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Original Paper

Empowering Social Digital Governance through a Digital Economy Platform Integrating All County-Level Data: Mechanisms, Practical Challenges and Implementation Pathways —Taking X City as an Example

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Abstract

This study focuses on the underlying mechanisms of county-level digital governance, taking X City in Yunnan Province as an example. Using data empowerment theory, collaborative governance theory and complex systems theory, it constructs a three dimensional analytical framework of "element aggregation-collaborative evolution-system resilience" to explore the enabling mechanism, practical dilemmas and implementation paths of the digital economy platform integrating county-level full-element data for social digital governance. This study reveals that X City has significantly improved government decision-making efficiency through full-element data aggregation. Simultaneously, in the process of collaborative evolution, governance subjects are evolving from "government-led" to "platform-driving" and "pluralistic balance", and the algorithm power game will be the core issue in future governance. Moreover, building complex system resilience requires a shift from traditional "rigid defense" thinking to an adaptive governance model integrating culture,

technology and institutions. Furthermore, due to some practical obstacles (e.g., quality loss) during the refinement of digital governance, some strategies, including establishing an algorithm power balance mechanism, cultivating complex system resilience and solving technology adaptability dilemmas, are proposed to solve these issues. To sum up, this study provides both theoretical support for county-level digital governance and useful references for digital governance practices in other regions.

Keywords

digital governance, digital economy platform, data empowerment theory, collaborative governance theory, complex systems theory

1. Introduction

Against the backdrop of the ongoing digital transformation, the global governance ecosystem is undergoing profound reshaping. Much of the domestic research pays particular attention to the construction of smart cities and digital villages, focusing on technological applications and policy support, such as enhancing the governance level of urban and rural public services (Liu, 2023) and bridging the urban-rural digital divide (Yang et al., 2025). In contrast, overseas studies center on digital inclusion and equity, highlighting technological standardization and cultural diversity, such as advancing social inclusion and safeguarding the cultural heritage of ethnic minorities (Niu et al., 2024). Regarding county-level digital governance, the social governance model is evolving from a single, government-led structure to a collaborative framework involving multiple stakeholders (Wang, 2024). This transformation not only represents an inevitable response to complex challenges that include intricate social structures, diverse public demands and intertwined global risks but also presents a historic opportunity for information technology to drive the modernization of governance systems. As a representative multi-national region in China's border area, X City, with its cross-border location, multi-ethnic population and active rural revitalization initiatives, serves as a unique case for examining the effectiveness of digital governance. In practice, although the implementation of digital tools such as county-level economic platforms has achieved remarkable effectiveness of data integration in breaking down information silos and fragmented governance, border areas still face deep-seated problems in terms of collaborative governance mechanisms, platform functionality pathways and the balance between development and security.

At present, the integration of full-element data at the municipal level provides a technical foundation for synergic governance, but the reconstruction of a coordinated relationship among the government, enterprises and the public still encounters institutional bottlenecks (Xu et al., 2014). Specifically, Departmental silos and ambiguities in the division of rights and responsibilities under the traditional bureaucracy have resulted in insufficient data-sharing willingness and a lack of coordination mechanisms, hindering the transformation of data resources into effective governance capacity.

Meanwhile, the extent to which data platforms empower governance—by breaking down institutional barriers and reshaping decision-making processes—requires further analysis at the level of its operational logic from the perspective of mechanism of action. Moreover, the unique context of border regions further complicates this challenge. In China's border areas, cross-border flow raises security concerns, multi-ethnic cultural integration demands social stability and rural revitalization efforts require efficient resource coordination. These factors necessitate the exploration of dynamic equilibrium paths between development and security in data-driven governance framework.

Based on this, this study addresses three core issues: (1) How can data integration be utilized to reconstruct the boundaries and collaboration models among governments, enterprises and the public, redefine their respective rights and responsibilities and establish a governance community grounded in data-based mutual trust? (2) In the context of full-element data at the municipal level, how can process reengineering and scenario adaptation contribute to the formation of a mechanism that enhances governmental efficiency? (3) How can border areas leverage data governance to the fullest to construct a resilient system that effectively balances security and development in some contexts such as cross-border data flow, ethnic cultural preservation and rural resource development? These issues not only reflect practical challenges in the digital transformation of X City but also represent theoretical advancements in the modernization of border governance in the digital era.

2. Literature Review

Some previous foreign research institutions and scholars summarized the connotation of the digital economy as "an economy based on digital technologies" (Collen & Kulikowski, 2015). Subsequently, the connotation of the digital economy extended to the entire economic activities, including applications in business, government affairs and non-governmental affairs (Malecki & Moriset, 2007). The scope of the digital economy has continuously expanded with the extensive application of digital technologies and now encompasses all forms of digital economic activities. In this process, the focus of academic research has also shifted accordingly, from traditional research on digital technology applications to more comprehensive fields such as platform economy, digital transformation and the growth, innovation and governance of the digital economy (Li et al., 2020). This marks the deepening of digital economy research, as scholars are attempting to understand and address how to effectively manage and promote economic activities in the context of rapid digital development, ensuring that technological progress can promote economic growth while also achieving sustainable and inclusive development (Kuang et al., 2024; Ma et al., 2025).

