

Guangdong-Hong Kong-Macau Greater Bay Area Innovation Ecosystem White Paper

With Support and Guidance by:

Guangzhou Municipal Board
for International Investment

Guangzhou Research Center
for Development of Science and Technology

Investment Promotion Center
of Guangzhou Development District



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Foreword

Following the promulgation of the “*Outline Development Plan for Guangdong-Hong Kong-Macao Greater Bay Area*”, governments at all levels have responded actively by launching a series of policies and implementation measures which achieved positive results. At present, China’s Economic Reform has entered a critical period and is undergoing substantial expansion. Policies emphasis on new infrastructure, new driving forces, integration of industries in Guangdong, Hong Kong and Macao have raised new requirements for industrial innovation and collaboration.

The Guangdong-Hong Kong-Macao Greater Bay Area (hereinafter referred to as Greater Bay Area or GBA for short) is at the forefront of the country in terms of industrial infrastructure. With its rapid development in recent years, the time has come for the Grater Bay Area to consider the long-term sustainable development of the region. As a pioneer in the economic reform, the Greater Bay Area not only needs to develop existing facilities and carry out incremental innovations, but should also aim to lead the innovation of the entire country.

This white paper will take the healthcare, semiconductor and display industries as examples to demonstrate the industrial strengths and resources endowments of the Greater Bay Area. Based on the data and analysis, we will further discuss the innovation ecosystem of the Greater Bay Area and its long-term innovation directions, identify the vital role of innovative multinational enterprises in building a healthy ecosystem, and put forward our views and suggestions.

It is in the hope that this white paper assumes the roles of: (i) the Greater Bay Area’s manifesto of innovation, demonstrating to all stakeholders the region’s commitment to innovation; (ii) a brochure for innovation, promoting the Greater Bay Area as a fertile land full of innovation momentum and attracting global talents and innovative enterprises; (iii) a driving force of innovation, to help the Greater Bay Area navigate the road towards an international innovation and technology hub.

Chapter I: Innovation Background and Supporting Resources in the GBA

The Guangdong-Hong Kong-Macao Greater Bay Area is one of the most dynamic and open regions in China. In the past 40 years of economic reforms, the Greater Bay Area has enjoyed rapid economic development and continuous industrial upgrading, playing a significant strategic role in the overall development of the country.

Although the Greater Bay Area covers less than 1% of China's land area, and is home to less than 5% of the country's population, the GDP of the region was 11.62 trillion yuan in 2019, accounting for more than one-tenth of the country's total. The region has developed a comprehensive industry chain and attracted many world-leading enterprises such as Huawei, TCL China Star Optoelectronics Technology Co., Ltd., BGI Genomics, Mindray, etc. By continuously increasing R&D investment, the Greater Bay Area has accounted for nearly half of the PCT applications in China in recent years, further stimulating innovation vitality in the region.

Hong Kong is one of the three major financial centers in the world, and Macao is a world-renowned tourist destination. The two Special Administration Regions (SAR) are the most internationalized and economically developed cities in China. Guangdong also leads the way in economic reforms. The Greater Bay Area comprises two of the first four special economic zones, giving it a first-mover advantage. By leveraging the advantages of Hong Kong and Macao in information, capital, talents, and technology, the Greater Bay Area drives the development of the entire Pearl River Delta.

The Greater Bay Area has an excellent industrial foundation and abundant factor endowments, laying a solid foundation for innovation and development. However, to continue to strengthen the region's innovation capability and promote further industrial upgrading will be no walk in the park and remains a great challenge for the Greater Bay Area.

1. GBA – A Promising Land: Review on industrial foundation

The announcement of the Outline Development Plan for Guangdong-Hong Kong-Macao Greater Bay Area in 2019 has brought historic opportunities for the innovative development of enterprises in the region. The Outline Development Plan calls for building a modern industry system that is internationally competitive, including accelerating the development of advanced manufacturing and strengthening strategic emerging industries. Relying on an open environment and a strong economic foundation, the major industries in the Greater Bay Area have developed rapidly and jointly formed an innovation ecosystem that is attractive to the market, industry-leading and internationally competitive. The cities complement one another in terms of economic development and resource endowment. Hong Kong and Macao have mature market economies and related operating systems. As an international financial center, Hong Kong is home to some of the highest-ranked Asian universities, nurturing a large number of financial and management talents; while the Pearl River Delta has a vast hinterland and innovative industrial clusters, presenting significant opportunities for growth and expansion. As China's economic reform has entered a critical period and is undergoing substantial expansion, traditional industry chains are confronting new challenges, and are in urgent need to find new driving forces to promote the industrial upgrading, transformation and sustainable development. This paper will take three most promising industries of healthcare, semiconductor and display in the Greater Bay Area as examples to demonstrate regional development and discuss related solutions.

1.1 Healthcare industry overview

1.1.1 The GBA is well grounded in the healthcare industry, with a list of top industry players

The Greater Bay Area is a key national development area for the biomedical industry which has developed rapidly in recent years. The region has a noticeable advantage in industrial agglomeration and a complete upstream and downstream industry chain, it has particularly moved ahead in R&D, production and circulation of traditional Chinese medicine (TCM) and chemical medicine.

The Greater Bay Area has a long history and profound accumulation in the traditional Chinese medicine industry. Taking Guangdong as an example, the province's Chinese medicine resources account for about 20% of the national medicine resources with a planting area of 5.75 million mu¹. According to statistics from the Ministry of Commerce, Guangdong's total sales of Chinese patent medicine in 2017 reached 33.434 billion yuan, accounting for 11.16%² of the country's total sales of Chinese patent medicine, ranking first in the country.

The Greater Bay Area is also one of the production and research bases of chemical drugs. Leading enterprises such as Guangzhou Baiyunshan Pharmaceutical, Livzon Pharmaceutical Group, United Laboratories Internet, Bright Future have settled in the region, selling products nationwide.

Guangzhou Pharmaceutical Holdings Limited

Guangzhou Pharmaceutical Holdings Limited is a leading pharmaceutical enterprise in the Greater Bay Area and across the country. Its business scope covers R&D and manufacturing of Chinese patent medicine and botanical medicine, chemical API and preparation, biological medicine and healthcare products, trade logistics and distribution, medical and health services, etc. It is a large conglomerate integrating science, industry and trade supported by the Guangzhou government. The Group's Chinese patent medicine and antibiotics businesses cover the whole industry chain, benefiting from strong brand and variety advantages. The Group carries out wholesale and retail businesses (such as Cai Zhi Lin, JIANMIN Pharmacy and Guangzhou Medical Pharmacy pharmaceutical chain stores) through its subsidiaries of Guangzhou Pharmaceuticals, Cai Zhi Lin Pharmaceutical and Guangzhou Medica Import and Export Company. Its products are sold across the country, especially in the southern region.

The biomedical industry in the Greater Bay Area has a relatively narrow base but is catching up fast. In 2020, Guangzhou was recognized as a Biomedical Innovation City with the Most Investment Value in China by the China Association of Enterprises with Foreign Investment and the China Pharmaceutical Industry

¹ Zhuangwei F, Nianfei H, Xueyan Y. Lingnan has good medicine! The scale of Guangdong's traditional Chinese medicine business is the largest in the country. Southern Rural News,2019-10-19,2019-10-19.

<http://static.nfapp.southcn.com/content/201910/19/c2723363.html>

² Excluding Hong Kong, Macao and Taiwan

Research and Development Association. Guangzhou ranked third with outstanding performance in infrastructure, supportive policies, R&D resources, innovation, financing and enterprise strength, secondly only to Shanghai and Beijing¹. Leading pharmaceutical company like AstraZeneca, well-known biopharma companies like BeiGene, Bio-Thera, Akesobio, CDMO companies like Lonza, vaccine manufacturer Shenzhen Kangtai Biological Products and heparin manufacturer Shenzhen Hepalink Pharmaceutical are all expanding their business coverage and accelerating their layout of business plans in the Greater Bay Area. In 2017, BeiGene set up a biologics manufacturing facility in the Guangzhou Development District. At the time of construction, the stock price of BeiGene was less than USD \$40 per share². Yet, after being listed in the US and Hong Kong in 2020, the market value rose to nearly 200 billion yuan in both markets³. In March 2020, InnoCare Pharma, an innovative biomedical company that has just established five years ago, successfully listed in Hong Kong. The company's R&D capabilities were highly recognized by the capital market, resulting in a 27% increase in its stock price on the first day of listing. Many leading TCM and chemical medicine companies such as Livzon Pharmaceutical Group and Guangzhou Xiangxue Pharmaceutical have also started to develop biomedical products to take advantage of the growing market.

In terms of innovation, various innovations have also continued to emerge. In 2019, the number of new registration applications for biological and chemical drugs totaled 536, achieving a compound annual growth rate of 44%⁴ since 2016, significantly higher than the national growth rate of 32% in the same period⁵.

¹ Shumin H. Guangzhou was awarded the Biomedical Innovation City with the Most Investment Value in China. Southern Daily, 2019-09-27.

http://kb.southcn.com/content/2020-09/27/content_191522157.htm

² Nasdaq Investors, BeiGene official website

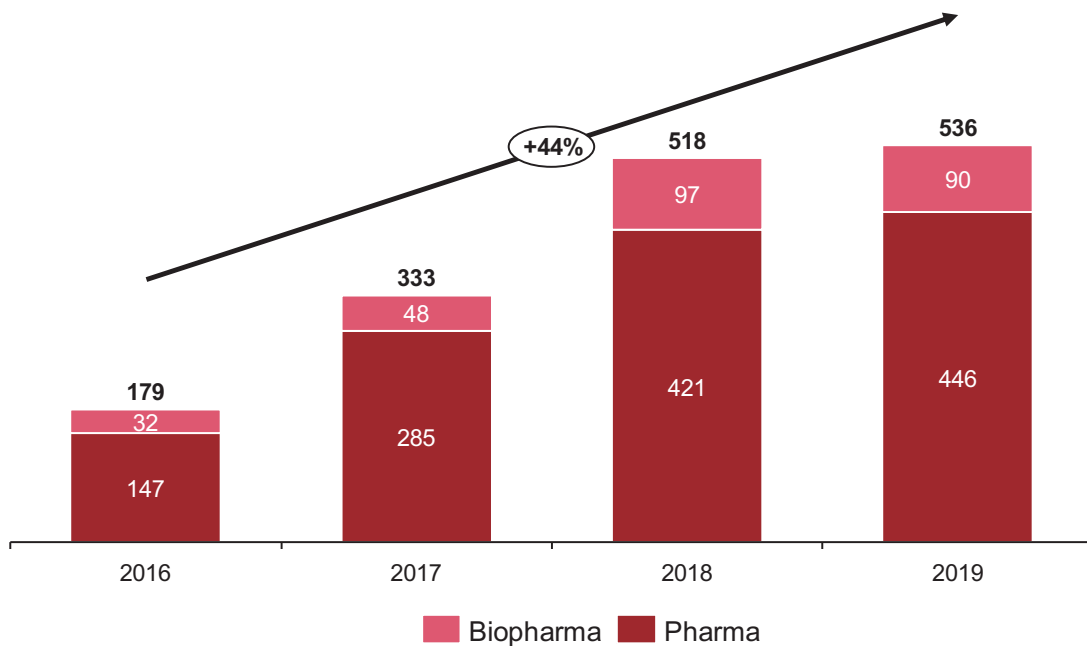
³ Yujun L. Shares of BeiGene Rose more than 5% to a new all-time high. Sina Finance, 2020-09-25. <https://finance.sina.com.cn/stock/relnews/hk/2020-09-25/doc-iivhuipp6355801.shtml>

⁴ PharmaGo

⁵ CDE Annual Drug Review Report for 2019, 2020-07-30.

<http://www.cde.org.cn/news.do?method=viewInfoCommon&id=68f4ec5a567a9c9a>

Figure 1-1-1 Number of new drug declared in the Greater Bay Area, 2016-2019



1.1.2 The GBA has strong medical device innovation capabilities, especially in its pillar industries

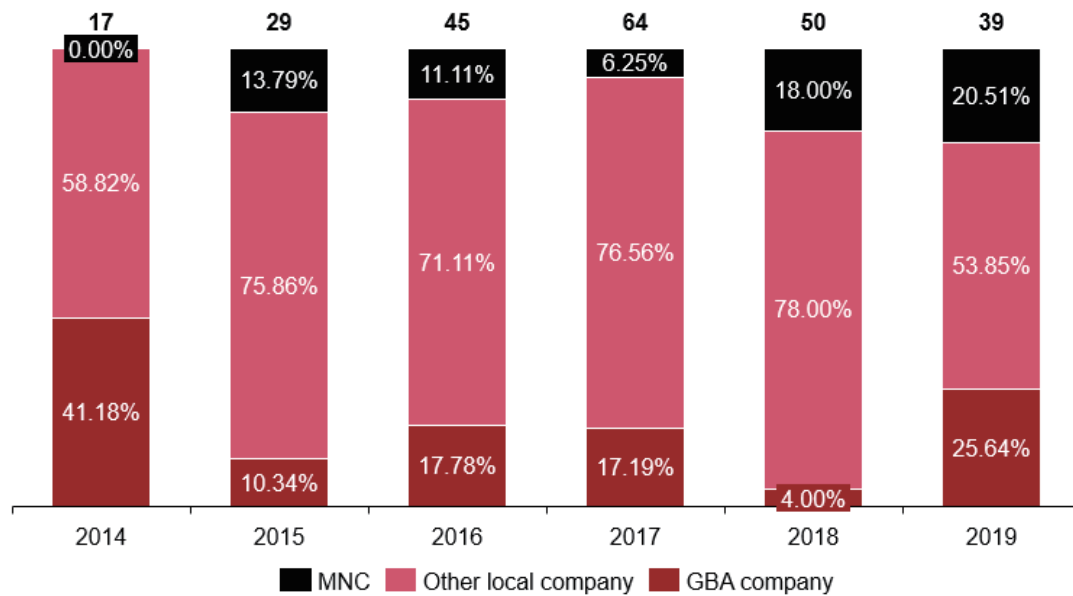
The Greater Bay Area is an important production and research base of medical devices in China. In 2019, the total output value of the medical device industry in the Greater Bay Area reached 125.483 billion yuan, accounting for 16.67% of the national total and ranking first in the country. In the first half of 2020, the number of type II and type III products registered in Guangdong reached 933 for the first time, accounting for the largest share of 15.4%¹ of the national total.

Meanwhile, the Greater Bay Area is also an innovation highland for medical devices. Innovation platforms such as high-performance medical device innovation centers have been set up in the Greater Bay Area, accelerating local industrial innovation. Since 2014, the National Medical Products Administration has formulated the “Special Approval Procedure for Innovative Medical Devices” to encourage research and innovation of medical devices. As of June 2020, a total of 265 products have entered the special review list of innovative medical devices, of which 44 products are from

¹ Joinchain. Rankings for the registration of medical equipment (type II and III product) are announced: Guangdong first! .Joinchain Medical Equipment Big Data Platform, 2020-07-06. https://www.sohu.com/a/405967375_120629259?_trans_=000018_mpcgame

companies in the Greater Bay Area, amounting to 19.0% of all selected domestic manufacturers.

Figure 1-1-2 Innovative medical device priority review and approval results, 2014-2019¹



Leading companies have played a central role in it. For example, Mindray is China's largest and world-leading supplier of medical devices and solutions. The color Doppler ultrasound and composite patient monitoring system developed by Mindray have been included in the priority review and approval list of National Medical Products Administration. Another example is LifeTech Scientific Corporation, as the industry's leading supplier of minimally invasive cardiovascular interventional medical devices, its products are sold in more than 100 countries. Xianjian has a total of 9 products selected for priority review and approval, the highest among all manufactures, including left atrial appendage occluder system and peripheral stent system.

Enterprises in the Greater Bay Area have regional characteristics and leading advantages in segments such as imaging and high-value consumables. This is particularly prominent in the in vitro diagnostic (IVD) industry, which is a pillar industry in the local medical device market. By the end of 2019, the total number of medical device registrations in the Greater Bay Area

¹National Medical Products Administration

was 19,452, of which IVD products accounted for 39.45%. Take the priority review results as another example, as of June 2020, IVD products accounted for more than 70%¹ of the products that had passed the priority review application of type II medical devices in Guangdong province. During the COVID-19 pandemic, the IVD industry in the Greater Bay Area has played an important role under the leadership of the government. For example, after obtaining the genetic sequence information of novel Coronavirus on January 12, 2020, Da An Gene Co., Ltd. of Sun Yat-sen University developed a new coronavirus nucleic acid detection kit within 48 hours, becoming one of the first two manufacturers to release specific nucleic acid detection reagents in China. The kit successfully passed the national registration approval on January 28, obtained the EU's CE certificate, and was recommended on the official website of the World Health Organization (WHO). In addition, since the core raw materials of the kit are controlled by Da An Gene Co., Ltd. of Sun Yat-sen University itself, the company can adjust its production capacity according to market needs, which can be expanded to more than 1 million kits per day.

BGI Group

BGI Genomics is a world-leading player in the research and development of gene sequencing-related equipment and reagents. Since its establishment in 1999, the company has conducted broad advanced genome research work, including the "China Part" of the International Human Genome Project (1%, undertaking most of the work), the International Human Haplotype Map Project (10%), and the first Asian Genome Map Project ("Yanhuang No. 1. In 2019, BGI's operating revenue was 2.8 billion yuan, making it one of the world's top ten gene sequencing companies.

During the pandemic, BGI and its partners have assisted in building and operating Huo-Yan Air Labs in 13 cities and many countries around the world, providing nucleic acid testing and tracing services. The daily testing of more than 10,000 samples has provided strong support for global pandemic prevention and medical treatment.

¹ Guangdong Drug Administration

1.1.3 The GBA has rich medical resources and strong resource conversion capabilities, and is at the forefront of model innovation

The GBA is enjoying some of the best medical resources in China. According to the “Number of National Medical and Health Institutions” issued by the National Health Commission in April 2020, there are 1,650 hospitals in Guangdong, of which 122 of them are grade 3A hospitals, some are among the top 50 in the country. As the capital of Guangdong, Guangzhou has 38 grade 3A hospitals. It is the city with the most concentrated medical resources across the province, which has enabled it to establish itself as a world leader in the fields of lung cancer, liver cancer and ophthalmology. Hong Kong has established world-leading medical standards. Its survival rate of breast cancer and the cure rate of rectal cancer are the highest in the world. Macao, on the other hand, has an efficient and stable basic healthcare system, which was recognized by the World Health Organization as an outstanding model in the Pacific region. The average life expectancy of the local population is as high as 84 years, ranking second in the world.

Table 1-1-1 National Ranking of Key Hospitals in the GBA, 2018¹

Ranking	Hospital	Location
6	The First Affiliated Hospital, Sun Yat-sen University	Guangzhou
17	Nanfang Hospital, Southern Medical University	Guangzhou
27	Guangdong Provincial People’s Hospital	Guangzhou
31	The First Affiliated Hospital of Guangzhou Medical University	Guangzhou
37	Sun Yat-sen University Cancer Center	Guangzhou
38	The Third Affiliated Hospital, Sun Yat-sen University	Guangzhou
43	Sun Yat-sen Memorial Hospital, Sun Yat-sen University	Guangzhou

¹ Institute of Hospital Management, Fudan University. 2018 Annual Specialty Comprehensive Ranking, 2019-11-10. <http://www.fudanmed.com/institute/news2018-2.aspx>

Abundant medical resources provide a basis for resource conversion. Clinical Trial’s data on clinical trial registration show that the Greater Bay Area’s medical institutions participated in 31.8%¹ of the clinical trials starting from 2016 to 2020. In addition, according to statistics, two hospitals in Guangzhou in the Greater Bay Area accounted for 20% of the total number of phase 1 clinical trial hosting institutions for oncology drugs in 2018.

