Research on the Mechanism of Digital Governance in Enhancing Urban Resilience: Analysis Based on Governance Practices in Typical Chinese Cities

Yihong Duan[1,*], Xin Guan[2]

[1]Faculty of Arts, Law and Social Sciences, University of Bristol, Bristol, BS8 1UH United Kingdom
[2]School of Public Policy and Management, University of Chinese Academy of Sciences, Beijing, 100190, China

*Corresponding author: Yihongduan2043545l6@gmail.com

Abstract. This paper adopts a three-dimensional analytical framework of "foundation support - behavioral adaptation - system governance" as the main line to systematically explore how digital governance can enhance urban resilience. The study indicates that as cities face increasingly complex environmental, social, and technological challenges, digital technology has become a key driving force for improving the city's ability to resist recovery, adapt and adjust, and transform innovatively. Based on grounded theory, an analysis of 228 pieces of data from four cities - Guangzhou, Shanghai, Shenzhen, and Hangzhou - was conducted. The study found that digital governance, by strengthening technical foundations such as perception monitoring, data platforms, and intelligent algorithms, forms a digital base that supports urban operation; through promoting public participation, enterprise collaboration, and government process reconfiguration, it activates a collaborative network of multiple entities; and through institutional construction, policy guidance, and digital inclusiveness, it provides continuous and standardized institutional guarantees for resilience enhancement. The practices of these four cities demonstrate that digital governance not only improves the city's rapid response and recovery capabilities in the face of emergencies, but also strengthens its flexible adaptability in the face of long-term changes, and promotes the transformation of urban governance models towards intelligent, platform-based, and innovative paths. This paper enriches the theoretical connotation of urban resilience in the digital era and provides practical inspiration for future smart city construction.

Keywords: Urban Resilience; Digital Governance; Multiple Case Study; Smart City

X. Pan et al. (eds.), *Proceedings of the 2026 11th International Conference on Financial Innovation and Economic Development (ICFIED 2026)*, Advances in Economics, Business and Management Research 382,
https://doi.org/10.2991/978-94-6239-642-5_119

1 Introduction

With the acceleration of global urbanization, urban systems are increasingly facing complex challenges and uncertainties from various aspects such as the natural environment, public health, and social economy. From sudden natural disasters to chronic resource pressures, how to maintain the stable operation of urban functions and achieve sustainable development has become a core issue in modern urban governance. Against this backdrop, the concept of "urban resilience" (Urban Resilience) emerged. Zeng et al. (2022) [1]pointed out that urban resilience is the comprehensive attribute of the urban system maintaining functional continuity when facing complexity, disruption, and change, and its core characteristics include reflection, redundancy, and robustness, etc. Vasilevska and Slavković (2024) [2]further emphasized that resilient cities can maintain key services running and achieve sustainable development when responding to sudden or chronic disturbances through learning and collaboration.

In recent years, the rapid development of digital technology has provided a new path for enhancing urban resilience. Khatibi et al. (2024) [3]proposed "urban digital resilience" (Urban Digital Resilience) as an extension of urban resilience in the digital context, emphasizing the enhancement of the urban system's intelligent response and recovery capabilities through information technologies such as the Internet of Things, big data, and artificial intelligence. Veglianti et al. (2021)[4] also pointed out that its core lies in using digital twins, intelligent sensing, and real-time data analysis to achieve rapid responses to external shocks, resource optimization allocation, and system function recovery. In this process, digital government construction plays a key role, enabling comprehensive empowerment of urban resilience through building technical foundations, adjusting the behaviors of multiple stakeholders, and improving institutional systems.

Guangzhou, Shanghai, Shenzhen, and Hangzhou, among other leading cities in China, have accumulated rich experience in digital governance practices. The practice shows that digital government not only solidifies the "basic support" of urban operation from the technical level but also promotes the collaborative interaction among the government, enterprises, and the public through "behavior adaptation", and improves institutional design and inclusive mechanisms at the "system governance" level, thereby systematically enhancing the city's resistance, recovery, adaptation, adjustment, and innovation transformation capabilities in the face of disturbances.

This paper attempts to explore the mechanism of digital governance in enhancing urban resilience through case analysis, with the aim of providing theoretical references and practical lessons for building more resilient smart cities.

2 Literature Review and Theoretical Foundation

2.1 Development History of Urban Resilience Theory

Urban resilience theory originated from ecology and systems engineering.Urban resilience theory originated from ecology and systems engineering. Holling (1973)[5] first

defined "resilience" as the ability of a system to absorb disturbances and maintain functional stability. Holling (1973) [5]first defined "resilience" as the ability of a system to absorb disturbances and maintain functional stability. This concept was later introduced into urban studies, and Folke et al. This concept was later introduced into urban studies, and Folke et al. (2002)[6] further emphasized that resilient systems must possess the ability to adapt and transform to cope with continuously changing external environments. Mao Lijuan et al. (2002)[7] further emphasized that resilient systems must possess the ability to adapt and transform to cope with continuously changing external environments. Mao Lijuan et al. (2024)[7] stated that after 2010, research gradually focused on the multi-dimensional resilience of urban systems, such as economic resilience, social resilience, ecological resilience, and infrastructure resilience. (2024) stated that after 2010, research gradually focused on the multi-dimensional resilience of urban systems, such as economic resilience, social resilience, ecological resilience, and infrastructure resilience. While Tu Xiaofang and Zhang Yuning (2024)[8] argued that urban resilience is the comprehensive attribute of a city in maintaining its core functions continuously when facing shocks such as natural disasters and public health crises through adaptation, absorption, and transformation.

