Hidden Synergy

Hong Kong's Role in the Development of Science and Technology in Chinese Higher Education

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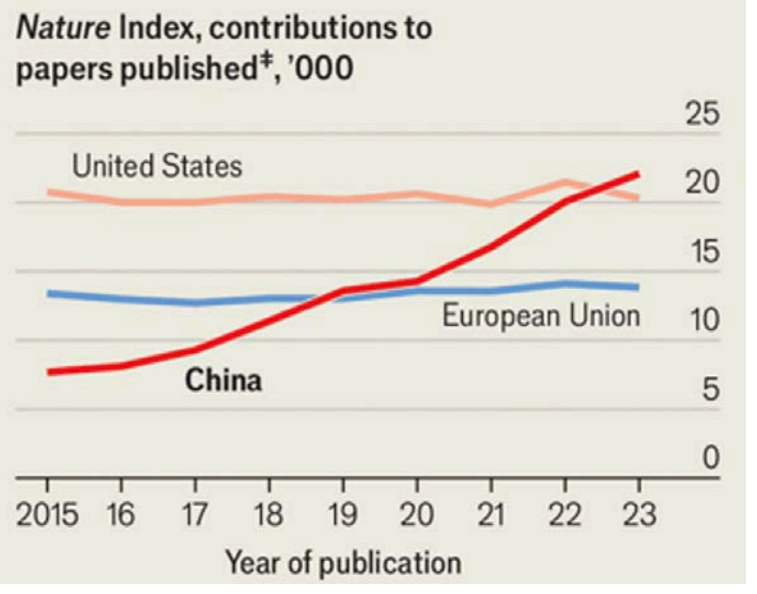
Background



By 2020, China:

- surpassed the United States as the leading producer of research papers *(Tollefson 2018)*,
- excelled not only in quantity but also in quality,
- the top 1 in top-cited scientific papers in 2019 (Wagner, Zhang, and Leydesdorff 2022).

Research question

How did China achieve such scientific and educational prominence in such a short period?

- **Conventional explanations**:

Highlighting the relationship between China and the United States

- **New exploratory perspective**
- Adopting the **historical evolutionary perspective** regarding this cross-border academic relationship, **Hong Kong** stands out as a crucial, yet underappreciated, role in advancing China's higher education and S&T capabilities

The role of Hong Kong has often been overlooked due to two primary factors:

- **Masking effect**: attention frequently focuses on the prominent **China-U.S. collaboration** in science and technology (*Hao & Hua 2023*)
- **Complicated cohesive analysis**: the collaborative relationship between Hong Kong and mainland China varies by S&T discipline and the geographic location of mainland institutions

Conventional explanations

The Structuralist Perspective

- assumes a **linear** and **nonhistorical** relationship between external pressures and institutional responses;
- emphasizes **external**, systemic forces that shape the actions and growth of universities.

The Culturalist Perspective

- emphasizes the importance of **historical legacies** and **cultural traditions** in shaping the development of higher education system;
- selectively highlight successes while **ignoring the persistent challenges** within the global higher education system.

New theoretical perspective: Evolutionary Institutionalism in Higher Education

Our approach:

- views economic and institutional changes as **dynamic**, **iterative** processes characterized by **continuous adaptation** and **experimentation**
- **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.
- **institutional agency and feedback loops**: universities act not merely as passive recipients of state-led reforms but as active participants in their developmental trajectories.

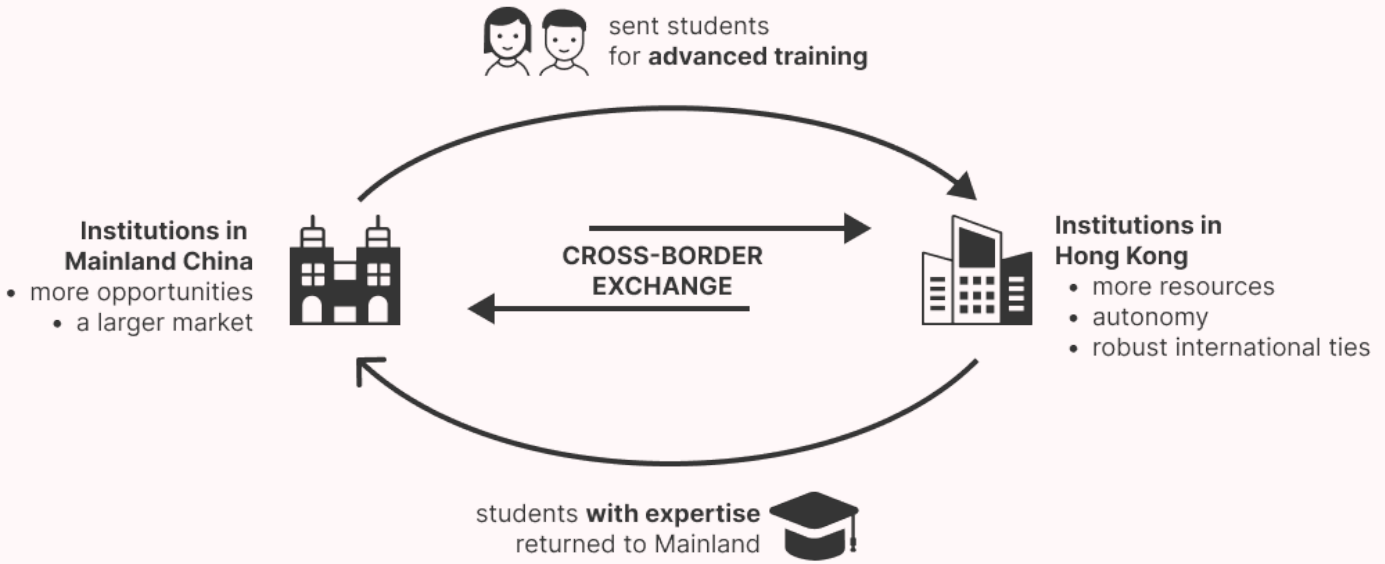
China-Hong Kong Collaboration: A Case of Organizational Learning

S&T sectors in Hong Kong

- Despite its reputation as a finance-driven, business-oriented city, Hong Kong characterized by **autonomy** and **international connections**, has quietly fostered a **strong academic and scientific community**, especially in collaboration with mainland institutions *(Woo 2007)*.

Reciprocal collaborating pattern

The "brain circulation"
among institutions in Mainland China and Hong Kong



Data and Methodologies

Data Source

- Publication information from *Web of Science (WoS)*
- PhD dissertation data from *university libraries*
- University archives
- Biographical data from *key educational leaders*