Figure 1-1-3 Number of clinical trial registrations in China, 2016-2020

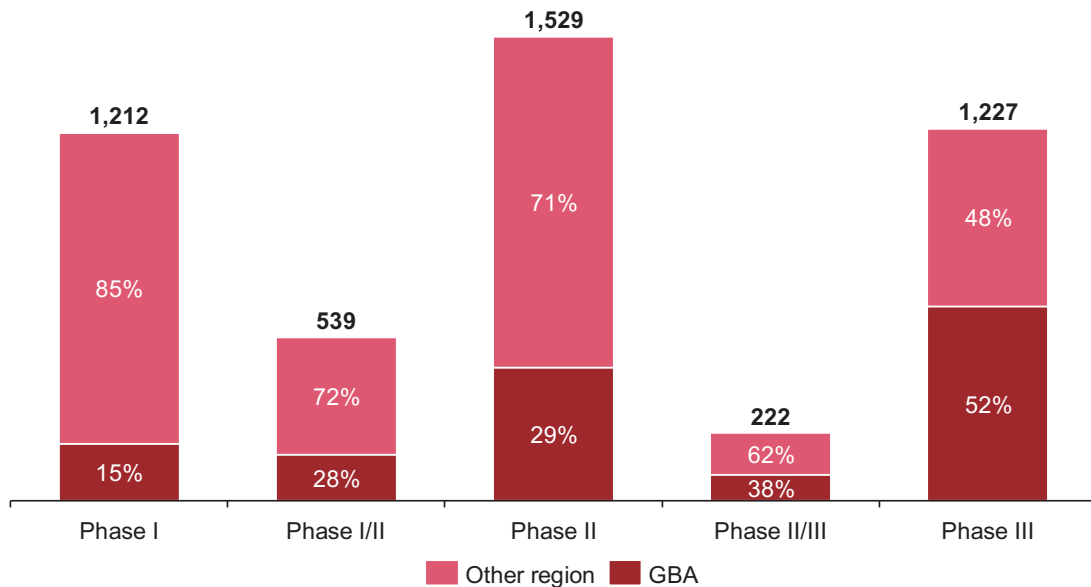
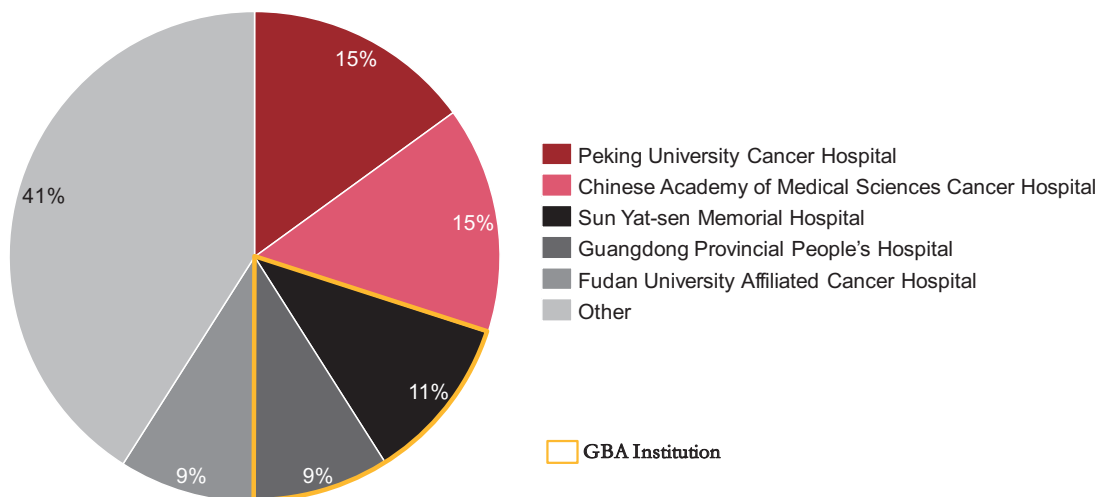


Figure 1-1-4 Distribution of phase I clinical trials of oncology drugs by host hospitals, 2017²



¹ Include Mainland, Hong Kong and Macao; exclude Taiwan

² Zhao S, Lv C, Gong J, Wenfeng F, Hu X, Ba Y, Xiaoyuan C, Zhimin Y, Shen L, Zhang L; Chinese Phase 1 Oncology trial Consortium. Challenges in anticancer drug R&D in China. Lancet Oncol. 2019; **20**(2):183-186.

In addition, medical service institutions in the Greater Bay Area are also pioneers in innovation nationwide. For example, the Guangdong Internet Medical Service Supervision Platform was launched in 2019, with 22 Internet hospitals offering online services. The service entities include Guangdong Provincial People's Hospital, Guangdong Second Provincial General Hospital, Guangdong Women and Children Health Hospital, The First Affiliated Hospital of Sun Yat-sen University, Shenzhen Hospital of Southern Medical University, Zhuhai People's Hospital, etc. Furthermore, after the General Office of the State Council promulgated the "Policies and Measures to Promote the Accelerated Development of Nongovernmental Medical Services" and multiple ministries and commissions issued the "Opinions on Promoting the Sustainable and Healthy and Standardized Development of Nongovernmental Medical Services", restrictions on the nongovernmental medical system of Greater Bay Area hospitals was loosened, injecting new vitality into the industry. Foshan Chancheng People's Hospital, as a forerunner, has led the new trend of collaborative development of nongovernmental medical services and public hospitals through an innovative PPP model.

1.1.4 The overall growth rate of the industry has slowed down, supervision has been strengthened, and the market structure has changed

The Greater Bay Area has the most developed medical industry in China. With the continuous advancement of the national medical reform in recent years and the accelerated changes in global R&D trends, the industry is becoming increasingly volatile and uncertain, bringing new challenges and opportunities to the development of the healthcare industry in the Greater Bay Area.

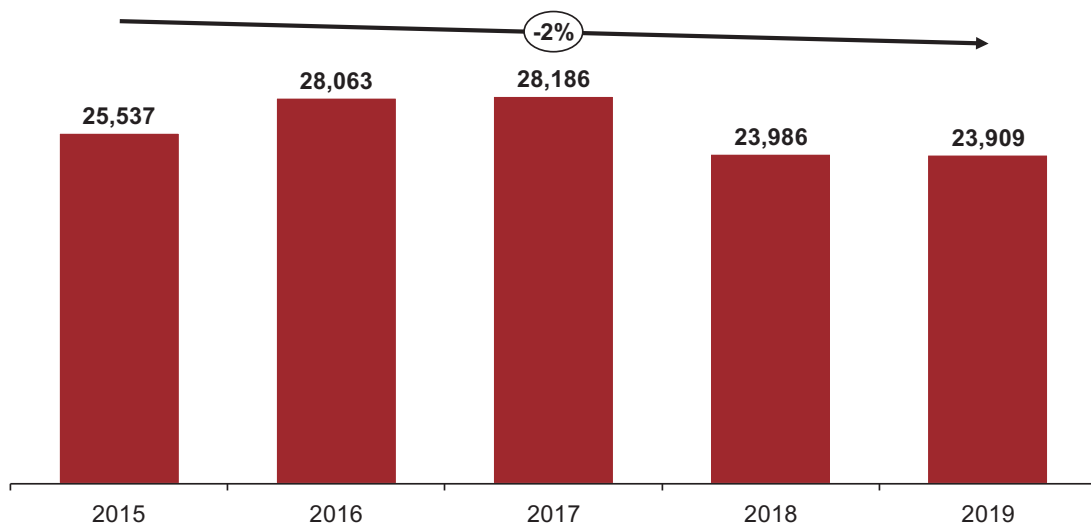
a) Slowdown in growth

Volume-based procurement was piloted in "4+7" cities, and 25 out of 31 products were selected in the first round. The average price of the winning products was reduced by 52%, of which 46% of the products were marked down by more than 50%, with the highest being 96%. Mass purchase has greatly reduced the prices of drugs that have passed the consistency evaluation of generic drugs, which has had a great impact on the pharmaceutical market.

Adjustment of the National Reimbursement Drug List (NRDL), regions no longer have the right to formulate their own list or adopt alternative methods to add new drugs in the list. Drugs that have not entered the NRDL will no longer be able to take indirect paths through local medical insurance. Some varieties that are locally protected will also face greater entry pressure.

A series of medical reform policies have had a great impact on the pharmaceutical market. The main business income of pharmaceutical manufacturing enterprises above the designated size has been gradually declining since 2017. The latest data for 2019 is only 85% of the peak in 2017, and the price mechanism and income distribution mechanism in the pharmaceutical market have been further normalized.

Figure 1-1-5 Main business revenue of pharmaceutical manufacturing enterprises above designated size in China (billion yuan), 2015-2019¹



b) Tightened supervision to improve the drug provision quality

The introduction of the new policy has not only greatly reduced the price of drugs, but also strengthened the supervision over the quality of drugs and the rationality of drug use, which has a far-reaching impact on the whole medical industry.

Generic drug consistency evaluation requires generic drugs to be consistent in quality and efficacy with the corresponding brand-

¹ National Bureau of Statistics of the People's Republic of China

name drugs. Some products that fail to pass the consistency evaluation will be removed from the list of basic drugs or lose the qualification of collective procurement, and in some provinces, it may lead to cancellation of approval in the worst case¹. In the long run, this will significantly improve the quality of China's generic drugs and the development progress of the industry as a whole, further ensure the safety of public drug use and reduce the cost of medical insurance.

The key products that need to be monitored for rational use has helped in defining the scope of clinical application of adjuvant drugs such as ganglioside, cattle encephalon glycoside and ignotin, salvia miltiorrhiza and ligustrazine, rat nerve growth factor, etc., improving the rationalization of clinical drug use. For example, the sales volume of rat nerve growth factor of Livzon Pharmaceutical Group reached 517 million yuan in 2017, but fell sharply in the following two years, dropping by 30% to 361 million yuan in 2019.

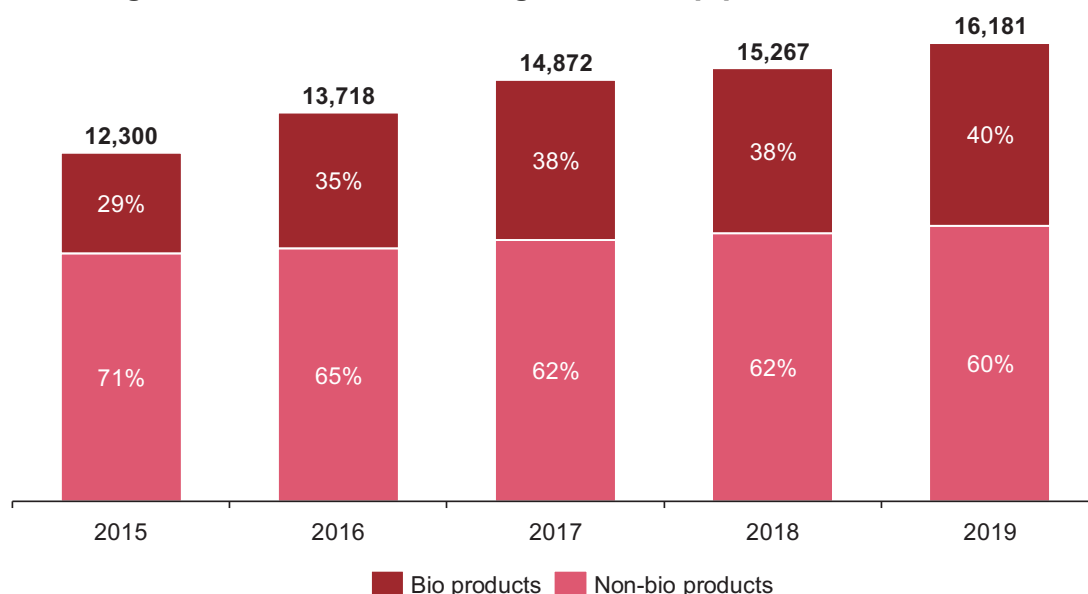
Strengthening the prescription management of the non-listed drugs has raised the prescription threshold of TCMs in order to maintain its healthy development. It is stipulated that non-TCM physicians should have at least one year of knowledge of TCM and passed the examination before they can prescribe Chinese patent medicine.

c) Changing market structure

The global drug market is undergoing substantial structural changes. Of the top 10 drugs sold globally in 2019, biological products accounted for 61% of sales. The proportion of biological products in the global R&D pipelines is also increasing.

¹ Jiangsu Provincial People's Government. Jiangsu province cleans up the generic drug market and the approval will be cancelled if the consistency evaluation is not passed, 2018-11-06

Figure 1-1-6 Distribution of global R&D pipelines, 2015-2019¹



China's drug market structure has also experienced major transformations. Traditional Chinese medicine injections such as Bei Tong, Xue Shuan Tong, and salvia miltiorrhiza have gradually dropped out of the top 10 drugs used in hospitals after 2015. Shen Jie, Ou Di Mei, and Ao De Jin, as key drugs for monitoring rational drug use, have also dropped out after 2016.

Table 1-1-2 China's top 10 hospital drug use, 2015-2019²

	2015	2016	2017	2018	2019
1	Shen Jie	Plavix	Lipitor	Lipitor	Dezocine
2	Xue Shuan Tong	Lipitor	Plavix	Dezocine	Pulmicort
3	Plavix	Shen Jie	Dezocine	Plavix	Lipitor
4	Bei Tong	Dezocine	Pulmicort	Pulmicort	Sulperazon
5	Lipitor	Xue Shuan Tong	Bei Tong	Sulperazon	Plavix
6	Ao De Jin	Bei Tong	Xue Shuan Tong	Xue Shuan Tong	Herceptin
7	Duo Pu Sai	Duo Pu Sai	Shen Jie	En Bi Pu	En Bi Pu
8	Dezocine	Ou Di Mei	Sulperazon	Bei Tong	Xue Shuan Tong
9	Xi Yan Ping	Ao De Jin	Duo Pu Sai	Herceptin	Ke Wei
10	Ou Di Mei	Sulperazon	Cephalosporine	Duo Pu Sai	Li Pu Su

TCM Injection	Adjuvant Medicine	Patent Expired Chemical Medicine	Innovative Medicine/Biological Medicine
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¹ Pharma Intelligence

² IQVIA (formerly known as QuintilesIMS)

The sales of innovative biological medicines are constantly increasing. In 2018, Herceptin, as the first biological drug to enter the top 10 medicines used in hospitals, gradually increased its sales volume. Products with barriers in dosage forms such as Pulmicort and Ke Wei have maintained their competitive advantages. As the world's only marketed paclitaxel liposome preparation for injection, the sales of Li Pu Su increased sharply in 2019.

With the further progress of medical reform, the structure of domestic drug use will continue to change. Sales of traditional and adjuvant drugs will continue to shrink, leaving more budgets for newer drugs that are more effective and have fewer side effects. **This has also brought new challenges to enterprises in the Greater Bay Area, where TCM and traditional chemical medicine are the mainstay.**

Transformation: Guangzhou Xiangxue Pharmaceutical Co., Ltd

Guangzhou Xiangxue Pharmaceutical Co., Ltd. was originally a traditional Chinese medicine company. With the substantial increase in investment in recent years, it has become a R&D company for innovative therapies. According to its announcement on March 21, 2020, the company's subsidiary Xiangxue Precision submitted its new drug clinical application registration for TAEST16001 injection to the National Medical Products Administration and has obtained the clinical trial license. Xiangxue Precision is currently carrying out clinical trials in accordance with the national clinical trial requirements. The injection belongs to type1 innovative drug in therapeutic biological products, and is the first TCR-T drug approved for clinical trials in China.

Transformation: Livzon Pharmaceutical Group Inc.

Livzon Pharmaceutical Group also entered the biological products industry earlier in 2010. Livzon and Joicare Pharmaceutical jointly funded the establishment of Livzon Mabpharm, which mainly engages in the technological research of biological and antibody drugs. A number of antibody/recombinant protein products under research have entered the clinical stage, while cell therapy products such as CAR-T are in the preclinical/POC stage.

1.1.5 The medical device industry faces the challenge of further improving core technologies

Domestic medical device companies are gradually building international competitiveness. The localization of medical device

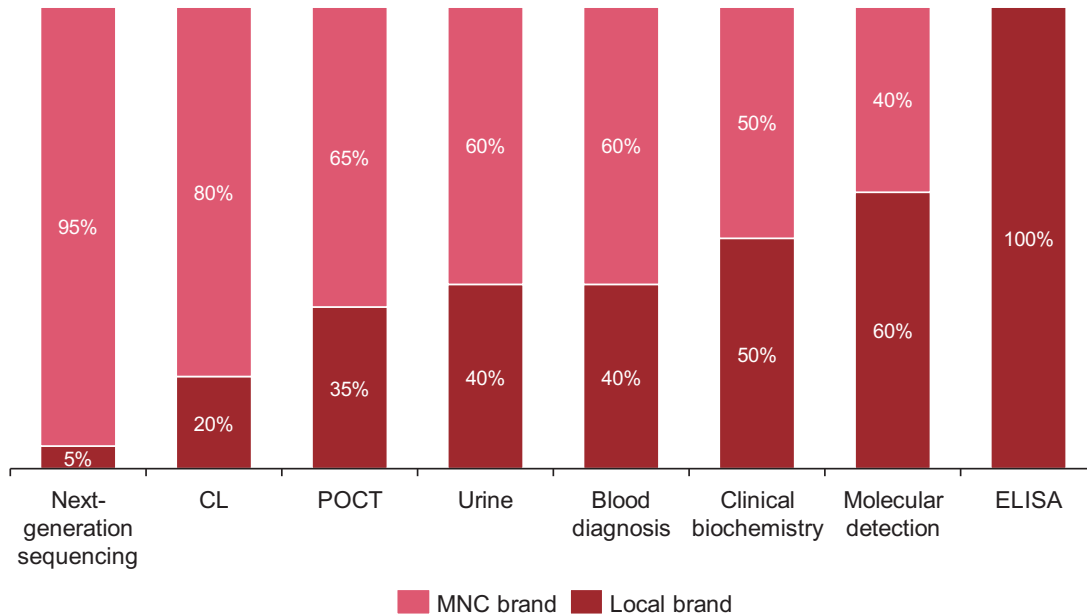
production is under rapid development. Take the ventilator as an example, which attracted much attention during the COVID-19 pandemic: China currently has 21 invasive ventilator manufacturers, among which 8 have obtained the mandatory EU CE certification for their main products. Their weekly production capacity is about 2,200 units, accounting for about one-fifth of the global production capacity. However, the development of medical devices continues to be plagued by problem caused by immature core technologies, resulting in:

Monopolization of high-end products by large MNCs. Taking IVD products as an example, the markets for enzyme-linked immunoassays, molecular testing, and clinical biochemistry are occupied by local brands, but foreign brands still have dominant positions in areas with high technological difficulties such as chemiluminescence and second-generation gene sequencing.

High dependence on import of core components. This has seriously affected the long-term development of the domestic medical device industry. For instance, many domestic ventilator manufacturers are fronting a shortage of parts. Core components such as turbo compressors, sensors and chips are mostly imported from companies such as Micronel in Switzerland, Honeywell in the United States and SMC in Japan. In particular, PMP is the raw material for the membrane in ECMO, however, only Membrana, a subsidiary of 3M in the United States, has the supply capacity in the world¹.

¹ Weike T. Domestic ventilators "turn over": overseas demand has exploded, and core components are still the key. 21st Century Business Herald, 2020-04-02, <https://baijiahao.baidu.com/s?id=1662819663326689793&wfr=spider&for=pc>

Figure 1-1-7 Market share of domestic and imported IVD brands in different fields in China¹



1.2 Semiconductor industry overview

1.2.1 The semiconductor industry in the Greater Bay Area is developing rapidly, with the overall industry chain inclined towards the design side

China's technology industry has been lagging in the “chip race”. In 2019, the country’s chip imports amounted to USD \$304 billion, and its own production rate was nearly 30%². Therefore, China’s chip industry needs to step up its efforts in order to achieve growth in the future.

