

Research on Collaborative Innovation Path of Data Resources for Sustainable Development of Smart City

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ABSTRACT

Under the background of the development of big data, a systematic research of data as resources, assets and capital, its multiple value and role in the sustainable development of smart cities becomes urgent. This study adopts the method of literature research and practical investigation and summarizes the five-dimensional PESTD (Politics, Economy, Society, Technology, Data) realization path of sustainable development of smart city, namely: policy-governance-innovation, economical-environmental-integration, societal-cultural-inclusive, technology-human-interactions, data-continuity-interconnectivity. It is pointed out that data, as the center of the five-dimensional construction of smart city, is a collaborative innovation and develops with other dimensions. Finally, based on the successful experience of smart city development abroad, this study puts forward the strategy and method of data resource collaborative innovation path for promoting the sustainable development of smart cities in China.

Keywords: Smart city, data assets, urban governance, collaborative innovation, sustainable development.

Mathematics Subject Classification : 62P25, 91D10

Journal of Economic Literature (JEL) Classification : O31, O14

1. INTRODUCTION

Smart city construction is based on a generation of information technology, through the dynamic monitoring, analysis, integration and utilization of various parts of the data, to achieve the perception of the urban environment, resource regulation, urban governance, coordinated development, harmony and win-win and other aspects of smart management (Xu and others, 2020). Since the concept of smart city was put forward in 2008, it has attracted wide attention in the world, and has continuously triggered

the development boom of smart city in the world. Smart city has become a strategic choice to promote global urbanization, improve the level of urban governance, crack the disease of big cities, improve the quality of public services, and develop the digital economy (Li, 2018). According to statistics, by the beginning of 2020, more than 500 cities, including all cities above the deputy provincial level and most prefecture-level cities, are building smart cities (Shen and others, 2018). With the gradual construction and application of smart cities, human beings will produce more and more data with various sensors. The quantity of data resources and the quality of data resources utilization have become an important means to construct urban digital ecological system and improve the ability of sustainable development of cities (Dameri and others, 2019). However, due to the insufficient attention paid to the sustainable management and utilization of data resources in the construction of smart cities in China, as well as the many problems of data segmentation and information isolation, the construction of smart cities has not achieved the due results, and the synergistic and emergent effects are not obvious. Therefore, this research aims to study the innovative strategy path of how data resources can effectively improve the sustainable development ability of smart cities.

In order to explore the effective path of sustainable development of smart cities in China, this study is based on the PEST (Politics, Economy, Society, Technology) environmental analysis model, aiming at the current problems faced by the sustainable development of smart cities in China, and further expands the environmental analysis model. This study summarizes the five development trends of smart city sustainable development PESTD (Politics, Economy, Society, Technology, Data) centered on data collaborative development. According to the policy and field research, this study analyzes the current situation and problems of smart city construction in China from the perspective of five dimensions of PESTD, comprehensively learns from the successful experience of foreign smart city construction and puts forward the strategic path of data resources collaborative innovation to realize the sustainable development of smart city in China.

2. LITERATURE REVIEW

The research on smart city construction in China and abroad has the characteristics of multi-disciplinary perspective, and comprehensively analyzes the five development trends of the sustainable development path of smart city: policy-governance-innovation, economical-environmental-integration, societal-cultural-inclusive, technology-human-interactions, data-continuity-interconnectivity, that is, the five-dimensional realization path of PESTD. With data as the core, it has the "5I" characteristics of Innovation, Integration, Inclusive, Interaction and Interconnectivity.

From the trend of policy-governance-innovation, Song and others (2014) mainly study the cooperation and co-governance among enterprises, governments and citizens, and realize intelligent integration and anytime and anywhere urban management based on the open space of metropolitan areas, so as to improve the performance and quality of urban management and build a fair, just, open and co-governance society (Song and others, 2014). Abella-Garcia and others (2015) and Wang and others (2014) took economy-environmental integration as the starting point and studied the content of intensive

development, resource integration, energy conservation (Abella-Garcia and others, 2015) and emission reduction, green ecology, urban self-organization mechanism, economic and efficient, and sustainable development (Wang and others, 2014). Hollands (2015) and Lara and others (2016) take the societal-cultural-inclusive as the direction, focusing on public services for the convenience (Hollands, 2015), benefit of the people, convenient life of citizens and cultural tolerance (Lara and others, 2016). Yin and others (2019) pay attention to urban comprehensive perception, human-computer interaction, precise learning, appropriate response and in-depth learning from the aspect of technology-human-interactions (Yin and others, 2019). Ianuale and others (2015) studied from the data-continuous-connectivity aspect (Ianuale and others, 2015), focusing on the sharing and opening of data resources across departments (Hashem and others, 2016), industries and fields (Ma and others, 2019), the innovative development and application of big data (Rathore and others, 2016), personal information security protection (Lavalley and others, 2020), interconnection and mutual trust (Taylor, 2020). Through literature research, it is found that there are few studies on the sustainable development path of smart city from a multidisciplinary perspective in the current literature, and few studies on the realization path of digital continuity of smart city with data speaking, data decision-making, data management and data innovation from the background of big data development and application.

