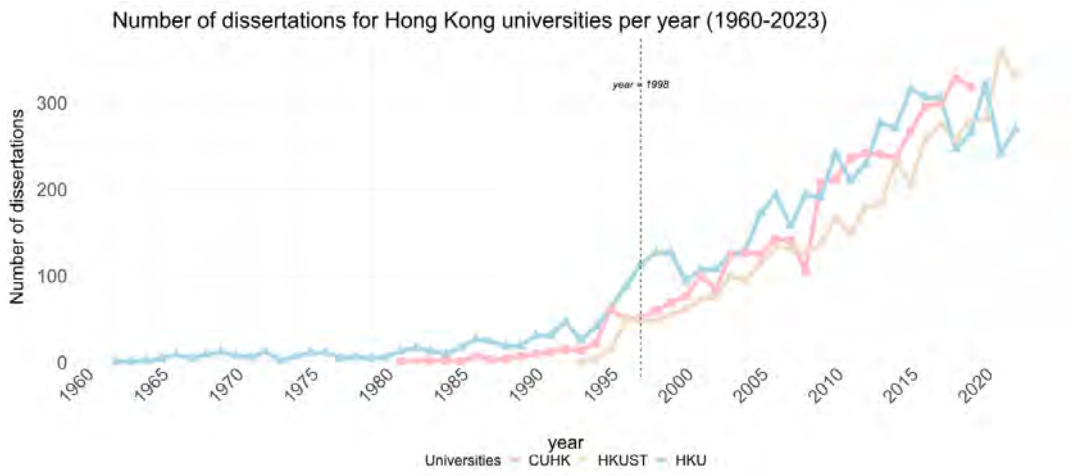

Figure 14: PhD dissertations for Hong Kong universities (1960-2023)

Further insight into Hong Kong's S&T growth emerges when examining the cultivation of PhD programs across disciplines. Figure 15 illustrates the distribution of PhD dissertations by subject areas across three prominent Hong Kong universities, reflecting the potential scale of researchers in each discipline and indicating which fields were prioritized. Despite each university having distinct advantage disciplines, certain fields consistently rank among the top five across institutions, including *chemistry*, *engineering*, *biology*, and *computer science*. The prevalence of these disciplines highlights their prominence in Hong Kong's academic landscape, contributing to the regional expertise that mainland universities sought to collaborate with.

The data on PhD dissertations align closely with the top subject areas for collaboration between Hong Kong and mainland China, partially explaining why certain disciplines became central to cross-border partnerships. This pattern suggests that collaboration tends to occur in fields where the early-developed institution demonstrates stronger professional capacity and performance, motivating the late-developing institution to learn from and emulate its partner. The consistency across subject areas reinforces that mainland institutions strategically seek partnerships with Hong Kong's top disciplines, further strengthening both regions' research outputs.

The advanced development of Hong Kong's S&T sector—evidenced by rising publication counts and increasing numbers of PhD graduates—offered Chinese higher education institutions an attractive, accessible model with robust academic capacity and geographical proximity. With lower physical and cultural barriers compared to other international collaborators, Hong Kong provided mainland China with a readily accessible example of S&T excellence. Before mainland universities fully developed their own research capacities, Hong Kong's flourishing S&T sector served as a valuable learning resource for late-developing regions like China. Hong Kong's strong S&T performance, measured by publication volume and impact, attracted a growing number of mainland students, establishing a virtuous cycle of

