

The Evolution, Current Status, and Research on Issues of Smart City Construction in Macau

Xiaonan Li¹, Zhixing Yin^{2,*}

¹School of Economics and Finance, Hainan University of Science and Technology, Haikou 571126, China

²Institute for Research on Portuguese-speaking countries, City University of Macau, Macau 999078, China

*Corresponding Author

Abstract

Since the Macau Special Administrative Region government proposed the construction of a smart city in the first five-year plan in 2015, the smart city construction in Macau has gone through three stages: initiation, construction, and improvement, and has achieved certain results in four areas: government, transportation, tourism, and healthcare. However, due to the limited local market in Macau, a lack of technical talent and investment from technology companies, and insufficient government promotion, the construction of Macau's smart city still lags behind that of developed cities in China's mainland.

Keywords

Macau; Five-Year Plan; Smart City.

1. Overview of Smart Cities

1.1. The Proposal and Development of the Smart City Concept

The proposal of the smart city concept is predicated on two fundamental conditions: first, the transformation of production technology from digitalization to networking and intelligence as the main trend driving social development; and second, the gradual ineffectiveness of traditional urban governance models due to a series of social, economic, and environmental problems brought about by the accelerated development of urbanization.

In December 2008, against the backdrop of the global financial crisis, IBM proposed the concept of "Smarter Planet" from the perspective of using information technology to promote social progress, with smart cities being the specific regional implementation of this concept. Inspired by the "Smarter Planet" concept, China introduced the "Perception China" concept in 2009, which called for strengthening the application of information and intelligent technologies in urban management to enhance the comprehensive management level of cities and to build smart cities in China.

In the early stages of the smart city concept, academia's definition of smart cities was largely technology-oriented, believing that smart cities are governments fully utilizing information technology to intelligently perceive, analyze, and respond to administrative management activities, that is, smart cities are a combination of the Internet of Things (IoT) and the Internet. As research on the concept deepened, academia's definition of smart cities shifted from focusing solely on information technology and other hardware facilities to also paying attention to the important role of information technology in enhancing social inclusiveness and citizens' happiness, believing that smart cities should not only have technological attributes but also humanistic attributes.

1.2. Characteristics and Evaluation System of Smart Cities

Compared with traditional cities, smart cities encompass a three-dimensional urban concept that includes digital cities, ecological cities, humanistic cities, and innovative cities. They represent the high integration of information construction, humanistic construction, and ecological construction. Based on the contemplation of the essence of smart cities and the analysis and sorting of literature, the general characteristics of smart cities are reflected in: (1) long-term strategic thinking and medium-to-short-term development planning at the government level; (2) suitable investment, innovation, and development environment at the organizational level; (3) good social security in terms of education, employment, and healthcare at the individual level; (4) a beautiful and livable natural environment and green ecological concepts at the environmental level.

According to the general characteristics of smart cities, their evaluation system can be roughly summarized as follows (Table 1):

Table 1. Smart City Evaluation System

Primary Indicators	Secondary Indicators
Smart Government	Online Services, Data Disclosure, Public Management Coverage Rate, Citizen Participation Rate
Smart Economy	Number of Startups, International Connections, Traffic Efficiency, Share of Emerging Economy in GDP
Smart Citizens	Proportion of Population with Higher Education, Proportion of Emerging Professions in Total Labor Force, Mobile Payment Penetration Rate
Smart Living	Basic Education Coverage Rate, Medical Insurance Coverage Rate, Cultural Industry's Share in GDP, Public Security
Smart Environment	Green Buildings and Green Homes Penetration Rate, Energy Consumption Monitoring, Air Quality, Waste Management and Recycling

2. Macau's Smart City Top-Level Planning and Project Deployment

2.1. Macau's Smart City Top-Level Planning

In 2015, the Macau Special Administrative Region Government proposed in its "2016 Fiscal Year Policy Address" that the government would initiate "research on the development plan for the era of big data in Macau, to align with the development direction of smart cities." Subsequently, the Macau Science and Technology Development Fund conducted a series of social surveys on the preliminary work of Macau's smart city development and selected and funded four research teams the following year to study two related topics: "Feasibility Study on Smart Mobility Development in Macau" and "Research on the Development Direction and Strategy of Macau's Smart City."

In 2016, the Macau Special Administrative Region Government released the draft text of the first five-year plan, "Macau Special Administrative Region Development Five-Year Plan (2016-2020)," which more clearly listed "building a smart city" as one of the eight major development strategies and deployments of Macau's first five-year plan. The plan, based on Macau's actual development status and in conjunction with the implementation of the national "13th Five-Year Plan" big data strategy, divided the construction of Macau's smart city into four major directions: smart tourism, smart transportation, smart government, and smart healthcare.