While Tu Xiaofang and Zhang Yuning (2024)[8] argued that urban resilience is the comprehensive attribute of a city in maintaining its core functions continuously through adaptation, absorption, and transformation when facing shocks such as natural disasters and public health crises.2.

2.2 Research Evolution of Digital Technology Empowering Urban Resilience

With the development of information technology, digital governance has become a key path to enhance urban resilience. Khatibi et al. With the development of information technology, digital governance has become a key path to enhance urban resilience. Khatibi et al. (2024) [3]proposed the concept of "Urban Digital Resilience", emphasizing the enhancement of urban intelligent response and recovery capabilities through the Internet of Things, big data, and artificial intelligence. (2024) proposed the concept of "Urban Digital Resilience", emphasizing the enhancement of urban intelligent response and recovery capabilities through the Internet of Things, big data, and artificial intelligence. Digital solutions can significantly enhance a city's resilience in coping with shocks by improving system flexibility, redundancy, and resource optimization allocation capabilities. Mao Lijuan et al. [7]The report jointly released by Arup and Resilient Cities Network (2023) pointed out that digital solutions can significantly enhance a city's resilience in coping with shocks by improving system flexibility, redundancy, and resource optimization allocation capabilities. Mao Lijuan et al. (2024)[7] conducted a large number of empirical studies in this field. (2024) conducted a large number of empirical studies in this field. Based on the data analysis of 285 cities in China, they verified the significant coupling and coordination relationship between digital technology and urban resilience.

Based on the data analysis of 285 cities in China, they verified the significant2. coupling and coordination relationship between digital technology and urban resilience.

2.3 The Impact of Digital Governance on Urban Resilience

This article selects the research by Yin Duanlong (2024)[9] to clearly reveal the complete action path of digital governance from the technical foundation to the behavioral actions of the subjects, and to the coordination of the system. This article selects the research by Yin Duanlong (2024)[9] to clearly reveal the complete action path of digital governance from the technical foundation to the behavioral actions of the subjects, and to the coordination of the system. This provides solid theoretical and literature support for this framework. This provides solid theoretical and literature support for this framework. The study points out that digitalization is essentially a fundamental technical element, constituting a new type of infrastructure for enhancing the economic resilience of cities. The study points out that digitalization is essentially a fundamental technical element, constituting a new type of infrastructure for enhancing urban economic resilience. Further, Yin Duanlong (2024) [9]did not limit the impact of digitalization to the macro level, but instead deeply analyzed its transmission mechanism, discovering that "improving the quality of regional labor force" is one of the key paths. Therefore, the behavioral pattern of connecting digital technology bases with en Further, Yin Duanlong (2024) [9]did not limit the impact of digitalization to the macro level, but instead deeply analyzed its transmission mechanism, discovering that "improving the quality of regional labor force" is one of the key paths. terprises and workers has become a key bridge for improving system efficiency. Therefore, the behavioral pattern of connecting digital technology bases with enterprises and workers has become a key bridge for improving system efficiency. Moreover, Yin Duanlong's (2024)[9] research further confirms that the actual effect of digitalization is constrained by complex factors at the system level. Moreover, Yin Duanlong's (2024) [9]research further confirms that the actual effect of digitalization is constrained by complex factors at the system level. This finding indicates that the final effectiveness of digital governance is highly dependent on institutional design, policy intervention, and cross-regional coordination mechanisms. This finding indicates that the final effectiveness of digital governance is highly dependent on institutional design, policy intervention, and cross-regional coordination mechanisms.

2.4 As the Core Implementation Carrier of Digital Governance, the Mechanism of Digital Government can be Summarized into the Following Three Levels

(1) Foundation support: Technology empowerment and resource integration

The modern governance system of digital government is rooted in a solid foundation of technology and resources. Yin Duanlong (2024) [9]research indicates that the introduction of digital technology can systematically enhance output, laying the theoretical foundation for technology empowerment. In practice, digital government implements extensive deployment of Internet of Things sensing networks to achieve real-time monitoring and data collection of urban operation status, building a comprehensive perception intelligent base (Zhang & Wang, 2024).[10] On this basis, resource integration becomes a key link, by building a unified data platform to converge and manage multi-

source heterogeneous information, forming the analytical capability to support intelligent decision-making. Ultimately, the deep integration of cutting-edge technologies such as artificial intelligence and big data significantly improves the efficiency of risk warning, resource allocation, and emergency response.