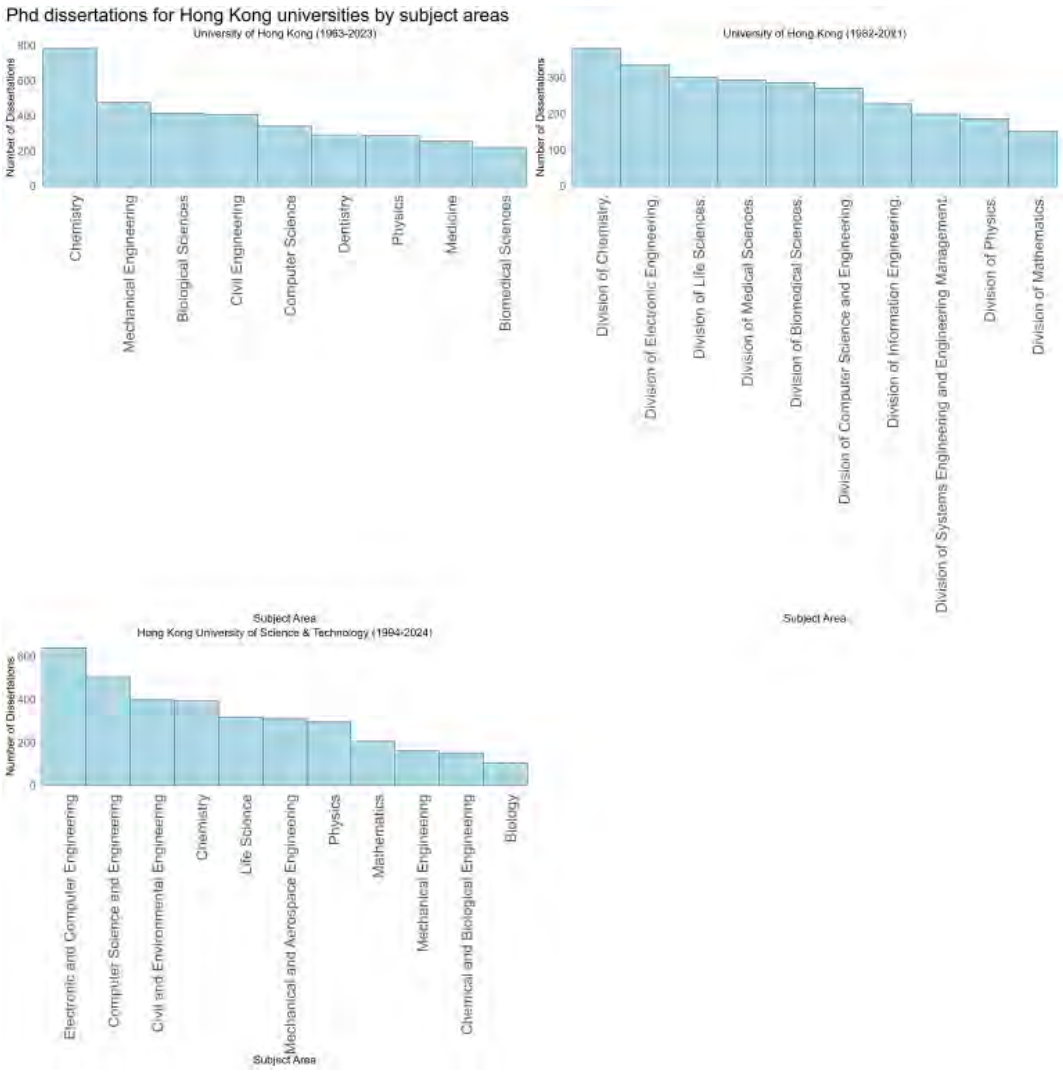

Figure 15: PhD dissertations for Hong Kong universities by subject areas

academic exchange and collaboration. For example, when HKUST was newly established in the 1990–91 academic year, it welcomed its first batch of mainland graduate students (Ch'i 2014).