The GBA has one of China's most developed industrial clusters for semiconductor, especially in the fields of semiconductor design and analog chip manufacturing. The region has partly realized high-end and independent production. In 2019, the revenue of semiconductor design of Shenzhen reached 75.87 billion yuan, making up 29.44%³ of the national total. In recent years, a large number of outstanding semiconductor design companies and national laboratories have emerged in major cities in the Greater

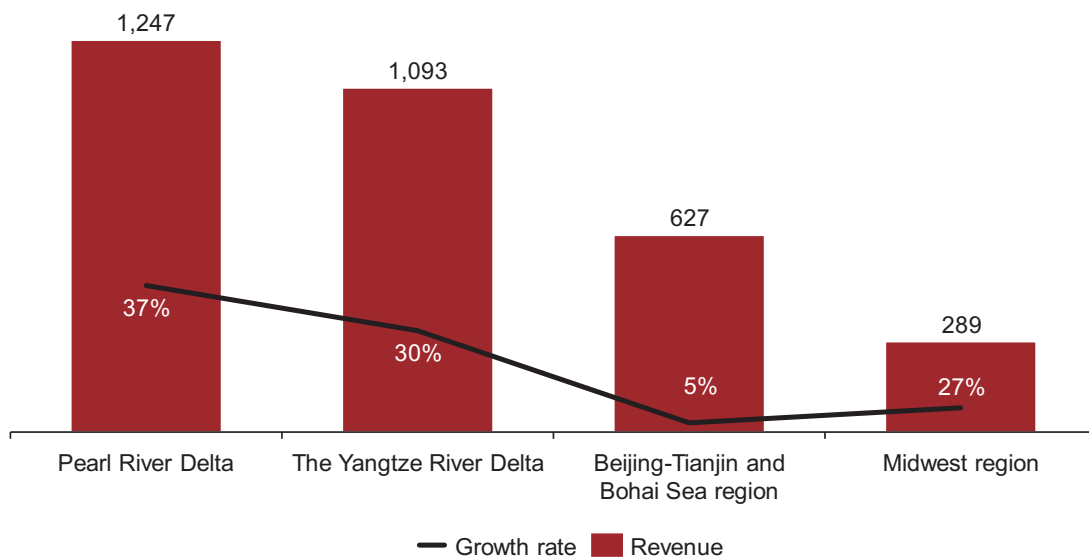
¹ Huaxia Keystone. China Medical Devices Listed Companies In vitro Diagnostics (IVD) Development White Paper, 2019-10

² From theory to practice, the training of chip talents is urgent. Guangming Daily, 2020-10-15

³ Shenzhen Semiconductor Industry Association. 2018 Shenzhen Semiconductor Industry Summary Conference, 2019-2-22, <https://xueqiu.com/2156146731/121763873>

Bay Area. Shenzhen's three major semiconductor design companies, HiSilicon, Sanechips Technology Co., Ltd. and Goodix, ranked among top ten in revenue in the country in 2018. Other renowned semiconductor design companies such as Guangzhou RUNXIN Information Technology Co., Ltd. and Anyka (Guangzhou) Microelectronics Technology Co., Ltd. are located in Guangzhou. Solomon Systech (International) Limited, a subsidiary of Huada Semiconductor Co., Ltd. is settled in Hong Kong. The national semiconductor laboratory of the University of Macao is in a leading position internationally in scientific research. In the past six years, it has been accepted 22 papers by IEEE ISSCC Summit and 18 papers by Hong Kong University of Science and Technology. In total, the Greater Bay Area has contributed 73% of the accepted papers in China, showing the region's superiority in production, education and research¹.

Figure1-1-8 Sales revenue (100 million yuan) and growth rate of semiconductor design industry in key regions of the country, 2019²



In the field of analog chip manufacturing, the Greater Bay Area is gradually catching up with the world's leading players. In 2019, the CanSemi Technology project with a total investment of 28.8 billion yuan officially entered the mass production stage, and the 12-inch chip production line began to be put into production. This production line is also the first 12-inch chip plant that takes virtual

¹ ISSCC.IEEE ISSCC Summit Launch

²China Semiconductor Industry Association Integrated Circuit Design Branch.China Integrated Circuit Design Industry 2019, 2019-11-25

IDM as its operating strategy in China. It is estimated that by 2022, CanSemi will have a total monthly production capacity of 40,000 pieces in Phase I and Phase II.

However, the GBA has a relatively weak industrial foundation in chip packaging, testing and manufacturing. This is mainly because the design business is closest to the consumer market, the active downstream chip consumer market in the Greater Bay Area (accounting for more than one-third of the country) has encouraged the rapid development of the design sector. Of course, the need to optimize the structure of the semiconductor industry is national. Stand on the current status and development experience of the global IC industry, the value ratio of general chip design, wafer manufacturing and packaging and testing is 30:40:30. However, China's manufacturing and packaging and testing sectors are relatively weak, the gap is further highlighted after excluding the revenue of wholly foreign-owned enterprises. The corresponding value ratio in 2019 is 70:15:15¹.

Figure 1-1-9 Distribution of the semiconductor industry chain in the Greater Bay Area



In recent years, domestic semiconductor production lines have been ramped up. China has the largest number of newly built wafer fabrication plants in the world between 2017 and 2020. Combined with other wafer foundry projects launched, the overall wafer capacity expansion is accelerated². Thanks to policy support and industry efforts, the semiconductor production capacity in the Greater Bay Area is also growing at a rapid pace. Since 2015, the

¹Core Thoughts.2019 Chinese mainland 2019 Integrated Circuit Industry Revenue Data Interpretation, 2020-3-27, <https://xueqiu.com/7814068463/145298030>

² SEMI.2018 China Semiconductor Silicon Wafer Outlook,2019-01-08

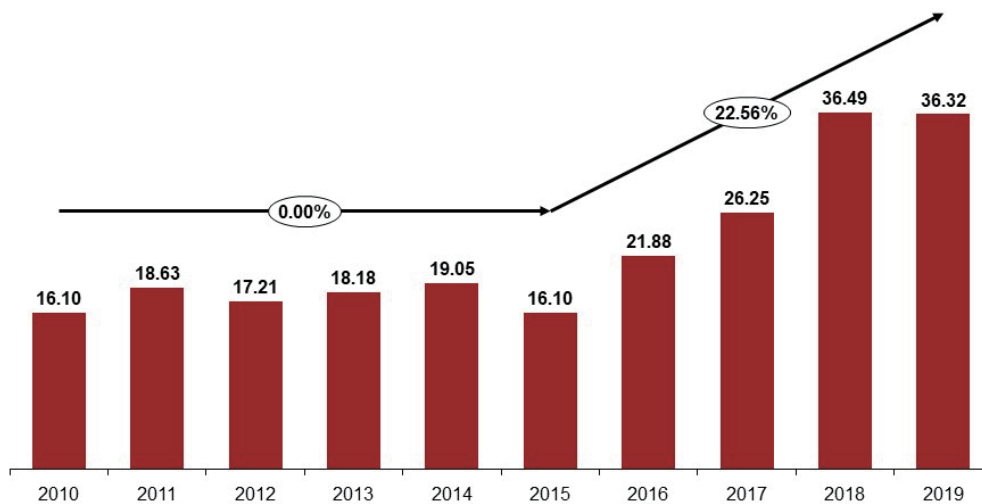
output of integrated circuits in Guangdong has increased sharply, with a 5-year average annual growth rate of 21.9%. The output in 2019 was 36.324 billion pieces, accounting for 17.8% of the total output of the country.

Guangzhou aim to develop itself into the national innovation hub for IC industry. In 2017, Huangpu District and Guangzhou Development District commenced the CanSemi project and accomplished the administrative approval, facility construction, and production within 18 months. CanSemi is developed into the only 12-inch chip production line in GBA and attracts 64 companies such as Anyka, On-Bright, GOWIN Semiconductor, etc. along the value chain. Collectively this cluster generated revenue of 6 billion yuan solely in 2020H1. On the core R&D and innovation, Guangzhou is developing a set of innovation capabilities to train, attract, and concentrate talents. In a joint effort with the Institute of Microelectronics (IME) of the Chinese Academy of Sciences (CAS), Guangdong Greater Bay Area Institute of Integrated Circuit and System was founded. Jointly with National Center for Nanoscience and Technology (NCNST), Guangdong - Hong Kong – Macao Greater Bay Area National Nanotechnology Innovation Research Institutes is also founded. Till recently, Guangzhou Development District has attracted more than 1000 researchers and industrial experts in IC industry. On talent development, Xidian University built a new site for graduate school in Huangpu District, focusing on electronics and telecommunication. With this joint effort, over 2000 graduate students are expected to be enrolled in three years. On the industry development side, Guangzhou Development District planned and reserved 6.6 square kilometre for industrial park on IC and semiconductor industries in China-Singapore Guangzhou Knowledge City and issued a set of supporting policies to attract leading players and encourage their investment on core R&D capability, production site, as well as shared incubation facility (e.g. public service platforms).

Shenzhen issued the “Action Plan for Further Promoting the Development of the Integrated Circuit Industry (2019-2023)” in May 2019. The plan points out that by 2023, Shenzhen will fill the gap in chip manufacturing and advanced testing, and build an internationally competitive integrated circuit industrial cluster. Other cities have also introduced corresponding plans to act jointly with

industry players (such as Guangdong Fenghua Semiconductor Technology Co., Ltd. and Guangzhou CanSemi Technology Inc.) in production, packaging and testing to continuously upgrade technology and increase production capacity, bringing new opportunities to the production and packaging and testing sectors of semiconductors in the Greater Bay Area.

**Figure 1-1-10 Semiconductor production in Guangdong
(billion chips), 2010-2019 ¹**



1.2.2 The upgrade of the entire industry chain requires the joint efforts of upstream material and equipment manufacturers

The improvement of the semiconductor industry is not only the expansion of the plant, but also the joint effort of the entire industry chain, especially the upstream material and equipment manufacturers.

Without the technological breakthroughs and R&D support of these manufacturers, chip manufacturers can only compete at the lower end. Taking the lithography machine as an example, the global high-end market is monopolized by the Dutch company ASML, and its mass production technology accuracy has reached 7nm. However, there is a huge gap between domestic lithography machines in terms of accuracy and stability. For well-known reasons, SMIC bought ASML's EUV lithography machine in 2018, but never received it.

¹ Guangdong Bureau of Statistics

1.3 New Display industry overview

1.3.1 The display industry in the GBA is in a leading position in the world, attracting many top players

As stated in the Outline Development Plan, the Greater Bay Area has laid a solid foundation for innovation and has set the goal of building a globally influential international innovation and technology hub. The development of new materials and technologies has presented exciting opportunities to the display industry. Relevant technologies such as flexible display and ULTRA HD display, especially OLED, are gradually becoming the new driving force for the development of display industry and are being rapidly applied to all kinds of scenes.

The Greater Bay Area is an important production base for the national display industry. Among the new production lines built and put into operation in 2019, the Greater Bay Area accounts for 31% of the production capacity in China, with an investment of 107 billion yuan¹. The high concentration of the downstream market has contributed to the high yield of the Greater Bay Area. Well-known manufactures such as Skyworth, Konka, ZTE, TCL, OPPO and vivo have set up production lines in the region.

The fertile ground has brought together many leading companies. To illustrate, the Foxconn Supervision 8K Project with a total investment of about 61 billion yuan landed in Zengcheng Development zone in Guangzhou. The project is the largest advanced manufacturing project in the city since the economic reforms. The production base is so far the largest plant in China's liquid-crystal display (LCD) industry, applying the world's most advanced production technology and equipment. The largest display manufacturer in the World, LG Display, has set up an 8.5-generation OLED panel production line in Guangzhou with a total investment of 46 billion yuan. This project has commenced production in August 2019, with the aim to further help the Greater Bay Area to become a development center for the OLED industry.

¹ Liu Wenqiang. White Paper on the Development of the New Display Industry (2019 edition). China Electronic Industry Information Development Research Institute. 2019-11-22

New Display: TCL China Star Optoelectronics Technology Co., Ltd.

In recent years, TCL has divested its non-core businesses through restructuring in order to focus on the semiconductor display and materials industries. In 2019, the company achieved an operating income of 33.99 billion yuan, keeping ahead of the industry, while its investment in R&D reached 5.46 billion yuan.

In 2018, TCL Corporation announced its latest joint investment of 42.7 billion yuan with Shenzhen Major Industry Development Fund to build an 11th-generation ultra-HD display production line. It will have the design capacity to manufacture about 90,000 glass substrates per month (3370mm×2940mm), and will primarily dedicate to larger displays as TCL sees the demand for large HD TV products continue to grow. The project will lead new technology trends in the industry and make positive contributions to major projects in strategic emerging industries in the Greater Bay Area.

1.3.2 Technology is faced with disruptive iterations, industry players should take immediate actions to seize the opportunities

The Greater Bay Area is one of the key display production bases in the world. Taking ultra-HD panel as an example, Guangdong has the largest 4k panel production capacity in China, and the amount of 4k TV chips produced accounts for 16% of the world's total. The Greater Bay Area is also transforming into a research and development center for new display technologies. The new display industry is facing technological update and iteration. Whether it is the white light OLED built upon original OLED technology, the new Micro LED, or the disruptive inkjet printing, all have exerted a profound impact on the industry.

Rapid technological iteration has created new opportunities for the industry, but also brought challenges to established enterprises. As the white light OLED market has reached the break-even point, it is believed that whoever takes the lead in making technological breakthroughs is likely to dominate the new display market in the next decade.

Micro LED

Micro LED display technology reduces the traditional LED design structure to micron levels without a sapphire substrate, and arrays these tiny chips into display pixels that can be controlled by a single driver to achieve high brightness, resolution and saturation, and low energy consumption. However, due to the problems of little technological progress of mass transfer and high product price, the production capacity remains at a low level. Many companies in the Greater Bay Area have made great efforts to improve mass transfer technologies, including Kuisite Microcrystal Optoelectronics and Shenzhen Mingyang Xinrui Semiconductor.

Printed Display OLED

Printed display is a technology that applies printed electronics to the display field and transfers metals, inorganic and organic materials to a substrate by printing methods such as spin coating, screen printing or inkjet printing to produce light-emitting display devices. The ultimate goal of printed display technology is to realize a fully printed light-emitting display device, which can be manufactured at low cost by feeding materials on demand under normal temperature and pressure. At present, the technology is still in the R&D stage. There are many technological difficulties that need to be overcome in areas such as printing materials and preparation processes.

The Greater Bay Area is one of the core areas for the R&D of printed display technology in China. Leading innovation centers such as National Printed and Flexible Display Innovation Center are located in the GBA. By collaborating with industry players, universities and research institute such as South China University of Technology, Tianma Microelectronics Co., Ltd. and TCL China Star Optoelectronics Technology Co., Ltd., the region successfully promoted the establishment of the public R&D platform for G4.5 printing OLED and the printing industrial park. Top upstream suppliers such as Merck Group and Sumitomo Chemical Group also took an active part, playing a crucial role in the development of technologies such as the 5-inch 400ppi ultra-high-resolution printing OLED prototype and the 31-inch H-QLED quantum dot display prototype.

To conclude, the Greater Bay Area has a robust foundation in key industries such as healthcare, semiconductor and display. The leading enterprises have gained competitive advantages to outperform its competitors both at home and abroad. However, in order for the Greater Bay Area to maintain its current leading position and continue to advance, it needs to take innovation as a catalyst to further promote its industrial development.

2. The GBA has abundant resources to support innovation

In March 2020, the Central Committee of the Communist Party of China and the State Council jointly issued the “Opinions on Building a Perfect Factor Market Allocation System and Mechanism”, which put forward reform opinions on the five factor endowments of land, labor, capital, technology and data. The GBA, with marked resource superiorities in the five factors, already possesses the fundamental conditions for industrial innovation and development.

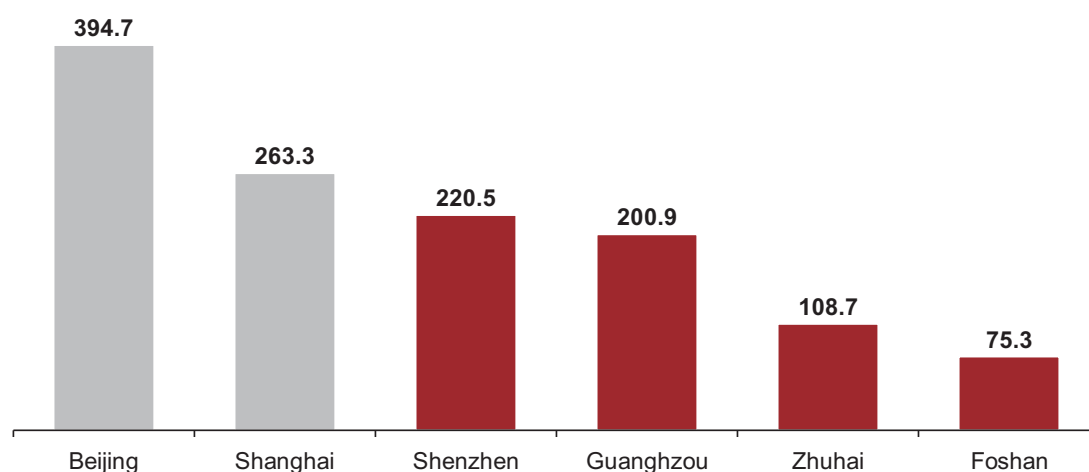
2.1 Tactical planning of land resources

Land is the most basic factor endowment and the most important production resource. The GBA consists of eleven cities, covering an area of 56,500 km², which is larger than the combined area of New York, San Francisco and Tokyo. Local governments have made well-thought-out plans to promote the efficient use of land resources, providing a broad space for industrial development.

2.1.1 Abundant land resources

The Greater Bay Area enjoys abundant land resources. For first-tier cities, rent for office space in Guangzhou and Shenzhen are more favorable than those in Beijing and Shanghai. The cost of office space weighs a large proportion of the total cost of startups, a lower rent can effectively reduce the threshold for starting a business, allowing more capital to be invested in other fields such as labor and technology, and strengthening companies’ R&D capabilities.

Figure 1-2-1 Monthly cost of grade A office buildings (yuan/m²), 2020H1¹



In the industrial sector, local governments in the Greater Bay Area have also actively introduced various policies to support the development of emerging industries. For example, in 2019, the Guangzhou government issued the “Implementation Measures for Improving the Efficiency of Industrial Land Utilization in Guangzhou”. The policy specifies the planning and management of new industrial land, that is, land used for R&D, creative thinking, design, experimentation, testing, cleaner production and supporting facilities. Its objective is to foster the expansion and renovation of the science and technology innovation platform, the science and technology innovation corridor of Guangzhou and Shenzhen, and the surrounding area of industrial agglomeration zones. Additionally, the Shenzhen government issued the “Administrative Regulations on Supporting the Development of Real economy and Promoting the Economical and Intensive Use of Industrial Land”, which requires the use of industrial land to be centered on industrial operation, and puts forward new suggestions on industrial land plot ratio and building service life.