Different countries and institutions have continuously explored the conceptual definition and scope standardization of the digital economy. First, from the perspective of digital technologies, the digital economy refers to the provision of relevant products and services through digital technologies (Kling &

Lamb, 2000). The emergence of digital technologies has brought about epoch-making innovations in traditional manufacturing industries. The accelerated process of industrial digitization has enabled traditional industries to keep up with the characteristics of the digital economy and the demands of the digital market, thus becoming an important part of building a modern industrial system (Lu et al., 2024; Su et al., 2023; Xu et al., 2022). As an innovative economic form with high-tech and high-added-value, the digital economy highly depends on the innovation environment (Salamatov et al., 2020). Moreover, to ensure the sustainable and extensive advantages of digital technology innovation, a favorable innovation environment needs to be created, providing corresponding institutional guarantees for digital technology innovation (Dneprovskaya et al., 2018). Second, from the perspective of production factors, in the era of the digital economy, data has become a new production factor. Building a digital economy with data as a key factor has become the direction for promoting the healthy development of the digital economy. In September 2016, the G20 Summit provided an official definition of the digital economy, regarding digital knowledge and information as the key production factors of the digital economy, which has been widely recognized by the international community (Lu et al., 2024). Based on this definition, two trends of digital economy innovation can be identified. From one perspective, digital technologies empowered by innovation have deepened the integration of the digital economy with various fields of the traditional economy and promoted the digital transformation of traditional industrial clusters through industrial linkage effects (Jorgenson & Vu, 2016). In terms of the innovative vitality of the digital economy, the infrastructure of the digital economy is crucial for its development, and broadband infrastructure plays a significant role in promoting innovation activities (Audretsch et al., 2015). From another perspective, digital technologies have promoted the formation of a business model centered on customer value creation, meeting a large number of long-tail and marginal demands and creating a long-tail effect at the consumption end (Warner & Wäger, 2018). The digital economy improves market transaction efficiency by reducing search costs, replication costs, transportation costs, etc. (Goldfarb & Tucker, 2017).

Although the continuous evolution of the digital economy has not only redefined economic production factors but also provided new paths for technological innovation and social development, previous studies have rarely explored the value of the digital economy from the perspective of social governance. In the journey of comprehensively promoting the great rejuvenation of the Chinese nation through Chinese-style modernization, building a digital power requires leveraging the key role of the digital economy in social governance. Especially in multi-ethnic border regions, how to use digital economy platforms to achieve factor aggregation and data sharing is of great significance for bridging regional development disparities, promoting the modernization of the social governance system, and thus facilitating common prosperity.

3. Method

3.1 Theoretical Integration Framework Construction

This study synthesizes the theoretical foundations of data empowerment, collaborative governance and complex systems to develop a comprehensive analytical framework. This framework enables digital economy platforms to enhance social digital governance by integrating full-element data at the county level, guided by the conceptual model of "element aggregation-collaborative evolution-system resilience". Consequently, this research model aims to explore the underlying mechanisms of social digital governance, identify key challenges encountered during the empowerment process and outline feasible implementation pathways to advance the digital transformation of county-level social governance.

3.1.1 Element Aggregation

Data empowerment theory outlines the developmental trajectory of data, progressing from resource utilization to assetization and ultimately to capitalization. Through processes of data collection, analysis and application, the transformation of data value and the realization of economic benefits are achieved. The integration of full-element data at the county level has been regarded as a core proposition for governing digital transformation. By integrating full-element data, the structural reorganization of governance resources can be achieved, with a particular emphasis on addressing the challenges of "data fragmentation" and "information silos" in county-level governance. Currently, in X City, government data faces the dilemma of "data abundance but knowledge poverty" due to departmental barriers and spatial fragmentation (Ren, 2023). Conversely, some successful practical experiences from Hangzhou and Shanghai demonstrate that the dual-wheel drive mode of technological integration (e.g., federated machine learning that enables data sharing under privacy protection (Peng et al., 2025)) and institutional innovations (e.g., the chief data officer system and government affairs data directory management (Pan, 2025)) can effectively reshape the data value chain. This integration not only breaks the "data silos" but also generates governance experiences through cross-domain data linkage (e.g., the integration of environmental protection plan and industrial data (Gong & Sun, 2025)), thereby laying the foundation for achieving precise decision-making and coordinated governance actions.

3.1.2 Collaborative Evolution

Given that the deep penetration of digital technology, the bureaucratic logic of traditional social governance is being deconstructed. Specifically, The traditional governance model relies on unilateral decision-making and resource allocation executed by government, exposing structural defects such as information flow obstructions (e.g., the health code and nucleic acid testing data are not synchronized during the Covid-19 (Du et al., 2025)) and the inefficiency of departmental coordination (e.g., the data entry duplication rate of the public security and civil administration department of a certain city reaches

30% (Xie, 2023)). On the contrary, the collaborative governance theory emphasizes the interaction and cooperation between the three-element subjects of the government, the market and society, revealing the dynamic game process of the government, enterprises, the public and other subjects on the digital platform (He & Ying, 2025). In this regard, the government has changed from a traditional single manager to a role of "service + coordinator"; enterprises participate in social governance through technical tools; social organizations and the public conduct collaborative governance through digital platforms. Furthermore, the "city brain" and "one-stop online service" created by technologies such as the Internet of Things and blockchain have promoted the transformation from government-led to diversified collaboration among government, enterprise and social organizations (Han et al., 2025). This transformation not only improves governance efficiency, but also reconstructs the basis of governance legitimacy in the digital era through data-driven precise policy implementation and resilience construction.