Table 2: Total PhD graduates for HKU, CUHK and HKUST from 1989-2005, all disciplinary fields

Year	CUHK			HKU			HKUST		
	Total	Mainland	M/T %	Total	Mainland	M/T %	Total	Mainland	M/T %
1989	7	5	0%	33	2	6%			
1990	11	4	36%	38	5	13%			
1991	10	2	20%	45	8	18%			
1992	17	6	35%	45	8	18%			
1993	20	8	40%	68	20	29%			
1994	19	5	26%	51	8	16%	1	0	0%
1995	33	12	36%	71	12	17%	5	3	60%
1996	78	45	58%	111	21	19%	15	4	27%
1997	70	32	46%	145	27	19%	50	25	50%
1998	66	33	50%	192	59	31%	50	27	54%
1999	88	45	51%	188	69	37%	50	34	68%
2000	107	50	47%	205	100	49%	61	39	64%

Year	CUHK			HKU			HKUST		
	Total	Mainland	M/T %	Total	Mainland	M/T %	Total	Mainland	M/T %
2001	113	70	62%	167	76	46%	69	34	49%
2002	154	98	64%	181	73	40%	79	45	57%
2003	110	62	56%	192	76	40%	85	54	64%
2004	174	105	60%	208	86	41%	110	66	60%
2005	170	98	58%	205	57	28%	114	74	65%

From Table 2, it is evident that the three flagship Hong Kong universities—HKU, CUHK, and HKUST—lacked robust "advanced research programs" during the 1980s and possibly throughout the first half of the 1990s. Due to limitations in Hong Kong's statistical reports, which aggregate research master's and PhD enrollment figures, precise PhD enrollment data are unavailable. For context, in 1993, the combined enrollment of research students was 845 at HKU, 852 at CUHK, and 330 at HKUST. Consequently, we rely on PhD thesis data as a proxy for analyzing trends in research student populations. Given the typical time lag of approximately three years between PhD admission and thesis completion, PhD thesis output can provide an estimated measure of earlier student enrollment sizes.

As shown in Table 2, annual PhD graduations at each university did not surpass 100 students until around 2000, indicating a relatively small PhD student body in the 1990s. We further analyzed graduates' names based on thesis records to estimate the number of students originating from mainland China.[5] The proportion of mainland students varies across institutions: CUHK and HKUST demonstrate a higher proportion of mainland students, while HKU's numbers are relatively lower. Here, universities in Hong Kong exhibit significant *institutional heterogeneity and selective adaptation*; they responded to new opportunities by admitting mainland students even in the absence of a formal, systematic framework. This flexibility not only allowed Hong Kong institutions to fill their research programs but also directly supported their expansion on the research side. Mainland students thus joined Hong Kong's emerging research universities at a critical juncture, supporting these institutions' growth as they expanded their advanced research programs.

The advanced growth and rapid development of Hong Kong's S&T sector likely served as a catalyst, prompting Chinese universities to increasingly seek partnerships with Hong Kong in the late 1990s. Since academic achievement and S&T advancement rely heavily on publication volume and the expansion of research teams, we support this hypothesis by examining the growth trends in academic publications and the increasing scale of PhD student enrollment in Hong Kong.

As shown in Figure 16, a comparison of publication outputs from 1990 to 2015 reveals that the academic performance of two leading Hong Kong universities—the University of Hong Kong and the Chinese University of Hong Kong—surpassed that of many mainland institutions. This prior development in Hong Kong's academic achievement highlights its collaborative potential and appeal for mainland institutions during that era.

4.2.3 Geographical characteristic

The spatial distribution of S&T collaboration between Hong Kong and mainland China reveals two prominent trends. First, Beijing plays an unparalleled role in this relationship. Although geographically distant from Hong Kong, the collaboration between institutions in Beijing and Hong Kong surpasses any other mainland region. Data from CUHK, HKU, and HKUST show that Beijing alone contributed 13,416 co-authored papers from 1980 to 2023, eclipsing even Guangdong Province, which, despite its proximity, generated 12,039 papers in collaboration with Hong Kong institutions over the same period.

The dominant role of Beijing in China's scientific landscape is expected, given that it is home to the Chinese Academy of Sciences (CAS), the nation's premier research institution. Since its establishment, CAS has been central to China's S&T development. In the early 1980s, CAS was responsible for over one-third of China's total S&T output by our calculation. Although CAS's proportional contribution has decreased in recent years, it still accounted for approximately 10% of the nation's S&T publications in 2018. This decline is not indicative of CAS's waning significance; rather, it reflects the rapid growth of other Chinese research institutions, which have expanded the overall pool of national scientific output.