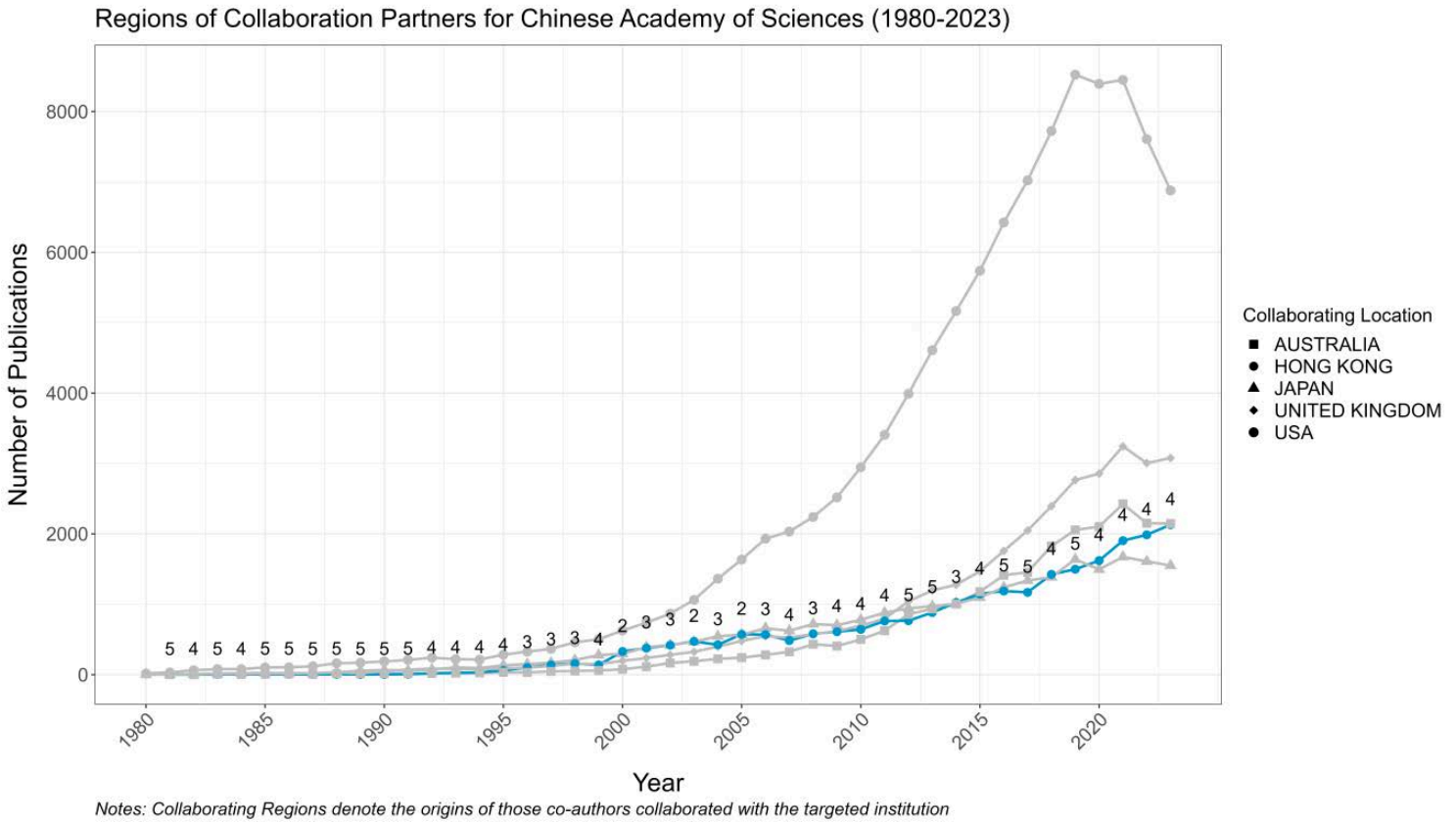
Selected universities

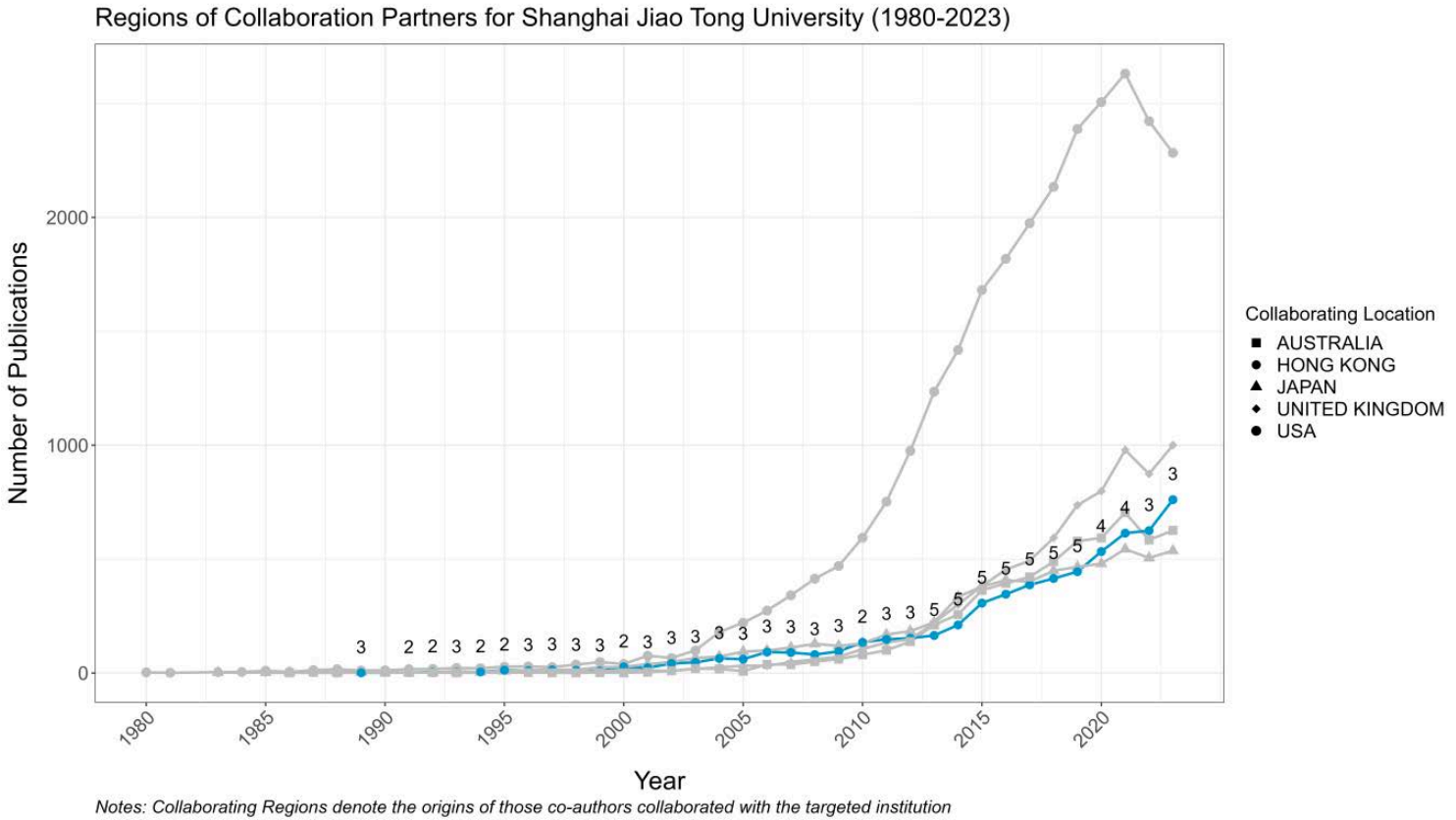
25+3

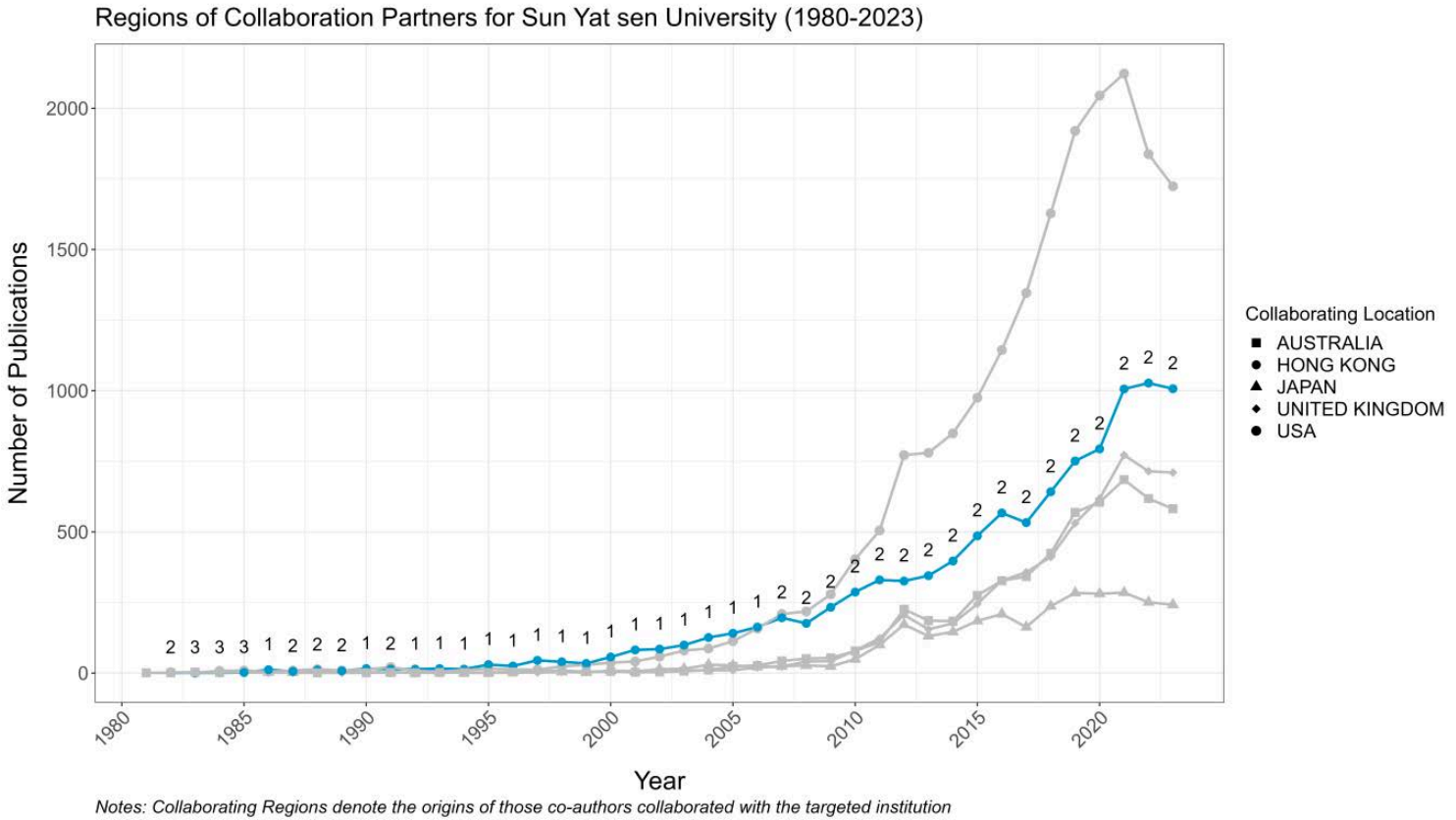
- 25 top-ranked institutions in Mainland China based on the Nature Index 2024
- 3 prestigious universities in Hong Kong