(2) Behavioral adjustment: Multi-party collaborative governance

Digital governance not only relies on the technical foundation but also achieves system adaptation through changing behavioral patterns. Yin Duanlong. (2024)[9] empirical research indicates that digitalization enhances economic resilience by improving regional labor force quality, reflecting that the public, as an important participant, actively adjusts its skills and behaviors to adapt to the development of digital economy. Digital government provides institutional channels through platform-based operations, by building a public digital participation platform to facilitate the expression of demands and supervision mechanisms (Yu Jianxing & Ren Zetao, 2012)[11]. At the same time, enterprises actively participate in urban service innovation through technological cooperation, jointly building a public-private collaboration model with the government (Stahl, 2022)[12], and jointly promoting the process of industrial digitalization and digital industrialization. Within the government, the reconfiguration of digital processes breaks departmental barriers and enhances the efficiency of public services and cross-departmental collaboration. This behavior adjustment process guided by the government, with the participation of the market and society, as a whole, promotes the transformation of governance models from decentralized management to "platform-driven digital government" and overall collaborative services (Huang et al., 2020)[13].

(3) System governance: Institutional guarantee and environment construction

The sustainability of digital governance ultimately depends on the system-level institutional construction and governance ecosystem shaping. Institutional design is the fundamental guarantee for resilience and sustainability. Digital government needs to build a stable institutional support system through laws, regulations, and policy frameworks. Yin Duanlong. (2024)[9] research reveals the key role of institutions and the environment: Their discovery on "spatial spillover effects" highlights the system importance of establishing innovative governance mechanisms, promoting cross-domain collaboration, and preventing regional development imbalances. In addition, digital inclusion policies aimed at social equity (such as adaptive services for the elderly and disabled) and a normative system for ensuring technological ethics jointly ensure the wide sharing of digital dividends and the safe and controllable application of technology (Du Xiaoyan et al., 2024)[14], becoming an indispensable part of building an inclusive digital society and consolidating the results of system governance.

2.5 The Progressive Framework of "Foundation Support - Behavioral Adaptation - System Governance" Strengthens the three core Capabilities of Urban Resilience at Different Levels

(1), Resistance and Recovery Capacity, this capability is the cornerstone of urban resilience, emphasizing the comprehensive ability of a city to resist shocks, absorb impacts, and quickly return to a basic operational state in the face of sudden external shocks (such as natural disasters, public health events, economic crises, etc.). Its realization

relies on the combination of "hard" structural measures (such as earthquake-resistant buildings, flood control facilities) and "soft" non-structural measures (such as emergency management, social collaboration) (Downey, 2017)[15].

(2), Adaptation and Regulation Capacity, this capability points to the ability of a city to maintain system stability and core functions continuity through dynamic learning, active adjustment of its internal structure, systems, and resource allocation when facing persistent chronic pressures (such as population structure changes, resource depletion, economic structure transformation). It goes beyond passive acceptance and emphasizes an active, progressive optimization process, highlighting the flexibility and wisdom of the urban governance system. This reflects the governance level of urban governments and markets in responding to changes, conducting flexible regulation and resource optimization (Zhu Yuanyuan et al., 2023)[16].

(3), Innovation and Transformation Capacity, this capability is the highest level of urban resilience, aiming to drive the urban system to achieve fundamental evolution and leap. It requires cities to promote innovation at the appropriate time and scale, strengthen cross-domain planning and cooperation, and ultimately shift the development model from simple sustainability to a new paradigm with regenerative capabilities, thereby obtaining development outcomes different from traditional paths (de Graaf-van Dinther, 2020)[17].

It should be emphasized that the three dimensions of "foundation support, behavioral adaptation, and system governance" and the three resilience capabilities of "resistance and recovery, adaptation and regulation, and innovation and transformation" do not have a simple linear correspondence relationship. Instead, they present a networked mode of cross-fusion and synergy. Therefore, the enhancement of urban digital resilience is essentially the deep integration of technological empowerment, entity collaboration, and institutional guidance, exerting a compound impact on the city's multi-level capabilities such as responding to short-term shocks, adapting to long-term pressures, and achieving paradigm leaps.

This article will be based on the research by Yin (2024)[9], and through the three-dimensional framework of "foundation support - behavioral adaptation - system governance", it will systematically examine how digital governance practices at different levels interact and jointly contribute to the three major capabilities of urban resilience - resistance and recovery ability, adaptability and regulation ability, and innovation and transformation ability. By combining typical cases, the study will deeply explain how digital resources and technologies can be transformed into the structural defense capabilities of cities in the face of shocks, how the coordinated efforts of multiple entities can dynamically optimize the regulatory efficiency of the urban system, and how institutional innovation can provide continuous impetus for urban transformation. Ultimately, it will reveal the overall mechanism and implementation path of digital governance in enhancing the complex resilience of cities.

The research framework of this article is as follows in Figure 1:

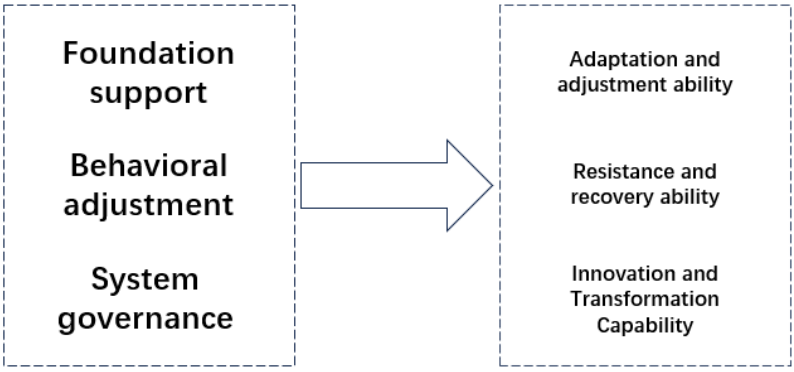

Fig. 1. "The Three Elements of Digital Governance and the Construction of Urban Resilience Capacity" theoretical framework