In 2018, the Macau Special Administrative Region Government integrated the research results of "Feasibility Study on Smart Mobility Development in Macau" and "Research on the Development Direction and Strategy of Macau's Smart City" into the "Macau Smart City Development Strategy and Key Area Construction" consultation document. The content

includes the goals of the special administrative region's smart city construction, development strategies, key areas and action plans, evaluation systems, and pilot projects that can be implemented in the short term. These contents were summarized through public consultation, ultimately compiling 155 typical opinions from all sectors, becoming an important reference for Macau's later smart city construction.

In 2019, the introduction of the "Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area" by the State Council transformed the construction of Macau's smart city from a single regional development into a part of the overall development within the Greater Bay Area. To further promote scientific research collaboration between Macau and the Greater Bay Area and integrate into the national innovation system, the Macau Special Administrative Region Government further established the "Science, Technology Innovation, and Smart City Working Group" under the "Guangdong-Hong Kong-Macao Greater Bay Area Construction Committee." This move aims to demonstrate the Macau Special Administrative Region Government's determination to cooperate with cities in the Greater Bay Area in the field of smart city construction, and to jointly build a smart city cluster in the Greater Bay Area.

2.2. Project Deployment of Macau's Smart City

2.2.1. Initial Stage (2015-2017)

In the "2016 Fiscal Year Policy Address" released by the Macau Special Administrative Region Government in 2015, the construction of a smart city was proposed for the first time, and support was given to introduce enterprises from mainland coastal provinces to cooperate in the fields of urban infrastructure, energy conservation and environmental protection, and smart transportation.

In 2017, to coordinate and advance the internal smart city construction work of the government, as well as the work of all sectors in academic research, industrial development, and social promotion, the Macau Special Administrative Region Government established the "Smart City Development Task Force" under the World Tourism and Leisure Center Committee and the "Smart City Task Committee" under the Science and Technology Committee. In the same year, the Macau Special Administrative Region Government also signed a "Strategic Cooperation Framework Agreement on Building Smart Cities" with Alibaba Group. This agreement applied Alibaba Group's cloud computing and artificial intelligence technologies to various fields in the Macau Special Administrative Region, including traffic management, tourism services, healthcare, urban integrated management, and talent training. It established an artificial intelligence core system for Macau's urban governance and laid the foundation for the Macau Special Administrative Region Government to build a dedicated cloud computing center and apply big data technology projects.

2.2.2. Construction Phase (2018-2020)

From 2018 to 2020, the Macau Special Administrative Region Government, guided by the "Macau Special Administrative Region Development Five-Year Plan (2016-2020)" and the annual "Policy Addresses," carried out a series of digital and intelligent construction and upgrading measures in the fields of government governance, education and training, infrastructure, and social security.

In terms of government governance, the Macau Special Administrative Region Government successively drafted and submitted to the Legislative Assembly for deliberation and passage of laws and regulations such as the "Cybersecurity Law," "Tax Incentives for Scientific Research and Innovation," "Telecommunications Network and Service Convergence System," and "Youth Entrepreneurship Assistance Plan," providing legal guarantees for the stable advancement of smart city construction. At the same time, the Macau Special Administrative Region Government actively played its guiding role in the socio-economic development, not only

strongly supporting local characteristic old shops to increase their visibility and build brands, but also actively guiding small and medium-sized enterprises to improve technical equipment, train technical personnel, and increase cooperation with mainland e-commerce enterprises to explore emerging mainland and Portuguese-speaking country e-commerce markets.

In the field of education and training, the Macau Special Administrative Region Government focused on the role of local public universities in technical talent training, government management personnel training, and cross-regional industry-university-research cooperation. The Macau Special Administrative Region Government not only successively cooperated with the University of Macau, Macao Polytechnic Institute, and Macao Institute for Tourism Studies to offer short-term series training courses for middle and senior civil servants, providing theoretical training in smart cities, big data governance, and e-government, but also, after the introduction of the "Guangdong-Hong Kong-Macao Greater Bay Area Development Plan Outline," further practiced cross-regional cooperation with the mainland. While increasing funding for national key laboratories and young scientific researchers, postdoctoral scholars, and interacting frequently with universities, research institutions, and technology enterprises in Guangzhou, Shenzhen, and Zhuhai, Macau enhanced its talent, technology, and industrial accumulation for smart city construction.