In addition to its substantial research contributions, CAS has been a primary facilitator of S&T collaboration. CAS leadership was proactive in identifying and establishing partnerships with international and regional collaborators, playing a strategic role in China's global S&T outreach. CAS frequently served as a first point of contact for visiting foreign scientists, leading to many enduring collaborations. It also actively pursued partnerships abroad, establishing connections that shaped the trajectory of China's scientific network.

[5] Due to time constraints preventing us from further analysis, these figures encompass students from all disciplines.

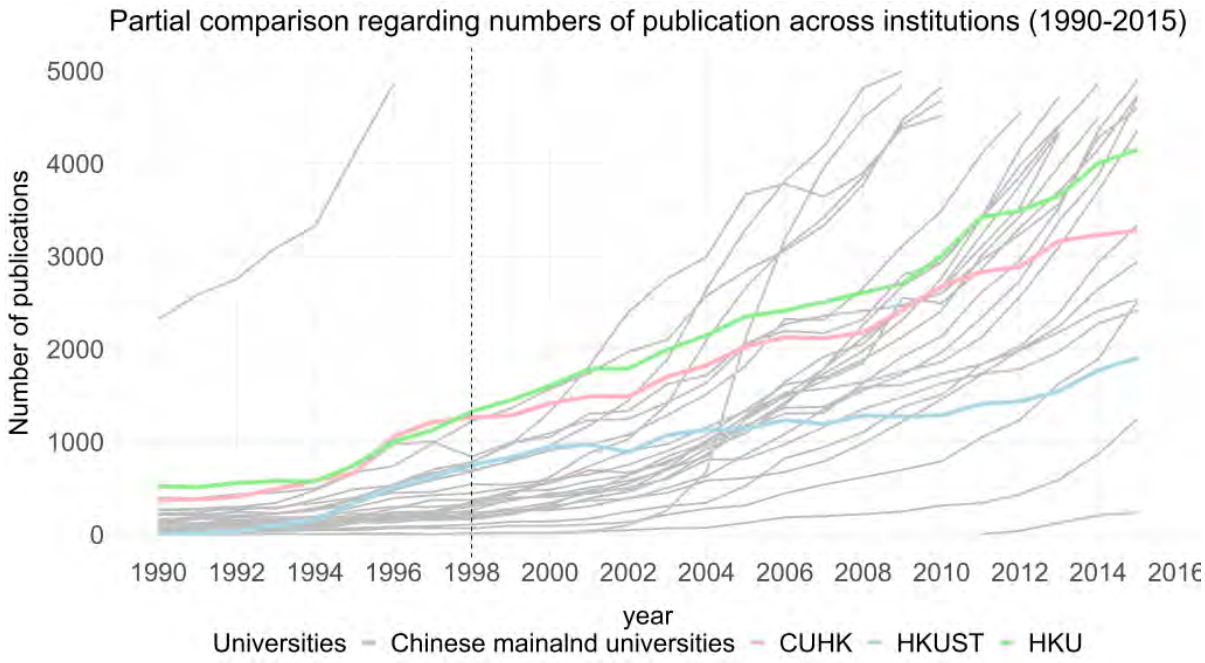

Figure 16: Partial comparison regarding numbers of publication across institutions (1990-2015)

One example of CAS's role in fostering Hong Kong-mainland collaborations occurred in 1991, well before Hong Kong had developed its own research university system. CAS President Zhou Guangzhao visited CUHK and HKUST, receiving an honorary doctorate from CUHK and becoming the only mainland member on HKUST's Presidential Advisory Board.[6] Zhou's subsequent visit to HKU in 1995, where he was awarded another honorary degree, further underscored CAS's commitment to forming cross-border academic connections. These high-profile visits served not only as ceremonial gestures but also as strategic moves to catalyze institutional collaborations, an example of *organizational reflexivity*, as Zhou's colleagues within CAS followed his example by establishing research partnerships and joint labs with Hong Kong institutions.

