



Multidimensional Data Analysis on Urban Science and Technology Innovation Capabilities in Guangzhou

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Abstract. This paper is a multidimensional data analysis on the scientific and technological innovation capabilities of Guangzhou based on the achievements of research institutions and enterprises. This paper analyzes by constructing an analysis model based on urban scientific research institutions and enterprises' scientific and technological innovation, use sequence analysis and classified distribution analysis to make statistics of the output data of urban scientific and technological achievements. The results show that Guangzhou has developed rapidly in the field of scientific and technological innovation, but there are still many opportunities for improvement. This paper concludes with suggestions on how to further improve these capabilities.

Keywords: Multidimensional Data Analysis · Technology Innovation Capabilities · The Output Of Research Institutions

1 Introduction

The world is continuously revolutionizing and transforming science, technology, and industry. Scientific and technological innovation is accelerating and is deeply integrated, and it has widely penetrated all aspects of human society. At present, global research and development (R&D) investment continue to trend, and R&D investment in Asian countries has grown particularly rapidly. The regional distribution shows a multipolar pattern of Asia, the United States, and Europe. This global scientific and technological innovation pattern has undergone major adjustments and will accelerate the development of the “three pillars” of North America, East Asia, and the European Union. With the acceleration of economic globalization and the rise of emerging economies, especially since the international financial crisis, the balance of global scientific and technological innovation forces has quietly changed, and it has begun to spread from developed countries to developing countries.

Urban technological innovation capability is a measure of technological innovation behavior in the urban innovation system. The most basic connotation should have two

aspects: one is the improvement of the scale and level of science and technology activities themselves, and the other is the enhancement of the influence of science and technology on economic development and the social environment. Scientific and technological innovation is inseparable from certain human resources, scientific and technological awareness, and material and technological foundations. Science and technology activities require human and financial inputs, and the outputs of science and technology activities are expressed as direct and indirect outputs and have impacts on the economic, social, and environmental [7]. Therefore, the main constituent elements of the urban technological innovation capability can be summarized into four: science and technological innovation resources, science and technological innovation inputs, knowledge output results, and socio-economic economic benefits, each of which is in turn influenced by certain factors [6]. Therefore, a multi-dimensional perspective is needed to analyze the urban technological innovation capability.

Over the past decade, Guangzhou's economy has been transitioning away from light industry and traditional services to modern manufacturing and service industries. The IAB industry in Guangzhou (i.e. new-generation information technology [I], artificial intelligence [A], and biomedical industry [B]) has been developing rapidly, expanding steadily, enhancing innovation capacity significantly, and highlighting industrial clustering effects [1]. As such, it is further becoming a strategic engine to promote economic development.

This paper uses literature research and internet survey methods to compile and summarize the statistical yearbooks published by the Guangzhou Municipal Bureau of Statistics and Guangzhou Municipal Intellectual Property Bureau. It also conducts a multi-dimensional data analysis of the achievements of research institutes and enterprises to understand the scientific and technological innovation capabilities of Guangzhou [5].

2 Multidimensional Data Analysis on Guangzhou's Innovation Capabilities

2.1 Analysis of the Output of Research Institutions

2.1.1 Total Number of Papers

Institutes based in Guangzhou have published a total of 165,680 papers in the Science Citation Index (SCI). From 2008 to 2018, the number of international scientific and technological papers published in Guangzhou has been increasing year by year, and it has maintained a high growth rate. In 2018, the number of papers published was more than 29,000, which means that it has continued to maintain a high growth rate. According to statistics from 2008 to 2018, Guangzhou ranked fourth in the country in terms of the number of SCI publications, second only to Beijing, Shanghai, and Nanjing. And the top eight cities in the country have published more than 100,000 international papers, indicating that the international papers published by Chinese scientific and technological workers are at a high level (see Fig. 1 and Table 1).