In terms of infrastructure and social security, the Macau Special Administrative Region Government, following the principle of "people-oriented, scientific planning," actively introduced advanced technical equipment and promoted the construction of the government's exclusive cloud computing center. In the field of e-government, by building a cloud computing center and integrating government data, online service platforms such as the Government Comprehensive Service Building information website, mobile version of service appointment and ticketing, "Municipal Facilities EasyGo," e-procurement platform, and new medical APPs were developed. A large number of one-stop self-service machines were also purchased and installed offline, further facilitating the handling of affairs for Macau citizens, optimizing the efficiency of social security, and enhancing the transparency of government public administrative services. In the field of mobile payment, by launching the first mobile payment APP - MPay (Macao Wallet), and gradually promoting the popularization of mainland mobile payment software such as Alipay and WeChat Pay in the Macau consumer market, not only was the payment convenience of Macau citizens improved, but also the tourism experience of mainland visitors to Macau was enhanced.

2.2.3. 5G Technology Application and Perfection Phase (From 2021 to Present)

Thanks to the Macau Special Administrative Region Government's early cooperation with Huawei in building urban basic network infrastructure and conducting 5G technology tests, Macau achieved over 90% indoor and outdoor 5G network signal coverage at the beginning of 2021. This has enabled the Macau Special Administrative Region Government to quickly leverage the "ultra-high speed, low latency" characteristics of this technology and rapidly apply it to research and teaching, municipal management, tourism interaction, and other fields, promoting the development of Macau's smart city.

In terms of research and teaching, 5G technology has significantly improved the efficiency of online teaching. During the COVID-19 pandemic, the number of online learners surged, and Macau society's demand for high-efficiency network transmission grew sharply. Relying on the support of 5G technology, online teaching in Macau's primary and secondary schools and universities has been carried out orderly. To meet the needs of the Macau Special Administrative Region Government for smart campus teaching development, Macau Telecom and the Macau University of Science and Technology cooperated to jointly create Macau's first 5G high-security "Smart Campus Private Network" - 5G Campus on the Go, allowing university teachers and students to enjoy unlimited 5G campus networks and campus applications from

any corner of Macau, establishing a secure and mobile research and learning network environment for teachers and students.

In terms of municipal management, 5G technology has greatly improved Macau's traffic dispatch efficiency. Its low latency characteristic enables the system to analyze data in real-time and adjust traffic lights flexibly according to road conditions, prioritizing the diversion of congested lanes, thereby effectively alleviating traffic congestion caused by "small land with many cars" in Macau and the "parking difficulty" caused by network delays of a few networked "ground-sensing devices." Currently, the Internet of Things system based on 5G technology is gradually being promoted in Macau's waste disposal stations. This system can monitor the weight, height, and real-time monitoring of garbage through multiple parameters, assisting municipal management personnel in allocating resources in a timely manner to clear garbage and prevent environmental and health problems caused by overloading of waste stations. In addition, through 5G technology for monitoring and data collection, the usage frequency of different locations can be grasped, and facility damage can be checked, thereby achieving more effective resource allocation and improving the efficiency of municipal management.

In terms of tourism interaction, the application of 5G technology allows visitors not only to appreciate the modern prosperity of Macau but also to experience the historical charm of ancient Macau through "time and space travel." With the support of 5G-enabled efficient VR or AR interactive experiences, visitors can clearly see the past life and historical marks of Macau, coupled with detailed explanations from tour guides, making the entire tourism experience more vivid and rich.

In terms of city promotion, the high-speed network of 5G enables Macau's World Heritage sites and related facilities to be displayed online in the form of AR and VR, allowing visitors to feel the charm of Macau before departure, as if they were on the spot. The panoramic image display method has successfully attracted global tourists to travel and leisure in Macau. Faced with a large number of tourists during the peak tourism season, Macau's various entry and exit ports actively adopt 5G technology, using biometric means such as facial and fingerprint recognition to verify the identity of travelers, providing more efficient customs services. In addition, the Macau International Airport has also introduced a luggage tracking system and boarding notification service. The application of these innovative technologies has significantly improved the travel experience of passengers, making the journey more relaxed and convenient.

3. Issues in the Construction of Macau's Smart City

3.1. Incomplete Development of Construction Projects

The "Macau Special Administrative Region Development Five-Year Plan (2016-2020)" released by the Macau Special Administrative Region Government focuses mainly on four major areas for smart city construction projects: tourism, transportation, government, and healthcare. In terms of the current development status of these fields, there is room for improvement in both the breadth and depth of smart projects.

In terms of breadth, some areas, such as smart campus projects, have not been fully developed, lacking online interactive teaching models and electronic teaching standards. In terms of depth, taking smart government projects as an example, although various departments have launched numerous online services, these services are mostly limited to basic functions such as appointment, inquiry, and document application, lacking continuous procedural operations. Due to the cross-departmental platform collaboration process still being established, Macau's smart government projects have not yet integrated electronic wallet features, and citizens still need to carry multiple identity documents, which still need to be improved compared to mainland cities.