3.1.3 System Resilience

Complex systems theory provides a paradigm breakthrough for exploring the resilience mechanism of social governance system (Zhong & Yang, 2025). To be specific, unlike the traditional concept of linear governance, this theory emphasizes that sociotechnical system can maintain dynamic stability through dissipative structure, and their resilience characteristics originate from three core mechanisms: (1) the self-organization ability generated by nonlinear interaction among multiple entities (Y. Wang, 2025a); (2) the adaptive adjustment of multi-level feedback loop (Li, 2025); (3) the innovative potential of fluctuations triggering the phase transition of the system (Liu & Zhang, 2024). As a border multi-national region, for one thing, the system resilience of the X City is reflected in the ability of the governance system to maintain core function when responding to structural disturbance in the context of the digital economy platform empowering county governance. It is specifically characterized by the triple dimensions of cross-border data flow risk immunity, national cultural digital inheritance steady state and urban-rural digital divide bridging elasticity. For another thing, in the process of multi-ethnic digital integration, the evolution of Hani language NLP engine follows the law of "using is innovating". User error correction data is fed back to the algorithm model in real time, forming a positive feedback loop for the coordinated evolution of language resource supply and demand (Wei & Zhou, 2025). These practices indicate that the resilience of the digital governance system is essentially the result of the joint action between the subject's adaptation and institutional constraints, and its evolutionary path is irreversible and path-dependent (Li & Gan, 2025).

Based on existing literature, the two questions regarding the digital economy integrating county-level full-element data empowers social digital governance remain to be addressed.

From one perspective, there is a gap in the collaborative relationship between the system and technology. "Data silo" is formed within the government due to the division of rights and

responsibilities among departments, leading to the absence of cross-departmental coordination rules (Peng & Lou, 2021). In addition, the collaboration among the government, enterprises and social organizations lacks definition of the boundaries between rights and responsibilities. When enterprises engage in governance, the algorithmic black box gives rise to a public trust crisis. Moreover, there exists a significant disparity in digital infrastructure between urban and rural areas, which, in turn, leads to a spatial imbalance in the application of technology empowerment (M. Wang, 2025). The technical logic of data platforms is out of touch with the complexity of the governance scenarios, resulting in insufficient technical adaptability (Sun et al., 2025).

From another perspective, there exists a fragmentation between governance objectives and scenario integration. Economic platforms focus on efficiency, yet they may overlook the protection of ethnic cultures or the risks associated with border security (Y. Wang, 2025b). For example, in the process of rural revitalization, the gap between rural digital depression and smart city development has intensified the imbalance in urban-rural development. The separation of data requirements and decision-making logic in different governance scenarios results in the fragmentation of platform functions (Wu et al., 2025). Besides, Algorithm design tends to prioritize the optimization of a single objective, neglecting the development requirement of social resilience in border multi-national regions. These two separations reflect the deep-seated dilemmas of the dual tension between “institution and technology” and the multi-dimensional contradictions between “goals and scenarios” in the digital social governance of county-level regions.

3.2 Research Methodology

The case study method is mainly used to select the digital economy platform in the X City of Yunnan Province as the analysis object. Next, we conducted field research and individual interviews to gather relevant information and data, presenting the practical effects and dilemmas of digital technology empowering social governance. Since being selected as the second batch of national smart city’s pilot cities in 2013, X City in Yunnan Province has continuously increased its efforts. Based on its own actual conditions, it has successively introduced policies such as *Notice on Regulating the Work Related to New Infrastructure Information Projects and Smart City Construction in X City* and *Smart City Construction Plan for X City* to continuously accelerate the smart city construction pace. With the focus of digital governance improvement, digital economy transformation and digital life experience, X City has built some digital governance applications such as command and control center and data security center. Additionally, it developed some digital economy platforms such as the Yinqiqiao 2.0 (a comprehensive financial services platform), business environment services, and crossing-the-bridge noodles (a famous traditional local dish in Yunnan province) industry services. More than 30 people’s livelihood applications were built such as intelligent community and 37111111 people’s livelihood service, promoting the intellectualized development of the lives of residents, community services and

community management. Therefore, it can be seen that relying on the digital economy platform system of X City to examine the underlying logical mechanisms behind the efficiency enhancement of digital empowerment in social governance is highly representative.

We have successively visited some key departments in X City, including Politics and Law Committee, Development and Reform Bureau, Administrative Law Enforcement Command and Dispatch Center, Public Security Bureau, Bureau for Letters and Calls, Civil Affairs Bureau and Bureau of Industry and Information Technology. We also conducted on-the-spot visits and investigations in three sub-district offices and the community neighborhood committees under their jurisdiction in the central urban area. Furthermore, we visited various primary, secondary and tertiary industry enterprises that have settled on the platform, and the first-hand information was obtained by us. This helped us understood the operation situation and outstanding features of the X City digital economy platform. Meanwhile, we conducted the visiting and the investigation study among the citizens, aiming to capture the citizens' awareness and satisfaction with X City's digital economy platform. These all provide a solid foundation for detailed explanation of the analysis framework and main perspectives. Based on our practices, our research focus is to systematically analyze the limits and effectiveness difficulties of digital technology application in social governance, and to explore paths to improve the effectiveness of digital technology to empower social governance. Finally, the research's purpose is to promote a bidirectional coupling between the digital economy platform and digital social governance as a whole.