2.1.2 Efficient land use with clear industry focus

Each of the 9 cities in Guangdong has its own national high-tech park, including Guangzhou High-Tech Industrial Development Zone, Shenzhen High-Tech Industrial Park and Dongguan Songshan Lake High-Tech Industrial Development Zone. In addition, the establishment of special industrial parks such as the Hong Kong Science and Technology Park and the TCM Science and

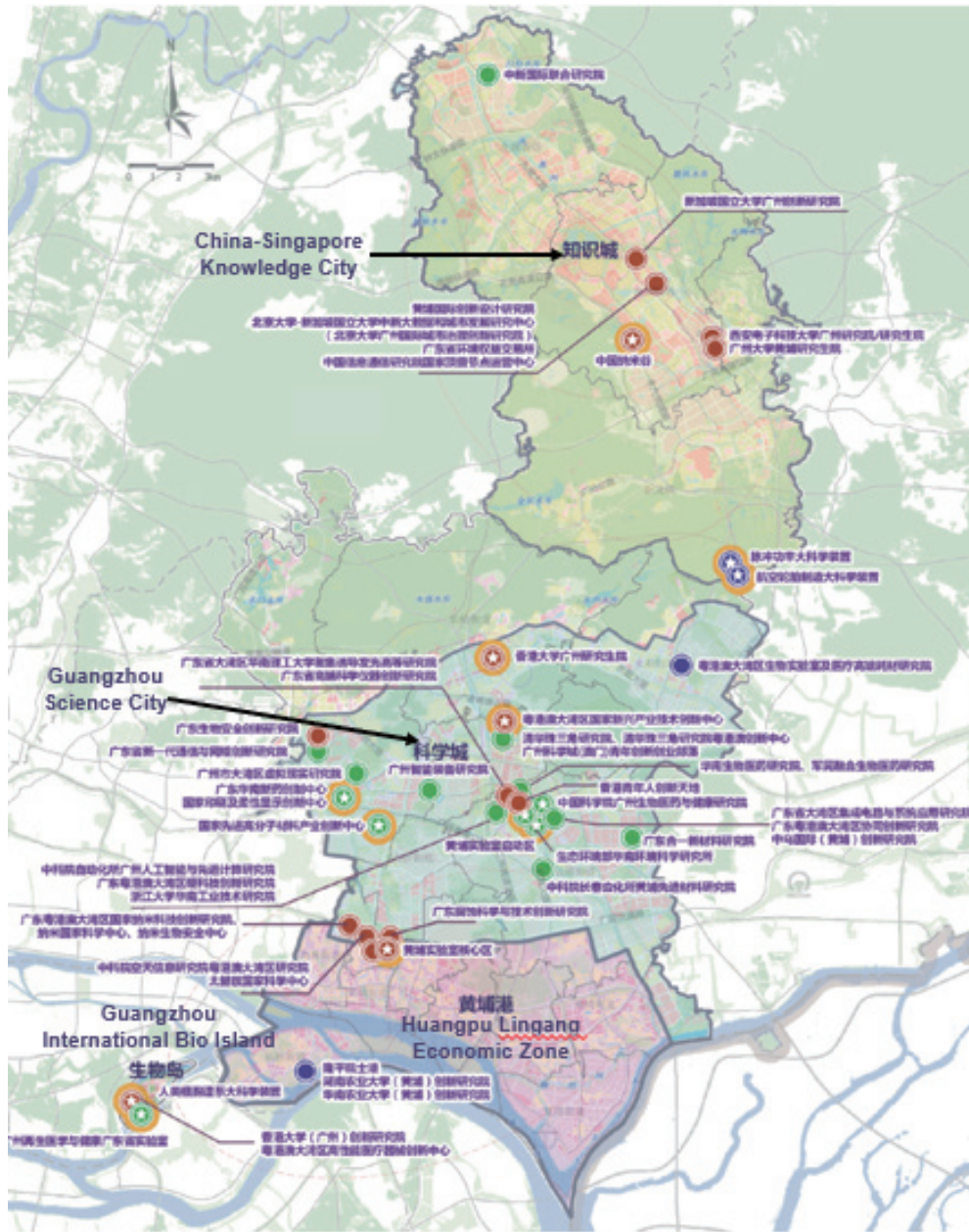
¹ First Taiping Davis, Great Bay Area Grade A Office Index, 2020-07-14, <https://www.sohu.com/a/407516296-124752>

Technology Industrial Park of Co-operation between Guangdong and Macao has provided the GBA with plentiful industrial land resources. Different industrial parks have their own development priorities. The development of peripheral disciplines facilitated by key industries has created an environment advocating diversified development and interdisciplinary integration.

a) Guangzhou Development District

Guangzhou Development District was established in 1984 with 4 major economic platforms, including China-Singapore Guangzhou Knowledge City, Huangpu Lingang Economic Zone, Guangzhou Science City and Guangzhou International Bio Island. The District is one of the first national economic and technological development zones with a total area of 484 km². Due to the successful introduction of the GE Biotechnology Park and the systematic approach of including biomedical companies such as BeiGene, Lonza, InnoCare Pharma, Hengrui Medicine, Luye Pharma and Akeso, it received the award from the United Nations for its excellence in promoting sustainable investment. Many recognized companies have also established their headquarters or production lines in the District, such as AstraZeneca, Burning Rock Biotech, Da An Gene, Guan Hao Biotech, Xiangxue Pharmaceutical, Yuexin Semiconductor and LG.

Figure1-2-2 Industrial layout of Guangzhou Development District¹



Take Guangzhou International Bio Island as an example, the island is divided by function, covering scientific research and production, technological and life service, and housing. The island focuses on the research of biological information, which also drives the industrial development of related fields such as medicine, healthcare, materials, food and environmental protection. The complete supporting service system has fostered a unique biotechnology research environment.

¹ Guangzhou Development District

b) Pingshan Park of Shenzhen National Hi-tech Zone

Pingshan Park of Shenzhen National Hi-tech Zone has just been founded in 2019, with an area of 51.6 km². The park aims to become a pioneer in biomedicine, new energy vehicles and the third-generation semiconductor. At present, it has attracted various industry leaders such as BYD, Sanofi Pasteur and SMIC to settle in.

The rising area is now home to four state-level industrial parks, namely the Shenzhen National Biological Industry Base, the National New Energy Automobile Industry Base, the Pilot Base of New Industrialization, and the National Export and Processing Zone. Pingshan will leverage these four parks to nurture and develop strategic emerging industries, forming an industrial cluster dedicated to the three dominant industries of biomedicine, new-generation information technology, new energy and connected vehicles, and create a modern high-tech park embracing headquarters, research and development institutions and production plants.

Figure 1-2-3 Pingshan Park of Shenzhen National Hi-tech Zone¹



c) Dongguan Songshan Lake National Hi-tech Industrial Development Zone

Dongguan Songshan Lake National Hi-tech Industrial Development Zone was established in 2001. It is the only national high-tech industrial development zone in Dongguan with a planned area of 103 km². Top players such as Huawei Consumer, TYSiC,

¹ Shenzhen Municipal People's Government. The establishment of a special team for the construction of Pingshan Park in Shenzhen National High-tech Zone, 2020-04-20, http://www.sz.gov.cn/cn/xxgk/zfxxgj/gqdt/content/post_7148443.html

Huabei Electronic Technology, TP-Link, 3SBio and SonoScape have established their headquarters or key production lines in the park.

In recent years, the park has tightly adhered to the Outline Development Plan, actively integrating innovation resources of the Greater Bay Area, and relying on the Spallation Neutron Source and the Songshan Lake Material Laboratory to plan and construct Songshan Lake Science City. The park and the Shenzhen Guangming Science City are most likely to be included in the construction of the Comprehensive National Science Center, constituting an important part of the international science and technology innovation center in the Greater Bay Area. Songshan Lake Hi-tech Zone has established a “4+1” industrial system centered on high-end electronic information, biological medicine, robot and smart equipment, new energy and modern service¹.

Figure1-2-4 Planning and actual shooting of Dongguan Songshan Lake National Hi-tech Industrial Development Zone²



d) Hong Kong Science and Technology Park

Founded in 2001, the Hong Kong Science and Technology Park covers an area of 22 hectares and is one of the most advanced laboratories and R&D bases in the world. Unicorn companies such as SenseTime and Lalamove are incubated by the park. The park focuses on the development of artificial intelligence and robotics, biomedical technology, data and smart city and fintech.

¹ Official website of Dongguan Songshan Lake High-tech Industrial Development Zone Management Committee

²Baidu Encyclopedia. Dongguan Songshan Lake High-tech Industrial Development Zone, [https://baike.baidu.com/item/Dongguan Songshan Lake High-tech Industrial Development Zone/1806857?fr=aladdin](https://baike.baidu.com/item/Dongguan%20Songshan%20Lake%20High-tech%20Industrial%20Development%20Zone/1806857?fr=aladdin)

Figure 1-2-5 Hong Kong Science and Technology Park¹



2.2 Vibrant and high-quality labor resources

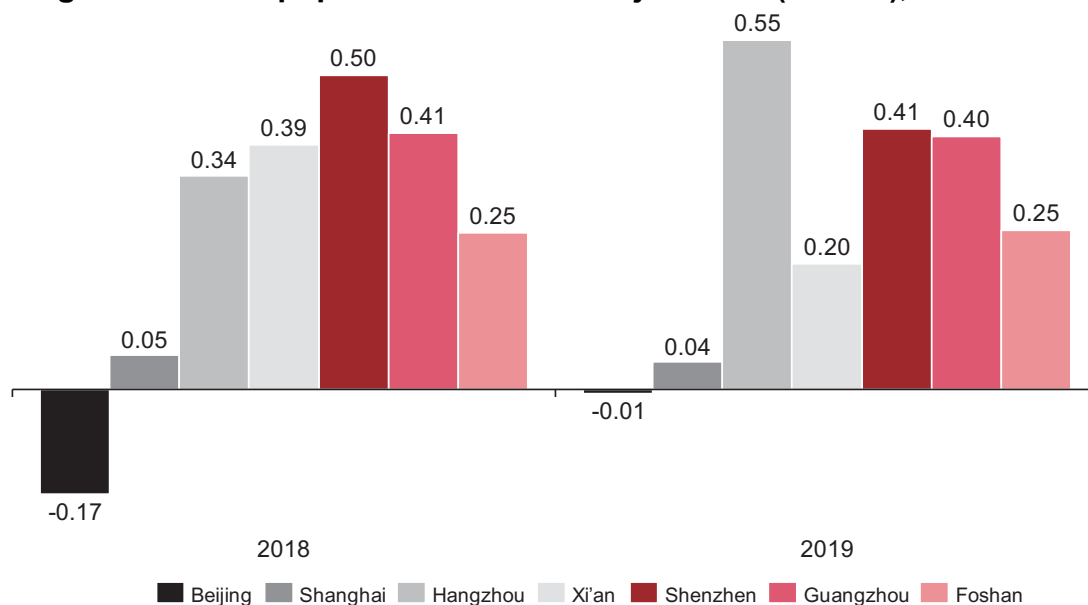
Talent is an important factor for development, sufficient and high-quality talent resources are the foundation for supporting sustained economic growth and an important driving force for innovation and development. As one of the most dynamic and innovative regions in China, the Greater Bay Area has maintained a high net inflow of high-quality talents. This is also an indispensable requirement for the continuous and innovative development of the Greater Bay Area.

2.2.1 Vibrant society

With the continuous economic development and rapid urbanization, the Greater Bay Area has maintained a high volume of population inflow. In 2019, the populations of the two megacities of Guangzhou and Shenzhen each increased by 400,000. This increase is rare in China, especially in the context of the accelerated aging of population and the slowdown in population growth.

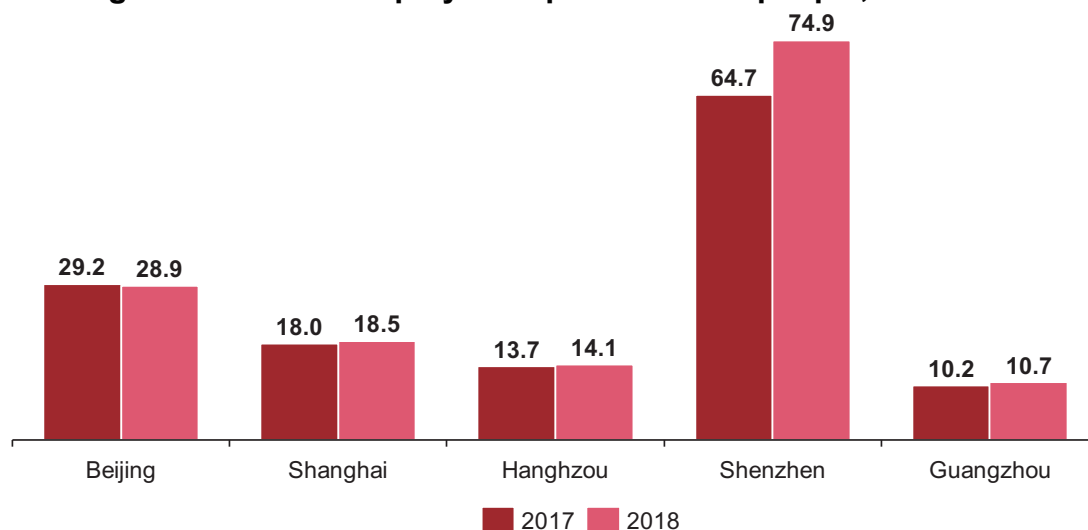
¹Science and Technology World Network. Hong Kong Science and Technology Park will become a plug and play 9+2 research and development center, 2012-05-24, http://www.twwtm.com/detail_182970.htm

Figure 1-2-6 Net population inflow in major cities (million), 2018-2019¹



2.2.2 High-quality talents

Figure 1-2-7 R&D employment per thousand people, 2017-2018



In addition to the continuous population growth, the quality of employment in the Greater Bay Area is also constantly improving. According to the number of R&D employments per thousand people, Shenzhen and Guangzhou are both at the forefront of the country. From 2014 to 2018, the average annual growth rate of the total









¹ Official websites of local governments

number of R&D employments was over 10% in Guangdong, far exceeding Beijing (3.7%) and Shanghai (3.5%)¹.

2.2.3 Excellent educational resources

a) The universities in the GBA are among the top in the world.

Table 1-2-1 QS Asian University Rankings, 2019

Ranking		University	Location
2		The Hong Kong University	Hong Kong
7		The Hong Kong University of Science and Technology	Hong Kong
9		The Chinese University of Hong Kong	Hong Kong
21		City University of Hong Kong	Hong Kong
31		The Hong Kong Polytechnic University	Hong Kong
39		Sun Yat-sen University	Guangzhou
65		Hong Kong Baptist University	Hong Kong
98		University of Macao	Macao

There are abundant higher education resources in the region, with a total of more than 180 colleges and universities, and some of them are among the best in Asia. In the QS Asian University Rankings 2019, the Greater Bay Area occupies three of the top 10 universities and eight of the top 100.

b) Education partnership projects have introduced high quality educational resources to the GBA

In addition to continuing to develop existing colleges and universities, the Greater Bay Area is actively carrying out various educational cooperation, an increasing number of well-known domestic and overseas universities are setting up educational institutions in cities in the Greater Bay Area. Examples include the Chinese University of Hong Kong (Shenzhen) established in accordance with the Regulations of Chinese-Foreign Cooperation in Running Schools, Beijing Normal University-Hong Kong Baptist

¹ Official websites of local statistics bureaus

University United International College, and the joint postgraduate courses offered by City University of Hong Kong and Harbin Institute of Technology in Huizhou. Moreover, top domestic universities such as Peking University and Tsinghua University have also opened branches such as graduate schools in the Greater Bay Area, greatly improving the quality of local education.

Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

In February 2006, the Chinese Academy of Sciences, the Shenzhen Municipal People's Government and the Chinese University of Hong Kong jointly established Shenzhen Institutes of Advanced Technology. After 13 years of development, Shenzhen Institutes of Advanced Technology has established a scientific research-oriented micro-collaborative innovation ecosystem integrating scientific research, education, industry and capital. By the end of 2019, it applied for 8,748 patents, of which 3,587 were authorized. Among the 1,516 patents applied by the academy in 2019, 366 were PCT patents, 42 were foreign patents, and a total of 669 were authorized, ranking first among the institutions within the Chinese Academy of Sciences.

Hong Kong University of Science and Technology (Guangzhou)

In December 2018, the Hong Kong University of Science and Technology signed a tripartite agreement with the Guangzhou Municipal People's Government and Guangzhou University to jointly establish the Hong Kong University of Science and Technology (Guangzhou). The school aims to nurture talents in interdisciplinary fields such as data science, robotics and automated system operations, biomedicine and biomedical engineering, advanced materials, smart manufacturing and artificial intelligence, deepen the cooperation between industry, university and research institutions in the Greater Bay Area, and facilitate local technological innovation, industrial upgrading and high-quality development.

2.3 Intensive capital resources

As a comprehensive reform pilot zone for the country to achieve modernization, the Greater Bay Area is one of the most economically developed regions in China, with mature financial markets, efficient financing channels and adequate capital flows.

2.3.1 Developed capital market

The Greater Bay Area is one of the regions with the most developed financial markets in China. According to the 26th Global Financial Centers Index, Hong Kong maintained its position as the world's top three financial centers, while Shenzhen and Guangzhou ranked 9th and 23rd respectively in the global rankings, second only to Shanghai and Beijing in China, and is the only region in China to have three cities on the list¹.

2.3.2 Diversified financing channels

The GBA has various financing channels and is highly active in investment and trading. By December 2019, the number of funds registered in the Greater Bay Area reached 6,185, comprising a quarter of the country's total. The Outline Development Plan proposed that private equity funds in Hong Kong should be supported to participate in the financing of innovative technology enterprises in the Greater Bay Area, and eligible innovative technology enterprises should be allowed to enter the Hong Kong listing and fund-raising platform, which will greatly benefit the development of innovative technology enterprises in the Greater Bay Area.

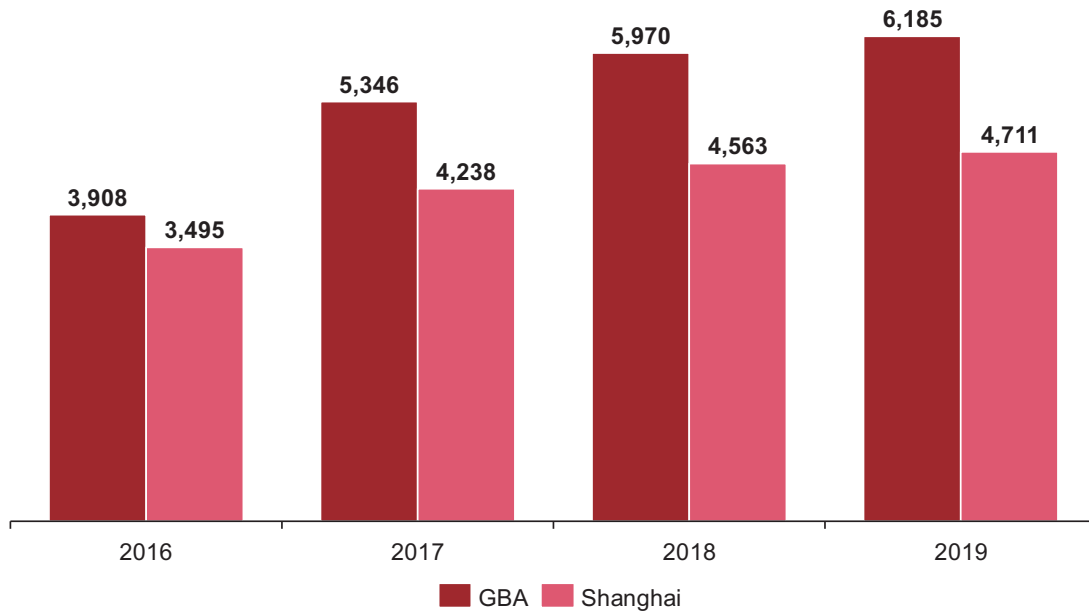
Two major stock exchanges, the Hong Kong Exchanges and the Shenzhen Stock Exchange, have played an important role in the Greater Bay Area over the years. Alongside with the newly established Shanghai Stock Exchange South Center and the Macao stock exchange that is under consideration, these platforms will provide investors with multi-level and all-round financing, investment, management and exit channels. Many leading companies such as Sino Biopharmaceutical, SMIC and Tencent are all listed on the Hong Kong Exchanges, highlighting the ability of the Greater Bay Area, especially Hong Kong, to attract financing for companies. Since April 2018, The Hong Kong Exchanges have allowed pre-revenue biotech companies to be listed on the Main Board. 20 biotech companies that meet the requirements have been listed on the Exchange, raising a total of HKD \$48 billion, and the scale of refinancing after listing has reached HKD \$460 billion.