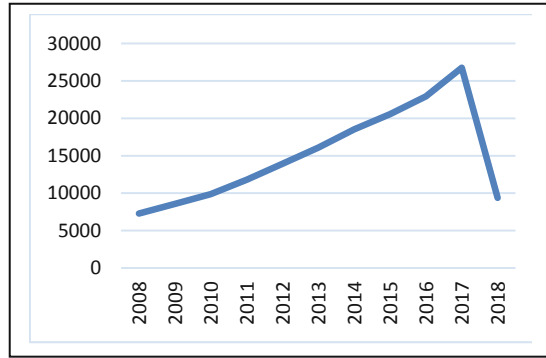


Fig. 1. Publications in SCI in Guangzhou from 2008–2018.

Table 1. Top 10 cities with the highest number of SCI publications in China.

No.	City	No. of papers
1	Beijing	627639
2	Shanghai	311225
3	Nanjing	202614
4	Guangzhou	165680
5	Wuhan	147686
6	Xi'an	121627
7	Hangzhou	122915
8	Chengdu	109724

2.1.2 Subject Distribution

The subject with the highest number of published papers in Guangzhou is biochemistry, with a total of 52,661 papers, accounting for 31.8% of the number of papers published in Guangzhou, and 36,214 papers in chemistry, accounting for 21.9%. In general, the subjects with the highest number of published papers in Guangzhou are mainly biology, medicine, engineering, chemistry, and physics (see Table 2).

2.1.3 Institutional Distribution

The results of the institutions with the highest number of international publications in Guangzhou in the past ten years show that, except for the Chinese Academy of Sciences, which is a research institute, the other nine are colleges and universities, and the concentration of publishing institutions is relatively high. It is shown that the top ten institutions in Guangzhou in terms of international output are the main institutions that publish international papers. The total number of papers published far exceeds the sum of other universities and research institutions in Guangzhou. Among them, Sun Yat-Sen University

Table 2. Top 10 subject areas with the most international publications in Guangzhou from 2008–2018 (Note: a paper can be divided into multiple subject areas).

Subject Area	Number	Share
Biochemistry	52661	31.8%
Chemistry	36214	21.9%
Genetics	33162	20.2%
Engineering	30716	18.5%
Pharmacology	29473	17.8%
Science and Technology	28335	17.1%
Cell Biology	24322	14.7%
Physics	23706	14.3%
Oncology	23257	14.03%
Materials Science	23099	14.04%

Table 3. Top ten institutions in Guangzhou with the most international papers.

No.	University	Number	Share
1	Sun Yat-sen University	85,102	51.4%
2	South China University of Technology	48,297	29.18%
3	Chinese Academy of Sciences	38,187	23.04%
4	Jinan University	19,175	11.57%
5	Southern Medical University	17,759	10.67%
6	South China Normal University	16,274	9.36%
7	Guangdong University of Technology	9,636	5.81%
8	South China University of Agriculture	7,754	4.69%
9	Guangzhou Medical University	7,143	4.31%
10	University of Chinese Academy of Sciences	5,757	3.47%

has published 85,102 papers, accounting for more than half of the international publication volume in Guangzhou. Among the schools with the highest number of publications, science and engineering colleges accounted for 40%, and the two medical universities in Guangzhou accounted for 14.98% of the total. Table 3 summarizes the details.

2.1.4 Journal Distribution

Statistics on the journals included in the SCI database show that scientific and technological workers in Guangzhou published the largest number of papers in ten journals, including *PLOS One*, with a total of 10,741 papers, accounting for 6.5% of the total.

Table 4. Top ten journals with the highest number of international papers published in Guangzhou.

No	Journal	Number	Share
1	PLOS ONE	2986	1.802%
2	SCIENTIFIC REPORTS	1896	1.144%
3	RSC ADVANCES	1349	0.814%
4	ONCOTARGET	1210	0.730%
5	MOLECULAR MEDICINE REPORTS	691	0.417%
6	ACS APPLIED MATERIALS INTERFACES	589	0.355%
7	CHINESE MEDICAL JOURNAL	522	0.315%
8	JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY	514	0.310%
9	BIORESOURCE TECHNOLOGY	510	0.308%
10	ACTA PHYSICA SINICA	474	0.286%

Table 5. The volume of international publications in Guangzhou (2008 to 2018).