3.2. Imperfect Mechanism for Data Collection, Opening, and Utilization

The Macau Special Administrative Region Government launched the "Data Open Platform" in 2019, aiming to make it easier for the public to access government data, promote the secondary development and application of data, and facilitate the construction of smart cities. However, the platform is still in the development stage and has some areas that need improvement. First, only 36 datasets are provided on the platform through API or link formats, while the other 260 datasets are published in file format. These files usually contain statistical data and lists, which are not frequently updated, thus their development potential and practical value are relatively low. Second, some departments may lack effective data collection systems. In the long run, this situation may hinder the development of smart cities.

3.3. Insufficient Participation of Cutting-Edge Technology Enterprises and Citizens

The construction of a smart city is a process involving multiple stakeholders, including government, enterprises, and citizens. However, the participation of cutting-edge enterprises and citizens in the construction of smart cities is still insufficient. Macau is a micro-market with a population of only 600,000, and the gambling industry and related tourism extension industries have long occupied more than 60% of the local market share. Therefore, it not only lacks local cutting-edge technology enterprises but also struggles to attract mainland and overseas cutting-edge technology enterprises to participate in the construction of Macau's smart city. Additionally, according to the survey report "Macau Youth's Views on the Development of Smart Cities" published by the Macau Youth Federation in October 2019, in the four core areas of smart city construction—transportation, healthcare, tourism, and government services—over 10% of the surveyed youths indicated that they were not aware of the relevant projects, and 28% of respondents could not recall any specific achievements. This reflects the Macau Special Administrative Region Government's insufficient promotion of smart city projects.

4. Conclusion

4.1. Enhancing Technological Innovation and Application Integration Capability

The main reason for the shortcomings in Macau's smart city project construction compared to mainland cities is the lack of technological innovation and application capabilities in related industries, as well as a shortage of relevant talent. On one hand, the Macau SAR government needs to increase investment in the research and development of technologies related to smart cities and to attract and cultivate high-end talent, providing necessary funding and talent support for smart city construction. On the other hand, it is essential to strengthen cooperation among the Macau SAR government, enterprises, universities, and research institutions to establish a collaborative mechanism for industry-university-research integration. Through such cooperation, research achievements can be transformed into practical applications, promoting the rapid development of Macau's smart city.

4.2. Improving Data Collection and Open Mechanisms

It is crucial to establish unified standards and norms for data collection, storage, sharing, and openness to ensure interoperability of data across different departments and fields. Various departments of the Macau SAR government should enhance data collection and management, establishing a sound data collection mechanism to ensure timely updates and accuracy of data. At the same time, while ensuring data security and privacy protection, the scope and depth of data openness should be gradually expanded.

4.3. Increasing Participation of Enterprises and Citizens in Construction

The Macau SAR government can attract research institutions and technology enterprises to settle in Macau by providing tax reductions and other preferential policies, facilitating local enterprises in introducing smart projects. Additionally, local enterprises should actively explore how to enhance their competitiveness through smart projects. Moreover, enterprises can utilize big data and precision marketing methods to tailor and promote suitable products for customers, providing higher quality services to Macau's clientele.

In addition to strengthening the promotion of existing smart projects, the SAR government can establish channels to collect citizens' opinions in various smart applications to continuously improve the projects. Furthermore, by organizing forums and setting up competitions, citizens can be encouraged to brainstorm and contribute suggestions for the construction and development of the smart city. In terms of social science popularization and campus education, efforts can be intensified to promote information technology, communications, and big data fields, enhancing the scientific literacy of youth and citizens, enabling them to participate more effectively in the construction of Macau's smart city.

References

- [1] Luo Xiaoping: "The Connotation of 'Smart City' - An Analysis." City Management and Technology, vol. 12 (2010) NO. 6, pp. 34-37.
- [2] Qin Honghua, Li Hanqing, Zhao Xia: "The Current Status of Domestic and International Development of 'Smart City'." Informationization Construction, vol. 9 (2010) NO. 9, pp. 50-52.
- [3] Chen Liuqin: "Smart City: A New Hotspot in Global Urban Development." Journal of Qingdao University of Science and Technology (Social Science Edition), vol. 27 (2011) NO. 1, pp. 8-16.
- [4] Lu Xiaomin, Chen Jie, Yuan Wei: "Reflections on the Top-Level Design of Smart Cities." E-Government, vol. 1 (2014) NO. 1, pp. 15-22.
- [5] Wu Yongchao: "Can Smart City Construction Enhance Urban Resilience? - A Quasi-Natural Experiment." Public Administration Review, vol. 14 (2021) NO. 4, pp. 25-44+196.