3 Case Selection and Research Methods

3.1 Case Selection

This study aims to systematically analyze the cutting-edge progress of digital governance in Chinese cities. Four first-tier or new first-tier cities in China, namely Guangzhou, Shanghai, Shenzhen, and Hangzhou, were selected as the research cases. This selection was based on their significant value in terms of governance models, practical outcomes, and innovation dimensions: Firstly, these systems respectively represent different paths such as systematic governance, platform-based operation, and digitalization of key facilities, showcasing the typical paradigms of current urban digital transformation; Secondly, these platforms have all completed large-scale deployment and undergone long-term operation verification, and their governance effectiveness has been verified through massive data, service scale, and application time; Moreover, the four cases respectively approach different fields such as urban operation, public services, data elements, and energy systems, forming a diverse and complementary observation perspective, and jointly constructing a complete map for understanding the complexity and possibilities of digital governance. Through in-depth analysis of these benchmark practices, it aims to provide solid empirical evidence for the development logic and future trends of digital governance in Chinese cities. The specific information for each case is summarized in Table 1.

3.2 Data Collection and Corpus Composition

The research focused on these four cases and systematically collected public text materials from government work reports, policy documents, official typical cases, and authoritative media reports. Through the screening, sorting, and structured excerpting of these materials for the purpose of serving this study, a raw database containing 228 valid corpora was ultimately constructed. The number of case corpora was as follows: 52 for Guangzhou, 55 for Shanghai, 55 for Shenzhen, and 66 for Hangzhou. These

corpora comprehensively cover the technical applications, behavioral actions of entities, and institutional designs in digital governance in each city, providing a rich and solid empirical factual basis for subsequent coding analysis.

3.3 Method of Corpus Analysis Based on Grounded Theory

This study mainly follows the principles and steps of grounded theory to systematically code and analyze all the corpora. Grounded theory is a systematic qualitative research method whose core objective is to generalize and develop theories from the actual collected data, rather than deriving from existing theoretical assumptions through deduction (Glaser & Strauss, 1967)[18]. The core process of analysis is as follows:

- Open coding: Researchers conduct a detailed analysis and tagging of 228 corpora, initially extracting concepts. Subsequently, these concepts are continuously compared and summarized to form more generalized categories. For example, from statements such as "construction of the IoT perception private network" and "accumulation of over 5 billion pieces of data", concepts like "sensing monitoring equipment" and "data resource integration" are abstracted, and ultimately categorized as "basic support".
- Core axis coding: At this stage, the focus is on discovering and establishing logical connections between categories. Through analysis, the three core categories of "basic support", "behavioral adaptation", and "system governance" are identified, which can effectively guide all other categories and form a clear logical chain, naturally becoming the three main dimensions that dominate the analysis. At the same time, the roles and paths of each dimension in the cities' "resistance and recovery", "adaptation and adjustment", and "innovation and transformation" capabilities are further analyzed, clarifying the causal conditions, action strategies, and results.
- Selective coding: With "the mechanism of digital governance enhancing urban resilience" as the core storyline, the three main dimensions are systematically integrated to construct a comprehensive theoretical framework. This framework clearly reveals that urban resilience is not the result of a single technology or policy, but a complex process of dynamic coupling and synergy among the "empowerment" provided by basic support, the "activation" achieved through behavioral adaptation, and the "sustainability" guaranteed by system governance.

This study ensures that the final theoretical model is deeply rooted in rich empirical evidence, thereby achieving a mechanistic explanation and theoretical construction of the complex relationship between digital governance and urban resilience. The detailed coding statistics derived from the corpus analysis are presented in Table 2.

Table 1. Overview of the Sample for Case Study Sampling

City Name	Location	Key areas of digital governance	Innovation level or certification	Case name
Guangzhou	Guangdong	Smart City and Data Element Market	The first action plan for the market-oriented allocation of data elements at the county and district levels in the country	A
Hangzhou	Zhejiang	Urban Brain and Digital Governance	National New Generation Artificial Intelligence Innovation Development Pilot Zone	B
Shanghai	Shanghai	Unified Management through One Network and Government Services	The United Nations' online services index for local areas ranks ninth globally.	C
Shenzhen	Guangdong	Digital Grid and Energy Management	The highest level of the digital transformation maturity standardization certification issued by the Ministry of Industry and Information Technology	D