No.	Country/Regions	Paper number	Share
1	United States	20,231	47.6%
2	Australia	5,029	11.8%
3	United Kingdom	3,775	0.09%
4	Canada	3,312	0.08%
5	Germany	3,055	0.071%
6	Japan	2,993	0.07%
7	Taiwan, China	2,169	0.051%
8	Singapore	1,956	0.046%

Institutions in Guangzhou have published a maximum of 2,986 papers in the high-ranked *PLOS One* journal, accounting for 27.8% of these papers (Table 4).

2.1.5 Cooperation

During the period from 2008 to 2018, eight countries and regions, including the US, Australia, the UK, Canada, Germany, Japan, Taiwan China, and Singapore, jointly published 42,520 international papers in cooperation with Guangzhou. Among them, the three countries/regions with the most cooperation are the US, Australia, and the UK. Papers published in cooperation with the US accounted for 47.6% of the total international papers, which is much higher than with other countries (see Table 5).

Table 6. Distribution of high-tech enterprises in Guangzhou from 2007 to 2016.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Liwan	22	22	18	18	18	15	12	15	34	27
Yue xiu	5	4	2	5	3	4	5	8	7	6
Haizhu	36	32	34	33	25	22	26	25	23	22
Tianhe	86	66	40	40	34	33	29	31	28	34
Baiyun	52	54	71	88	66	64	83	90	121	162
Huangpu	25	25	21	32	31	33	31	28	139	168
Fanyu	105	140	136	141	145	98	107	111	166	161
Huadu	28	46	56	53	63	72	81	104	119	80
Nansha	85	32	28	28	30	58	65	62	76	94
Conghua	26	28	30	36	36	37	42	44	54	59
Zengcheng	67	71	94	115	136	179	182	199	186	153
Luogang	140	172	197	313	175	174	163	136		
Total	558	692	727	902	762	789	826	853	953	966

2.2 Analysis of the Technological Innovation Capabilities of Enterprises

Scientific and technological innovation of enterprises is mainly explained in three parts: the distribution of high-tech enterprises in various regions of Guangzhou, scientific research achievements, and internal expenditure of R&D funds. The following statistical data are derived from the Guangzhou Statistical Network's statistical yearbook data, as of 2017 [2].

2.2.1 Enterprise Distribution

The results show that the enterprises above designated size in Guangzhou have maintained a growth trend, reaching a peak of 966 in 2016. Luogang District (now merged into Huangpu District) has the largest distribution of enterprises among all districts in the city under its unique geographical advantages, reaching 313 in 2010 (see Table 6). After the merger with Huangpu District in 2014 due to policy reasons, the distribution of enterprises in Huangpu District has grown more rapidly.

2.2.2 Analysis on the Output of Scientific and Technological Achievements of Enterprises

Through the output analysis of the distribution of technical fields, the scientific and technological achievements of enterprises have shown an upward trend year by year, and the growth rate is the largest from 2013 to 2015. The most scientific and technological achievements are concentrated in the field of mechatronics technology, which reached a peak of 654 in 2016, an increase of 2.21 times compared with 2007. In 2013, the volume of electronics and information technology grew the fastest, with an increase of 46%, and

Table 7. Scientific and technological achievements of enterprises above designated size.

	Number of patent applications	Number of Invention Patent Applications	Number of new product items	Number of R&D projects
2007	1698	721	2175	1803
2008	1548	1052	1783	1457
2009	3501	1282	4315	3953
2010	4051	1526	4088	3934
2011	5312	2058	4645	5013
2012	6957	2875	5993	6303
2013	8540	3472	6033	6270
2014	9715	3678	6797	7354
2015	10194	4234	7908	
2016	15620	6050	12046	

it was still showing a rapid upward trend. The number of scientific and technological achievements in the field of new material technology has maintained rapid growth, reaching 611 in 2016.

The scientific and technological achievements of enterprises are increasing year by year. The number of patent applications and the number of new product projects showed a slow upward trend in 2007 and rose sharply after 2015. The number of enterprise patent applications in Guangzhou has increased rapidly since 2010, with the fastest growth rate from 2015 to 2016, with an increase of 65.3% (Table 7).