The Greater Bay Area is home to many listed companies. As of September 2019, there are a total of 533 A-share listed companies

¹Z/Yen Group, China (Shenzhen) Institute of Integrated Development. GFCI 26, 2019-09-19

in the region, accounting for 14.5%¹ of the total number of A-share listed companies, playing an important role in China's capital market.

Figure 1-2-8 Number of funds registered in the GBA and Shanghai, 2016-2019²



2.4 Evolving intellectual property protection system

A sound patent protection system ensures the efficient flow of technological resources. The GBA has a robust patent protection system.

2.4.1 The number of patent application ranks first in the country

In 2019, the Greater Bay Area applied for nearly 26,000 PCTs (Patent Cooperation Treaty), amounting to 43.8% of the number of total applications nationwide. It is also the region with the largest number of international patent applications in China. The number of PCT application well demonstrate the appreciation of intellectual property and innovation ability of the Greater Bay Area.

¹ Wind Information.Wind Economic Database

² Asset Management Association of China

Figure 1-2-9 The number of PCT applications of the GBA ¹

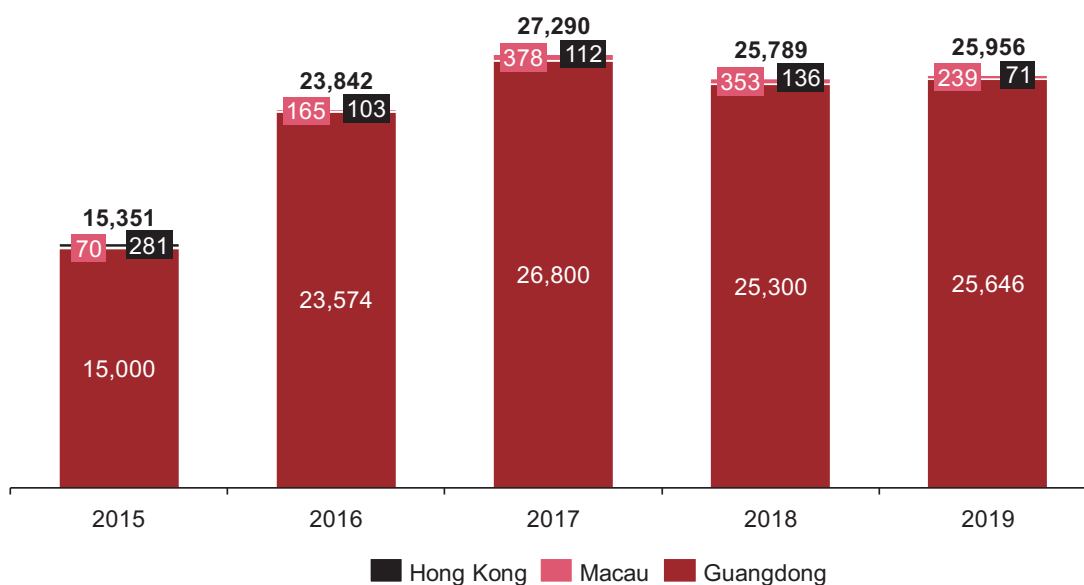


Table 1-2-2 PwC City of Opportunity top 10 cities for patent authorization, 2020

Rank	City	Region
1	Shenzhen	Greater Bay Area
2	Zhongshan	Greater Bay Area
3	Zhuhai	Greater Bay Area
4	Suzhou	Yangtze River Delta
5	Foshan	Greater Bay Area
6	Guangzhou	Greater Bay Area
7	Beijing	Beijing-Tianjin-Hebei
8	Hangzhou	Yangtze River Delta
9	Ningbo	Yangtze River Delta
10	Wuxi	Yangtze River Delta

¹WIPO

2.4.2 Policies promote the patent protection

The local governments in the GBA attach great importance to patent protection. For example, the Guangzhou government is committed to fully realizing the whole process of online application for intellectual property funding, and has issued “Several Measures on Strengthening Intellectual Property Protection” in 2020, which suggests to speed up the establishment of China (Guangzhou) Intellectual Property Protection Center, and supports the Guangzhou Development District, Yuexiu district and Tianhe district in building experimental demonstration zones for the cluster development of intellectual property service industries (including the China-Singapore Guangzhou Knowledge City, the industrial park of intellectual property services, and the Yuexiu Service Center of Intellectual Property), strengthening the protection of intellectual property and ensuring the circulation of technological elements.

Intellectual Property Protection Case Study

Guangzhou Tinci Materials Technology Co., Ltd. sued a company based in Anhui and 99 related individuals in July 2016, claiming that the company had illegally obtained and sold the production technology and business data of Tinci’s product. After careful investigation and examination, relevant experts verified that the technology and related data are trade secrets belonging to Tinci. In July 2019, the Guangzhou Intellectual Property Court found after trial that the product R&D director of Tinci disclosed the technological information to a company in Anhui. As the practice was considered as a malicious infringement and the circumstances were serious, the court decided that the person involved and the defendant company constituted a joint infringement and were sentenced to pay Tinci 30 million yuan for compensation. The judgment fulfilled the local intention to strengthen the protection of intellectual property rights and played an exemplary role.

2.5 Data resources with unique advantages

The “Advice about Establishing A Perfect Market-oriented Mechanism and System of the Elements Allocation” Given by the CPC Central Committee and the State Council, officially introduced by the Central Committee in April 2020, emphasizes that data is becoming the fourth factor of production.

The Greater Bay Area has a tremendous first-mover advantage in data. Leading IT enterprises such as Huawei and Tencent have accumulated a massive amount of data in the past. The Guangdong-Hong Kong-Macao Data Industrialization Alliance, initiated by 18 entities, including Tsinghua’s X-lab, the editorial

board of National Data Strategy, the Electronic Government Association of Guangdong Province, and the China Mobile Group Design Institute, will further push forward the data industrialization in China and promote the implementation of policies in the Greater Bay Area.

The Greater Bay Area also has unique advantages in terms of the breadth and depth of industry data. For example, in 2016, approved by the National Development and Reform Commission, the Ministry of Finance, the Ministry of Industry and Information Technology, and the National Health Commission, the China National Gene Bank located in Shenzhen, constructed by the BGI Research, was officially put into operation.

The project has a business structure of “three databases and two platforms” including a bioinformatics database, grasping the full integration of samples, data, and living organisms, and creating a leading, open, non-profitable and supportive service platform for genetic resource mining. This project is of great significance to the application and development of genomics in the fields of precision medicine and health, future agriculture, marine development and microbes.

Chapter II Challenges, Opportunities and Visions of Innovation in the Greater Bay Area

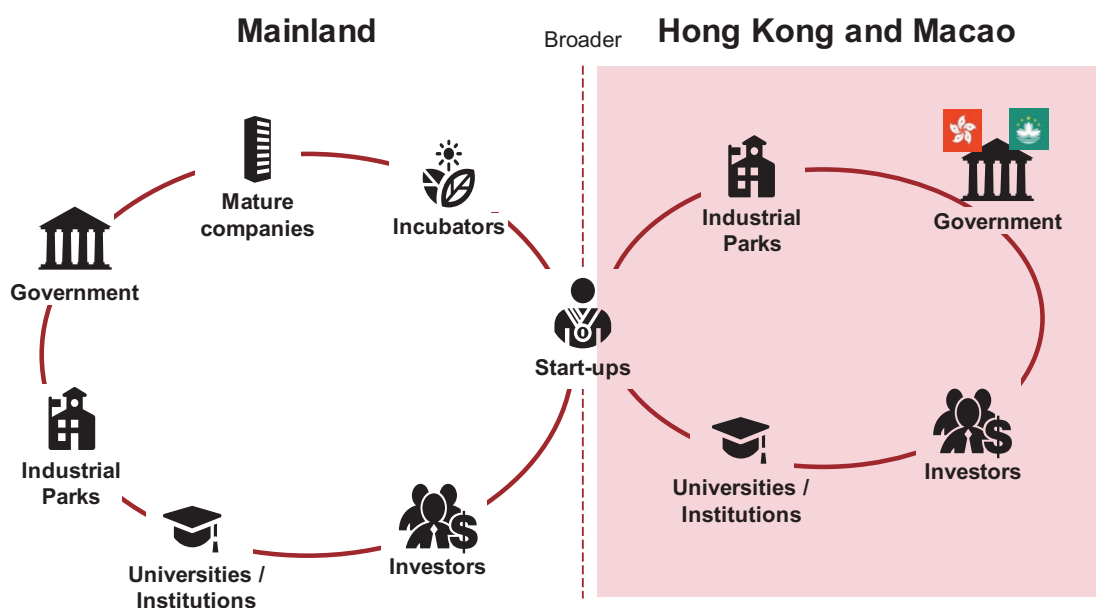
1. The current situation and challenges of local innovation in the Greater Bay Area

The key industries in the Greater Bay Area have a strong foundation and abundant resource endowments. However, the overall industrial development has gradually moved up the value chain to a higher position. To continue to give play to the immense advantages of the GBA and take lead in future development, it is necessary to accelerate industrial upgrading and create a dynamic environment.

The innovation ecosystem of the Greater Bay Area has a lot in common with the one in other regions, while retaining its own unique characteristics. In terms of government management, governments in the Greater Bay Area are actively introducing research and industry projects into the area, promoting science and technology innovation in the region, and creating an open and highly efficient environment. However, there is still room for further improvement in resource allocation and project management. On the subject of research and development, although local education and science are highly productive and have made remarkable progress, the region is still relatively weak in basic research and key infrastructure construction. Industrial parks such as Guangzhou Development District and Dongguan Songshan Lake National Hi-tech Industrial Development Zone have attracted various leading players through generous policies. Nevertheless, park operators still need to strengthen the degree of professionalism and differentiation in park management and investment attraction. In addition, the GBA has played an active role in nurturing entrepreneurs and providing related investment and financing channels, leading to a high concentration of unicorn enterprise. However, compared with abundant financial support, the industrial resources available to start-up enterprises are still relatively limited. Although Hong Kong and Macao have superior educational and scientific research

resources, the small scale of local commercial market has limited the commercialization of scientific and technological achievements. The Greater Bay Area offers a neat solution to the problem. At the same time, Hong Kong and Macao are the most internationalized cities in China, enterprises in the Greater Bay Area can leverage this advantage to accelerate their business expansion in the international market by referring to advanced management strategies and R&D technologies globally.

Figure 2-1-1 Innovation ecosystem in the GBA



1.1 Basic research: The key to long term success

Basic scientific research is an important determinant of the long-term innovation capability of a region. However, the Greater Bay Area has not developed significant advantages in areas of university development, large-scale projects and investments.

According to ESI's statistics, top universities in the GBA, such as Sun Yat-sen University, the University of Hong Kong, and the Chinese University of Hong Kong, have dominant disciplines in applied majors such as materials and clinical medicine. Sun Yat-sen University is the only institution that showed outstanding academic performance in fundamental subjects such as mathematics and physics¹. In the Nature Index 2020 Annual Tables, only two

¹ NatureIndex. Top 200 Institutions, 2020, <https://www.natureindex.com/annual-tables/2020/institution/all/all>

universities, Sun Yat-sen University (35th) and Southern University of Science and Technology (99th), are among the top 100 research institutions in the world, ranking 9th and 20th in China. Other Greater Bay Area cities showed relatively poor performance in the Nature Index 2018 Science Cities ranking.

Table 2-1-1 Global Nature Index Science Cities (Top 50), 2020¹

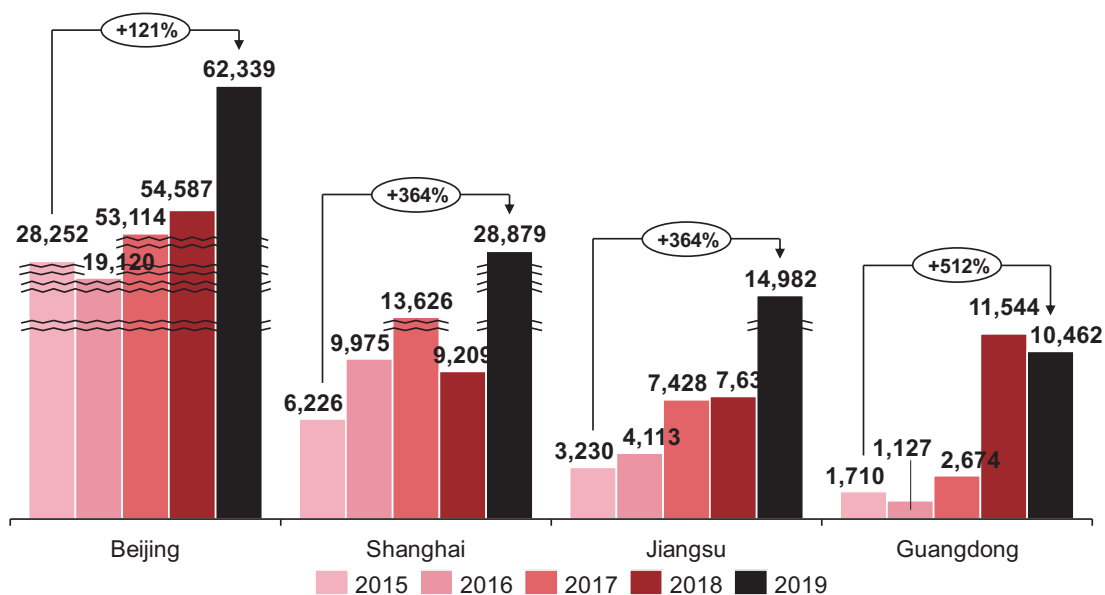
Rank	City	Region
1	Beijing	Beijing-Tianjin-Hebei
5	Shanghai	Yangtze River Delta
8	Nanjing	Yangtze River Delta
13	Wuhan	Other
15	Guangzhou	Greater Bay Area
20	Hefei	Yangtze River Delta
24	Tianjin	Beijing-Tianjin-Hebei
26	Hangzhou	Yangtze River Delta
27	Hong Kong	Greater Bay Area
32	Shenzhen	Greater Bay Area
34	Xi'an	Other
37	Chengdu	Other
38	Changchun	Other
41	Changsha	Other
45	Suzhou	Yangtze River Delta

Among the major national scientific and technological infrastructure projects during the 11th to 13th Five-Year Plan period, GBA institutions only participated in projects of China Initiative Accelerator Driven System(CiADS), China Environment for Network Innovations (CENI) and High Precision Gravity Measurement, of which CiADS is the only project that is led by a GBA institute, namely

¹ NatureIndex. Nature Index 2020 Science Cities., 2020, <https://www.natureindex.com/supplements/nature-index-2020-science-cities/tables/overall>

the Guangzhou Branch of the Chinese Academy of Sciences. Meanwhile, Guangdong enjoys less research funding than Beijing and Shanghai for major projects and research programs of the National Natural Science Foundation of China each year. The foremost reason for this is that the limited project undertaking capacity of the Greater Bay Area, and most scientific research institutions are located in Beijing and Shanghai. However, in the last five years, the amount of fund granted to Guangdong has increased substantially, especially the fund into the life science sector (the proportion of total funding in the province increased from 0 in 2015 to 47.6% in 2019), allowing the government and research institutions to increase their investment in fundamental research.

Figure 2-1-2 Main regions' funding status of major projects of the National Natural Science Foundation of China (million yuan), 2015-2019¹



1.2 Commercialization capability: The winning factor in building an innovation ecosystem

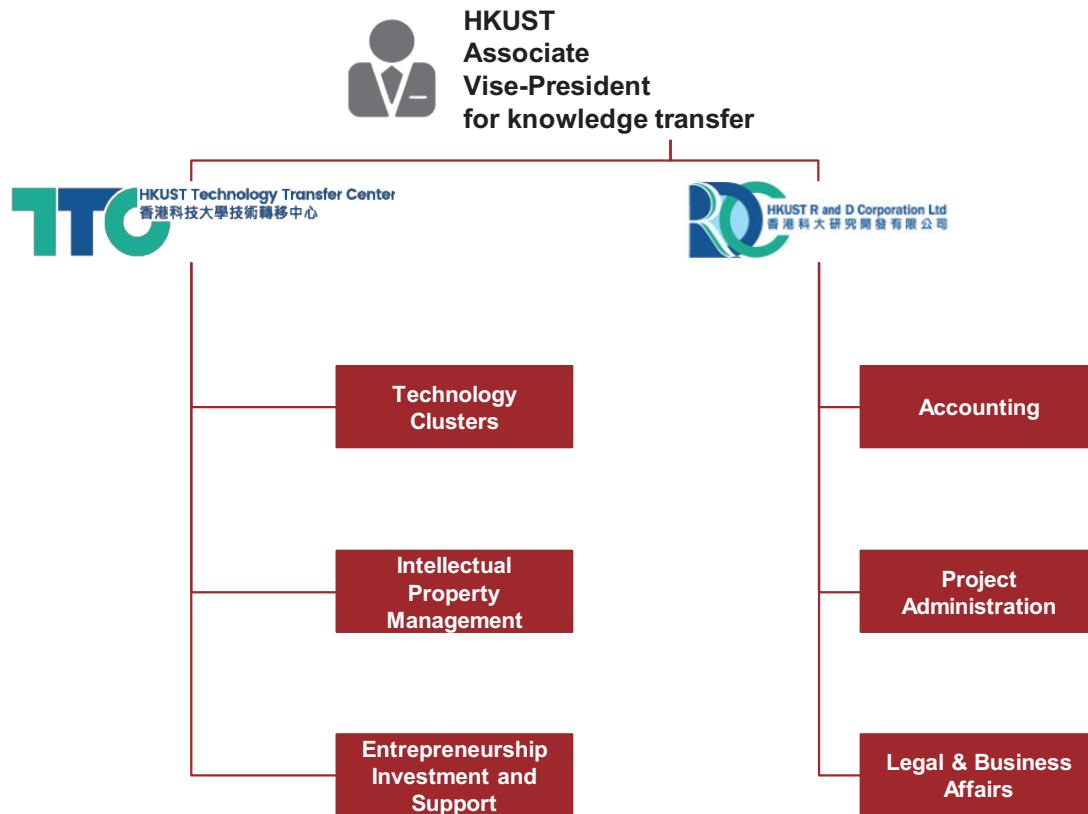
Strong commercialization capability is an important bridge to link scientific research and industry development. The GBA is one of the best regions in China in transforming technological achievements into commercial applications. Some universities and

¹ LetPub

institutions have established relatively mature technology transfer mechanisms, including technology transfer offices. Shenzhen University and South China University of Technology are among the best in China and the world in terms of the number of PCT applications. In 2020, Lixin Pharmaceuticals paid 100 million yuan to acquire the exclusive development right in the global market for the new antineoplastic multi-kinase inhibitor JND32066 developed by Professor Ding Ke, Dean of the School of Pharmacy of Jinan University and Director of the Institute of Pharmaceutical Chemistry and Biology. The emergence of successful cases will further encourage scientific researchers to attach importance to technology transfers.

Universities in Hong Kong, Macao and other cities have also established specialized technology transfer offices to promote the interaction between universities and industries. Taking the Hong Kong University of Science and Technology as an example, the university has a full-time associate vice president responsible for knowledge transfer, who heads the Technology Transfer Center (TTC) and the Research and Development Corporation (RDC). The TTC consists of three departments, which are jointly responsible for the management and protection of the university's intellectual property rights; driving and promoting technology transfer; handling external partnerships, such as contract and negotiation; assisting early technology R&D; as well as strengthening entrepreneurial technology transfer and nurturing startups. The RDC, on the other hand, works closely with industries to explore market demand and cooperation opportunities; provide technical consulting, testing and analysis services to industries; manage the commercial licenses, contracts, projects, stocks and convertible securities of technologies owned by the university.