4 Case Analysis of Digital Governance Enhancing Urban Resilience

4.1 Shanghai's "One Network for Comprehensive Management" Case: The Digital Revolution in Super-Metropolitan Governance

In 2017, Pudong New Area was the first to establish a city operation comprehensive management center, providing valuable experience for exploring governance at the city level. Based on the exploration in Pudong (Zou Junyan et al., 2021)[19], in early 2019, Shanghai officially proposed the construction goal of "One Screen for Global View, One Network for the Entire City". In 2020, the Shanghai City Operation Management Center was officially established, and the "Three-Year Action Plan for the Construction of Shanghai's Urban Operation 'One Network for Comprehensive Management'" was released. In the same year, the system had integrated over 30 departments' 100+ basic data and connected a smart perception network consisting of 880,000 front-end sensing "neurons". Since then, the system has been continuously updated. Relying on the pioneering "Three-level Platform, Five-level Application" system and the concept of "Minimum Management Unit", it solves the most prominent problems at the lowest level and the earliest time with relatively minimal costs. Since 2021, the platform has aggregated, shared, and exchanged over 34 million pieces of data every day. The number of terminal devices connected to the city-wide smart perception network has increased to over 5.1 million. For example, the "Civilized Eye" project launched in Jiading District has achieved a closed-loop disposal from discovery to dispatch within minutes. The Shanghai Municipal Transportation Commission uses "One Network for Comprehensive Management" to coordinate enterprise inspections, ensuring that high-credit enterprises are not disturbed without prior request.

4.2 Hangzhou "City Brain" Case

As one of the first batch of pilot cities, Hangzhou completed the construction of the country's first digital urban management system in March 2006 and put it into operation. In August of the same year, it passed the acceptance inspection by the Ministry of Housing and Urban-Rural Development and was hailed as the "Hangzhou Model" of digital urban management. In 2008, Hangzhou issued the country's first local regulations on digital urban management. Since 2019, Hangzhou has begun to build a city operation management service platform based on digital urban management. By 2023, this platform has become one of the first cities in the country to pass the acceptance inspection and meet the standards. In July of the same year, Hangzhou began to pilot the "one network for unified management" in the field of urban management. In 2025, Hangzhou has fully launched the construction of the "urban brain 3.0", aiming to build an "intelligent body of a megacity". The "one network for unified management" platform of Hangzhou has connected 341,000 IoT sensing devices, collected 970 million dynamic data of the city's "life lines" such as water, gas, roads, bridges, and tunnels, and constructed a three-dimensional intelligent sensing system covering "underground, aboveground, facade, and aerial". As of September 2025, Hangzhou's digital urban management has discovered and assigned 38.9537 million problems over the past 20 years, and the timely resolution rate has increased from 26.7% at the beginning of operation to 98.9%. Hangzhou was the first to build a city-level parking system, connecting 1.84 million parking spaces and providing services to over 400 million times. The "first departure, then payment" function has shortened the departure time for drivers to within 2 seconds, and has saved 2 million hours of waiting time. For enterprises, Hangzhou has also developed an administrative inspection plan coordination management system to promote "comprehensive inspections once" for enterprises and reduce repetitive inspections that disturb enterprises

4.3 Guangzhou's "Digital Twin and Data Elements" Case

According to the report by People's Daily journalist Jiang (2025), in July 2022, Guangzhou issued the "Digital Government Unified Basic Operation Management Reform Plan", and then launched the unified operation pilot in June 2023 until September 2024. Guangzhou announced the completion and activation of the country's first super-large city digital operation guarantee center in July 2024, providing operation services for nearly 250,000 devices of over 350 government agencies and institutions. On July 15, 2024, the Smart Urban Management Platform of Bingzhou District was officially launched. The Smart Urban Management System of Baiyun District uses AI for "automatic capture and dispatch", reducing the handling time of work orders from several days to a few hours, with a reduction rate of 91.7%, and has generated over 6 million work orders, with a regular rectification rate that has remained at around 99%. As of June 2025, the Smart Urban Management System of Baiyun District has managed over 150,000 urban components, 29,000 urban management materials, and 10,000 urban management personnel, with over 700,000 work orders flowing. Since the launch of the Smart Urban Management Platform of Bingzhou District in 2024, it has completed

19,000 cases of urban governance collection and filing, with processing efficiency increasing by over 50%. In terms of gas safety management, Baiyun District used the digital platform to integrate information from 9 gas cylinder enterprises, 198 gas stations, and 340,000 gas cylinder users, achieving zero carbon monoxide poisoning for two consecutive years. In 2025, to welcome the 15th National Congress, Guangzhou relied on the "Guizhi Guan" urban digital base, built a competition command system. After the competition, 85% of the software functions and equipment of the system will be transformed into urban infrastructure, achieving seamless switching between competition guarantee and daily governance.

4.4 Shenzhen "Digital Grid" Case

Since 2012, the Shenzhen Power Supply Bureau has been exploring the application of digital technologies such as intelligent sensors in the production and operation of the power grid. By 2020, it successfully implemented technologies such as unmanned aerial vehicle inspections of transmission lines and programmed equipment operations in actual production, and completed the construction of Shenzhen's first intelligent substation pilot project. In 2021, the Shenzhen Power Supply Bureau vigorously promoted the large-scale construction of intelligent terminals such as video monitoring, and explored the establishment of digital configuration standards and technical equipment standards suitable for Shenzhen's megacity power grid. From 2023 to 2024, the coverage of cameras and intelligent sensors for transmission and transformation, as well as unmanned aircraft nests, was fully completed, and various large and small model algorithms were put into practical application. By 2024, Shenzhen completed the full-scale construction of an ultra-megacity digital grid and innovatively proposed an implementation path of "digitalization of all equipment, intelligentization of production and operation, three-dimensionalization of safety prevention and control, collaborative creation of an ecosystem, and agility of urban empowerment". In the same year, Shenzhen released the first domestic "Evaluation System for Ultra-Megacity Digital Grid" group standard, providing "Shenzhen experience" to the industry. Through high-standard self-healing intelligent distribution networks, the success rate of distribution network self-healing actions in Shenzhen reached 94%, and about 80% of users could quickly restore power when a fault occurred. In 2025, the Shenzhen power grid achieved three-dimensional coverage of "transmission, transformation, and distribution" both above and below ground, and connected the models of 600,000 buildings in the city, building a "city + power grid" digital twin platform.