2.2.3 Analysis of Internal Expenditure of Enterprise R&D Funds

The internal expenditure of enterprise R&D funds includes two parts, which are based on the purpose and source of the expenditure, both of which are on the rise. Among them, recurring expenditures account for most expenditures, with an average of 80 to 90%; corporate funds are the main source of project funding and the main part of all expenditures, accounting for about 90% of total expenditures (see Table 8). As can be seen from the table below, in recent years, while recurring expenditures and corporate capital expenditures have trended upward, other expenditures have trended downward. Most of the resources are invested in the internal R&D activities of the enterprise, and the internal R&D intensity is generally greater than 90%. This shows that the innovation contribution of the high-tech zone mainly comes from these enterprises, with strong investments in science and technology.

Table 8. Internal expenditure of enterprise R&D funds (unit: ten thousand yuan).

	Purpose of Expenditure		Source of expenditure				Total
	Recurring expenditures	Asset-based expenditures	Government Funds	Enterprise Funds	Foreign Funds	Other Funds	
2009	904,121	126,383	30,209	986,878	7,966	5,451	1,030,504
2010	1,022,297	165,432	37,295	1,092,792	50,000	7,642	1,187,729
2011	1,196,586	210,075	65,224	1,321,700	8,633	11,104	140,661
2012	1,334,418	246,162	69,777	1,490,246	14,264	6,293	1,580,580
2013	1,457,898	199,038	60,366	1,573,973	11,414	11,183	1,656,936
2014	1,672,090	224,153	46,026	1,836,089	5,485	8,643	1,896,243
2015	1,899,927	198,026	51,267	2,022,103	17,783	6,795	2,097,953
2016	2,080,484	209,295	61,571	2,217,840	2,397	7,971	22,899,779

3 Conclusions

This multidimensional data analysis of Guangzhou's capabilities for innovation found that Guangzhou has developed rapidly in the field of scientific and technological innovation, but there are still many areas for improvement. From the perspective of the innovation environment, as a developed city with a per capita GDP much higher than the national average, Guangzhou has released several policies and measures to support strategic emerging industries and the development of scientific and technological innovation. It also has geographic advantages with opportunities for cooperation with Hong Kong and Macau. Guangzhou has carried out a lot of international cooperation in the field of scientific and technological innovation, but from a national perspective, it has few advantages. In terms of the number of enterprises, the high-tech enterprises in Guangzhou have reached a certain scale, and the proportion of listed companies is much higher than that of the whole country. In terms of educational resources, the field of talent training in Guangzhou has grown rapidly. At present, Guangzhou has established several national-level strategic emerging industry bases, and the environment for innovation is good.

4 Suggestions on Enhancing the Technology Innovation Capability of Guangzhou

4.1 Continuously Promote the Construction of National Laboratories

Based on the construction and development of laboratories in Guangdong Province, Guangzhou can continuously promote the construction of national laboratories, explore the idea of jointly building a national laboratory relying on relevant industry–university–research resources in the Guangdong–Hong Kong–Macau Greater Bay Area and uncover the connection between applied basic research and industrialization [4]. It is important

to fast-track, form a precise connection between the innovation chain and the industrial chain, realize the full application of scientific and technological achievements, and achieve a win-win situation for the economy and society. This will help continuously improve Guangzhou's scientific and technological innovation capabilities. Under the guidance of the new environment of the national laboratory, this will be conducive to the output of major scientific research results.

4.2 Aggregate Industries and Attach Importance to the Transformation of Achievements

Guangzhou should make use of the existing parks and R&D bases to improve supporting facilities and configure the industrial chain, guide the development of enterprise agglomeration, improve the level of enterprise agglomeration, increase the degree of industrial concentration, and further enhance the development potential of the industry. On this basis, Guangzhou should further promote the alliance of powerful enterprises, cultivate a group of leading enterprises with strong, independent innovation capabilities, and master core technologies, which in turn will drive the sustainable development of the industry [3]. At the same time, Guangzhou should focus on supporting innovative small- and medium-sized enterprises and encourage institutions and enterprises to accelerate the transformation and industrialization of R&D results.

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