CAS-HKUST collaborations underscore this point. Below are the visits from CAS leadership to HKUST from the university's founding until Hong Kong was handed over to the PRC:

- 1991-92, 1992-93: Zhou Guangzhao, President of CAS
- 1993.10.28-31: Xu Zhihong, Vice President of CAS
- 1994.3.21: Teng Teng, Vice President of CAS
- 1994.8.24: Xu Zhihong, Vice President of CAS
- 1994.8.26: First joint marine research lab established between HKUST and CAS in Sanya, Hainan
- 1994.9.29: Li Zhensheng, Vice President of CAS
- 1994.12.15: Lu Yongxiang, Vice President of CAS
- 1995.3.16-17: Yi Xunyan, Vice President of CAS, along with Zhu Xuan, Deputy Secretary General and Director of Bureau of Planning and Finance, CAS
- 1995.5.25: Chen Yiyu, Vice President of CAS
- 1995.11.4: Lu Yongxiang, Vice President of CAS
- 1995.11.13: Hong Zhongxiang, Director, Institute of Atmospheric Physics, CAS
- 1997.1.10: Second joint research lab established in microelectronics
- 1998: Third joint research lab established in nanotechnology

While CAS occupies a unique position within China's S&T establishment, the collaboration patterns become more geographically distinct when excluding Beijing and Shanghai (another S&T hub with historical and industrial connections to Hong Kong). Proximity emerges as a key factor in S&T collaboration, with Guangdong Province serving as the primary regional partner for Hong Kong institutions. The degree of collaboration generally decreases with distance from Hong Kong, especially in an era when long-distance communication and frequent travel were limited (from 1980

[6]Zhou also delivered a moving speech in Hong Kong. See G. Zhou (1991).

to 2000). Given these constraints, the relative ease of access made collaboration with geographically closer regions, such as Guangdong, more feasible and productive.

A second factor reinforcing collaboration between Guangdong and Hong Kong is Guangdong's unique educational landscape. Despite being an economic powerhouse and early recipient of investment from Hong Kong, Guangdong has historically lacked comprehensive research universities. The province hosts a limited number of higher education institutions, including Sun Yat-Sen University (SYSU), South China Normal University (SCNU, primarily a teaching institution for much of its history), South China University of Technology (SCUT), and, more recently, Shenzhen University (SZU). This limited academic infrastructure prompted Guangdong to establish close ties with Hong Kong's universities to enhance its scientific and technological capabilities.

Driven by a desire to leverage its economic strength, Guangdong initiated several key partnerships with Hong Kong institutions. For instance, in the 1990s, Guangdong and HKUST collaborated to establish industrial parks aimed at fostering joint research and development. Later, Guangdong invited universities from Hong Kong to open satellite campuses, as seen with CUHK and HKUST. These initiatives have not only reinforced the collaborative network between the two regions but also provided Guangdong access to Hong Kong's robust academic resources, allowing both areas to mutually benefit from each other's strengths. Through such measures, the collaborative efforts between Guangdong and Hong Kong have become increasingly institutionalized and strategically aligned, fostering a dynamic regional S&T partnership.

In this context, the spatial pattern of S&T collaboration between Hong Kong and the mainland reflects both strategic institutional choices and logistical considerations, influenced by historical, geographic, and technological factors.

5 Discussion

This paper examines the rapid rise of China's higher education system in science and technology (S&T), with a specific focus on Hong Kong's often-overlooked influence. Moving beyond structuralist and cultural explanations, we use an evolutionary institutional framework to capture the dynamic and adaptive nature of China's academic and scientific development. Through analyzing cross-border collaborations between Hong Kong and mainland Chinese universities, we show that China's S&T success results not solely from government-led initiatives or historical cultural factors. Instead, this evolution has been significantly shaped by institutional actors engaging in experimentation, strategic adaptation, and mutual exchange.