Therefore, this research aims to systematically analyze the current situation and existing problems of China's smart city construction from a multidisciplinary perspective, comprehensively learn from the practical experience of foreign smart city construction, and then put forward the innovative path strategy and method to achieve the sustainable development of China's smart city.

3. GENERATION OF THE DATA

This research mainly uses the literature method and the investigation method. Through the review of the previous research literature on the sustainable development of smart cities, the object, content and purpose of the research are clarified. To ensure the comprehensiveness of the review, we selected the Chinese and the English articles published in core and peer-reviewed journals over the past ten years. The literature sources were foreign language literature in the Science Citation Index Expanded (SCI-Expanded) and Social Sciences Citation Index (SSCI) from the Web of Science TM core collection, as well as Chinese database of Chinese Social Sciences Citation Index (CSSCI) journal sources. With the title "Smart City + Data" as the retrieval condition, the time span is from 2011 to 2021, and the retrieval time is February 6, 2021, a total of 246 literatures were obtained. This study selected the above-mentioned literatures one by one, and eliminated the literatures with inconsistent research themes, no keywords and no authors, and finally obtained 45 valid literature sources. In addition, a number of other papers and monographs were found in the references of selected articles based on the topic relevance criterion and the popularity in terms of citations. Besides, this study analyzes and investigates the policy documents of smart city construction of representative smart cities in China, such as Shanghai, Beijing and Shenzhen, finds out the problems and shortcomings of sustainable development of smart city construction in China, and puts forward the corresponding path suggestions to realize the sustainable

development of smart city in China. The case selection considers the positive correlation between the development of smart cities and the economic level. According to the ranking of China's urban Gross Domestic Product (GDP) in 2020, Shanghai (3870.058-billion-yuan Renminbi), Beijing (3610.026-billion-yuan Renminbi) and Shenzhen (2767.024-billion-yuan Renminbi) rank among the top three cities in China, which are the three most advanced cities in China and the benchmark and model of China's smart city construction (Liu, 2021). The exploration of the sustainable development capacity path of smart cities in Shanghai, Beijing and Shenzhen is of best practice demonstration and applicability and can be used for reference by other cities

4. RESULTS

4.1. Analysis and discussion of the current situation and problems of the development of smart cities in china

According to the research idea of five-dimensional collaborative innovation, referring to the current situation of smart city construction in China, this study discusses the current situation and problems of smart city construction in China by investigating the construction practice of smart cities in Shanghai, Beijing and Shenzhen, and combining with the participation in smart city forums and conferences at home and abroad.

4.1.1. Policy-governance-innovation

The construction and development of smart cities cannot be separated from policy support and smart urban governance. China's smart city governance needs to be government-oriented, from the legal system, co-governance, information technology three aspects (Ali Haidery and others, 2020) to build an innovative 2.0 government, to achieve urban smart governance (Yu & Zhang, 2019). The construction of smart city management mainly focuses on the transportation system, social management, environmental protection, water management, food safety, urban safety, urban planning and public utilities management related to urban operation and management. Smart city management is an important part of smart city, so it can be studied as a typical case of urban governance.

The construction of smart city management in China mainly focuses on the following aspects: improving the intelligent level of urban facilities through emerging information technology, strengthening the collection of information with intelligent equipment as the carrier, and strengthening the comprehensive application of information technology; establishment and improvement of the professional databases, application systems and monitoring networks of urban management, and building of data centers to lay the foundation for urban management, government decision-making and service provision; building of a comprehensive urban management information platform, gradually realizing the interconnection and interoperability with relevant industry systems. In the process of smart urban management construction, various regions have explored their own management experience and excellent practices in combination with the specific problems of urban management (Ruhlandt, 2018). On the basis of comprehensive and unified construction data, systems and platforms, we should give full play to the advantages of integration and carry out comprehensive urban governance.

Strengthening the coordination among various departments is the development trend of smart city management. Because urban operation and management is a comprehensive problem, the division of departments and systems increases the difficulty of coordination (Koblianska & Kalachevska, 2019). To integrate data resources according to the management objects and management objectives and realize cross-industry and cross-department collaboration is the key for improving urban management effect and efficiency. Establish business coordination mechanism, integrate workflow, implement high-level command, and realize coordinated operation of all departments through unified coordination of competent departments and smart city operation command center. Coordination is the development trend of smart urban management in practical work and policy making, but the specific workflow, cooperation mechanism and coordination mechanism still need to be clarified and innovated (Riva Sanseverino and others, 2018).