Analysis and Disscussion

Top Collaboration Locations for Mainland Chinese Universities

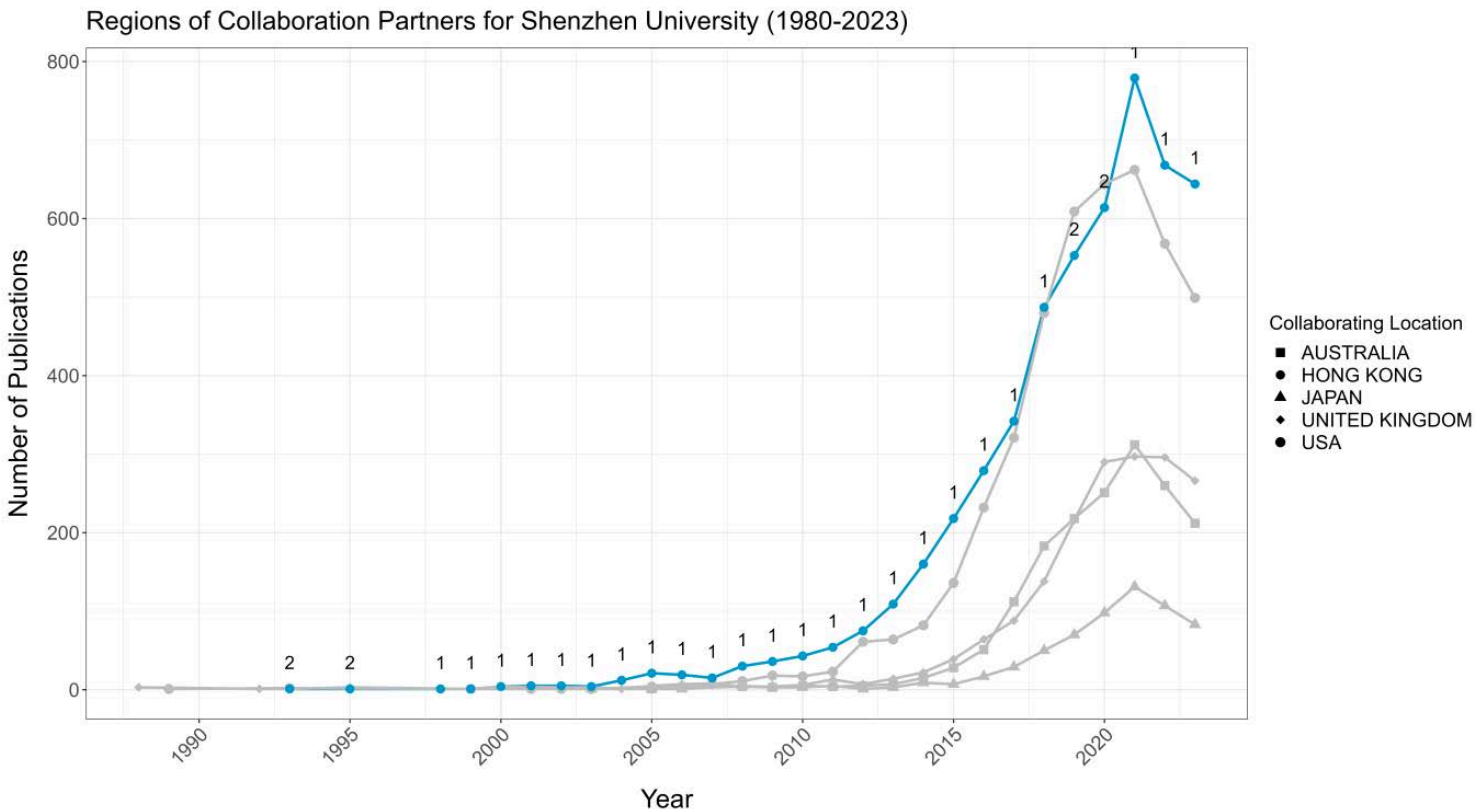


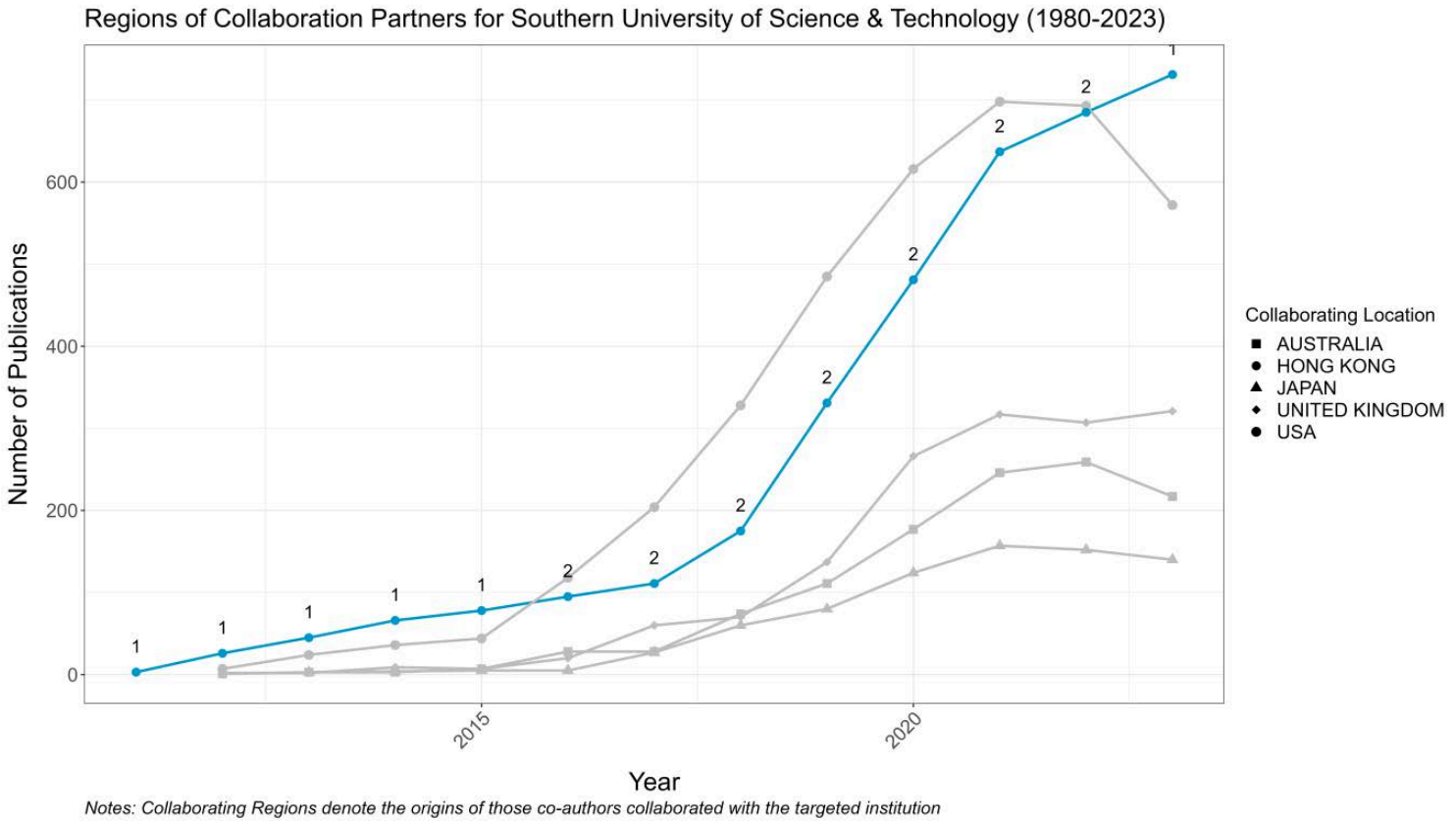

Regions of Collaboration Partners for Shanghai Jiao Tong University (1980-2023)
Number of Publications
2000
1000
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
Collaborating Location
AUSTRALIA
HONG KONG
JAPAN
UNITED KINGDOM
USA
Notes: Collaborating Regions denote the origins of those co-authors collaborated with the targeted institution


Regions of Collaboration Partners for Sun Yat sen University (1980-2023)
Number of Publications
2000
1500
1000
500
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
Collaborating Location
AUSTRALIA
HONG KONG
JAPAN
UNITED KINGDOM
USA
Notes: Collaborating Regions denote the origins of those co-authors collaborated with the targeted institution

Geographical heterogeneity

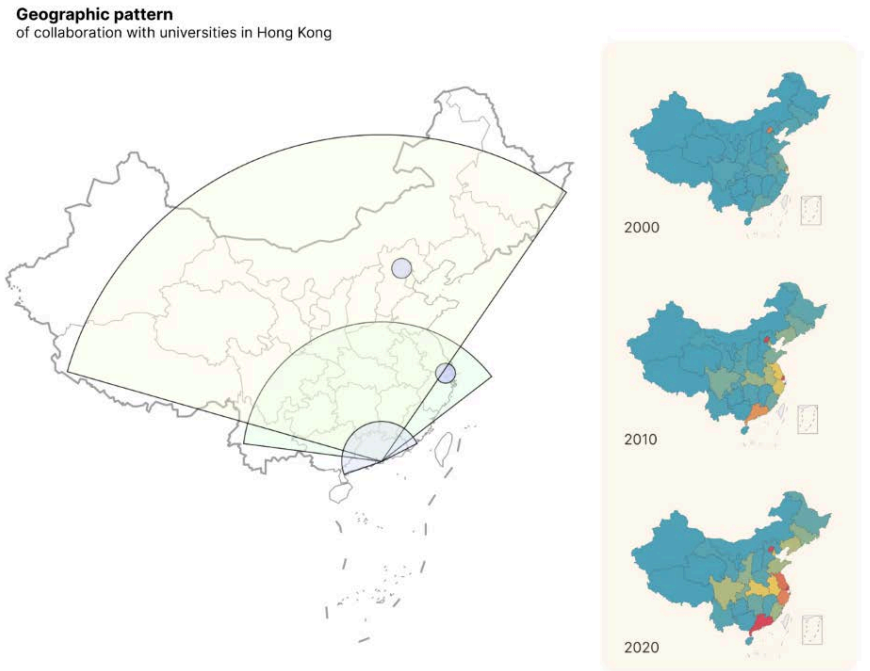
Top Collaboration Locations for universities in Guangdong province



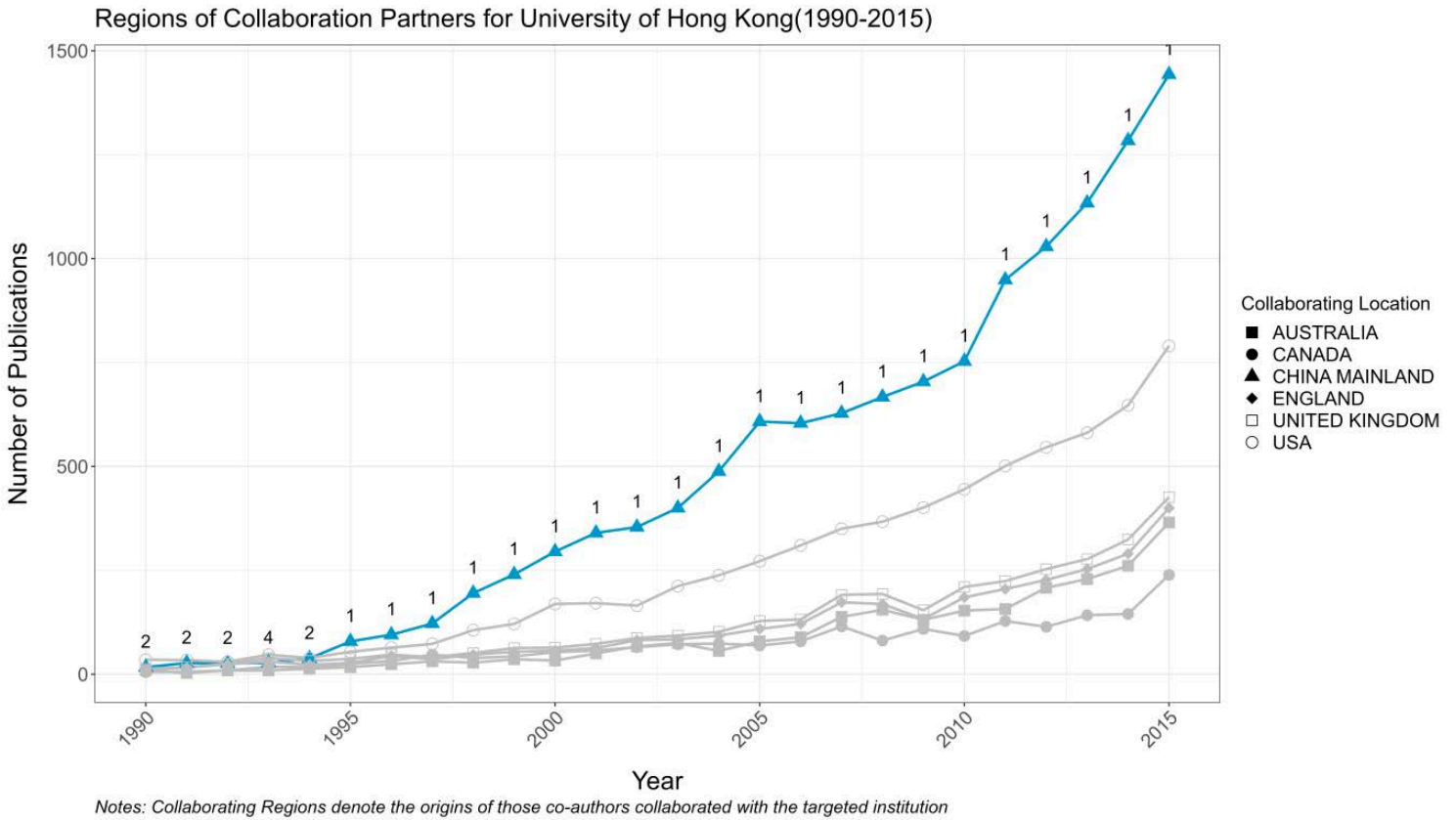

Regions of Collaboration Partners for Southern University of Science & Technology (1980-2023)
Number of Publications
0
200
400
600
2015
2020
Year
Collaborating Location
AUSTRALIA
HONG KONG
JAPAN
UNITED KINGDOM
USA
Notes: Collaborating Regions denote the origins of those co-authors collaborated with the targeted institution