In China's higher education sector, institutional actors embrace learning as a continuous, iterative process, frequently testing new strategies without a fixed goal. These actors adapt as resources and constraints shift, underscoring Herbert Simon's insight that in complex environments, choices cannot be fully optimized due to bounded rationality (H. A. Simon 1955) . Accordingly, Chinese universities and research institutions do not seek to optimize their strategies but pursue routines that yield viable outcomes. This adaptive approach aligns with Richard Nelson's assertion that institutions respond to changing contexts through "learning and selection" forces, enabling effective routines to endure and evolve (R. R. Nelson 2018).

Hong Kong's role as a key partner in this development highlights the power of regional collaboration and innovation Saxenian (2006). Its role has often been overlooked due to two primary factors: attention frequently focuses on the prominent China-U.S. collaboration in science and technology Hao and Hua (2023), while secondary yet crucial collaborations receive less focus; and the collaborative relationship between Hong Kong and mainland China varies by S&T discipline and the geographic location of mainland institutions, complicating cohesive analysis. By integrating diverse data sources, this study offers a comprehensive view of this partnership, showing how Hong Kong's unique academic environment—marked by autonomy and robust international ties—provides a supportive space for mainland Chinese students and scholars. This "cross-border knowledge exchange" blends mainland talent with Hong Kong's academic resources and freedoms. Unlike typical study-abroad scenarios where Chinese S&T students often remain overseas—resulting in brain drain—this partnership with Hong Kong encourages graduates to return to mainland China. This cycle, where students gain advanced training and then bring expertise back to China, reduces talent loss and strengthens both regions' academic and scientific communities.

This cross-border dynamic has also introduced new institutional models, including provincial-level joint research facilities, civil servant professional development programs, and graduate student exchanges—initiatives challenging to replicate with more distant partners. Hong Kong reciprocates by welcoming mainland students with generous scholarships, training them in advanced research environments featuring world-class faculty. These interactions establish a "knowledge transfer loop," where students receive advanced training in Hong Kong and return to China for academic roles, reinforcing both Hong Kong's research sector and China's scientific capacity. This mutually beneficial flow supports Hong Kong's rapid rise in higher education, particularly in research (Postiglione 2011), while avoiding saturation in its job market and bolstering China's educational system.

Our findings highlight the need for a historically grounded, context-sensitive analysis of higher education development. The evolutionary framework offers a fresh perspective on how institutions change through reflexivity, diversity, and strategic adaptation to local and global forces. This framework shows that China's S&T rise is not merely a top-down narrative but a complex, adaptive process in which universities leverage partnerships—particularly with Hong Kong—to overcome institutional limitations and foster innovation. Recognizing Hong Kong's role within this framework broadens our understanding of the forces shaping China's S&T landscape, suggesting that sustainable growth requires both internal reform and external partnerships, along with adaptability to global shifts.

This historical perspective has implications for future higher education policy, emphasizing that fostering inter-regional collaborations and institutional flexibility are essential strategies for advancing academic excellence and innovation. Through these cross-border partnerships, China's higher education system can experiment, adapt, and integrate new knowledge, contributing to its rapid growth in science and technology. By highlighting these adaptive and collaborative dynamics, this paper expands the discussion on how institutional networks and partnerships drive S&T development in non-Western contexts, illuminating pathways for innovation in a globally interconnected academic landscape.

Acknowledgements

We thank Huang Jingyang and Wu Xuan for their invaluable insights into the history of research universities in Hong Kong.

Appendix

Appendix A: Fields on S&T and non-S&T sector based on UNESCO nomenclature.

Table 3: Fields of S&T sectors

Nomenclature	Field
11	Logic
12	Mathematics
21	Astronomy and astrophysics
22	Physics
23	Chemistry
24	Life Sciences
25	Earth and Space Sciences
31	Agricultural Sciences
32	Medical Sciences
33	Technological Sciences

Table 4: Fields of S&T sectors

Nomenclature	Field
51	Anthropology
52	Demographics
53	Economic Sciences
54	Geography
55	History
56	Juridical Sciences and Law
57	Linguistics
58	Pedagogy
59	Political Science
61	Psychology
62	Science of Arts and Letters
63	Sociology
71	Ethics
72	Philosophy

Appendix B: Number of PhD dissertations in S&T sector for HKU, CUHK and HKUST (1990-2020)

Table 5: PhD dissertations in S&T sector for HKU, CUHK and HKUST from 1990 to 2020.