In addition, urban management is a complex system involving government, enterprises, citizens and other subjects, including urban construction, urban society, urban economy and other aspects (Jiang, 2020). At present, in the construction of smart cities in China, the government is still the main body of construction, and the participation of non-governmental organizations and citizens is limited. However, the trend of coordination, co-governance and innovation in the construction of smart cities is obvious, attracting multi-subjects to participate in urban governance, and guiding non-governmental organizations and citizens to participate in it is the future direction of urban governance.

4.1.2. Economical-environment integration

At present, a number of policies issued by the state have made it clear that the development of urban economy in China should aim at the construction of urban ecological environment and urban sustainability, and encourage full use of data resources and information technology to solve the problems of sustainable development and imbalance of population, environment and resources, including more compact, rational and efficient urban planning, more rational population distribution, more resource-saving and more environment-friendly, that is, the construction of resource-saving and environment-friendly green, ecological, sponge cities and landscape cities. It includes the construction of urban and rural ecological space, the comprehensive utilization of underground space, the utilization of renewable energy, the joint commissioning and control of urban lifeline heat and electricity, energy-saving and environment-friendly housing, people-oriented public transport, job-housing balance and so on.

To create a smart living environment and eco-friendly living environment is the goal and characteristics of smart city construction (Chauhan and others, 2020), coupled with the current deteriorating environmental problems in China, ecological environment construction has become an important part of smart city construction. The construction of smart city ecological environment aims at achieving sustainable development, which mainly consists of smart environment carried out by public institutions, smart energy construction and green manufacturing of private institutions (Shkarupa and others, 2016; 2017).

Economy-environment-intensive development is reflected in the following aspects: improving the intelligent level of equipment, strengthening the collection of environmental information, improving the

environmental perception system; within the ecological environment construction system, strengthen the data collection, transmission, monitoring, monitoring and supervision of the environment, and promote the informatization of the whole process of ecological environmental protection; strengthen the integration of ecological and environmental information with information in other fields, promote information sharing among departments, build an information sharing platform, and promote the development of sharing standards and mechanisms. Intelligent energy construction mainly includes the installation of intelligent meters, the use of new energy vehicles, and the construction of intelligent buildings. The ecological environment protection of enterprises is mainly to promote low-carbon manufacturing, and to carry out information system construction around the life cycle management of products (Koblianska and others, 2020; Rubi and others, 2021).

4.1.3. Societal-cultural-inclusiveness

Societal-cultural-inclusiveness is mainly reflected in the supply of public services for people's livelihood in the construction of smart cities in China, which is the main feature of smart society, focusing on medical care, employment, consumption, social security, education, tourism and community services, people-oriented, comprehensive consideration of user needs and satisfaction, is an important indicator to measure the success of smart city construction (Han and others, 2021).

Public service construction mainly includes: building industry cloud platform, integrating information resources, building data centers, establishing centralized, unified and standardized information systems, realizing the interconnection and interoperability among systems and platforms, and promoting the coordination and unified management among departments; expanding the application scope of citizen cards, promoting the interconnection of bank cards, multi-card integration and "one certificate for all" have become the future development trend; based on the unified system or platform to carry out services, gradually develop to a unified entrance, provide citizens and enterprises with digital convenient life, carry out personalized services according to the needs, implement service integration, and establish a one-stop park public management service system. Hangzhou citizen card, Shenzhen knowledge network project and benefit people project are typical practices (Camero & Alba, 2019).

In the construction of public service in smart cities in China, the participation and interaction of service objects are insufficient. The government is the main body of public service construction, and the resources of public service are also in the hands of the government. The matching degree between the needs of the society and the services provided by the government, as well as the institutional mechanism for the participation, evaluation and feedback of citizens, enterprises and institutions are still to be explored (Voordijk & Dorrestijn, 2021). The construction of smart city should fully grasp the new network and new data environment oriented to Innovation 2.0, build the entire public life and urban governance space as an ecosystem for user innovation, open innovation, collaborative innovation and mass innovation, and strengthen the collaborative function of open mass innovation and public service participated by the government, market and society. Shared bicycle is such a typical sample of building a smart society to solve the problem of urban travel relying on the open space of urban areas. Integrating public service resources according to industry and service content, promoting data management and sharing between internal sectors of the industry, promoting data opening between government and society, strengthening cooperation between departments, providing citizens with a

unified, simple entrance and digital convenient life, building a comprehensive public management service system, and building a government 2.0 ecology of social participation in mass innovation and governance are the development direction of construction of public service.