Figure 2-1-3 Organizational structure of technology transfer at HKUST



However, the development of commercialization mechanism in the GBA is still in its infancy. Compared to their counterparts in developed countries, the technology transfer offices in Mainland China have been established for a relatively short period of time and lack talents who are proficient in both technology and commercialization. At present, there are very few successful commercialization cases that bring great value. In particular, there is still room for further exploration of the commercialization of basic research results that can have a major impact on industries. On the contrary, institutions in Hong Kong and Macao have strong commercialization capabilities, but are limited by insufficient downstream market resources. Therefore, many high-quality scientific research achievements are unable to realize commercialization. In the future, the greater Bay Area is expected to build an efficient commercialization mechanism, strengthen the talent reserve for the technology transfer offices in the Mainland, attach importance to and increase relevant investment, learn from the advanced experience of Hong Kong and Macao, and share

industrial resources with the universities in the two cities for common progress.

1.3 Effective collaboration mechanism: The cornerstone of cross-regional partnership

The Greater Bay Area has unique geographical advantages. Hong Kong, Guangzhou and Macao have gathered the best educational resources in the Greater Bay Area and have an outstanding record of scientific research achievements. Guangdong has a large land area, a huge consumer market and wide-ranging industry resources. However, the GBA still needs a cross-regional coordination mechanisms to fully exploit all the advantages and realize a win-win result.

Hong Kong is known for its remarkable biomedical research achievements and international connectedness. For example, in the past few decades, Hong Kong has seen the birth of non-invasive prenatal testing and drug development for neurodegenerative diseases. For example, according to the QS World University Rankings 2020, only 6 universities in Mainland China are listed in the world's top 100, and none of them is located in the Greater Bay Area, while Hong Kong alone occupies 5 places in the ranking. Nonetheless, Hong Kong is facing problems such as insufficient funds for scientific research, lack of engineering talents, few equipment and laboratories, inadequate industrial investment and limited downstream application markets. Due to such resource constraints, local technology companies are less able to reach the stage of commercialization. Taking the biomedical industry as an example, most pharmaceutical manufacturing enterprises in Hong Kong have their sub-packaging business imported, there are only 23 non-import sub-packaging pharmaceutical manufacturers such as Bright Future and Advanced Pharmaceutical Co. Limited¹. Consequently, Hong Kong still has a long way to go in turning research investment into practical applications.

¹Drugoffice.Gov.Hk, 2020, https://www.drugoffice.gov.hk/gb/unigb/www.drugoffice.gov.hk/eps/do/tc/consumer/licensed_drug_dealers/index.html

Commercial Application of Non-Invasive Prenatal Testing (NIPT)

Professor Dennis Lo, Associate Dean of Faculty of Medicine and Chairman of the Department of Chemical Pathology of the Chinese University of Hong Kong, conducted a series of studies on cell-free fetal DNA in 1997, and pioneered a new way to detect Down's syndrome using second-generation gene sequencing. In 2017, Professor Lo, Professor Rossa Chiu and Professor Allen Chan jointly established DRA Company Limited, to develop, produce and sale IVD products and provide testing services for non-invasive fetal genetic and genomic disease, leveraging the team's patents and technology accumulation in the field of non-invasive prenatal testing.

Mainland China is one of the largest markets for NIPT, the release of two-child policy has further boosted the market demand due to an increase in the number of elderly parturients. In January 2018, Guangzhou KingMed Diagnostics Group Co., Ltd. acquired 50% of DRA's equity at a price of 150 million yuan, with the aim to provide a broader market for the commercial application of NIPT technology based upon its extensive business coverage in the Mainland.

Macao has the best-in-class chip designing capabilities. In 2019, at the 66th International Solid-State Circuits Conference (ISSCC), the University of Macao published 8 academic papers, exceeding the total of all universities in the Mainland, second only to Intel. The number also surpassed world-renowned companies and institutions such as IBM, Samsung and the Korea Advanced Institute of Science and Technology. However, the value chain of chip manufacturing is long and complex, posing significant challenges on technology advancement. The industry cannot rely solely on the efforts of major educational institutions and key laboratories, nor can the financial resources of the municipal government support the large R&D spending in the field. Thus, further support from the state is needed.

In terms of the circulation and collaboration of financial resources, the Ministry of Science and Technology and the Ministry of Finance jointly published the "Provisions on Encouraging Higher Education Institutions and Scientific Research Institutions in Hong Kong SAR and Macao SAR to Participate in the Implementation of Science and Technology Plans (Special Projects, Funds, etc.) financed by the Central Government (Trial)" in 2018, allowing research institutions in Hong Kong and Macao to undertake science

and technology projects through competition and obtain project funding. Guangzhou Municipal Science and Technology Bureau also issued a series of measures such as “Policies and Measures for Further Accelerating the Promotion of Science and Technology Innovation in Guangzhou” and “Measures for the Management of Science and Technology Projects in Guangzhou”, enabling direct cross-boundary disbursement of project funds and encouraging universities and scientific research institutions in Hong Kong and Macao to take the lead or apply independently for municipal science and technology projects, so as to jointly promote the cross-boundary use of municipal government funding for scientific research.

However, in addition to the circulation of financial resources, the flow of physical resources is still subject to certain restrictions. For example, biological samples are subject to heavy regulations for reasons such as biosafety. However, the circulation of biological samples is of great significance for breaking down the silos of biomedical R&D in the Mainland, Hong Kong and Macao and avoid the duplication of effort. Therefore, a more creative approach is needed in the future to relax specific restrictions on the basis of ensuring biosafety, and to overcome the scientific research barriers among the three jurisdictions. In addition, the government should continue to promote the landing of Hong Kong and Macao projects in the Mainland, give full play to Hong Kong and Macao's scientific research capabilities, and encourage the integration of scientific research and investment application of the three jurisdictions.

In respect of the mobility of human resources, the construction of infrastructures such as the Hong Kong-Zhuhai-Macao Bridge and the Guangzhou-Hong Kong High-Speed Railway has greatly improved the convenience of workforce flow. Cities such as Guangzhou and Shenzhen introduced several preferential policies for overseas talents and permanent residents of Hong Kong and Macao, including personal income tax reduction to 15% and fast track permanent residence permit. However, in terms of the management of population flow during the COVID-19 pandemic, medium- to long-term employment and talent mobility, there are still many problems remain to be solved, reasons of which include inconsistent standards of professional qualifications, large taxation differences with cities such as Hong Kong, and gaps in supporting facilities and systems.

Hong Kong and Macao have continued to prosper in their roles as a great global connector. The two cities have established globalized financial systems as well as thorough legal systems such as comprehensive patent and intellectual property laws. At the same time, both cities are highly internationalized in language, education and daily life. They are the preferred locations for foreign enterprises to enter the Chinese market and favorable platforms for mainland enterprises to expand overseas. The development of the Greater Bay Area should leverage this advantage to provide enterprises with a global vision. To illustrate, Insilico Medicine, an American high-tech company that specializes in applying AI technology to targeted drugs, has registered a branch in Hong Kong and started business in the Mainland. The company's main reasons for choosing Hong Kong include its mature legal environment in areas such as business and intellectual property protection, and its proximity to the vast Mainland market in China¹.

Companies in mainland China should realize that global competition is far more fierce than local competition. In cases when the evolution of science and technology hit a bottleneck and the industry is broken down into ever finer segments, it will be increasingly difficult for independent startups to make a difference. Companies must build a strong local presence, think globally, accurately position themselves in the industry chain, and actively collaborate and compete with other industry participants on a global scale, in order to build into an innovative company with a global vision and achieve long-term development.

Other cities in the Greater Bay Area also have a high degree of internationalization. However, compared with Hong Kong and Macao, it is necessary for the cities to improve the living environment to attract more foreign talents and experts, such as the penetration of English, the convenience of the immigration procedure for family members, and international leisure and entertainment activities. The international hub of Hong Kong and Macao will bring positive spillover effects, introducing high-quality global resources for the construction of innovation ecosystems in the GBA cities in the Mainland.

¹ "Alex Zhavoronkov - CEO, Insilico Medicine". Pharmaboardroom, 2020, <https://pharmaboardroom.com/interviews/alex-zhavoronkov-ceo-insilico-medicine/>

1.4 Efficient allocation of supporting resources: Measures to maximize resource utilization

The Greater Bay Area has developed a wide range of financial support program for startups, especially in the forms of venture capital and government subsidies. Nevertheless, companies at different stages have different requirements for resources. For early-stage startups, government subsidies and policy inclination can provide generic support. But for growth-stage companies, especially innovative companies, they are exposed to market competition, and market-oriented technological collaboration may be far more valuable than financial support. For example, in the pre-clinical development of new drugs, appropriate animal models can greatly improve the accuracy of proof-of-concept. In clinical trials, a sound quality control and evaluation mechanism can reduce the possibility of trial failure caused by poor production quality

The operation of industrial parks also requires industrial resources. Most of the parks are operated by the local governments, giving full play to their guiding roles. In the planning and construction stage of the parks, the governments should pay more attention to the opinions of industry players. For instance, when attracting investment, the governments should not only look at the size and reputation of the company, but also focus on the technological leading degrees of the project and the matching of local resources. Some industrial parks provide generous policies to large-scale and famous companies in the hope that they can attract more companies to settle in. However, some companies only set up their supporting business rather than core R&D business in the park, and have very limited ability to drive industrial development and little clustering effect on the industrial chain. On the contrary, some small projects may have excellent technology, which can complement the local industry chain and promote collaborative development.

For mature parks, it is critical to bring in expert resources in order to set up specialized innovation incentive mechanisms and standards, improve parks' operating model, and identify projects with strong technological advantages. At the same time, it can help to explore synergistic opportunities and promote the effective

utilization of resources to improve the medium and long-term returns of projects.

Industrial parks should be more precise in introducing different types of enterprises. Cities and regions have different resource endowments. To avoid duplication of effort and improve resource efficiency, it is important for companies to make accurate use of the supporting resources, including establishing long-term strategic plans, recognizing the advantages and disadvantages of various activities in the industry chain, and diversifying company investments.

2. Opportunities for Innovation in the GBA

2.1 Macro Environmental Support

Policy support is an indispensable part of the development of industries in the GBA. A series of policies issued by the governments have provided strong support for local companies, and including continuous optimization of the business environment to facilitate steady and in-depth development of companies; innovation directions that help companies seize new opportunities; financial subsidies aimed at attracting talents and enabling companies to achieve high-quality development and capital market reforms, and to provide a flexible and barrier-free investment and financing environment.

2.1.1 Optimize the Business Environment and Attracting Superior Industrial Resources

The business environment is the invisible foundation of building a world-class urban agglomeration and an international scientific and technological innovation center with global influence. At the same time, the establishment of the GBA aims to strengthen communication with Hong Kong and Macao, improve the business environment of 9+2 cities, and create a good environment for the innovation and development of enterprises. For example, in 2020, Guangzhou formulated "Measures for Guangzhou to achieve the international advanced level of comprehensive optimization of the business environment", put forward a focus on the whole life cycle of enterprises to deepen reform, enhanced the satisfaction of the main government service market, built a dynamic burst of innovation

and entrepreneurship to create an environment, and strengthened international advanced business rules convergence and other measures, which are necessary for optimizing urban business environment and attracting global superior industrial resources. In 2020, Shenzhen ranked first in the business environment, while Hong Kong (No .5) and Guangzhou (No .8) were among the best in the City of Opportunity report released by PwC and the China Development Research Foundation.

Table 2-2-1 PwC City of Opportunity business environment ranking, 2020

Rank	City	Region
1	Hong Kong	GBA
2	Macao	GBA
3	Shenzhen	GBA
4	Beijing	Beijing, Tianjin
5	Shanghai	Yangtze River Delta
6	Chengdu	Other
7	Guangzhou	GBA

2.1.2. Guide the direction of innovation and further focus on the development of subdivision industries

Governments in the Greater Bay Area has been committed to encouraging and supporting innovation. A series of innovation policies issued by the local governments have provided guidance on business innovation and promoted healthy and stable economic development.

In the field of healthcare, the GBA government has launched policies to encourage innovative research and development of drugs and devices, and to promote the reform of the medical system. Among them, Action Plan for Innovation and Development of Guangzhou Biopharmaceutical Industry (2018-2020) and Shenzhen Biopharmaceutical Industry agglomeration Development Program (2020-2025) all focus on the research and development of gene drugs, antibody drugs, new target chemical drugs, gene drugs, cell products and polypeptide drugs. In addition, in vitro diagnosis, at

home medical monitoring and health equipment, wearable devices and mobile medicine and other products have also been the focus of government attention.

With regard to semiconductors, the GBA Government has issued a number of support policies, such as the Notice of Several Opinions on Accelerating the Development of Semiconductor and Integrated Circuit Industries in Guangdong, to support the third-generation semiconductor industry, including semiconductor materials such as gallium nitride (GaN), silicon carbide (SiC) and the integrated circuit sector, leverage the comprehensive advantages of the Greater Bay Area to promote cross-boundary collaboration, and enhance chip manufacturing capabilities.

As for the display industry, the action plan for the development of ultra-high-definition video industry in Guangdong province (2019-2022) and the five-year action plan for speeding up the development of IAB industry in Guangzhou (2018-2022) have proposed to speed up the construction of new display device production lines and other major projects.

2.1.3. Strengthen innovation subsidies

Policy not only provides directions for innovation, but also supports the development of innovation. All 11 cities in the Greater Bay Area have introduced relevant financial subsidy programs and talent policies to support enterprise innovation and help the region become an international innovation and technology hub.

Financial subsidy measures include financial support for product R&D, loan interest relief and tax deductions for R&D expenses. The Five-Year Plan of Action for Accelerating the Development of IAB Industry in Guangzhou (2018-2022), for example, proposes that the government will allocate 1 billion yuan per year to support a number of major IAB and innovative projects; the Guangzhou Municipal Regulations on Accelerating the Development of Biopharmaceutical Industry stipulates that financial support for biological products, 1-6 types of traditional Chinese medicines and 1-2 types of chemicals that are independently developed and transformed in this city should be provided in stages, up to 10 million yuan; and the Shenzhen Municipal Measures for Promoting the Agglomeration and Development of Biomedical

Industry proposes that drugs that meet the requirements should be funded at 40% of the actual R&D costs.

In addition to the subsidies for enterprises, Guangdong-Hong Kong-Macao GBA actively creates a good environment for talent, further improves the incentive mechanism of innovative talents, and provides strong intellectual support and talent guarantee for the innovation and development of the GBA. The GBA City has issued a series of policies, aiming at the "talent war" in the top. For example, Guangzhou's "Guangju Talent Program" and "Meiyu 10" talent policy, through the provision of living subsidies, security and issuance of "talent green card", provide children with priority to school, experimental equipment and raw materials import and export convenient customs clearance and other innovative measures to gather "high-precision" talent; Shenzhen's "Peacock Program" stipulates that qualified overseas high-level talent, can enjoy 1.6 million to 3 million yuan incentive subsidies, as well as in residence and entry and exit, settlement, children's admission, spouse employment, medical insurance and other preferential policies. In addition, the government will give up to 80 million yuan of special funding to the world-class team that has been introduced, and provide support in starting a business, project research and development, policy matching, and transformation of achievements.

2.1.4. Reform Capital Market and Enrich Investment Exit Channel

At the beginning of 2018, the Hong Kong Exchanges promulgated a series of major reforms and new policies, under which the non-profit and non-income biotechnology companies may go public in Hong Kong. This action has created a very favorable capital environment for the rapid development of biomedical technology companies in The GBA region. Innovative drugs require a lot of financial support during the R&D period, but do not bring revenue to the company. The listing of early stage biotechnology companies will boost the research and development of innovative drug in Hong Kong and have a beneficial and far-reaching impact on the development of the entire pharmaceutical industry. InnoCare Pharma, a biopharmaceutical company committed to the development of drugs for cancer treatments and autoimmune

diseases, and Akeso Inc., an R&D company that specializes in innovative antibody drugs, have benefited from this major reform, and successfully listed in HKEX during the product development period.

2.2 Technological innovation opportunities

The innovation direction of the GBA is of great strategic significance, and many factors such as industrial orientation and regional characteristics need to be considered. Based on the comprehensive market potential and the GBA's current ability, it is found that four industries, namely artificial intelligence, cell and gene therapy, liquid biopsy and printing, will become the innovation pillars of the GBA, bringing new kinetic energy to the industrial development of the region, and leading the industrial innovation in China and even the world.

2.2.1 Artificial intelligence

Artificial intelligence (AI) is the core driving force for the new round of industrial transformation, which will give birth to new technologies, industries and models.

The Greater Bay Area has a leading position in artificial intelligence. As of February 2019, there were 745 artificial intelligence enterprises in China, among which the Pearl River Delta accounted for 16.9%. Huawei, Tencent, Intelifusion, DJ-Innovations, Snapask are expanding their businesses across the industry chain, covering from upstream processor, AI algorithm to downstream applications such as computer vision, AI computing platform, smart hardware, voice intelligence, autonomous driving, etc.

The rapid integration of AI into industries will certainly facilitate industry transformation and upgrading. Taking the healthcare industry as an example, the Greater Bay Area has not only a decent industrial foundation, but also a willingness to try new technologies and models. For example, BGI Genomics integrated AI technology in gene sequencing to improve the efficiency and accuracy of image recognition, as well as the speed and accuracy of gene sequence and gene variation identification. Another example is Tencent Miying, which greatly improved detection and typing efficiency of

diseases such as cervical cancer, breast cancer, diabetic retinopathy by enabling medical imaging through AI. In addition, the population of the Greater Bay Area is younger, and consumers are more receptive to the integration of the healthcare industry and the new generation of information technology. These characteristics pave the way for the development of AI-assisted medical treatment in the Greater Bay Area.

2.2.2 Liquid biopsy

The concept of precision medicine was first put forward in 2011, which has a great impact on the future development of medicine. Accurate diagnosis is the first step of precision medicine, and liquid biopsy is an important means of accurate diagnosis.

Liquid biopsy is one of the breakthrough techniques for accurate diagnosis of tumor diseases. Nowadays, in clinical research, the techniques of liquid biopsy mainly include free circulating tumor cell detection, circulating tumor DNA detection, exocrine and circulating RNA detection and so on. Compared with traditional tissue biopsy, liquid biopsy has the unique advantages of real-time dynamic detection, overcoming tumor heterogeneity and providing comprehensive detection information. With the development of technology, the application of liquid biopsy will become an important mean of tumor disease monitoring and treatment.

The GBA has innate industrial advantages in the field of liquid biopsy. Traditional gene detection companies such as Burning Rock Biotech and BGI Genomics have been laying out in the field of liquid biopsy, taking advantage of their technical advantages in gene detection to further expand their business scope. In addition, AnchorDX, HaploX and other startups focused on liquid biopsy also settled there, effectively promoting the sustainable development of liquid biopsy and precision medicine in the GBA.

2.2.3 Engineering Biology and Its Applications

The development of gene editing technology has promoted the emergence of new treatment methods. The later development pipeline of the next generation of biological therapy drugs (cell, gene

and nucleotide drugs) rose from 120 in 2015 to 269 at the end of 2018, accounting for 10% of the later research and development pipeline, becoming a hot spot of R&D.¹

The GBA is one of the researches and development centers in the field of cell gene therapy. Guangzhou, Shenzhen and other places have introduced policies to support the development and transformation of cell and gene therapy. Some new research institutions, such as Shenzhen International Institute for Biomedical Research, have entered the GBA in recent years to provide services and support for small and medium-sized companies in laboratory animals, gene therapy carriers and so on. For example, the newly established One-Stop Public Service platform for R&D and Evaluation of Cell and Gene Therapy Drug in Guangdong-Hong Kong-Macao GBA in 2019, provides service for start-up companies about cell and gene therapy drug project pilot, toxicological safety assessment, drug registration application, batch production and other aspects.