4. Result

4.1 Digital Economy Platform Architecture Solution in X City

The county-level digital economy platform is a comprehensive industrial service platform that promotes the qualitative change of the real economy through digital transformation. It is based on the digitalization of industries and the industrialization of digital technology. By integrating and revitalizing existing resources, fully exploring market potential, filling market gaps and facilitating the coordinated development of industries, it drives the real economy to achieve a qualitative leap. The platform construction of the digital economy platform project in X City follows the "6+1+1" working concept. It focuses on six major fields, namely public transportation, education and training, community consumption, culture and tourism, industrial supply and medical and elderly care services. It explores local integrated payment and carbon inclusion. The platform consists of 12 modules, including digital transportation, digital education, digital community, digital new consumption, digital agriculture, digital trade, digital logistics, digital energy, digital industrial parks, digital culture and tourism, comprehensive digital medical and elderly care services and digital carbon inclusion. It has three major functions: supply-demand information, transaction settlement and supply data. As a result, it forms a "1+1+12+N" system. Moreover, this project automatically collects data through the API

interfaces of 12 sub-module applications. It has aggregated 6.95 million data records from 12 sub-module application platforms, including those for digital transportation, digital education, digital agricultural trade and digital new consumption. The accumulated data volume has reached 500GB. Consequently, it has achieved progress in innovating actual operations through data governance.

In the data middle-platform module, cutting-edge big data technologies and cloud computing platforms are harnessed to construct a highly efficient and stable data processing and analysis system. This system has the capacity to conduct real-time operations of collecting, storing, cleansing, integrating, mining and exchanging data originating from a wide array of sources. These sources span multiple domains, including but not limited to transportation, education, agriculture, consumption, community affairs, industry, tourism, logistics, new energy, healthcare, industrial parks and carbon inclusive program.

4.2 Governance Empowerment Practices Based on a Three-Dimensional Framework Mechanism

As an innovative enabling point for county-level social governance, the aggregation of all elements, under the empowering action path, respectively promotes the overall improvement of the four collaborative evolution capabilities in county-level social governance scenarios: the collaboration of "information governance and trust building", the collaboration of "data sharing and collaborative governance", the collaboration of "dynamic monitoring and adaptive governance" and the collaboration of "emotional computing and cultural governance". This enables the county-level social governance system to achieve a systematic dynamic balance across four dimensions of resilience: trust resilience, collaborative resilience, adaptive resilience and cultural resilience. Ultimately, the goals of county-level social governance are realized.

4.2.1 Full-element Data Integration and Governance Community Construction

The integration of full-element data is the core of the three dimensional analysis framework of "element aggregation-collaborative evolution-system resilience". X City has creatively established the Smart Innovation and Development Center of X City, a cross-departmental data sharing institution, to achieve data linkage among different departments. By integrating government affairs data, people's livelihood data, industrial data and spatial data, a comprehensive full-element data pool has been constructed, providing comprehensive information resources for governance. This integration not only breaks down departmental barriers but also generates governance knowledge through cross-domain data association, offering underlying support for precise decision-making and collaborative actions.

4.2.2 Systematic Dynamic Balance of Trust Resilience: Synergy between Information Governance and Trust Building

The synergy between information governance and trust building can enhance the trust resilience of social governance. By ensuring the authenticity of information and the order of its dissemination, information governance provides a foundation for trust building. In turn, trust building promotes the

effectiveness of information governance by enhancing public trust in governance entities and information sources. This synergistic relationship helps maintain public trust in governance institutions in a complex and ever-changing social environment, thereby improving the stability and reliability of social governance. In X City, data sharing has been achieved among departments such as property management, public security and market supervision. The property management department provides basic information of residents and housing information, the public security department offers public security information and population management information and the market supervision department supplies information on market entities and regulatory information. Through the sharing of these data, the government can gain a more comprehensive understanding of the actual situation in communities and improve governance efficiency. In the digital agricultural trade module of X City, the data from cooperatives provides important references for the government to formulate agricultural policies. Cooperatives provide data on agricultural product production, sales, prices, etc. through digital platforms. Based on these data, the government can understand the market situation of agricultural products and the production needs of farmers. For instance, the government can formulate reasonable price subsidy policies for agricultural products according to the price data provided by cooperatives to protect the interests of farmers. Meanwhile, the government can also formulate guiding policies for agricultural production based on the production data of agricultural products provided by cooperatives to promote the sustainable development of agriculture. X City has established a carbon credit system to guide citizens to participate in green governance. When using digital platforms, citizens can earn carbon credits through green travel, energy conservation and emission reduction. These carbon credits can be used to exchange for goods or services, such as coupons and gifts. To illustrate, citizens can earn carbon credits by choosing public transportation and reducing energy consumption, and these credits can be redeemed for various coupons and gifts on the digital platform.

4.2.3 Systematic Dynamic Balance of Collaborative Resilience: Synergy Between Data Sharing and Collaborative Governance

The synergy between data sharing and collaborative governance can enhance the collaborative resilience of social governance. Data sharing provides data support and decision-making basis for collaborative governance by promoting data circulation and information exchange among different governance entities. Subsequently, collaborative governance enhances the practical application value of data sharing by integrating resources and forces from all parties to jointly address complex social issues. This synergistic relationship helps improve the collaboration and efficiency of social governance, and its adaptability and flexibility can be strengthened. In X City, precise allocation of education and training resources has been achieved through the analysis of student accident insurance data. Student accident insurance data provides information on students' basic details, health conditions and academic performance. The government and educational institutions can understand students' needs and

situations based on this data. For example, the government can formulate corresponding health education policies and provide health education services according to the students' health conditions in the insurance data. Educational institutions can develop personalized teaching plans and offer precise educational services based on the students' academic performance in the data. Furthermore, the Yinqiqiao platform in the digital new consumption module has promoted the construction of a credit evaluation system for Small and Medium-sized Enterprises (SMEs). By integrating multi-dimensional data such as payment flow and logistics data, the government and financial institutions can have a more comprehensive understanding of the credit status of SMEs. For instance, payment flow data reflects the enterprise's capital flow, and logistics data reflects its production and sales. These data serve as important bases for credit evaluation. The establishment of the community unified payment platform has promoted the development of grassroots self-governance. Through this platform, residents can conveniently pay various fees, such as property management fees, utility bills and fees for community street-vendor stalls. Simultaneously, the platform provides functions for fee transparency and co-governance decision-making. To illustrate, residents (including street-vendors in the community) can view detailed fee information on the platform, understand how the fees are used and participate in community co-governance decisions, such as voting on community affairs and reporting issues through the "take-a-photo-and-report" function. This community unified payment platform not only improves the efficiency of community management but also promotes residents' participation and self-governance. In this way, X City has successfully applied digital technology to grassroots self-governance, forming a governance model jointly participated in by the government, communities, and residents.