In addition to public services, societal-cultural-inclusive in the construction of smart cities is also reflected in the protection of human ecological environment and the continuation of urban historical context. But in reality, on the one hand, the construction of smart cities everywhere follows the traditional construction ideas, coupled with the imitation between cities, forming a pattern of "one side of a thousand cities" (Riva Sanseverino and others, 2018), lacking urban characteristics; on the other hand, the construction of smart cities in some areas is also the destruction of traditional historical buildings, because the historical buildings and their carrying history and culture cannot be restored, causing the destruction of human ecological environment. Landscape city construction continues the historical context of harmony between man and nature and ecological construction and endows smart city with humanistic and ecological connotation through the construction of smart gardens (Janik and others, 2020). History cannot be remolded, and memory cannot be broken, in the smart city construction and traditional historical buildings to seek harmonious coexistence, inclusive cultural diversity, ecological co-prosperity and social diversity is an urgent problem to be solved.

4.1.4. Technology-human-interactions

Information technology mainly provides tools and technical support for the construction of smart cities in China. At present, the key technologies developed by cities embrace big data, Internet of Things, cloud computing, and artificial intelligence, software and information services, integrated circuits, e-commerce, information security, satellite navigation and so on. Strengthen the application of emerging technologies in traditional industries, promote the deep integration of informatization and industrialization, and use the Internet as a platform to carry out cross-border integration with government affairs, industry, urban development and public services. The formulation of technical standards and norms has become the key to the development of information technology in the construction of smart cities.

In terms of the main body of information technology development, the government mainly carries out the construction of information infrastructure and public service platform, and the construction of urban information infrastructure focuses on broadband, wireless, integration of three networks, functional facilities, communication and the next generation Internet, etc. Public service platform is mainly built for enterprises, communities and citizens, with the provision of integrated services as the development direction. At the enterprise level, information technology is mainly used to transform and promote network operation. The integration and overall construction of resources, systems and platforms to achieve integrated big data management and decision-making innovation has become a development trend (Paroutis and others, 2014).

In the aspect of resource integration, it mainly uses information technology to integrate resources and strengthen the sharing of data resources across regions, departments, businesses and industries; in terms of system and platform integration, application systems should be integrated according to service objects, platform integration should be strengthened, and services for management and decision-making should be mainly provided by the system and platform, gradually forming full-field, full-coverage

and whole-process services. In the system construction planning, division of departments should be gradually improved, and overall planning should be strengthened (Voordijk & Dorrestijn, 2021).

Generally speaking, China's smart city construction is technology-oriented, information technology is the center and focus of China's smart city construction, while the related infrastructure and intelligent application construction results are the most obvious and practical. However, the value and effectiveness of information technology construction lacks effective evaluation, and information technology construction is not the center of smart city construction, but an auxiliary tool for urban development. In the construction of local smart cities in China, there is a general lack of humanistic care and people-oriented concept, and a lack of citizen participation in the construction, use and experience of information infrastructure (Lu and others, 2015). "People-oriented" is the future development direction of smart city construction, a large number of technical facilities investment in smart city construction, its effect should be based on human perception as an important evaluation, at the same time, people are the main body of smart city construction, service is the purpose of smart city construction.

4.1.5. Data-continuity-interconnectivity

In the construction of smart city, data-continuity-interconnectivity refers to the sustainable management and reuse of data, is the construction of digital ecological system of urban management, public service and social governance interconnection, mutual trust and mutual recognition, is the digital capability construction of business management activities to achieve data, information, grid and intelligence. It is the construction of digital service capability of smart city using data to speak, manage, make decisions and act (Batty, 2013).

Data-continuous-interconnection is most obvious in the construction of smart government affairs. It includes the construction of public basic database, the construction and improvement of basic databases such as population, legal person, spatial geography and macro economy, and the integration of basic databases becomes the future development direction; the construction of government information resources catalogue, the promotion of government information disclosure, the gradual improvement of information disclosure system and norms, the realization of cross-sectoral and cross-sectoral information sharing, the integration of public service data, and the construction of a comprehensive service system; the construction of government websites aims at a unified electronic public service portal, and is committed to building an online service hall that integrates information disclosure, administrative examination and approval, convenient services and electronic supervision, so as to promote the process of paperless and improve the efficiency of government services.

In the future planning of China's smart government, local governments have strengthened the overall planning and top-level design, aiming at intensive construction, guiding the development of smart government with the overall construction plan of e-government, integrating government information resources with the public cloud platform of e-government, and promoting the integration and publicity of information resources through the research of information sharing and exchange mechanism.