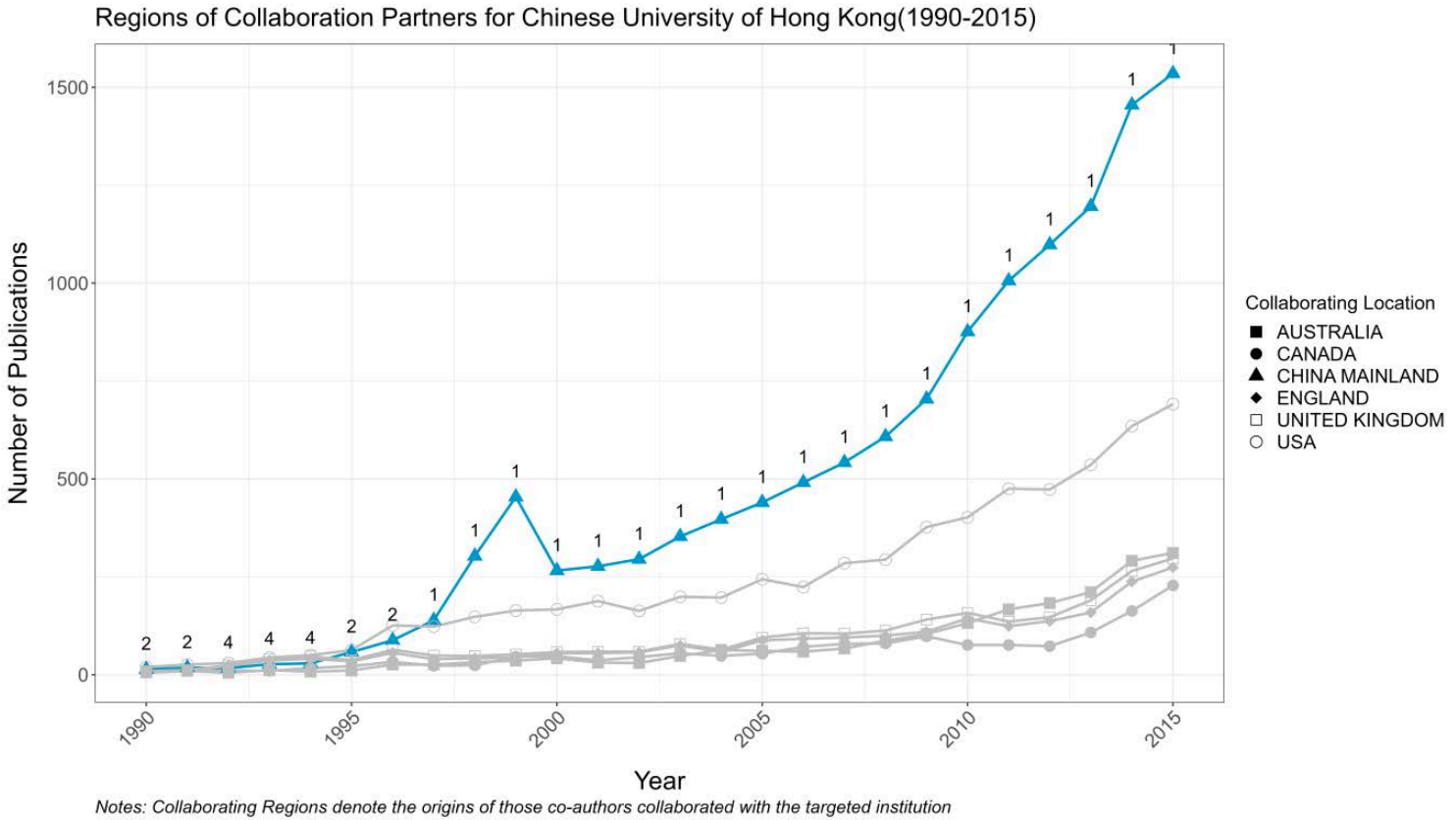
Geographic pattern of collaboration with universities in Hong Kong

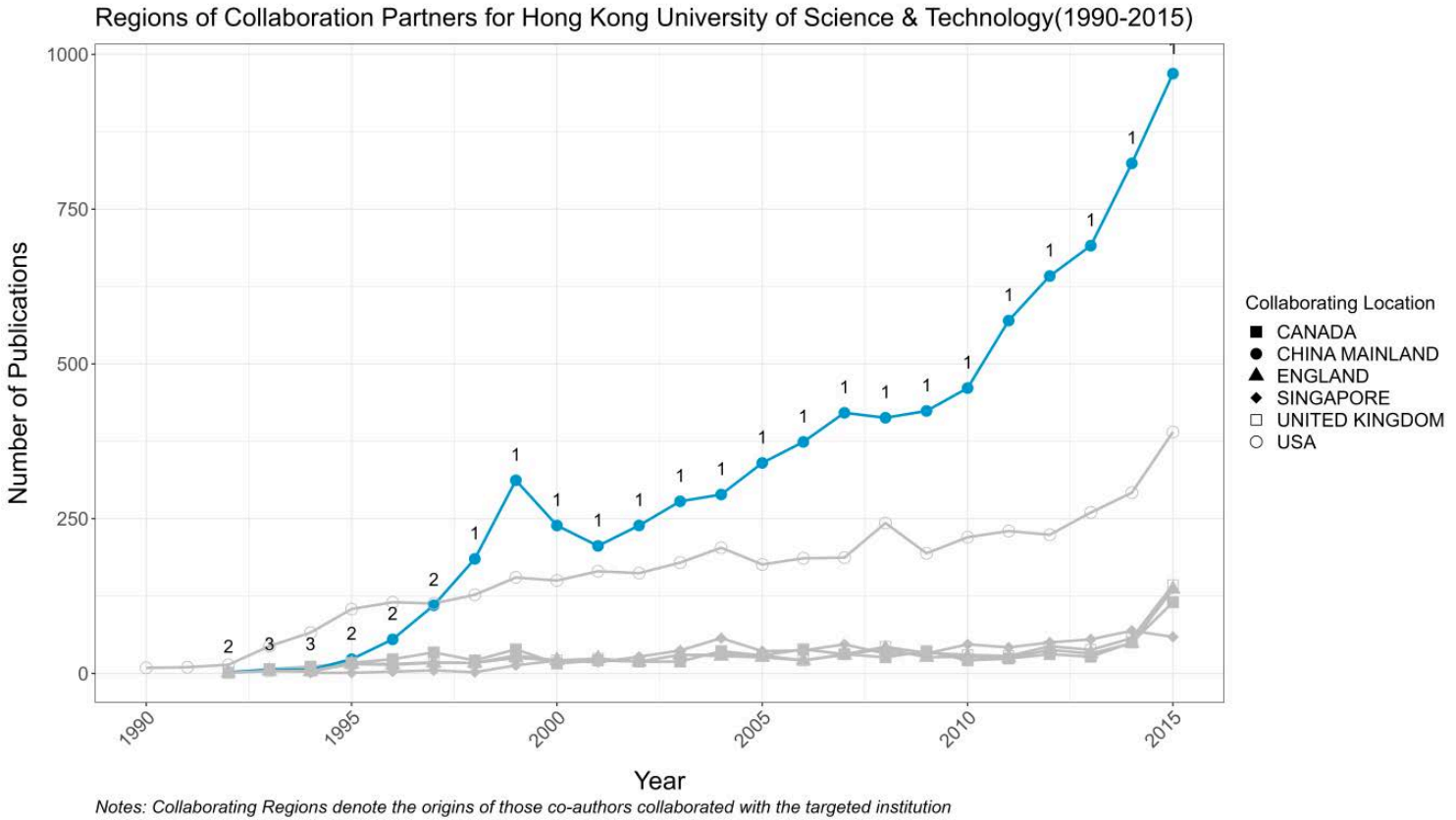
Regions remain high-frequent collaboration with Hong Kong:



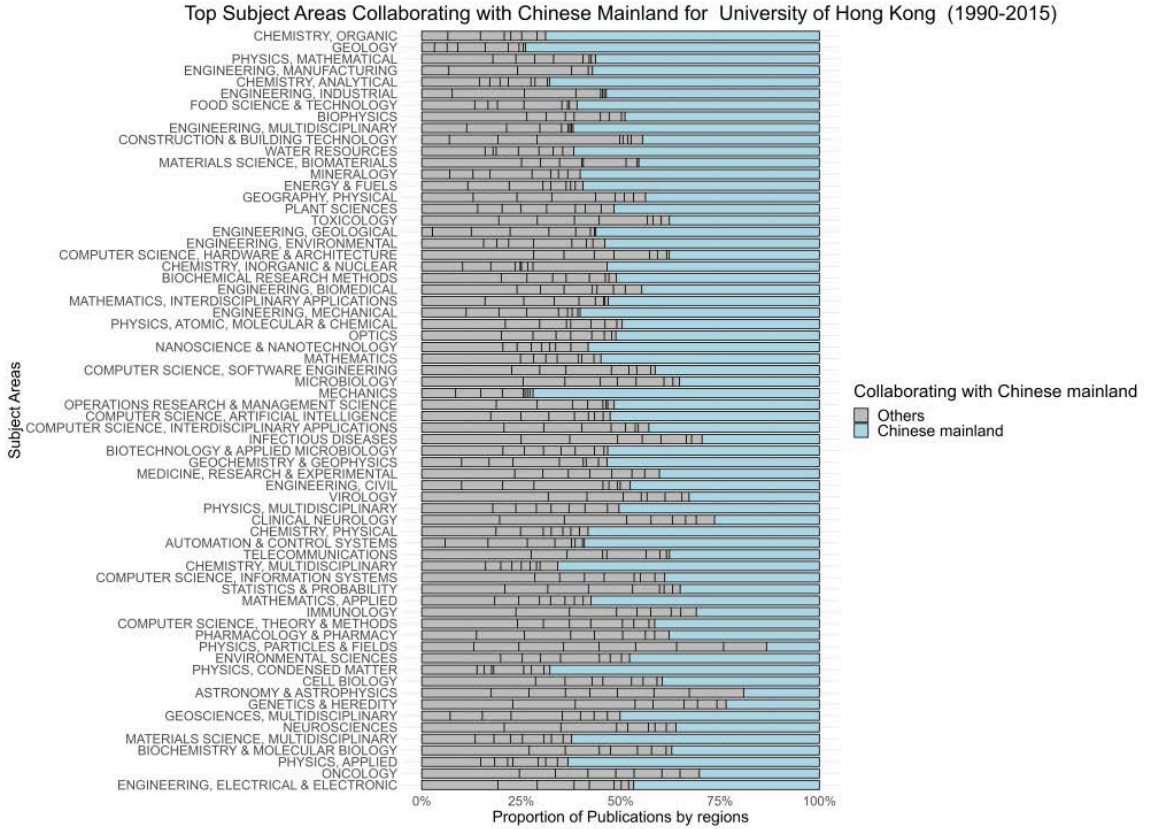
Top collaboration location for Hong Kong unviersities