In addition to direct application in human therapy, gene editing technology has been widely used in other fields. For example, in the organ-like field, gene editing can customize the production of quasi organs that meet the needs of research, and greatly improve the efficiency of basic research in biotechnology and clinical application of pharmaceutical products. For example, in the field of artificial meat, gene editing technology can adjust the original cell lines to improve the production efficiency and reduce the production cost of artificial meat.

2.2.4. Printed Display

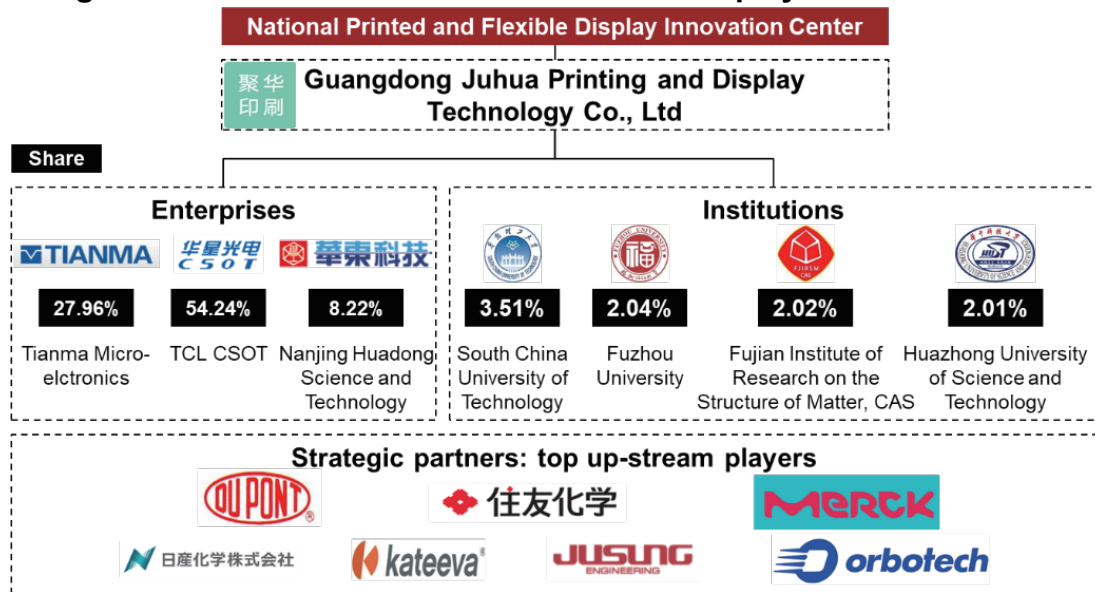
Printed display is one of the most subversive technologies in the display industry. It has advantages on light, flexible, large area, low cost and green manufacturing. It is considered as one of the important directions of the development of the new display industry in the future.

The industry and R&D base of the GBA already have considerable scale and advantages. LG display, TCL and other

¹IQVIA. The Changing Landscape Of Research And Development, 2020, <https://www.iqvia.com/insights/the-iqvia-institute/reports/the-changing-landscape-of-research-and-development>

leading enterprises invest heavily in Guangdong, driving the overall industrial chain. The landing in GBAs of the National Printing and flexible display Innovation Center and HKU-TCL Joint Research Laboratory for new printable OLED materials and technology, established a public technology platform which link the upstream and downstream, tightly circle the industry players and communicate among the industry research, and share the R&D experience.

Figure 2-2-1 National Printed and Flexible Display Innovation Center



2.2.5 5G

5G has brought the next wave of technology disruption in the telecommunication industry in recent years. Its application scope is far beyond 4G, bringing new opportunities to the whole industry chain. According to IHS Markit's prediction, by 2035, 5G will generate a global economic output of USD \$13.2 trillion and 22.3 million jobs. Undoubtedly, the Greater Bay Area is the core base of global R&D in 5G. Huawei, ZTE and other world-leading enterprises have established their presence in the region, promoting the overall development of the industry. In the future, the Greater Bay Area should continue to focus on the new generation of information technology represented by 5G, and promote its integration with traditional industrial and agriculture sectors.

2.2.6 New Energy Vehicles

The technological progress of the automobile industry drives the development of the entire industry chain. New energy vehicle is an important strategic layout for China to overtake the automobile industry.

The Greater Bay Area is one of the traditional automobile production bases in China. Well-known brands such as GAC Group, Toyota, Honda, Dongfeng Nissan have set up production bases in the region. In the future, the Greater Bay Area should grasp the development trend of new energy vehicles, make use of the layout of traditional and new energy automobile manufacturers such as BYD and Xpeng in the GBA, develop the upstream and downstream industries, and cultivate new growth momentum.

3. The vision of the Greater Bay Area

In the 40 years of economic reforms, the Greater Bay Area, with its unique advantages, has painted a rich and colorful picture in part of China's modern history.

In the future, innovation will be the new core power to promote the development of the industry in the GBA. A healthy innovation ecosystem will continue to generate this momentum, leading the evolution of the Greater Bay Area into the fast lane.

Such an innovative ecosystem should be established on the existing factor endowments in the GBA. The 11 cities in the GBA economic vary in development level and basic industrial capacity, determining that each city cannot and is not suitable for the development of universal industries. Through differentiated positioning and good coordination mechanism, the Greater Bay Area can truly complement each other's strengths and grow together, forging world-class urban clusters.

Also, this kind of innovative ecosystem must be exoteric. According to historical experience, standing still leads to backwardness, while embracing evolutions brings progress. From the point of view of innovation, the open ecosystem can make the industrial elements flow more smoothly and greatly improve the efficiency of innovation and development. What's more, an open ecosystem can maximize the competitive advantage brought by the scientific research and technological transformation, and enhance the community's attention to the development of science and technology.

Looking to the future, the community is full of confidence that the Greater Bay Area can promote the sustainable development of innovative ecosystem. We look forward to seeing that the industry in the Greater Bay Area can realize more and more upgrades.

Chapter III Reimagine the Innovation Ecosystem in the GBA

1. The future of the exoteric innovation ecosystem

The establishment of an exoteric innovation ecosystem requires the collaboration and joint efforts of all parties.

Undoubtedly, the government should play a leading role in the process. The government should point out the main directions of industry development from a strategic viewpoint, and coordinate the development goals of the management bodies at all levels, creating synergetic effects to improve the efficiency of innovative development.

Meanwhile, the government can formulate industrial policies and provide essential resources such as land, talents and capital, to support and protect the innovation ecosystem. The innovation ecosystem in the Greater Bay Area should be inclusive and be able to accommodate various entrepreneurs and research institutions of different industries, scale and nature along the industry chain. It should also take public welfare into consideration, to focus on the long-term development of industries rather than short-term profits. Therefore, only the government has the capability to lead and construct such an open and inclusive innovation ecosystem.

Research institutions especially universities have advantages in basic research, which is the main source of technological innovation. Hence, they should pay more attention to the role of basic research in the innovation ecosystem, increase investment in basic scientific disciplines, and strengthen their innovation capabilities, to create a better atmosphere for innovation. Besides, Research institutions should also strive for the development of major scientific research infrastructure in the Greater Bay Area leveraging the resources provided by the government. Meanwhile, to collaborate with industries to look for simple and efficient ways of turning research achievements into market-oriented applications. In addition, strengthening research cooperation among Guangdong, Hong Kong and Macao allows the three jurisdictions to complement each other and jointly improve the education standard and basic research ability of the whole region.

Industry players should support the establishment of innovation ecosystem in an all-round way. While many well-known companies are committed to ecosystem development, most of them are commercially oriented, aiming to increase their own business influence rather than promote technological innovation. On the other hand, some of the most advanced enterprises, such as HUAWEI and BGI Genomics, have established various kinds of research institutes to supplement the industrial development of the local innovation ecosystem.

Besides, some full-blown enterprises, especially MNCs, should leverage their industrial resources and professional experience to assist the government to identify an appropriate direction of innovation, locate pain points that restrict industry development, screen out high-quality projects, and provide professional advice for the operation of industrial parks. They can also provide guidance for SMEs (small and medium-sized enterprises), which are the main force of innovation, to improve the success rate of transformation and enhance the efficiency of resource utilization. Well-developed enterprises can also co-invest with governments and venture capitals to incubate entrepreneurial projects and commercialize research results.

Merck China Innovation Hub

Merck Innovation Hub is one of the most successful cases in which MNCs help local startups and research institutes incubate innovative technologies. Merck Group, established in 1668, entered the Chinese market in 1993. The company operates across innovative drugs, life science and performance materials. In 2018, Merck signed an agreement with Guangzhou Development District to set up an innovation hub in Guangzhou. THE Guangdong Innovation Hub is designed to take advantage of the innovation ecosystem consisting numerous industrial parks, incubators, research institutes and investment companies to promote the development of innovative technologies in healthcare, life science and high-performance materials sectors.

Taking the accelerator project as an example, the hub selected 18 out of about 700 companies to participate in the project. Seven among the 18 enterprises are from the Greater Bay Area, including Xtretch Technologies, a company owning a patent in flexible and stretchable packaging technology, SPSE TECH, which provides biomaterial solutions, and Moon (Guangzhou) Biotech Co., Ltd., which focuses on the development innovative live microbial drugs related to metabolic diseases and tumor immunity. The companies selected are eligible to obtain technological and financial support from Merck and its partners as well as international exchange opportunities.

2. Recommendations for key initiatives

2.1 To establish innovative infrastructure to facilitate scientific research and technology conversion

Facing the transformation of growth drivers under the new normal, the state has proposed to speed up the progress of new infrastructure construction. Innovative infrastructure is one the three major development areas, which mainly refers to the infrastructure that supports scientific research, technology development and product development with public welfare attributes. The proactive engagement in new infrastructure construction, especially open public service platforms and common technology platforms that are in line with the industrial characteristics of the Greater Bay Area, will be a connector for SMEs to access industrial resources and be a great support for local innovation ecosystem.

2.1.1 Open public service platforms

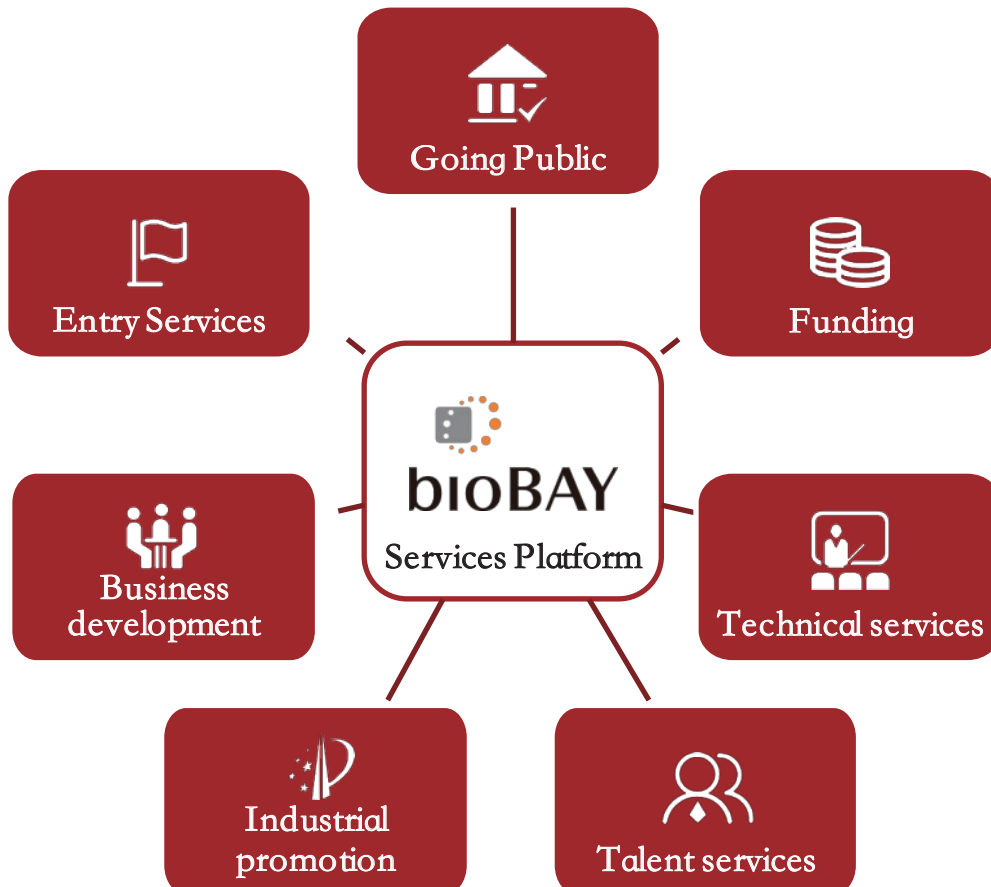
a) The significance

Some fast-developing regions have established relatively mature public service platforms, making positive impacts on the development of the local biomedical innovation ecosystem. For example, BioBAY, a biomedical industrial park in Suzhou, has rapidly become one of the top domestic medical parks in the past decade with the help of its specialized services. The park provides settled companies with a variety of services, ranging from listing consultation, investment (fund), technological services (GMP verification and small molecule technology), industry promotion (intellectual property protection and industry support) to settling services (business registration and information services). Taking talent services as an example, BioBAY has gathered a large number of domestic and international universities and research institutes around the park through Suzhou's talents recruitment scheme and attracted talents by collaborating with industry associations in china, while maintaining a high talent retention rate through policies and subsidies.

Apart from well-known companies such as Innovent, Hutchison Whampoa Limited, and BrightGene Bio-Medical Technology Co., Ltd., the BioBAY has attracted more than 430 hi-tech companies, formulating an industrial cluster of new drug

creation, medical equipment and biotechnology, and building an innovative industry ecosystem for nearly 15,000 high-level R&D talents to communicate and collaborate. Projects such as the Cold Spring Harbor Asia have made the biomedical park a global academic and industrial exchange center in the field of life sciences.

Figure 3-2-1 BioBAY services platform overview



b) The ideal model

Local stakeholders can refer to the successful case of BioBay to build a public service platform with its own unique advantages. It should include not only the physical platform but also non-physical components to encourage the leadership of governments, the market participation of enterprises, whilst being open and non-profitable.

Governments should play a leading role in ensuring the characteristic mentioned and supporting the initial establishment of the platform through policies such as financial subsidies, rental reduction and exemption, reserved equipment office space for startups.

Developed enterprises can participate in the operation of the platform by providing funds, equipment, and industry insights. In particular, companies' expert resources can help the platform establish a professional project assessment and incentive mechanism, enhancing the professional operation capabilities of the platform.

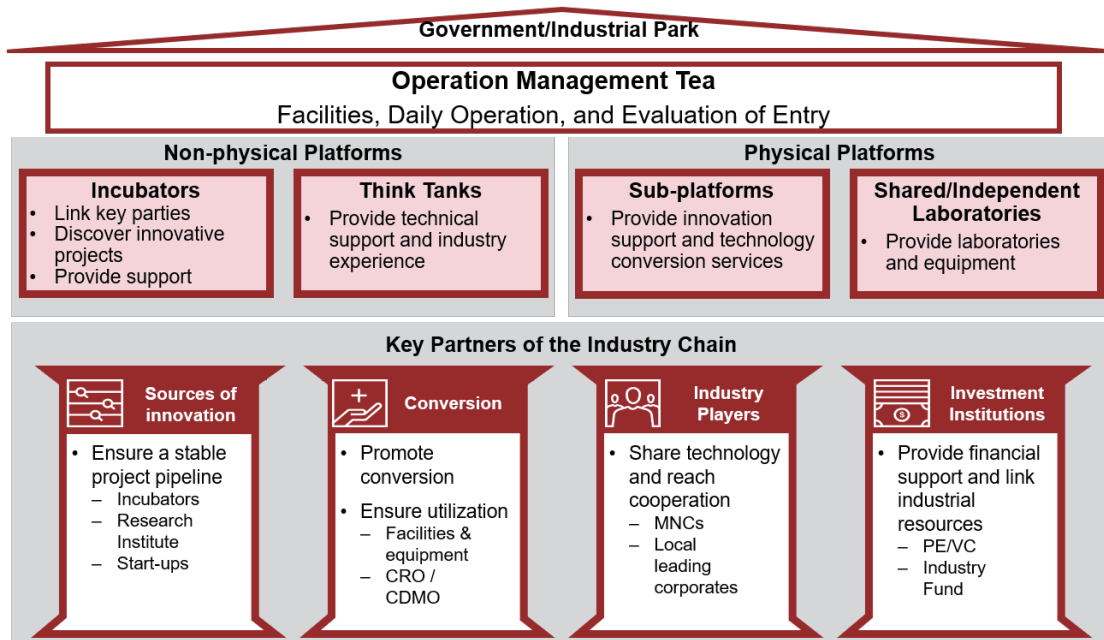
The settlement of professional service institutions can provide startups with professional knowledge input, shared equipment and services to accelerate the commercialization of innovation achievements.

Investors can participate in the construction of the platform and make direct or indirect investments in rising companies incubated by the platform to provide financial support.

c) The implementation plan

The establishment of the public service platform can be divided into two steps. The first step is to build a non-physical service platform, including virtual innovation incubators and think tanks. The non-physical platform needs less investment which can greatly reduce the participation threshold of all parties and attract a broad range of companies that are committed to the construction of the innovation ecosystem in the Greater Bay Area. The second step is to set up a physical platform to provide startups with sufficient resources, promoting the further development of the innovation ecosystem.

Figure 3-2-2 Pubic service platform model



d) The industry aggregation

Public service platforms can promote collaboration and improve efficiency through industry aggregation, so as to achieve common progress in all sectors within a single industry. Taking cell and gene therapy as an example, the industry is characterized by high levels of R&D expertise and a small production scale. For instance, the platform can introduce R&D and production companies of viral vectors to reduce the cost of independent development by existing startups, and increasing the success rate of R&D. Industry aggregation can also improve the efficiency of quality control platforms, which serve as an intermediate platform for public service platforms to provide startups with professional industry knowledge, reducing the risk of failure caused by production quality and technical compliance.

2.1.2 Generic Technology Platform¹

Generic technology platform refers to research entities that conduct R&D of generic technology and is one of the keys to promote generic technology breakthroughs and innovations. It plays a crucial role in strengthening the conversion of technological achievements and is also of great significance for the Greater Bay

¹ Haiyan T, Ran H. Common Technology Platform, Catalyst of the Science and Technology Center. *Technology China*, 2018 (08): 27-30.

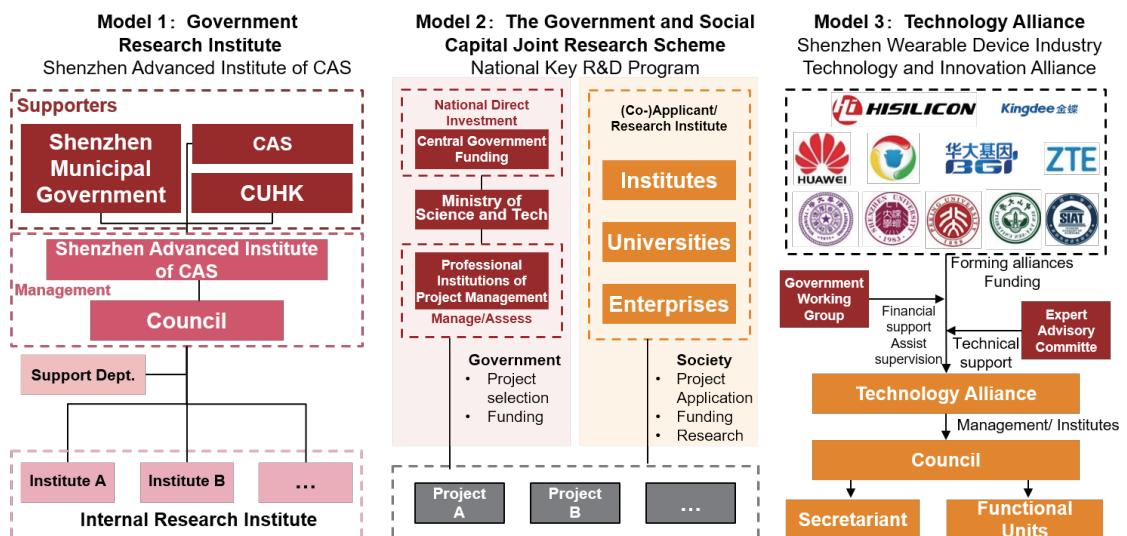
Area to build a global science and innovation center and boost the development of emerging industries.