In the process of smart city construction, the important value and role of data resources have been paid attention to, but the sustainable management and utilization of data resources and the construction of digital ecosystem centered on data resources lack enough attention, the relevant policies and systems are not yet perfect, and the corresponding resource allocation needs to be strengthened. Data is an

important asset of smart city, unified data system, unified general function platform and unified city information service network are the future direction of smart city construction, but the current data asset registration catalogue and its ownership regulations are not clear. In the process of opening up government information resources, the mechanism of data sharing and opening up and the contract norms are not perfect. The digital environment of paperless office and digital migration still needs to be constructed, and its realization needs the joint guarantee of relevant technical specifications, functional requirements, standard system, legal norms and institutional mechanisms. For example, at the technical level, standards and norms are mainly formulated around intelligent equipment and production process, data, technology and operation, especially to promote the full life cycle management of electronic documents; at the legislative level, it focuses on the legislative construction of informatization, information security, personal information protection, e-commerce, e-government, credit management, and information resource development and utilization, and formulate legal norms in technology, application and management, so as to guide, encourage and supervise the development of smart cities in China; at the level of institutional mechanism, cross-industry and cross-sectoral collaboration is the consensus of smart city construction in China at present, but the specific coordination mechanism between departments has not yet been constructed, the problems of unclear powers and responsibilities between departments, lack of authorization and system isolation still exist, and the key to the construction of institutional mechanism is to carry out government process reengineering and unify government portals.

4.2. Case discussion and experience reference of sustainable development of foreign smart cities

Foreign smart city construction regards data as resources, assets and capital, and studies the path of digital continuity of smart city with data speaking, data decision-making, data management and data innovation from the background of big data development and application, that is significant for the sustainable development of smart city in China.

4.2.1. Innovation of management mode and precision of urban governance

From the perspective of management, the working mechanism of comprehensive integrated management and collaborative innovation cooperation in the application practice of smart city big data in foreign countries is worth learning, which is mainly realized through multi-stakeholder cooperation and multi-dimensional cross-level subject cooperation (Yigitcanlar & Kamruzzaman, 2019). The realization of multi-stakeholder cooperation mainly refers to the establishment of a partnership of stakeholder leaders to encourage cooperation among universities, industry and government to jointly provide support for decision-making optimization, intellectual service, technological and industrial innovation and sustainable development of social services. Multi-dimensional cross-hierarchy cooperation mainly refers to the establishment of cross-departmental, interdisciplinary and cross-regional researchers, managers, technical personnel and users of the exchange and communication mechanism (such as meeting joint system), to improve the execution ability of cross-departmental collaborative operation and cooperation innovation service ability (Abdullo and others, 2021).

In terms of urban governance, the application of big data in foreign smart cities is application-oriented, seeking cross-border integration and collaborative innovation, and has accumulated some successful experience. For example, driven by urban problems, Brazil has achieved city-wide sharing of data, information, knowledge and decisions, and established a management model for the government's rapid emergency plan to provide optimization of urban governance. In order to respond to floods, fires and other security incidents, Brazil has established a cross-sectoral and cross-system integration platform, which combines more than 30 departments to participate in data monitoring and intelligent analysis, providing the possibility for emergency early warning and joint action of various departments to deal with disasters (Macke and others, 2018). Australia, together with ten center members and three universities, actively seeks highway solutions, through real-time traveler information integration, using simulation and visualization technology modeling experiments, to study traffic travel conditions, so as to guide government decision-making, optimize traffic network efficiency, and improve travel reliability and safety (Yigitcanlar & Kamruzzaman, 2019).

4.2.2. Sustainable development of economic development and construction of ecological system

Driven by innovative products, the Dutch government realizes data sharing among the government, enterprises, universities and citizens, and explores the future model of Internet development demonstration application ecosystem (Tan & Taeihagh, 2020). In order to solve energy and climate problems, the Dutch government has launched a real-life field future Internet experiment project based on the behavior of residents and regional users. Through the Open Connection project, residents are encouraged to provide testing of innovative products and services. Launched by the Amsterdam innovation motor, Amsterdam City, liander and KPN, it has built various energy, climate change and open connectivity projects involving more than 70 partners, providing testing of various innovative products and services, understanding the behavior of residents and regional users, and providing sustainable economic investment (Varró & Bunders, 2020).

4.2.3. People-oriented and participatory smart city construction

A pilot project carried out by the EU based on the concept of people-oriented smart city construction aims to build a citizen centered smart city, build an all-round and sustainable ecological environment based on the interaction between citizens and the government, expand social employment, increase social wealth and ultimately create social happiness through participatory innovation. The project is based on the concept of "joint design and joint search for solutions". On the basis of clarifying the aspirations, interests and needs of the public, the project connects the government and the public with technical means to jointly seek solutions to problems in the fields of health, environment, public participation and transportation. The project explores the realization way of people-oriented smart city construction through three stages: rebuild neighborhood, empower neighborhood and scale neighborhood value. The project has been piloted in four cities – Aalborg (Denmark), Birmingham (the UK), Lisbon (Portugal) and Milan (Italy) -- and has had some success (Devine-Wright & Batel, 2017).