5 The Mechanism of Digital Governance in Enhancing Urban Resilience

Urban governance modernization not only relies on a single technological breakthrough, but also on the systematic capabilities catalyzed by the deep integration of technology, behavior, and institutions. The three-dimensional analytical framework of "basic support, behavioral adaptation, and system governance" constructed in this paper

clearly reveals how digital governance systematically nurtures a city's resistance and recovery capabilities, adaptability and adjustment capabilities, innovation and transformation capabilities from the bottom-up logic. The following will specifically explain this mechanism by combining the practical data of four first-tier cities.

The core capability enhancement of urban governance modernization is a systematic project driven by the deep coupling and joint drive of three dimensions: basic support, behavioral adaptation, and system governance. These three dimensions are like the body, nerves, and genes of an organism, jointly determining the comprehensive performance of a city when facing challenges, adapting to changes, and creating the future.

The basic support dimension constitutes the digital foundation of a city's capabilities, providing indispensable software and hardware foundations for the exertion of various capabilities. It first provides precise perception and early warning capabilities for resistance and recovery capabilities, such as Shenzhen's deployment of tens of thousands of video terminals and drones to achieve "six full coverages" of the power grid (data D-1-1, 2, 4), reducing fault handling from hourly to second-level; Shanghai's deployment of over 5.1 million IoT sensing "nerve cells" (data C-1-2, 3) constitutes the neural network for urban risk warning. At the same time, the basic support also provides data-driven decision support for adaptability and adjustment capabilities, with Guangzhou and Shenzhen's digital twin platforms (data A-1-2, 12; data D-2-9) achieving 1:1 three-dimensional restoration of urban facilities, making it possible to simulate and optimize in the virtual space. Further, it becomes the core technical engine for innovation and transformation capabilities, with Shenzhen achieving a transformation in operation mode and its independently developed domestic information security system (data D-3-3) achieving breakthrough innovations at the underlying technology level.

The behavioral adaptation dimension activates the collaborative network of multiple entities, converting technological potential into actual governance effectiveness. This dimension significantly enhances the city's adaptability and adjustment capabilities. Hangzhou's "20-second entry" (data B2-12) and Shanghai's "E-Cheng" with over 3.7 billion uses (data B-2-14) directly reflect the precise response and extreme acceleration of digital services to public demands; Guangzhou's "Zhu Shi Tong" mini-program (data A-2-7, 8) through hundreds of "finger-tap" services, adjusted the matching degree between government supply and citizen demands. At the same time, behavioral adaptation provided an open and cooperative ecological soil for innovation and transformation capabilities, with Hangzhou integrating the technological forces of enterprises such as Alibaba (data B-3-8), and Shenzhen jointly establishing a research center with Huawei and BYD and releasing industry white papers (data D-3-4, 5, 6), which are vivid practices of leveraging market entities to jointly define future industry rules.

The system governance dimension lays the institutional framework for the continuous transformation of the city, being the rule system that ensures the steady and far-reaching progress of digital transformation. This dimension is the most powerful force driving innovation and transformation capabilities. Guangzhou issued the first district-level data element market-oriented reform plan in the country (data A-3-7) and innovated the "six-in-one" governance model (data A-3-9), and Shenzhen built the first virtual power plant (data D-2-19). These institutional and mechanism innovations themselves have opened up new development tracks for the city. At the same time, system

governance injects organizational resilience into resistance and recovery capabilities. Hangzhou's "three-level platform, five-level application" city operation system (data B-1-7) ensures the command efficiency in emergencies. Furthermore, it ensures the inclusive and universal adaptability and adjustment capabilities through top-level design. Hangzhou and Shanghai jointly focused on and launched the "E-Chengmen Code" offline service (B-2-23, 24; C-2-15), bridging the digital divide at the institutional level and ensuring social equity in the digitalization process.