4.2.4 Systematic Dynamic Balance of Adaptive Resilience: Synergy between Dynamic Monitoring and Adaptive Governance

The synergy between dynamic monitoring and adaptive governance can enhance the adaptive resilience of social governance. Dynamic monitoring provides timely and accurate information support for adaptive governance by collecting and analyzing real-time data on social operations. Adaptive governance, in turn, flexibly adjusts governance strategies and measures according to the results of dynamic monitoring to address the ever-changing social environment and governance needs. This synergistic relationship helps improve the flexibility and adaptability of social governance and enhances its ability to maintain dynamic balance. In X City, smuggling monitoring has been strengthened by integrating border trade data. Logistics data provides information on cargo transportation and transactions, while border trade data offers relevant information on cross-border trade. By integrating these data, the government can achieve real-time monitoring and early warning of smuggling activities. Financial institutions can provide differentiated loan interest rates and loan amounts based on the credit evaluation results of Small and Medium-sized Enterprises (SMEs), thereby

reducing financial risks and promoting the development of SMEs. In the old-city renovation planning of X City, scientific decision-making support is provided through 3D twin modeling of digital communities. 3D community modeling offers a three-dimensional model of the community, including information on buildings, roads and public facilities. The government can understand the actual situation and renovation needs of the community by analyzing the data from 3D community modeling. To illustrate, the government can formulate reasonable old-city renovation plans and optimize the layout of buildings and the allocation of public facilities based on the 3D community modeling data. This model of using 3D community modeling to assist old-city renovation planning not only improves the scientific nature and effectiveness of decision-making but also promotes the smooth implementation of old-city renovation.

4.2.5 Systematic Dynamic Balance of Cultural Resilience: Synergy between Affective Computing and Cultural Governance

The synergy between affective computing and cultural governance can enhance the cultural resilience of social governance. The in-depth coupling of affective computing and cultural governance constructs a double-helix mechanism for the generation of cultural resilience, and their collaborative effect is achieved through the reciprocal construction cycle of data and meaning. Affective computing provides an emotional foundation and cultural insights for cultural governance by analyzing and understanding the public's emotional states and value orientations. Cultural governance, in turn, enhances the public's emotional identification and cultural sense of belonging to social governance by shaping and guiding social and cultural values, thereby promoting the practical application effect of affective computing. This collaborative mechanism essentially realizes the dialectical unity of technological perception and cultural reflexivity: the fine-grained monitoring of affective computing provides "social neural impulses" for cultural governance, while the symbolic intervention of cultural governance feeds back into the contextual adjustment of the affective computing model. In X City, real-time monitoring and analysis of public emotions have been achieved through digital platforms. For instance, in the digital tourism module, the digital inheritance of ethnic culture has been realized through the digital project of intangible cultural heritage, which has enhanced the public's sense of identity and belonging to ethnic culture. Through the digital tourism platform, intangible cultural heritage is digitized and made into digital products, such as digital museums and digital exhibitions. This not only protects the intangible cultural heritage but also promotes the development of cultural tourism.

4.3 Analysis of Practical Obstructions

In the three-dimensional analytical framework of "element aggregation-collaborative evolution-system resilience", several structural bottlenecks have emerged in the process of X City's digital economy platforms empowering social digital governance. These bottlenecks not only expose the practical dilemmas in the integration of digital technology and the governance system but also reflect the special

challenges faced by multi-national border regions during the digital transformation process.

The core dilemma that the element aggregation layer poses to platform empowerment lies in the structural imbalance among data scale expansion, quality assurance and security compliance, giving rise to an irreconcilable dilemma on scale, quality and security.

4.3.1 Obstacles of Scale Expansion

According to the *50th Statistical Report on the Development of the Internet in China*, as of June 2022, the internet penetration rate in urban areas of China reached 82.9%, a 1.6% increase compared to December 2021 (Thepaper News, 2022). In contrast, the internet penetration rate in rural areas was only 58.8% (Thepaper News, 2022). Although it increased by 1.2% compared to December 2021 (Thepaper News, 2022), the gap remained significant. This urban-rural disparity in internet development indicates the uneven spatial distribution of current digital infrastructure construction.

With the rapid development of the digital economy, information has become a core element for reorganizing core resources, and the ability to access and utilize digital information has become an important indicator for measuring the development competitiveness of a region. However, the lag in rural digital infrastructure construction directly weakens its digital utilization ability and information access ability. This not only hinders rural areas from integrating into the trend of digital economic development but also has a negative impact on rural digital social governance and industrial digital-intelligent construction.

Furthermore, the lag in rural digital infrastructure prevents it from receiving the massive amount of information transmitted from cities, affecting the effectiveness of information sharing. This leads to a disconnection between rural and urban areas in terms of element integration, hindering the expansion of data scale. Meanwhile, the insufficient data-carrying capacity in rural areas also prevents cities from effectively driving the expansion of the scale of rural digital economic platform construction, thereby affecting the overall balance of the digitalization process between urban and rural areas.