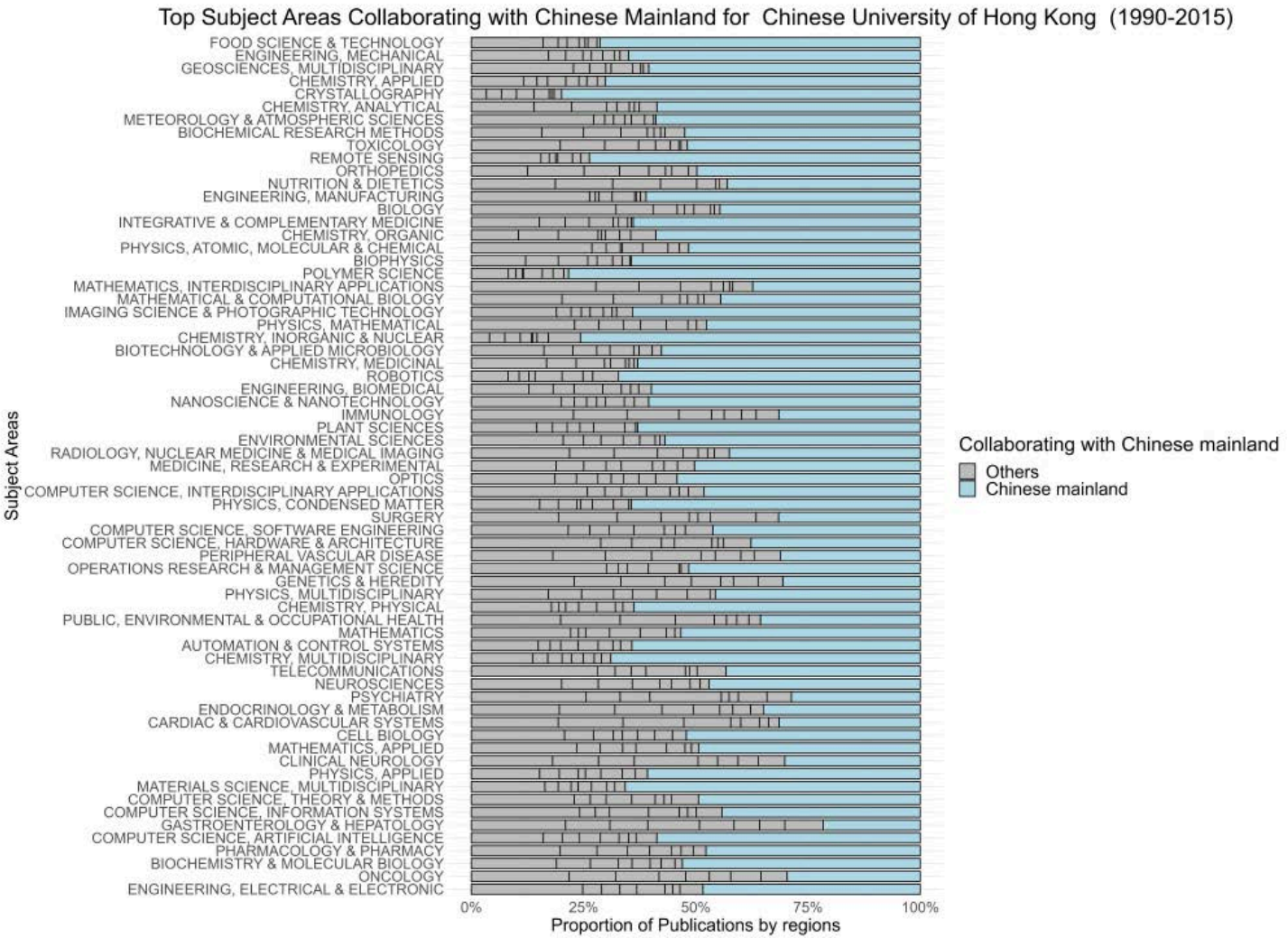


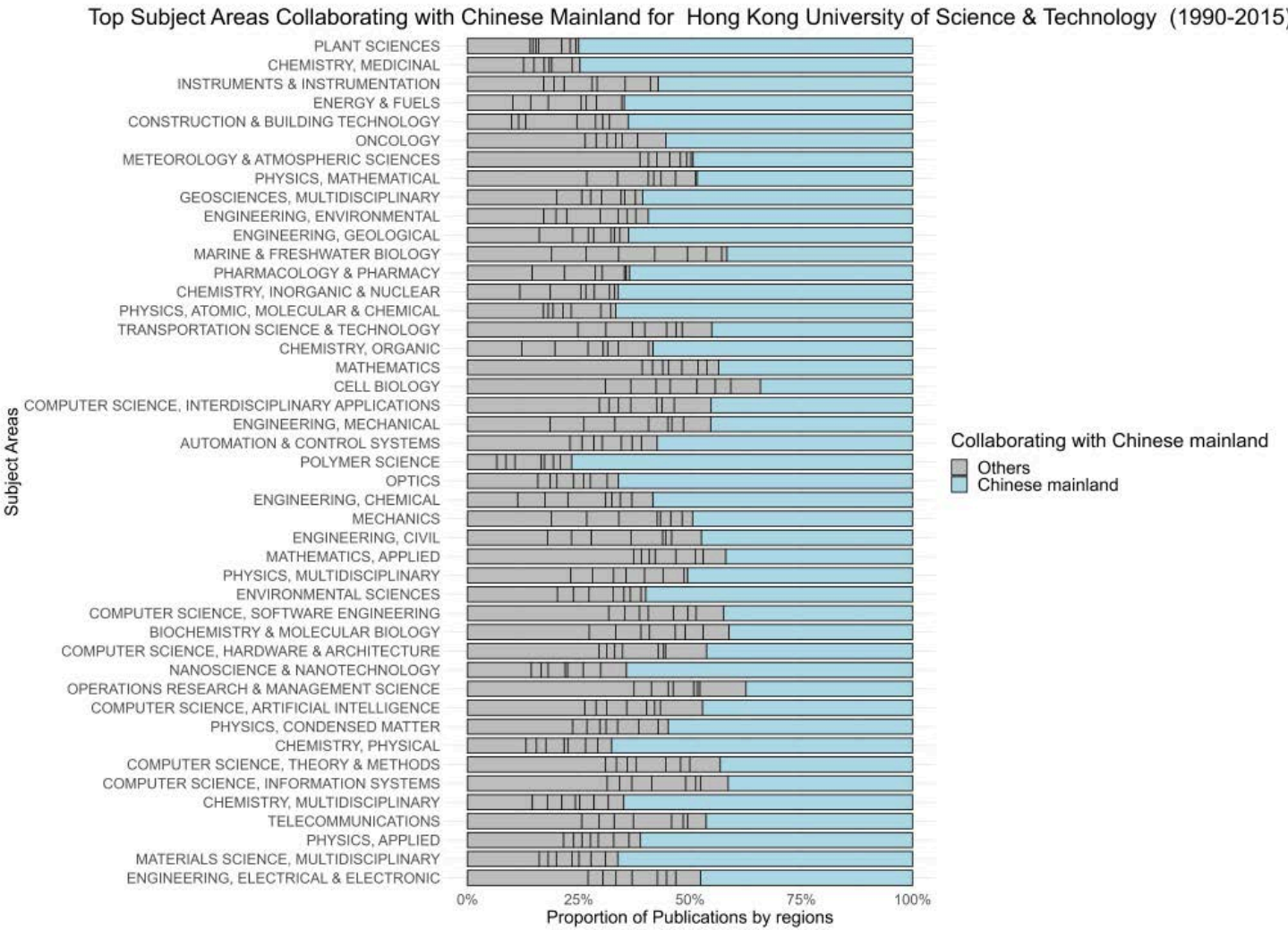

Regions of Collaboration Partners for Chinese University of Hong Kong(1990-2015)
Number of Publications
1500
1000
500
0
1990
1995
2000
2005
2010
2015
Year
Collaborating Location
AUSTRALIA
CANADA
CHINA MAINLAND
ENGLAND
UNITED KINGDOM
USA
Notes: Collaborating Regions denote the origins of those co-authors collaborated with the targeted institution


Regions of Collaboration Partners for Hong Kong University of Science & Technology(1990-2015)
Number of Publications
1000
750
500
250
0
1990
1995
2000
2005
2010
2015
Year
Collaborating Location
CANADA
CHINA MAINLAND
ENGLAND
SINGAPORE
UNITED KINGDOM
USA
Notes: Collaborating Regions denote the origins of those co-authors collaborated with the targeted institution

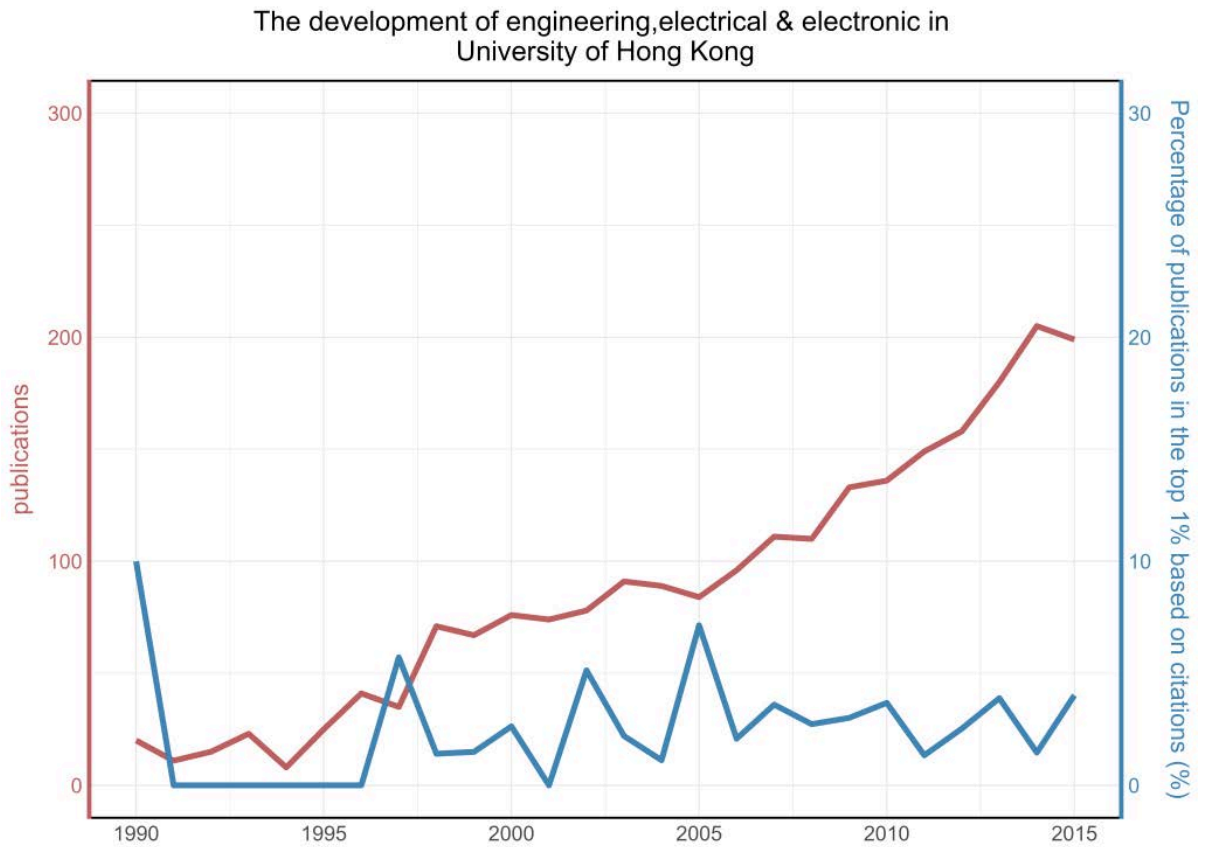
Top Collaborating Subject Areas between Hong Kong and Mainland China