Table 2. Coding Statistics Table of Multiple Case Studies on Digital Governance Practices

Primary code	Secondary code	Number of items	Example of citation
Foundation support	Perception and Monitoring Equipment	24	In Shanghai, 880,000 "neurons" have been set up using drones, high-definition cameras, etc. Through these neurons, over 5.1 million IoT sensing devices of nearly 100 types have been integrated into this center, generating more than 34 million pieces of data every day. (C-1-2)
	Data resource platform	30	Build an energy big data center, achieving the first in China to synchronize real-time power grid data with the data center within seconds. (D-2-4)
	Digital technology	27	In combination with the construction of the artificial intelligence algorithm engine, establish prediction and warning mechanisms for factors such as crowd capacity, traffic congestion, and weather conditions. (A-2-1)
Behavioral adjustment	Public digital participation	24	Citizens can activate the "Pay the Maximum Once" convenient medical treatment service through various means such as the self-service registration and check-in machines, the "Health Hangzhou" WeChat platform, etc. (B-2-11)
	Enterprise/University Digital Cooperation	16	Shenzhen Power Supply Bureau has jointly collaborated with Huawei to achieve several leading achievements, including the first artificial intelligence pre-training model in the national power industry based on the Ascend ecosystem. (D-3-4)
	Government Digital Governance	22	In response to the phenomenon of group renting, the operation center of the new area in Pudong has established an application scenario. Through a data model, it can accurately identify suspected cases of group renting and achieve real-time handling. (C-2-21)
System governance	Institutions and Policies	20	The first action plan for the market-oriented allocation of data elements at the county and district levels in the country has been released. (A-3-7)
	Innovative governance mechanism	28	Establish a city operation system consisting of "three-level platforms and five-level applications" (city - district - sub-district - grid - community). (B-1-7)
	Digital environment construction	37	Relying on the "Qingxin Online" platform, explore the integration of "zero paper", "zero human intervention", "zero-time limit" and "zero trips" - the "invisible intelligent approval" model into the smart city construction. (B-3-7)

It is worth emphasizing that these three mechanisms do not operate independently but form a closely interrelated relationship. Technological empowerment provides platform tools for diverse collaborations, diverse collaborations accumulate practical experience for institutional innovation, and institutional innovation points the way and provides guarantees for technological development. The positive interaction among these mechanisms enables digital governance to comprehensively enhance the city's overall resilience in the face of short-term shocks, long-term pressures, and systemic changes, and drives the city towards a more intelligent, inclusive and sustainable development direction. The correlation structure model illustrating the interaction between the multi-dimensional elements of digital governance and urban resilience capabilities is depicted in Figure. 2.

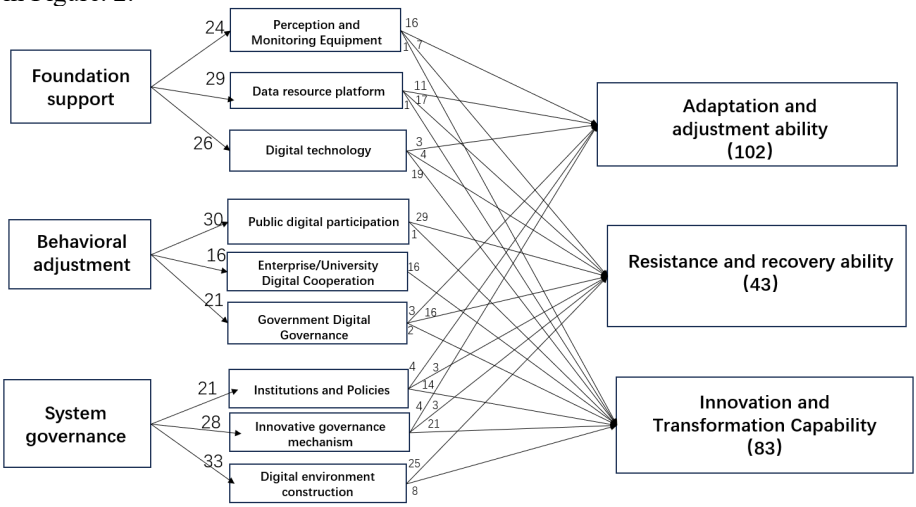

Fig. 2. The correlation structure model of multi-dimensional elements of digital governance and urban resilience capabilities

6 Conclusion

This paper constructs a theoretical framework of "foundation support - behavioral adaptation - system governance" to systematically explain the internal mechanism by which digital governance enhances urban resilience. The research shows that digital governance forms a systematic solution to address complex urban challenges through the triple interaction of technological empowerment, entity collaboration, and institutional innovation. The practices of four frontier cities have confirmed that digital governance not only improves the immediate response capacity of cities to sudden shocks, but also cultivates the adaptive regulatory ability to face long-term pressures, and opens up new paths for the fundamental transformation of urban development paradigms. This research not only enriches the connotation of urban resilience theory in the digital era, but also provides practical insights for promoting urban governance modernization: In

the future, digital governance should pay more attention to the deep integration of technological application and institutional innovation, ensuring technological advancement while strengthening inclusive design and social participation, so as to build a new model of more resilient and sustainable smart city development. It is suggested that subsequent research can further explore the role paths of digital governance in different-sized cities and at different development stages, providing more precise theoretical support for differentiated policy formulation.