4.2.4. Technical system design of "data-knowledge-action"

From the perspective of technology, there are differences in the open utilization of data in different countries. Such as the Brazilian government is a unified planning, unified collect real-time data and

unified development, unified maintenance and again by the way, the Australian government is based on the existing system integration and development, while the Dutch government has explored new products distributed data acquisition and intelligent grid application demonstration (Voordijk & Dorrestijn, 2021), but taken together, governments are reflected in big data applications "data integration – knowledge mining and social intelligence analysis – intelligent operation and cooperative action" of the integrated design concept (fig. 1).

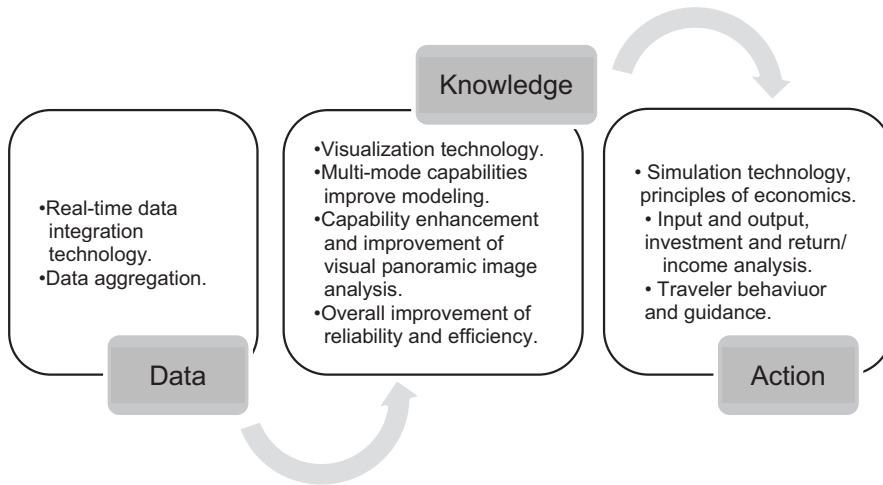


Figure 1. Foreign smart city big data application technology system design concept

Source: authors' development on the data of Internet of Things Reporting Center,
<http://www.wlwbzx.com/>

4.2.5. National strategy from open data initiative to digital continuity plan

Government data opening began in the USA, when President Barack Obama issued two executive orders to open government data in 2009 and 2013. In September 2011, Brazil, the USA, the UK and other eight countries jointly signed the Open Data Statement to establish an open government partnership (Lee, 2014). Subsequently, the UK, the EU, Japan and other countries have formulated the government data open action plan, as of April 2014, 63 countries in the world have formulated the open government data plan. In the process of data opening, countries generally do the following: (1) always take data as a national asset to manage, and establish corresponding systems, such as data asset catalog and data open catalog, comb and constantly update data assets; (2) open data have laws to follow; (3) there is an action plan to guide data opening work; (4) open these data assets to the public through a unified data open portal website; (5) attach importance to public participation and feedback mechanism; (6) there are clear licensing methods and shared licensing agreements; (7) attach importance to privacy protection (for example, special privacy protection experts in the UK and the USA). From the practice of foreign government data opening, under the guarantee of laws and regulations, countries bring government data opening into the construction of smart cities, and finally stimulate social innovation through data opening (Jung, 2020) (fig. 2).

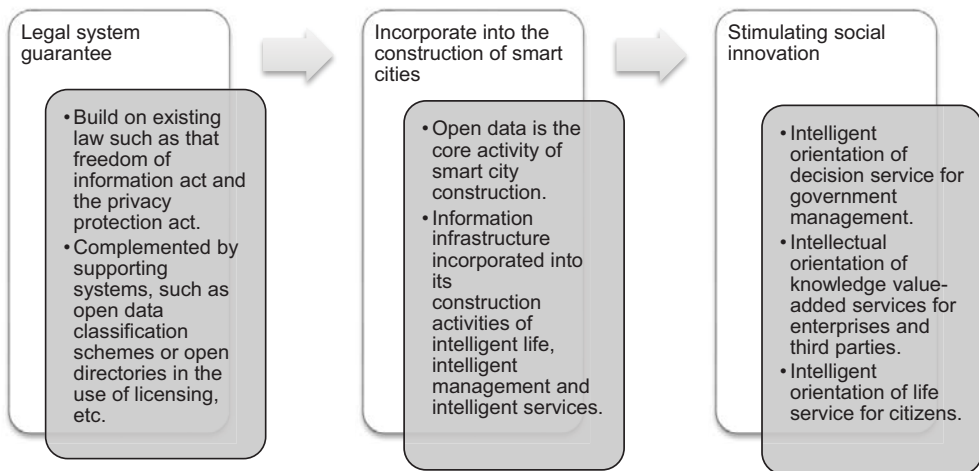


Figure 2. The Way of Foreign Government Data Opening

Source: authors' development on the data of Global Internet of Things Observation,
<https://xueqiu.com/>