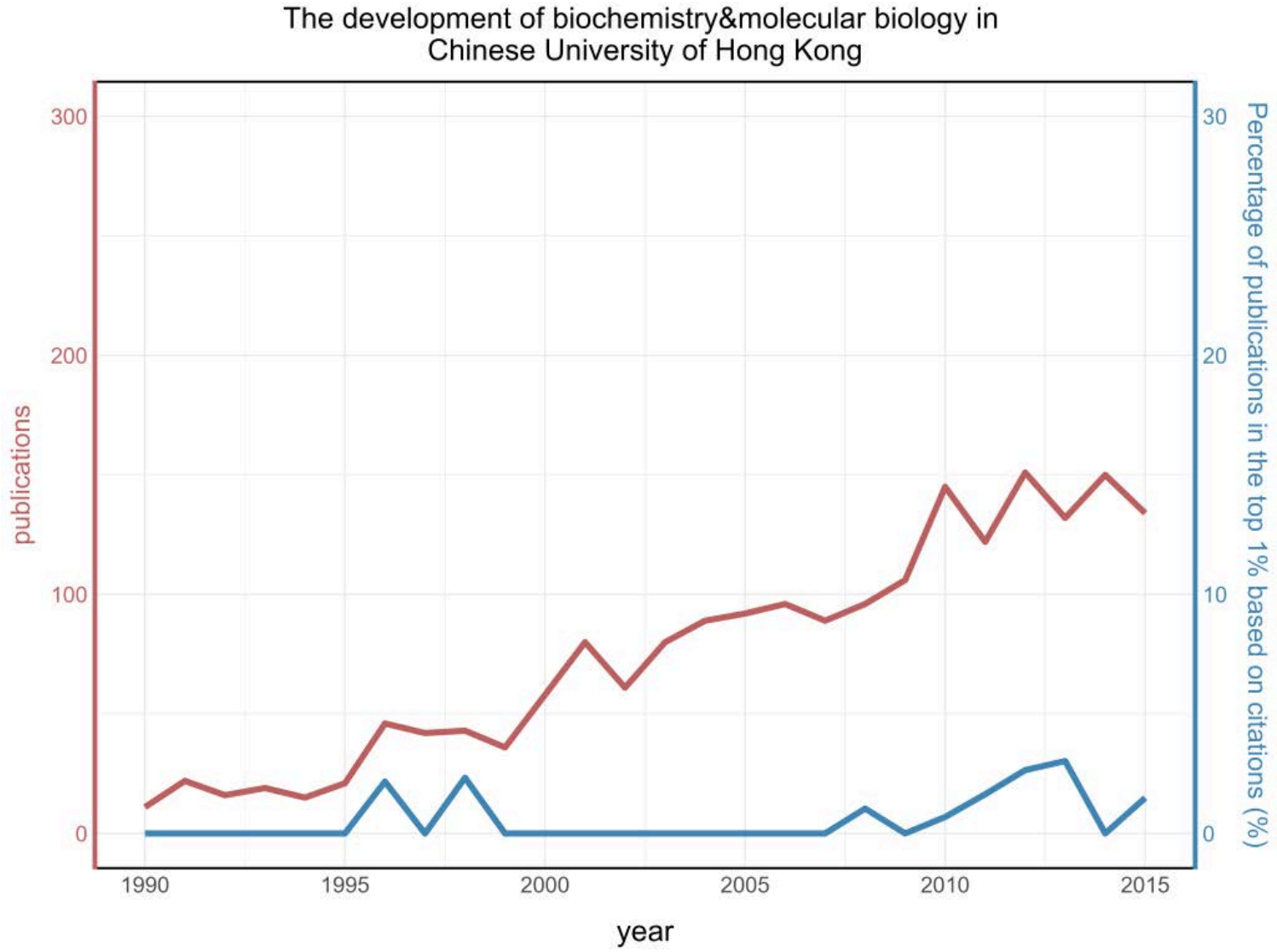


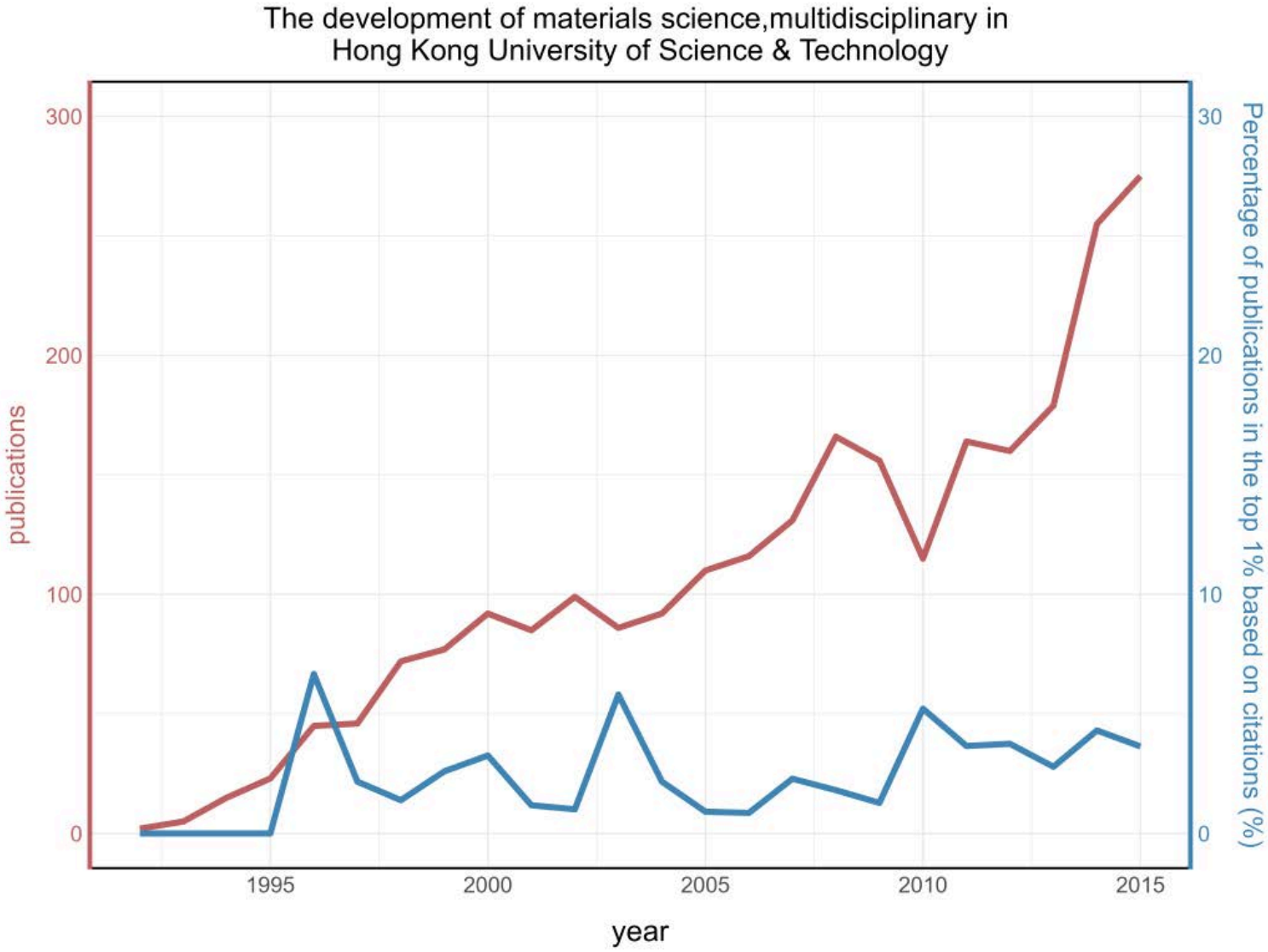

Top Subject Areas Collaborating with Chinese Mainland for Chinese University of Hong Kong (1990-2015)
Subject Areas
FOOD SCIENCE & TECHNOLOGY
ENGINEERING, MECHANICAL
GEOSCIENCES, MULTIDISCIPLINARY
CHEMISTRY, APPLIED
CRYSTALLOGRAPHY
CHEMISTRY, ANALYTICAL
METEOROLOGY & ATMOSPHERIC SCIENCES
BIOCHEMICAL RESEARCH METHODS
TOXICOLOGY
REMOTE SENSING
ORTHOPEDICS
NUTRITION & DIETETICS
ENGINEERING, MANUFACTURING
BIOLOGY
INTEGRATIVE & COMPLEMENTARY MEDICINE
CHEMISTRY, ORGANIC
PHYSICS, ATOMIC, MOLECULAR & CHEMICAL
BIOPHYSICS
POLYMER SCIENCE
MATHEMATICS, INTERDISCIPLINARY APPLICATIONS
MATHEMATICAL & COMPUTATIONAL BIOLOGY
IMAGING SCIENCE & PHOTOGRAPHIC TECHNOLOGY
PHYSICS, MATHEMATICAL
CHEMISTRY, INORGANIC & NUCLEAR
BIOTECHNOLOGY & APPLIED MICROBIOLOGY
CHEMISTRY, MEDICINAL
ROBOTICS
ENGINEERING, BIOMEDICAL
NANOSCIENCE & NANOTECHNOLOGY
IMMUNOLOGY
PLANT SCIENCES
ENVIRONMENTAL SCIENCES
RADIOLOGY, NUCLEAR MEDICINE & MEDICAL IMAGING
MEDICINE, RESEARCH & EXPERIMENTAL
OPTICS
COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS
PHYSICS, CONDENSED MATTER
SURGERY
COMPUTER SCIENCE, SOFTWARE ENGINEERING
COMPUTER SCIENCE, HARDWARE & ARCHITECTURE
PERIPHERAL VASCULAR DISEASE
OPERATIONS RESEARCH & MANAGEMENT SCIENCE
GENETICS & HEREDITY
PHYSICS, MULTIDISCIPLINARY
CHEMISTRY, PHYSICAL
PUBLIC, ENVIRONMENTAL & OCCUPATIONAL HEALTH
MATHEMATICS
AUTOMATION & CONTROL SYSTEMS
CHEMISTRY, MULTIDISCIPLINARY
TELECOMMUNICATIONS
NEUROSCIENCES
PSYCHIATRY
ENDOCRINOLOGY & METABOLISM
CARDIAC & CARDIOVASCULAR SYSTEMS
CELL BIOLOGY
MATHEMATICS, APPLIED
CLINICAL NEUROLOGY
PHYSICS, APPLIED
MATERIALS SCIENCE, MULTIDISCIPLINARY
COMPUTER SCIENCE, THEORY & METHODS
COMPUTER SCIENCE, INFORMATION SYSTEMS
GASTROENTEROLOGY & HEPATOLOGY
COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE
PHARMACOLOGY & PHARMACY
BIOCHEMISTRY & MOLECULAR BIOLOGY
ONCOLOGY
ENGINEERING, ELECTRICAL & ELECTRONIC
0%
25%
50%
75%
100%
Proportion of Publications by regions
Collaborating with Chinese mainland
Others
Chinese mainland