Year	HKU	CUHK	HKUST
1990	19	7	
1991	31	10	
1992	31	12	
1993	47	15	
1994	26	14	1
1995	41	22	5
1996	63	61	15
1997	88	51	49
1998	113	51	48
1999	127	60	48
2000	127	69	55
2001	94	77	62
2002	107	99	73
2003	108	85	76
2004	125	125	100
2005	130	127	95
2006	173	125	115
2007	193	143	133
2008	158	141	132
2009	194	106	127
2010	191	208	136
2011	242	212	167
2012	210	237	149
2013	230	242	180
2014	277	241	184
2015	271	236	231
2016	316	268	207
2017	307	296	259
2018	306	299	275
2019	247	329	258
2020	266	319	280

References

Ch'i, Hsi-Sheng. 2014. *Hong Kong University of Science and Technology: What More Is There to Say?* Shenzhen: Haitian Publishing House.

Chien, Chih-Yung. 2024. *Daring to Lead: Building HKUST in Three Years*. Edited by Yuecen Zhong. China: Sanlian Publishing House.

Crow, James Mitchell. 2022. "US–China Partnerships Bring Strength in Numbers to Big Science Projects." *Nature* 603 (S6-S8). https://doi.org/10.1038/d41586-022-00570-0.

Hao, Karen, and Sha Hua. 2023. "The U.S. Is Turning Away from Its Biggest Scientific Partner at a Precarious Time." *The Wall Street Journal*. https://www.wsj.com/world/china/the-u-s-is-turning-away-from-its-biggest-scientific-partner-at-a-precarious-time-9fb9adaa.

Hayhoe, Ruth, and Qiang Zha. 2005. "The Role of Public Universities in the Move to Mass Higher Education: Some Reflections on the Experience of Taiwan, Hong Kong, and China." In *Taking Public Universities Seriously*, edited by Frank Iacobucci and Carolyn Tuohy, 5–25. University of Toronto Press.

Jin, Jin, and Hugo Horta. 2018. "Same University, Same Challenges? Development Strategies of Two Schools at a Prestigious Chinese University in a Changing Higher Education Landscape." *Tertiary Education and Management* 24 (2): 95–114. https://doi.org/10.1080/13583883.2017.1346700.

Kung, Shain-dow. 2000. *A Last Stand: The Journey from Mill Worker to Vice President of HKUST*. Shandong Friendship Publishing House.

Nelson, Adam R. 2013. "Regionalisation and Internationalisation in Higher Education and Development: A Historical Perspective, c. 1950–1970." *Journal of Higher Education Policy and Management* 35 (3): 238–48. https://doi.org/10.1080/1360080X.2013.786858.

Nelson, Richard R. 2018. "Economics from an Evolutionary Perspective." In *Modern Evolutionary Economics: An Overview*, by Richard R. Nelson, Giovanni Dosi, Constance E. Helfat, Andreas Pyka, Pier Paolo Saviotti, Keun Lee, Kurt Dopfer, Franco Malerba, and Sidney G. Winter. Cambridge: Cambridge University Press.

Postiglione, Gerard A. 2005. "China's Global Bridging: The Transformation of University Mobility Between Hong Kong and the United States." *Journal of Studies in International Education* 9 (1): 5–25.

———. 2011. "The Rise of Research Universities: The Hong Kong University of Science and Technology." In *The Road to Academic Excellence*, edited by Philip G. Altbach and Jamil Salmi, 63–100. World Bank Publications.