The governments of the UK, Australia, New Zealand, the USA, and the Netherlands have launched digital continuity projects (Taylor & While, 2017). The British government first launched the Digital Continuity Project in 2007, aiming to complete the digital operation of 95% of government business activities by 2015, register and manage electronic documents as information assets, and ensure that various change risks are manageable and controllable. The New Zealand government launched the Digital Continuity Action Plan in 2009, aiming to achieve 70% of the government's business activities in digital operation by 2017, and electronic document management has been included in the sustainable development resource allocation of the digital society to ensure the sustainable supply of various management elements. The Australian Government established the Digital Continuity Action Plan in 2012, aiming to achieve 100% digital operation of the government by 2020. Electronic management of electronic documents is regarded as an effective means of government governance, which requires ensuring the credibility, desirability and sustainable reuse of electronic documents. In 2011, President Obama of the USA signed a presidential decree to manage government documents, aiming to achieve paperless office of the federal government in 2019, requiring all government departments to set up chief document managers to manage electronic documents in an automated way and ensure the continuity of e-government (Hu & Zheng, 2020).

Governments have put forward digital continuity projects, which require digital information to be maintained in a digital manner, unaffected by changes in digital technology, and always intact, accessible and usable. In general, national digital continuity projects aim to improve the responsiveness of data and information, balance the allocation and supply of data and information, and stimulate the

innovative use of data and information. In order to achieve digital continuity, governments manage data and information as assets, and support corresponding technical safeguards and business rules (table 1).

Table 1: The purpose and realization way of foreign government digital continuity

Country	Digital continuity purpose	Digital continuity realization approach
The UK	Continuous maintenance of digital assets to improve the effectiveness of government management.	Information is managed as an asset, defining digital continuity requirements, assessing and managing digital continuity risks, and maintaining digital continuity.
New Zealand	Maintaining the continuity of the digital environment and improving the service capacity of the public sector in the digital society.	Whole-of-government approach, national knowledge asset retention strategy: including technical measures, planned infrastructure, social motivation, economic sustainability and other digital environmental maintenance and continuous supply of resources.
Australia	Maintaining the continuity of digital information, connecting society, government and business, and improving the overall decision-making ability of the government.	Optimize government governance methods to avoid business risks caused by information loss or non-reuse: including digital continuity principles, plans, practices, results, demand analysis of comprehensive integration of information, people, process, technology and business, benefit optimization scheme and risk control operation tools and specification determination.
The USA	Continuity maintenance of digital files, support the continuity of e-government in paperless office environment, and guarantee information disclosure and data opening.	Electronic document automatic management system development and certification, paperless preservation and sustainable reuse of digital format and other technical support and management standards, continuous management information technology facilities innovation.
The Netherlands	Digital content continuity maintenance, support the government cross-departmental business collaboration and social management innovation in the cloud office environment.	ISO30300 document management system applies business standardization management, ISO15489 document management standard applies information standardization management, ISO14721 trusted space information infrastructure and ISO16363 trusted digital warehouse architecture and application.

Source: authors' development on the data of China Social Science Network, <http://www.cssn.cn/>

4.2.6. Building smart city construction path with data resources coordinated and innovative development

Through the above analysis, it can be seen that data, as the center of the five-dimension development path construction in smart city construction, can cooperate with other dimensions for innovation and development (fig. 3). The innovation of management mode and the precision of urban governance are based on the application practice of big data to realize the integrated application, cross-border integration and interconnection of data resources. The sustainable development of economic

development and ecological system construction takes data sharing as the path and innovation as the driving force to realize the innovative application ecological model of the Internet. The people-oriented and participatory smart city construction encourages multiple stakeholders to participate and obtain data information and feedback from different stakeholders, so as to achieve a dynamic, humanistic and inclusive smart social ecological system. Based on the construction of smart city in technology, the technical system design of "data-knowledge-action" is constructed, which fully reflects that data, as the center of five-dimension collaborative development, can help the construction of sustainable development of smart city. From the perspective of data itself, foreign governments attach great importance to data openness and digital continuity.

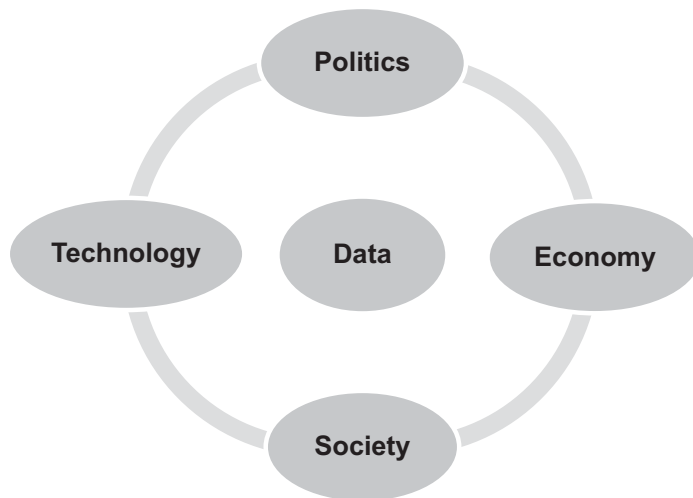


Figure 3. PESTD: five dimensions collaborative innovation and development of smart city construction path