Globally, the most typical generic technology platforms include the US National Institute of Standards and Technology, Advanced Technology Program, Manufacturing Program, and Sematech, EU Framework Program for research and Eureka Program, Germany Fraunhofer-Gesellschaft the British Energy Technology Institute, and the Japanese National Institute of Advanced Industrial Science and Technology. These platforms have played an important role in the development and conversion of industrial technologies.

a) The existing models of generic technology platform

According to the construction model of the platform, there are 3 different models: 1) government research institute, 2) government and social capital joint research scheme, and 3) technology alliance.

Figure 3-2-3 The existing models of generic technology platform



Governments are highly involved in the early stage of platform construction due to the characteristics of generic technology. It not only reflects the importance of governments in promoting the development of local strategic industries, but also facilitates the research on market-oriented technology platforms. However, in the long run, governments can act as a supervisor and coordinator rather than an operator after a sound operating mechanism has been established.

b) The development direction of generic technology platforms in the GBA

The Greater Bay Area has established a relatively mature generic technology platform in the new display industry, namely the National Printed and Flexible Display Innovation Center. The construction work was undertaken by Guangdong Juhua Printing Display Technology (controlled by TCL Corporation) and was officially launched in Guangzhou in 2018. The center has fostered numerous fruitful scientific research achievements since its establishment, including the public platform of G4.5 printing and display, the prototype of 5-inch 400 ppi ultra-high-resolution printed OLED, and the prototype of 31-inch quantum dot H-QLED.

Generic technology can play a vital role within and across industries, but is also highly dependent on the external environment. Independent technology investment made by a single enterprise will limit the development efficiency and its wide application in the future. Therefore, establishing a more inclusive generic technology service platform that integrates multiple industries is suggested, to support resource sharing and to provide open access to SMEs for the healthy development of industries.

In addition to the new display industry, generic technologies have also been developed in the life science industry which governments, industries, and research institutes should pay attention to. For example, technologies such as gene editing and viral vectors play an important role in fields such as medicine and agriculture.

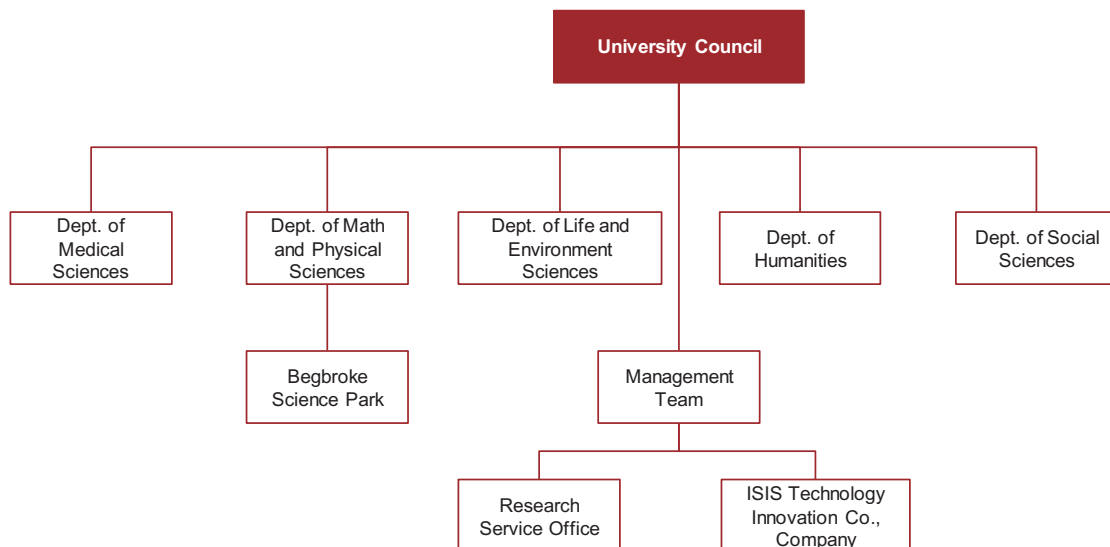
2.2 To improve the commercialization mechanism for research achievements

The commercial application of technologies not only requires clear rights to use, dispose and benefit from technological achievements, but also relies on market mechanisms that promote the capitalization of technological achievements through venture capital, intellectual property securitization and technology insurance. It also depends on the construction of major systems focusing on market-based empowerment, outcome evaluation and income distribution.

2.2.1 Enhance the function of technology transfer office of institutions

Universities in regions with rich scientific research results and developed industries have set up specialized technology transfer offices (TTO), to provide intellectual property-related services for technologies generated on campus and facilitate the cooperation with commercial partners. Taking the University of Oxford as an example, the university has established a scientific and technological achievement conversion system. The system involves different institutions such as the University Council, departments of various disciplines, ISIS technology Innovation. Among them, the University Council is the management and decision-making body. The research offices and ISIS Technology Innovation under the council are responsible for the concrete conversion work. Since its establishment, ISIS Technology Innovation has applied for 1,500 patents for the scientific and technological achievements of the University of Oxford, signed 750 technology license agreements, and established over 100 derivative companies.

Figure 3-2-4 The technology conversion system in Oxford University ¹



Universities in the GBA, especially those in the Mainland, could enhance the function of TTOs by bringing in internal and external talents specializing in technology and commercialization and expanding the internal impact of TTOs. Besides, universities can

¹ Qiang C, Yuehua B, Xuhua C. Transformation and Collaborative Innovation of Scientific and Technological Achievements in Universities. Beijing: Tsinghua University Press, 2017

also consider establishing cross-regional TTOs to learn from the experience of universities in Hong Kong and Macao in technology conversion and patent protection, and seek commercial opportunities in the Mainland for research achievements from Hong Kong and Macao. Such a cross-regional TTO can enhance the efficiency of technology transfer and broaden the application scope for research achievements.

2.2.2 Optimize the benefit distribution system

The benefit distribution system is of great significance to the entire conversion mechanism. A balanced system can motivate scientific researchers, improve the efficiency of conversion and foster a positive innovation atmosphere.

At present, some of the domestic universities have promoted the commercial application of research achievements by allowing researchers to start their own company for commercialization. However, using public resources of universities and research institutes to conduct research and development for personal gains is also a challenge to the fair competition mechanism of the market. Therefore, the governments in the Greater Bay Area need to discuss how to assign the ownership of patents in a fair way and how to improve the benefit distribution system, so as to boost research productivity and ensure fair competition

It should be recognized that talent is the most important asset to promote scientific research breakthroughs. Therefore, researches should be assigned with an appropriate proportion in the benefit distribution system. Universities and institutions provide researchers with essential infrastructures and resources, giving priority to the former in obtaining patent authorization will encourage them to create a better research environment for researches. Additionally, encouraging the non-exclusive licensing of patents in China can broaden the application scope of advanced technologies and benefit more users.

2.3 To promote the integration of cities in GBA and contribute to the reform and opening of China

2.3.1 To enhance the convenience of workforce flow

The integration of people is the key of territorial integration. In the short term, there has been an obstruction regarding the

personnel flow among Guangdong Province, Hong Kong and Macao due to the impact of 2019-nCov. However, the governments of these three districts have been actively fighting for a wider reciprocal openness while taking the control of the epidemic as a prerequisite. For example, since the 6th of July, Zhuhai had extended the moveable area of relevant personnel up to the nine Guangdong cities of the GBA, among whom were people exempt from quarantine inbound for official or business affair as well as with special situation. Still, further openness of border is waiting for more instruction considering the condition of this epidemic.

In the long term, the extension of demonstration zone of talents cooperation in Guangdong, Hong Kong and Macao talent can cast a profound influence to the fusion of these three areas. At present, this area includes only Nansha (Guangdong Province), Qianhai (the city of Shenzhen) and Hengqin (the city of Zhuhai). Geographically, the area can be extended to the six other cities in Guangdong Province as well as other industrial zones of significance. In the aspect of the talent construction, a unified certification system of talent's skill level can be built around the whole GBA, coping with the situation where talent from different cities are facing multiple levels of acknowledgement to meet up to. Such deed can provide convenience for the circulation of talents of different levels and orientation.

2.3.2 Special import and export management policies

Moreover, while the sovereignty of the Lok Ma Chau River Cover Area and Hengqin Economic Zone remain to be the mainland government's, it is the government of Hong Kong and Macao which actually administrate these areas. Such special situation should be made the most of to provide some particular border management for the GBA enterprises. For example, point-to-point export of biological samples towards Sci&Tech parks and academies in the GBA can accelerate the integration as well as coordinate the development among these three areas. At the same time, biological safety can be guaranteed.

2.3.3 To support measures for mainland landing of Hong Kong and Macao projects

Attracting Hong Kong and Macao projects to land in the mainland will promote the commercialization and marketization of

high-quality projects, enhancing the innovational competitiveness of the GBA. At present, the GBA has set up special supports for Taiwan related projects. For example, Dongguan Songshan Lake Industrial Park has specifically established a Taiwan Industrial Park and has a Dongguan Taiwan Youth Innovation and entrepreneurship service center, providing registration services, site office, policy capital application, management consultant, technical support, venture capital financing and other one-stop industrialization incubation for the Taiwan youth entrepreneurial team settled in the base service. Dongguan launched the introduction of Taiwan Youth Entrepreneurship Program in 2015, allocating 50 million yuan to support Taiwan's young talents in Dongguan to innovate and start their own businesses. The scope of funding covers talent subsidies, start-up funds, site rental subsidies and accommodation subsidies.

The nine Guangdong cities in the GBA can learn from these initiatives for Taiwan's entrepreneurship projects and explore similar support measures for young entrepreneurs in Hong Kong and Macao. Such measures may include further construction of youth innovation and entrepreneurship bases in Guangdong, Hong Kong and Macao, optimizing the business environment and business registration process, etc. With these support measures, these cities can facilitate and support the mainland landing of Hong Kong and Macao projects. Compared with other cities in the mainland, Guangdong is close to Hong Kong and Macao in terms of culture as well as transportation. For the start-up companies in Hong Kong, searching for a broader market is the only way to break through the regional limitations. The GBA is undoubtedly attractive as a window into the mainland market. With the policy support of Guangdong nine cities, the GBA is destined to attract a large number of excellent start-up companies.

The Landing of a Hong Kong project in Guangdong

Focusing on Precise Medical Liquid Biopsy Technology, CELLOMICS is a start-up company whose core technology was hatched originally in the City University of Hong Kong. However, in Hong Kong, the cost of manpower, material and land are relatively high while in the mainland there is broad market, standard production capacity and plenty of skilled workers. Taking the preferential policies provided by the Shenzhen government for high-tech companies as well as other advantages into consideration, the company finally settled in Shenzhen. This company's landing has enriched Shenzhen's layout in the field of liquid biopsy and promoted the process of industrialization of advanced technology, becoming a successful example for the landing of Hong Kong and Macao projects in the mainland.

2.4 To strengthen the role of industrial resources and to jointly promote the sustainable development of innovative ecosystem

2.4.1 To support the ecological construction with Research and development of drugs and medical devices

The Guangdong, Hong Kong and Macao Sub-Center of Center for Drug Evaluation (CDE) is expected to be landed in Guangdong to speed up the review and approval of medicine and medical devices and to stimulate the development of medicine and medical devices in the GBA.

- a) To seize the historical opportunity of state support and technological change, jointly building an innovative ecology

Local enterprises can actively cooperate with the landing of the sub-center, and jointly establish an ecological environment to support the research and development of new medicines. Important measures include:

To strengthen the construction of supporting infrastructure, including Biotechnology Development Center, Drug Safety Evaluation and Research Center, etc. It is necessary to enhance the degree of emphasis local biomedical companies have towards the quality inspection, optimize the technological quality detection capability of biological pharmaceutical products in the GBA and accelerate the service efficiency of quality detection of regional biomedical products.

Enterprises in the GBA can also actively participate in the policy shaping of biotechnology standards through the sub-center. With the rapid development of new therapies, the current technical standards usually lag behind the relevant technology. The landing of the sub-center will facilitate the communication between the industry and the regulators. If the industry can seize such historical opportunities, actively share the latest technology trends with regulators and discuss the potential technical standards, it will greatly promote the development of industry standardization.

- b) To make full use of the advantages of regulatory advancement and to facilitate the R&D of new medicines and devices in Hong Kong and Macao

In addition, the forward process of review and approval of pharmaceuticals and medical devices which facilitate the biopharmaceutical products from Hong Kong and Macao can directly realize the clinical trials and apply for indications in the GBA, which is more convenient than the former paths, promoting the integration of regulatory and review of biopharmaceuticals in Guangdong, Hong Kong and Macao. In the future, the GBA can consider taking advantages of the local regulatory convenience, highlighting the ability of Hong Kong and Macao to link up at home and abroad to attract potential enterprises and promote the overall development of the GBA. In addition, the GBA can make the most of the touch point role of the Hong Kong Science and Technology Park and expand the radiation scope of biomedical start-ups in it in order to fully release the scientific research capacity of Hong Kong and to further promote the transformation from R&D to the market.

2.4.2 To strengthen the government's role in guiding the industry fund

Government of the GBA has invested a large amount of funds, cooperating with investment institutions and industrial funds to establish various large-scale specialized government guidance funds, which have supported the establishment and development of a large number of small and medium-sized companies by leveraging larger social capital.

In the operation of fund guiding, industrial resources are still of great significance. In particular, the judgment of industry experts for professional technology can greatly reduce the risk of project

investment, realizing the rational use of resources to meet the real needs.

The guiding funds can introduce industry experts into the project decision-making process, like through investment committee, to analyze and judge the technical aspects of the project, and give reference to help investors make better decisions. The risk of investment can be shared by involving the strategic investment from industrial fund. Moreover, the merger and acquisition operated by the industrial fund at the right can provide exit opportunities for government guiding fund in the project, optimizing the operation efficiency.

2.4.3. To strengthen specialization in operating industrial parks and attracting investments

With the rapid development of science and technology, the speed of commercialization of cutting-edge technology is also improved. High-end technology poses a great challenge to managers. Hence, the establishment of a sound evaluation mechanism, the strengthening of expert resources in daily operation, the accurate arrangement of matching experts will enable the management personnel, and further improve the operational efficiency of the innovation carrier.

- a) To improve the professional mechanism of investment attraction and project evaluation

Compared with other parks, the GBA still prefers large-scale and well-known enterprises in policy while pays less attention to the specific subdivision demand in the industrial chain. When seeking enterprises, the park should pay special attention to the enterprises that are technologically advanced in some subdivision fields, which also have large demands in the industrial chain in both upstream and downstream, but are small in size and not quite prestigious. To realize this, the park needs to establish a more perfect and reasonable audit mechanism during enterprise seeking. For example, industrial experts should be included during the enterprise selection as they can provide suggestions in technology evaluation, development prospect and the matching degree between the park and the potential enterprise. It will be a more sufficient way to select enterprises than only to select enterprises only based on the size, scale and reputation.

In addition, with the continuous progress of innovation ecology in the GBA, more start-up companies will be attracted or incubated. The increase of projects will bring great challenge to the operation and management of the government and the park. The traditional decision-making process of project-by-project review will reduce the management quality due to the heavy workload on the operators. Therefore, improving the evaluation mechanism of the project and introducing more professional evaluation standards and methods will help to improve the operational efficiency of the park and boost the prosperity and development of innovation ecology.

b) To strengthen the specialized operation mode of the park

At present, the operation of the park is usually led by the government, which plays an indispensable role in the initial phase of establishment and construction of the park. However, with the park's operational mode gradually becoming mature, the degree of specialization of the project will increase. At this time, docking more experts from universities, research institutes, industries and even investment institutions can provide more cutting-edge and professional opinions for the operation of the park, strengthen the transformation of projects, and provide more abundant resources. In the process of development, the park can also gradually strengthen the functions of professional committees, assume more responsibility with regard to daily management and decision-making, share the operational pressure and risk of the park, and improve the degree of specialization of the park operation. Taking Guangdong Province as an example, Guangdong Medical Products Administration and Guangzhou Development District signed a cooperation framework agreement in August 2020 to jointly build a technical support platform for legal inspection and institutional testing in order to carry out cooperation in talent cultivation and so on.

c) To make full use of the innovation resources of MNCs

With the development of China's R&D capability and the increasing value of Chinese market in the world, more and more MNCs no longer regard China just as the sales market and begin to exploit China's R&D potential. Meanwhile, in the transfer process of this R&D link, China can make full use of the innovation resources of MNCs, such as global expert resources, international vision and advanced technology, etc., so as to rapidly improve its own

capability. This transfer process is reflected in many aspects. For example, China's position in the R&D innovation strategy of MNCs has been significantly improved, and many transnational enterprises have set up innovation parks in China, such as AstraZeneca's I-campus and Merck China Innovation Hub, etc. At the same time, MNCs also began to set up R&D centers or support innovative enterprises in local areas because of their productions that become gradually more in line with Chinese demand. In addition, MNCs also link up with local technological innovation resources to magnify their own energy effects with the help of the latter, thus influence more local innovative enterprises.

An exemplary case is "Kechuang No. 1" of the Shanghai Free Trade Zone is a successful case¹. The project mainly provides two types of services for offshore innovation and entrepreneurship. The first is registration within the zone and overseas operation, mainly to assist domestic innovation and entrepreneurial talents and enterprises to carry out innovation and entrepreneurship by using offshore policy, innovation and entrepreneurship resources. Such services include assisting domestic innovation and entrepreneurial enterprises and talents, making use of tariff-free international R&D equipment and consumables in the bonded area, and leveraging offshore account (capital) and other resources to carry out innovation and entrepreneurship more efficiently and at a lower cost. The second is overseas registration and operation in the zone, which mainly helps innovative enterprises and talents registered overseas stay in bonded.

¹ Jianxun C. New Thinking in the Construction of the Global Science and Technology Center. Shanghai Jiao Tong university press, 2018

Conclusion

The Guangdong-Hong Kong-Macao Greater Bay Area is one of the regions with the strongest economic vitality and the highest degree of openness in China. It is also an important window to connect Chinese enterprises to the world, and a fertile ground for the growth of innovative and entrepreneurial enterprises. With the initial geographical superiority and the accumulated advantages such as scientific research achievements and industry construction, the Greater Bay Area has been equipped with unique advantages in land, labor, capital, technology and data. Various industries in the Greater Bay Area enjoyed a rapid growth and occupy favorable ecological positions in the international community.

Meanwhile, the overall industrial development of The Greater Bay Area has gradually climbed to a higher position from the lower end in the value chain, raising the demand for industrial upgrading and the establishment of innovation ecosystem.

Through the analysis of the dominant industries and existing resource endowments of the Greater Bay Area, combined with the best practices in and out of China, this paper puts forward several suggestions for the construction of the innovation ecosystem in the Greater Bay Area, including building an open public service platform, optimizing the commercial application of scientific research achievements, accelerating the integration of the Guangdong-Hong Kong-Macao Greater Bay Area, and contribute to the reform and opening of China, in the hope to restore a true Greater Bay Area and bring more inspirations to the public.

The Guangdong-Hong Kong-Macao Greater Bay Area is a rising star in China's development path of innovation and entrepreneurship and will become one of the world's foremost economic regions.

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