Prasad, Eswar P. 2019. "Why China No Longer Needs Hong Kong." *The New York Times*. https://www.nytimes.com/2019/07/03/opinion/hong-kong-protest.html.

Rhoads, Robert A., Xiaoyang Wang, Xiaoguang Shi, and Yongcai Chang. 2014. *China's Rising Research Universities: A New Era of Global Ambition*. Baltimore: Johns Hopkins University Press.

Saxenian, Annalee. 2006. *The New Argonauts: Regional Advantage in a Global Economy*. Harvard University Press.

Shaw, Yu-ming. 2013. *The Chronicle of the Diaoyu Islands Movement: The Passion, Divisions, and Choices of Intellectuals in the 1970s*. Taipei: Linking Publishing Company.

Shen, Keqi, and Kaihua Zhao. 2001. "Early History of CUSPEA." Columbia University: A talk presented at the CUSPEA & Beyond Symposium. https://web.archive.org/web/20070312215039/http://www.ocpaweb.org/newsitems/2001/khzhao_talk.html.

Simon, Denis Fred, and Cong Cao. 2009. *China's Emerging Technological Edge: Assessing the Role of High-End Talent*. Cambridge University Press.

Simon, Herbert A. 1955. "A Behavioral Model of Rational Choice." *The Quarterly Journal of Economics* 69 (1): 99–118. http://www.jstor.org/stable/1884852.

Suttmeier, Richard P. 1980. *Science, Technology, and China's Drive for Modernization*. Stanford, CA: Hoover Institution Press.

The Economist. 2024. "China Has Become a Scientific Superpower." *The Economist*. https://www.economist.com/science-and-technology/2024/06/12/china-has-become-a-scientific-superpower.

The Hong Kong University of Science and Technology. 1992. "Annual Report 1991-1992." The Hong Kong University of Science and Technology.

Tollefson, Jeff. 2018. "China Declared World's Largest Producer of Scientific Articles." *Nature* 553 (390). https://doi.org/10.1038/d41586-018-00927-4.

UNESCO. 1988. *Proposed International Standard Nomenclature for Fields of Science and Technology*. https://unesdoc.unesco.org/ark:/48223/pf0000082946.

Wagner, Caroline S., Lin Zhang, and Loet Leydesdorff. 2022. "A Discussion of Measuring the Top-1% Most-Highly Cited Publications: Quality and Impact of Chinese Papers." *Scientometrics* 127 (4): 1825–39. https://doi.org/10.1007/s11192-022-04291-z.

Wang, Siyi, and Glen A. Jones. 2021. "Competing Institutional Logics of Academic Personnel System Reforms in Leading Chinese Universities." *Journal of Higher Education Policy and Management* 43 (1): 49–66. https://doi.org/10.1080/1360080X.2020.1747958.

Woo, Chia-Wei. 2007. *Building the Hong Kong University of Science and Technology: Stories and Profiles from the Early Days*. Beijing: Tsinghua University Press.

Yang, Jianye. 2016. *Chen Ning Yang: A Biography*. Enlarged Edition. Beijing: Sanlian Publishing House.

Yang, Lili, Simon Marginson, and Xin Xu. 2024. "'Thinking Through the World': A Tianxia Heuristic for Higher Education." *Globalisation, Societies and Education* 22 (2): 139–55. https://doi.org/10.1080/14767724.2022.2098696.

Yang, Rui. 2022. *The Chinese Idea of a University: Phoenix Reborn*. Pokfulam Road, Hong Kong: University of Hong Kong Press.

Yau, Shing-Tung, and Steve Nadis. 2019. *The Shape of a Life: One Mathematician's Search for the Universe's Hidden Geometry*. New Haven: Yale University Press.

Zhou, Guangzhao. 1991. "Chinese Science and Technology in the Process of Modernization." *Twenty-First Century* 8: 4–5.

Zhou, Ping, and Loet Leydesdorff. 2006. "The Emergence of China as a Leading Nation in Science." *Research Policy* 35 (1): 83–104. https://doi.org/10.1016/j.respol.2005.08.006.