4.3.2 Low Data Quality

In the current policy context of public data governance, the incompatibility of standard systems and conflicts in semantic interpretations have emerged as prominent structural issues constraining the efficiency of data integration. For a long time, different departments and levels have independently formulated their own data calibers and classification coding rules, resulting in a chaotic primary key system and inconsistent time-space benchmarks, thus creating irreconcilable systematic deviations. This underlying heterogeneity makes it difficult to establish effective associations when cross-domain data is aggregated. A large amount of statistical data, business data and Internet of Things (IoT) sensing data are merely physically stacked, creating an illusion of “data abundance”, but failing to be transformed into governance knowledge that can support decision-making, leading to a governance dilemma of “abundant data but poor knowledge”. Besides, although the volume of government data is

growing rapidly, there is a systematic decline in quality dimensions such as consistency, accuracy and usability, which directly affects the effectiveness of precise policy-making and scientific governance.

Moreover, the unclear definition of data ownership and the inefficient data circulation mechanism constitute the core bottlenecks at the institutional level. Currently, there is a lack of legally binding and clear definitions regarding the ownership, usage rights and management rights of public data. In addition, there is a lack of unified and standardized institutional arrangements for authorized operation and open sharing, which leads to a continuous increase in the cost of cross-departmental data collaboration. In practice, there are widespread circulation barriers in digital utilization, To be specific, a large amount of data resources are often misused or abused due to permission issues. Some data that could have been shared also have low utilization rates because of institutional barriers. Not only is it difficult to realize their value, but it also has a negative impact on the regional balanced development of digital governance. In some regions with relatively backward digital development, it is even difficult to keep up with the pace of digital governance. Of particular note is that the differences in the understanding of data ownership and the divergence in value judgments among different departments have further aggravated a deep-seated institutional obstacle for data integration.

4.3.3 The Weakness of Security

In the dimension of security and compliance, for one thing, The laws, regulations, and technological means for safeguarding data security are still imperfect. At present, incidents of the leakage of important data, significant research results and personal privacy occur from time to time, which gives rise to people's concerns about the security of data sharing and digital construction. Undoubtedly, this will impede the progress of digital construction. However, the laws, regulations and technological means for maintaining data security fail to impose restrictions on data leakage. Regarding data leakage incidents, the laws and regulations lack enforcement and effective punitive measures. Meanwhile, technological updates cannot effectively fill the loopholes in data leakage and promptly recover losses to the greatest extent. In particular, due to the limitations of technological development and data management mechanisms in border regions, data leakage incidents are often difficult to handle efficiently. Moreover, at the national level, there is also a lack of rules, regulations and technical guidelines for preventing data leakage.

For another thing, the governance system faces a structural tension between rigid constraints and innovation needs. There is an institutional contradiction between the principles of traceability and auditability followed in the management of sensitive data and the need for flexible data use in business innovation. Some units in practice fall into a negative cycle of "over-collection—over-protection—over-documentation", which not only squeezes the institutional space for governance innovation but also reveals a lag in the adaptation between technical protection capabilities and institutional norms. In special governance scenarios such as multi-ethnic border

regions, the security boundaries of cross-border data flow are even more blurred, and the governance complexity has increased significantly. Therefore, it is urgent to establish a precise data security governance mechanism with hierarchical and classified management.

4.3.4 The Weakness of the Regional Coordination Mechanism

The weakness of the regional coordination mechanism has become a key factor constraining the overall effectiveness of data governance. Currently, the construction of computing power network infrastructure and data factor markets shows an obvious regional fragmentation trend. There is a lack of unified technical standards, institutional norms, and organizational guarantee mechanisms for cross-regional data exchange and collaborative governance. When dealing with regional public issues, localities often adopt local governance strategies. There is a lack of institutionalized coordination channels and resource-sharing platforms, resulting in fragmented governance actions. Hence, it is difficult to form a coordinated governance force and achieve scale effect at the regional level.

4.4 Two Types of Frictions at the Collaborative Evolutionary Level

In the process of digital transformation, two types of critical frictions have emerged between the platform-driven new governance model and the traditional hierarchical bureaucracy, as well as between algorithmic power and public authority. These frictions have restricted the effective improvement of collaborative governance efficiency.

4.4.1 The Friction between Platforms and the Bureaucracy

The friction between platforms and the bureaucracy is mainly manifested in the asymmetry of power-responsibility allocation. Digital platforms possess the ability to integrate and dispatch across domains. However, the traditional segmented management system has not achieved effective docking in power-responsibility allocation. There is a lack of a consistent mapping mechanism among the list of responsibilities, process specifications, and data permissions. Although platforms have significant influence in the actual governance process, the corresponding boundaries of power and responsibility are blurred, and the accountability mechanism is incomplete. As a result, competition among departments prevails over systematic integration. In the process of promoting cross-departmental and cross-hierarchical collaboration, the costs of data sharing and business connection are high, and the attribution of responsibilities is unclear. Cross-domain governance often relies on ad-hoc coordination mechanisms, with insufficient institutionalization and standardization.