References

1. Zeng, X., Yu, Y., Yang, S., Lv, Y., & Sarker, M. N. I. (2022). Urban resilience for urban sustainability: Concepts, dimensions, and perspectives. *Sustainability*, *14*(5), 2481. https://doi.org/10.3390/su14052481.
2. Vasilevska, L., & Slavković, M. (2024). Urban resilience: Definitions, understanding and conceptualization. *Facta Universitatis, Series: Architecture and Civil Engineering*, 097-103. https://doi.org/10.2298/FUACE230630023V.
3. Khatibi, H., Wilkinson, S., Sweya, L. N., Baghersad, M., & Dianat, H. (2024). Navigating Climate Change Challenges through Smart Resilient Cities: A Comprehensive Assessment Framework. *Land*, *13*(3), 266. https://doi.org/10.3390/land13030266
4. Veglianti, E., Sidani, D., & De Marco, M. (2021). Digital resilience for cities' smartness. ITAIS 2021 Proceedings. 21. https://aisel.aisnet.org/itais2021/21.
5. Burnside, W. R., Pulver, S., Fiorella, K. J., Avolio, M. L., & Alexander, S. M. (Eds.). (2022). C. S. Holling (1973). In Foundations of Socio-Environmental Research: Legacy Readings with Commentaries (pp. 460–482). chapter, Cambridge: Cambridge University Press. https://doi.org/10.1017/9781009177856.038.
6. Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: building adaptive capacity in a world of transformations. *AMBIO: A journal of the human environment*, *31*(5), 437-440. https://doi.org/10.1579/0044-7447-31.5.437.
7. Mao, L., Xia, J., & Liu, R. (2024). A Study on the Coupling of Digital Technology and Urban Resilience: An Empirical Analysis Based on Data of 285 Cities in China. *Journal of Hohai University (philosophy and Social Sciences)*, *26*(2), 95-106. https://kns.cnki.net/kcms2/article/abstract?v=f0DSObGwzqhPKg9RHZ7tXcnD9ud9UNd1UOJNmbWIiP0EXLUW3xUUYRJ1rcjvqhog86ZX7YTU6-S4QinWqyRzlrLVJ43BuR77fUqa5eGn_la89Mteq3Na_StwD8s4Ohj8RH9mrP3XIY4xosB8rcCyY4TZ78A6pnNtneL7CHvZ5iD6FpSoWfqNkw==&uniplatform=NZKPT&language=CHS.
8. TU, X., ZHANG, Y. How Digital Technology Enables Urban Governance to Be Resilient[J]. Journal of Beijing University of Aeronautics and Astronautics Social Sciences Edition, 2025, 38(1): 95-102. DOI: 10.13766/j.bhsk.1008-2204.2024.1185.
9. Yin, D., L. (2024). Research on the Impact of Digital Economic Development on the Resilience of Export Trade. E-Commerce Letters, 13(02):3508-3515. DOI:10.12677/ecl.2024.132429.
10. Zhang, Y., & Wang, F. (2024). Theoretical Connotation and Improvement Path of Government Digital Resilience–A Case Study Based on the Practice of Urban Emergency Management Digital Transformation in China. In 2024 Tenth International Conference on eDemocracy & eGovernment (ICEDEG) (pp. 1-8). IEEE. DOI: 10.1109/ICEDEG61611.2024.10702053.

11. Yu, J., & Ren, Z. (2012). Collaborative Governance in Contemporary Chinese Social Construction. *Academic Monthly*, 44(8), 23-31. DOI: 10.19862/j.cnki.xsyk.2012.08.005.
12. Stahl, C. (2022). *Social Norms, Mental Models and Other Behavioural Drivers of Petty Corruption--the Case of Uganda*. Basel Institute on Governance. https://www.jstor.org/stable/resrep39398.
13. Huang, H., Zeng, Y., Zhang, Q., Liu, X., Zhao, Q., Wu, Z., ... & Zhang, W. (2020). Platform-driven Digital Government: Capabilities, Transformation and Modernization. *E-Government*. https://doi.org/10.16582/j.cnki.dzzw.2020.07.001.
14. Du, X., Wu, Q., & Xu, L. (2024). The Realization Mechanism and Optimization Path of Digital Empowerment of Community Resilience Governance under the Concept of People-Centered Cities. *Journal of Xi'an Jiaotong University (Social Science Edition)*, 44(3), 115-124.DOI: 10.15896/j.xjtuskxb.202403011.
15. Downey, D. C. (Ed.). (2017). *Cities and disasters*. CRC Press. DOI: 10.5860/choice.195475.
16. ZHU, Y. Y., LUO, Y., CHEN, J., & JIANG, Z. L. (2023). Research on industrial transformation and its economic resilience in resource-exhausted cities: A case study of Daye city, Hubei province. Journal of Natural Resources, 38(1), 73-90. DOI: 10.31497/zrzyxb.20230105.
17. de Graaf-van Dinther, R. (2020). Future outlook: emerging trends and key ingredients for the transition to resilient delta cities. *Climate Resilient Urban Areas: Governance, design and development in coastal delta cities*, 191-206. https://link.springer.com/chapter/10.1007/978-3-030-57537-3_10.
18. Glaser, B. G., Strauss, A. L., & Strutzel, E. (1968). The discovery of grounded theory; strategies for qualitative research. *Nursing research*, *17*(4), 364. https://journals.lww.com/nursingresearchonline/citation/1968/07000/the_discovery_of_grounded_theory__strategies_for.14.aspx.
19. ZOU Junyan, XU Minghui, PANG Xiaojing. City brain development status, typical practice and path recommendation[J]. Information and Communications Technology and Policy, 2021, 47(11): 6-. Doi: 10.12267/j.issn.2096-5931.2021.11.002.