Top Subject Areas Collaborating with Chinese Mainland for Hong Kong University of Science & Technology (1990-2015)
PLANT SCIENCES
CHEMISTRY, MEDICINAL
INSTRUMENTS & INSTRUMENTATION
ENERGY & FUELS
CONSTRUCTION & BUILDING TECHNOLOGY
ONCOLOGY
METEOROLOGY & ATMOSPHERIC SCIENCES
PHYSICS, MATHEMATICAL
GEOSCIENCES, MULTIDISCIPLINARY
ENGINEERING, ENVIRONMENTAL
ENGINEERING, GEOLOGICAL
MARINE & FRESHWATER BIOLOGY
PHARMACOLOGY & PHARMACY
CHEMISTRY, INORGANIC & NUCLEAR
PHYSICS, ATOMIC, MOLECULAR & CHEMICAL
TRANSPORTATION SCIENCE & TECHNOLOGY
CHEMISTRY, ORGANIC
MATHEMATICS
CELL BIOLOGY
COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS
ENGINEERING, MECHANICAL
AUTOMATION & CONTROL SYSTEMS
POLYMER SCIENCE
OPTICS
ENGINEERING, CHEMICAL
MECHANICS
ENGINEERING, CIVIL
MATHEMATICS, APPLIED
PHYSICS, MULTIDISCIPLINARY
ENVIRONMENTAL SCIENCES
COMPUTER SCIENCE, SOFTWARE ENGINEERING
BIOCHEMISTRY & MOLECULAR BIOLOGY
COMPUTER SCIENCE, HARDWARE & ARCHITECTURE
NANOSCIENCE & NANOTECHNOLOGY
OPERATIONS RESEARCH & MANAGEMENT SCIENCE
COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE
PHYSICS, CONDENSED MATTER
CHEMISTRY, PHYSICAL
COMPUTER SCIENCE, THEORY & METHODS
COMPUTER SCIENCE, INFORMATION SYSTEMS
CHEMISTRY, MULTIDISCIPLINARY
TELECOMMUNICATIONS
PHYSICS, APPLIED
MATERIALS SCIENCE, MULTIDISCIPLINARY
ENGINEERING, ELECTRICAL & ELECTRONIC
Subject Areas
0%
25%
50%
75%
100%
Proportion of Publications by regions
Collaborating with Chinese mainland
Others
Chinese mainland

Development trends in *advantage* disciplines at each university from 1990 to 2015




The development of biochemistry&molecular biology in
Chinese University of Hong Kong
publications
Percentage of publications in the top 1% based on citations (%)
300
200
100
0
30
20
10
0
1990
1995
2000
2005
2010
2015
year

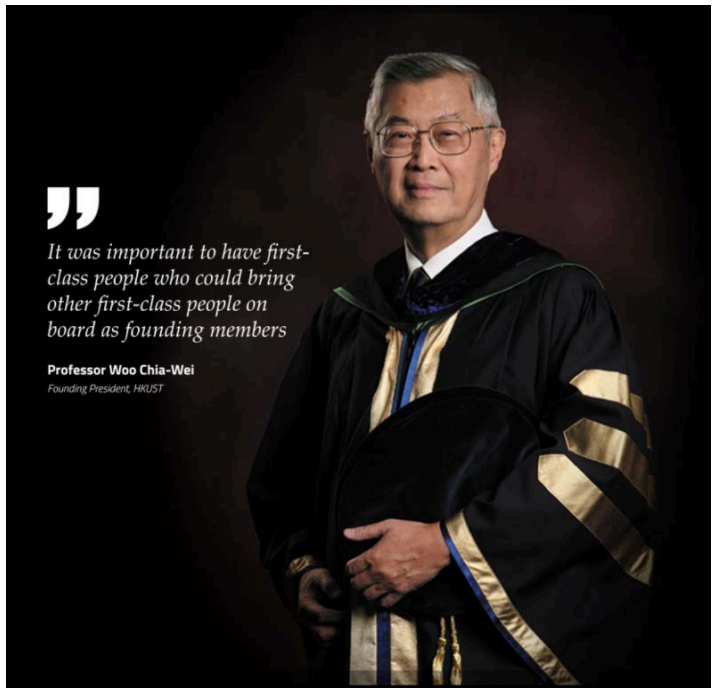

The development of materials science,multidisciplinary in
Hong Kong University of Science & Technology
publications
Percentage of publications in the top 1% based on citations (%)
300
200
100
0
30
20
10
0
1995
2000
2005
2010
2015
year

Explanation from an Evolutionary Perspective

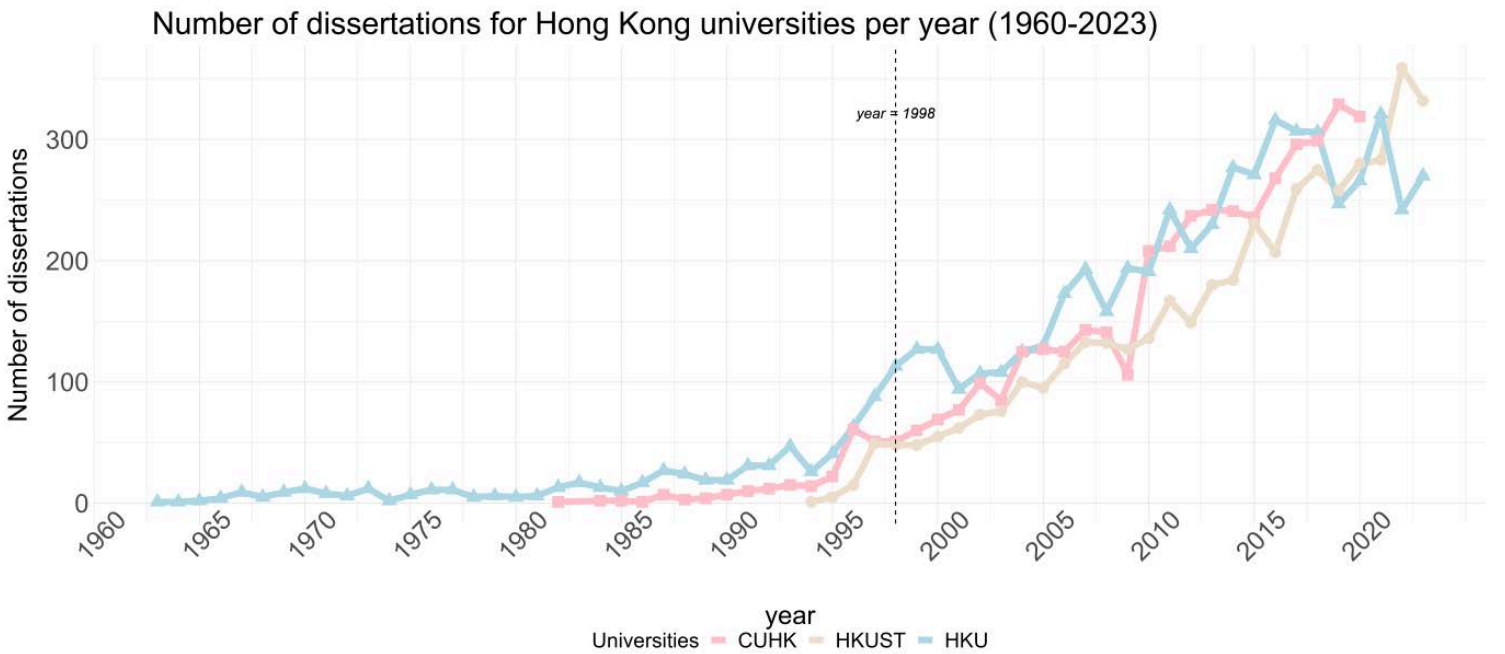
- Points of Contact
- Temporal Characteristics
- Geographical characteristic