4.4.2 The Friction between Algorithms and Authority

The friction between algorithms and public authority is mainly reflected in the tension between the algorithmic black box and the principle of governance transparency. In key decision-making processes such as risk scoring, task assignment, and resource allocation, the technical algorithms relied upon generally lack transparency and interpretability. The parameter setting and weight distribution of judgment models are mostly dominated by technology suppliers. The mechanisms for public

participation and democratic consultation are underdeveloped. This not only leads to the replacement of administrative discretion by technical standards to some extent but also triggers public doubts about algorithmic bias and decision-making fairness. Meanwhile, due to the lack of a rights protection mechanism covering the entire process of "notification-explanation-appeal-correction" and an independent review procedure, the legitimacy basis of algorithmic decisions is weakened, which in turn affects the legitimacy of the governance system. This issue is particularly prominent in border multi-ethnic areas, where there is a structural tension between cultural diversity and the universal technical standards required by digital governance. Most current algorithm designs are based on the logic and cultural norms of the mainstream society and can hardly fully reflect the behavioral characteristics and cultural habits of ethnic minority groups. This further intensifies the conflict between algorithmic authority and local legal practices.

4.5 Four Weaknesses in System Resilience

From the perspective of complex system theory, X City has structural shortcomings in building system resilience, making it difficult to effectively address the unique governance challenges in border regions.

4.5.1 Insufficient Structural Resilience

The insufficient structural resilience is manifested in the instability of the multi-agent collaborative network. Specifically, in the current governance system, the power-responsibility relationships among multiple actors such as the government, society and enterprises remain unclear, and the collaboration mechanisms lack stability. The functional positioning of social organizations and professional social workers in digital co-governance is ambiguous, and they receive insufficient resource support. Furthermore, grassroots self-governance forces have not been fully empowered through the digital governance system. Particularly in border ethnic regions, there is an adaptability gap between the existing ethnic cultural traditions and social organizational forms and the standardized digital governance framework, which increases the difficulty of building an efficient governance community.

4.5.2 Insufficient Spatial Resilience

Although digital platforms have improved the efficiency of information flow, they have failed to achieve effective synergy among the physical space, social space and information space. To be specific, the risk monitoring capabilities in the physical space, the organizational mobilization capabilities in the social space and the data intelligence capabilities in the information space remain relatively fragmented. This insufficient spatial coupling results in breakpoints in the vertical chain between risk identification, early-warning monitoring and emergency response. When dealing with cross-border risks and public emergencies, the cross-spatial collaboration capabilities are significantly inadequate.

4.5.3 Insufficient Spatial Resilience

The weakness in process resilience is reflected in the imperfect closed-loop mechanism. In the governance process of "monitoring-assessment-response-evaluation", there is a widespread

phenomenon of "emphasizing response, neglecting evaluation and weak feedback". One-sided pursuit of response speed while ignoring process efficiency and knowledge accumulation makes it difficult to achieve continuous optimization of algorithm models and business processes. Moreover, in the face of the complexity, dynamics and uncertainty of social governance issues in border regions, the current mechanisms lack sufficient adaptability and learning ability, leaving grassroots units ill-equipped to handle complex challenges.

4.5.4 Insufficient Cultural Resilience

The weakest aspect is cultural resilience. Specifically, although digital platforms have strengthened information connections, they have achieved limited results in cultivating community identity, enhancing social trust, and shaping public spirit, which are crucial for promoting ethnic unity and integration. Especially in border areas where a large number of ethnic minorities reside, platform-based governance has not fully incorporated local knowledge and cultural diversity. Instead, it may, to some extent, weaken the role of traditional governance networks in uniting people of all ethnic groups. Simultaneously, the elderly and digital vulnerable groups face high participation barriers and have difficulty sharing the benefits of digital governance. Their marginalized situation further exacerbates the risk of cultural fragmentation in the digital age.

5. Discussion

Based on the systematic diagnosis of the three-dimensional framework of "element aggregation-collaborative evolution-system resilience", the implementation path for the digital economy platform in X City to empower social digital governance should be carried out around three dimensions: high-quality governance of data elements, collaborative evolution of multiple subjects, and optimization of the system resilience structure.

5.1 Element Aggregation: Strengthening Data Management and Utilization

5.1.1 Bridging the Gaps in the Digital Divide and Legal Deficiency

The regional, urban and rural disparities in digitization are an important constraint on the expansion of the scale of data, which can easily have a knock on negative impact on digital governance. For this reason, as a multi-ethnic frontier region, it should make good use of policy advantages. Specifically, simply seizing the policy advantages of digital China construction and tilting of funds and talents in border areas, it should accelerate the construction of regional digital economic platforms and digital governance frameworks. Meanwhile, relevant departments should actively learn from the development experience of advanced regions in digital governance and smart city construction and formulate their own development strategies in combination with regional realities. In addition, multi-ethnic border areas should take advantage of the opportunity of rural revitalization to increase financial investment in digital construction in rural areas and encourage excellent digital technical talents to work in rural areas,

accelerating the construction of urban-rural digital integration and breaking down the barriers to urban-rural digital sharing.

Furthermore, improving relevant laws and regulations is also crucial, so relevant departments should actively draft and promulgate relevant laws on data ownership division and security protection. From one perspective, this can provide legal protection against misuse and abuse of data and further enhance the effectiveness and accuracy of data utilization. From another perspective, the punitive power of the law can effectively combat the phenomenon of data theft by lawbreakers taking advantage of technological loopholes and deter potential lawbreakers, effectively curbing the risk of important data loss and privacy leakage. Besides, data related to digital social governance may be a matter of national security. In view of this, the government should invite digital technology experts to jointly formulate data security guidelines to provide relevant departments with guidance on data security management from a technical perspective and to effectively reduce losses from data leakage.