Source: Wang Hongyue's development

Smart city is a new type of urban form based on the new generation of information technology, through the dynamic monitoring, analysis, integration and utilization of the data of various parts of the city, to achieve a thorough perception of the urban living environment, the comprehensive regulation and control of urban resources, the coordination of various parts of the city, the convenient operation of all aspects of the urban, and the harmonious win-win between people and the city (Camero & Alba, 2019). Mining urban data resources, realizing data resource collaboration and interconnection, and constructing data integration system are the foundation of realizing smart city construction, and also the core content throughout the whole process of smart city construction. This study analyzes the data collection, processing, integration, analysis, application and other modes in the process of smart city construction in foreign countries, compares the development status of smart city construction in China,

draws lessons from foreign excellent experience, and constructs the collaborative innovation path of data resources for sustainable development of smart cities in China.

4.3. Strategies and methods of data resources collaborative innovation path to realize sustainable development of smart cities in China

Compared with the experience of international smart city construction, China's sustainable management and utilization of data resources in the construction of smart city does not pay enough attention to the role of improving the digital governance capacity, digital service capacity and vitality of smart city, and building a new economic, efficient, green and low-carbon smart city ecosystem. Therefore, the sustainable management and utilization of urban data resources should be improved from the following five aspects:

First, innovate the awareness of data asset management, enhance the ability of digital control, and promote collaboration, co-governance and innovation. It is necessary to build multi-subject and stakeholder alliances that cross levels, departments and systems, implement the comprehensive integrated management of urban data in the whole life period, whole process and all elements, improve the system of data asset registration, collection, sharing, utilization, disposal and personal information protection, and ensure the security of urban data resources.

Second, innovate the data resource utilization system, and build open mass innovation space in urban areas. The city as a whole should build a digital ecological environment that is continuously connected, multi-participatory and government-led to promote sharing, openness and reuse. To build data as the allocation mechanism for optimal utilization of social resources, as the supply mechanism for innovative application of public assets, the public, enterprises, experts and other parties are encouraged to participate, brainpower to stimulate innovative application of data, and expand information consumption. Third, innovate the data decision-making analysis methods, improve the level of digital governance, and promote precision, accuracy and efficiency. New ways of urban management should be constructed to realize scientific decision-making based on data, improve the pertinence and effectiveness of urban governance, and help the city run efficiently.

Fourth, innovate the operation mode of data capital, improve digital service capacity, and promote co-creation, co-construction and win-win. Data-driven new technologies, new products, new services and new formats need to be constructed, green intensive development of smart city construction projects should be implemented, social capital should be encouraged and standardized to participate in data operation, healthy economic development should be promoted, and information service efficiency for the benefit of the people should be improved.

Fifth, innovate the way data energy functions, enhance the vitality of digital cities, and promote interconnection, interoperability and mutual trust. From data to information to knowledge to smart action, the cultivation mechanism of smart citizens' literacy needs to be constructed. The digital continuity plan of individual, organization and social activities should be implemented, the digital human environment from data to information should be improved, the digital memory should be maintained, the multi value of data should be mined, the digital identity should be realized, and the competition and innovation should be supported.

5. DISCUSSION AND CONCLUSION

Data-centric smart city technology is the technical basis to support the construction of smart city, fully tap the data resources of the city, build the digital ecosystem of smart city, improve the level of urban governance and service is the direction of sustainable and healthy development of China's future smart city. From a multidisciplinary perspective, this study systematically summarizes the PESTD five-dimensional realization path of sustainable development of smart cities in China, namely, policy-governance-innovation, economical-environmental- integration, societal-cultural-inclusive, technology-human-interactions, data-continuity-interconnectivity, and points out that data is the center of the five-dimensional construction of smart cities. Collaborative innovation and development with other dimensions (Politics, Economy, Society, and Technology), and has the “5I” characteristics of Innovation, Integration, Inclusive, Interaction and Interconnectivity. Through comprehensive analysis of foreign models of data collection, processing, integration, analysis and application in the process of smart city construction, it is found that China does not pay enough attention to the sustainable management and utilization of data resources and the construction of digital ecological system of smart city in the process of smart city construction. Therefore, this study puts forward the strategic path of collaborative innovation and development of data resources for the sustainable development of smart cities in China, which has important theoretical and practical significance as a new research perspective for the sustainable development and construction of smart cities in China.

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