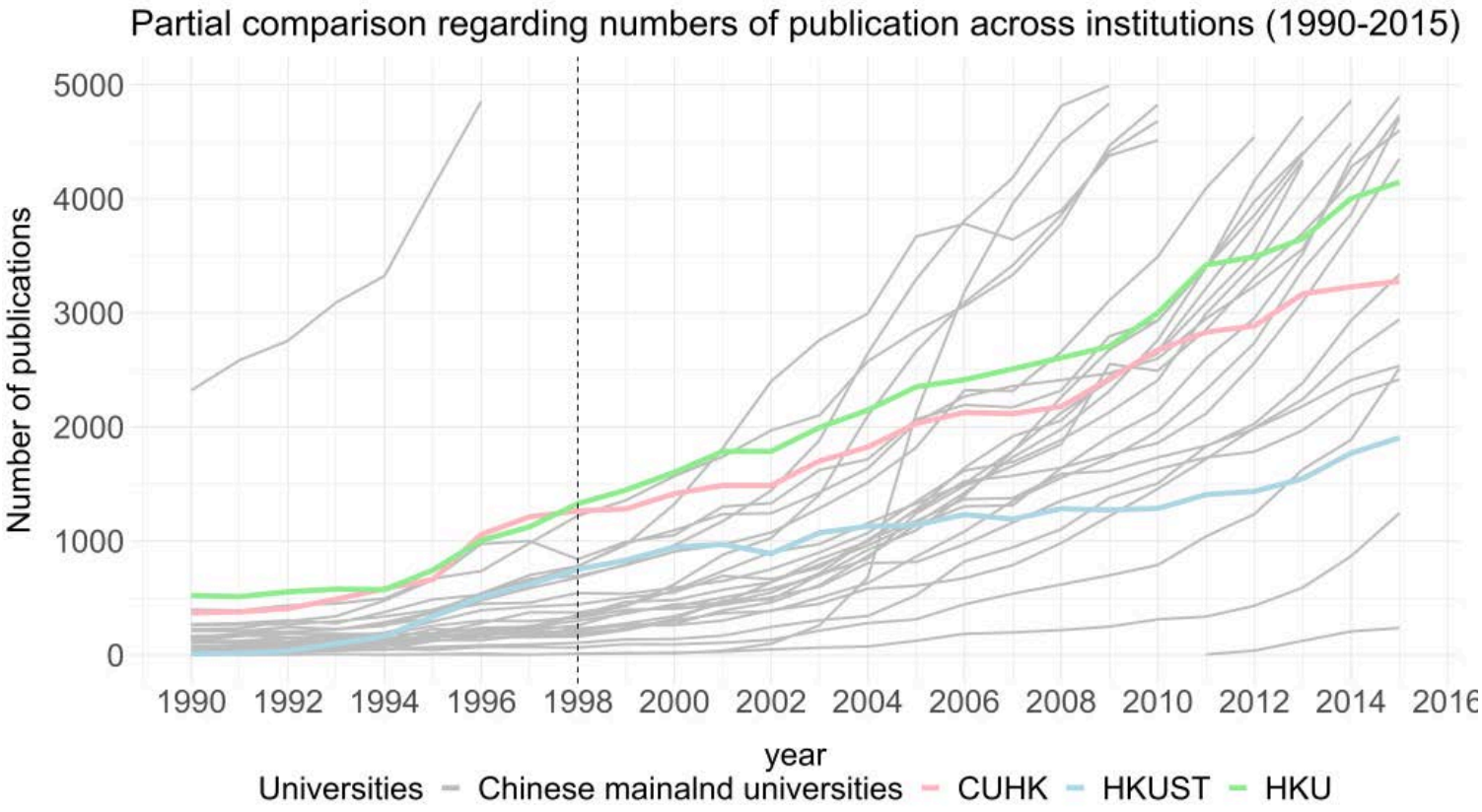
Points of Contact

Renowned scientists (**Lee Tsung-Dao**) and figures(**Woo Chia-Wei**,**Kung Shain-dow**) became conduits for collaboration and eagerly created channels to assist Chinese scientists.

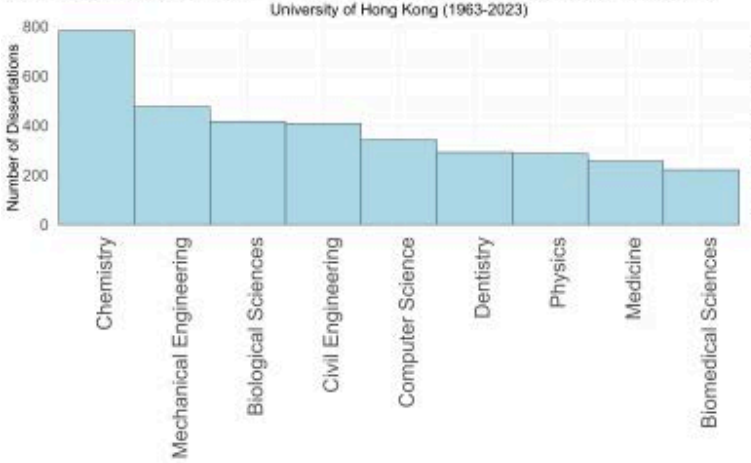


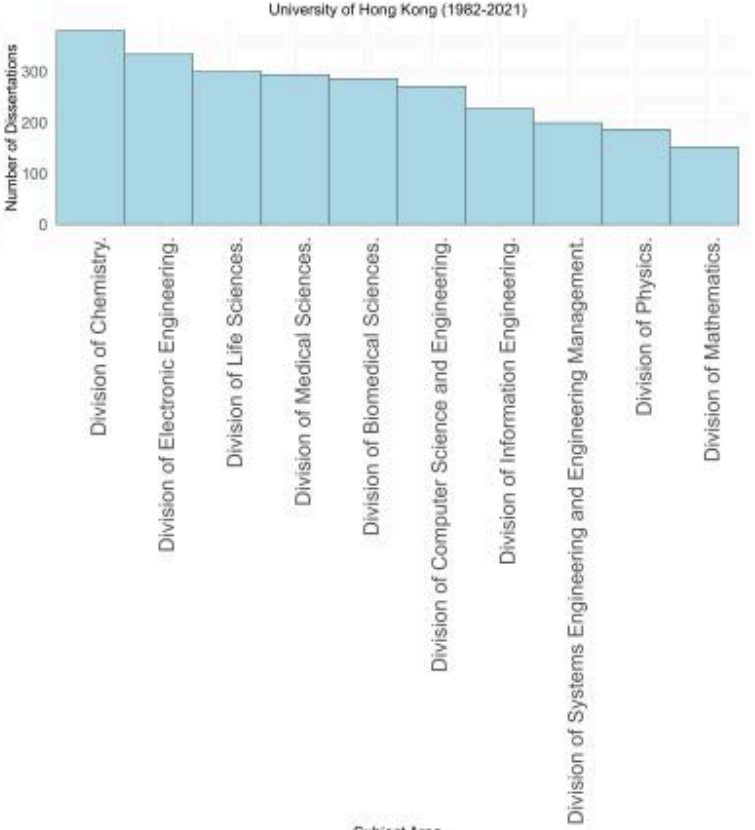
Temporal Characteristics

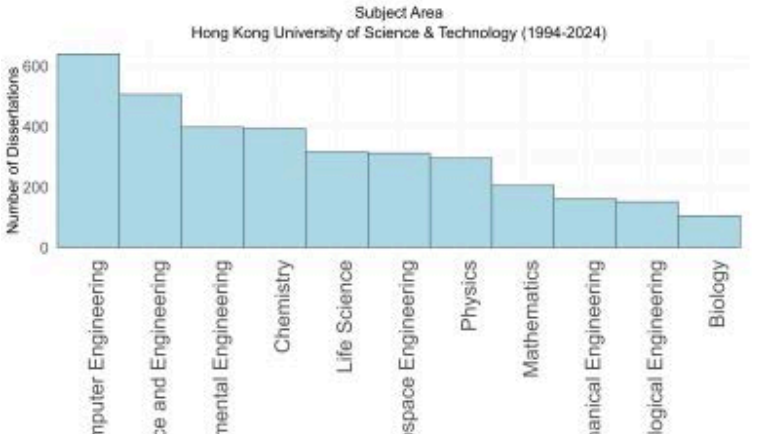



Partial comparison regarding numbers of publication across institutions (1990-2015)
Number of publications
5000
4000
3000
2000
1000
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
year
Universities
Chinese mainalnd universities
CUHK
HKUST
HKU

Phd dissertations for Hong Kong universities by subject areas







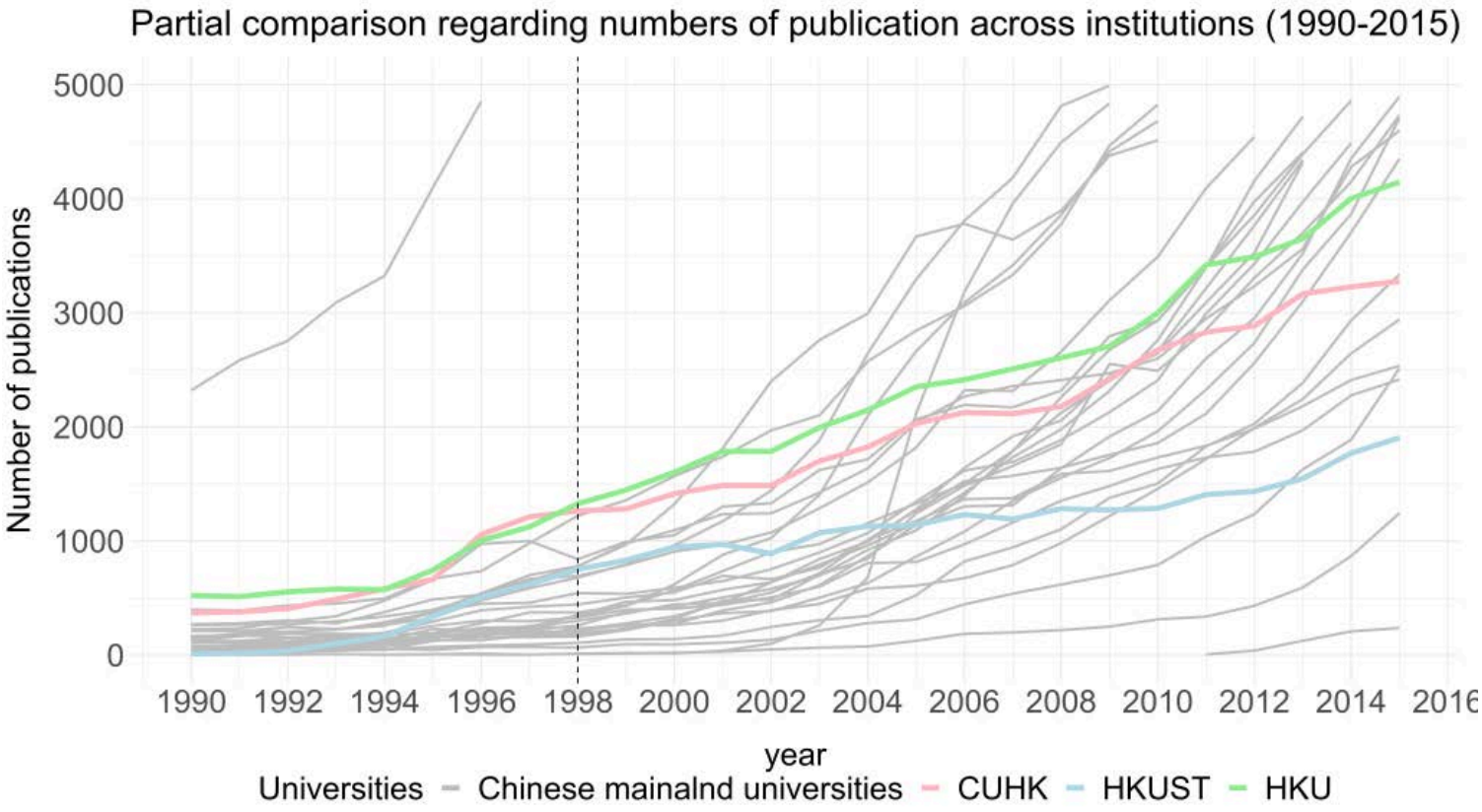

Partial comparison regarding numbers of publication across institutions (1990-2015)
Number of publications
5000
4000
3000
2000
1000
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
year
Universities
Chinese mainalnd universities
CUHK
HKUST
HKU

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%
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%

Geographical characteristic

An example regarding the collaboration between *CAS* and *HKUST*

- 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

Discussion & Conclusion

- 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.
- This "cross-border knowledge exchange" blends mainland talent with Hong Kong's academic resources and freedoms. 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.

Limitations and further exploration

- Exploring the structure of research funding among the collaborators
- Adopting social network analysis beyond statistical description in further research
- The classification of disciplines in PhD dissertations is rough and need further refine