5.1.2 Quality Management and Construction of the Responsibility Chain

Establishing a comprehensive data sharing standard and quality responsibility system is the foundation for optimizing data quality. In this regard, the relevant government departments in charge of the operation of digital economy platforms should exercise their resource-integration functions. They need to integrate data standards from different departments and levels, unify the calibers, encoding, primary keys and time standards of core data items, and construct a comprehensive data framework with consistent calibers, semantics and logic. In addition, it is necessary to vigorously promote the Chief Data Officer (CDO) system in departments. Relevant departments should clearly define the specific responsibilities and functions in each link of data collection, sharing and other processes, forming a closed-loop of “quality-responsibility”. Ultimately, data quality management can be embed into the entire business process chain.

Moreover, strengthening the data traceability and auditing mechanism can achieve traceability of data from generation, circulation to application. Specifically, some technological means such as blockchain can be relied on, constructing an unalterable responsibility-chain log to ensure that every data operation can be traced, investigated and held accountable. Simultaneously, a data quality assessment and dynamic feedback model should be established and regular data health checks should be conducted, which can promote immediate early-warning and closed-loop rectification of problematic data and comprehensively improve data credibility and availability. In border areas with multiple ethnic groups, special attention should be paid to characteristic data such as language, culture and geography, and regional data governance specifications should be constructed.

5.1.3 Ensuring the Secure and Compliant Circulation of Data

Adhering to the principles of data categorization and data minimization can help establish an efficient and reliable data security circulation framework. The principle of data categorization requires

classifying data based on its importance and sensitivity. Meanwhile, the principle of data minimization emphasizes that only the necessary information should be involved in data processing, thereby reducing potential risks. Accordingly, different types of data，such as public data, sensitive data and core data, should be clearly distinguished and governed through differentiated security strategies. For instance, public data may be shared under appropriately relaxed conditions, while core data should be subject to strict access controls and encryption.

To enable secure and controlled data sharing, various privacy-enhancing technologies, including privacy-preserving computation, federated learning and secure multi-party computation, should be deployed in an integrated manner. These technologies can facilitate cross-institutional collaboration and analysis without exposing raw data, thus balancing the needs of data utilization and privacy protection.

Moreover, it is essential to establish a regional integrated data security operations center. Such a center would be responsible for continuous monitoring and incident response throughout the entire data lifecycle - from collection and storage to exchange and application. By combining automated tools and human intervention, the center can promptly identify and mitigate security threats, thereby strengthening overall defensive capabilities.

In response to the distinctive challenges of cross-border data flows in border regions, innovative mechanisms such as the “data passport” scheme should be explored. This would provide verifiable authorization credentials for cross-border data transfers. Additionally, adaptive control measures, such as geofencing technology to restrict data flows within designated areas and trigger-based desensitization that automatically masks sensitive information in case of anomalies, should be established. These approaches help ensure that data mobility continues to support economic development while safeguarding fundamental security boundaries.

5.1.4 Improving the Institutional Guarantee

Advancing the pilot initiatives for the registration and confirmation of public data rights should be prioritized in key sectors and typical scenarios. This will help explore feasible pathways for defining and registering public data property rights. Therefore, it is essential to thoroughly investigate how public data authorization mechanisms can be effectively linked with open data sharing systems. Clear definitions are needed regarding the scope, procedures and conditions for authorized data use, as well as the rules governing the transition from authorized operation to open sharing. Furthermore, the rights, obligations and responsibilities of all participants in the public data lifecycle, including data producers, processors, and users, must be clearly delineated. A sound incentive mechanism for benefit distribution should be established, with the core evaluation metric being the level of contribution to data value creation. This ensures that value creation and benefit returns are aligned during the market-based allocation of data elements. In promoting high-quality development of the digital economy, it is crucial

to balance both economic and social objectives. Policy tools and mechanisms should be scientifically designed and effectively implemented to channel the value generated by data elements back into public welfare.

Strengthening the coordinated development of cross-regional data factor markets is another critical step. Regional barriers must be dismantled to facilitate the establishment of unified and standardized regional data transaction standards, along with secure and trustworthy mutual recognition mechanisms for data circulation. Especially in border ethnic regions such as X City, it is important to leverage unique geographical advantages and actively lead or participate in constructing a regional framework for mutual recognition of data governance rules. Such a framework should address the frequent, complex and urgent needs of cross-border data flows. It ought to cover security assessments, risk early warning and emergency response mechanisms for cross-border data transfers. Consequently, by establishing regular cooperation mechanisms for risk identification, assessment and sharing, a solid and predictable institutional foundation can be provided. This will support deeper digital economic and trade cooperation with neighboring countries and regions.

5.2 Co-evolution Level: From Platform Dominance to Multi-governance and Algorithmic Checks and Balances

5.2.1 Reshaping Collaborative Mode

We should be committed to advancing the "Three-Lists-in-One" mechanism. Specifically, we will promote the integrated development of a "Three-Lists-in-One" mechanism by systematically mapping the problem list (covering public concerns and social contradictions), the process list (defining handling steps and decision-making pathways), the data list (linking information collection and analytical indicators) and the responsibility list (specifying departmental duties and individual accountability). This ensures that each issue is accurately linked to its corresponding procedure, data support, and responsible personnel, thereby establishing a closed-loop governance and accountability system of "issue-process-data-responsible agent". This structure significantly enhances the transparency and timeliness of problem resolution.

Furthermore, it is necessary to establish a digital protocol for cross-department collaboration. To be specific, a digital cooperation protocol should be developed to facilitate interdepartmental collaboration. By adopting smart contracts and shared platform technologies, data interfaces and approval procedures can be standardized. This reduces reliance on repetitive meetings and document circulation, cuts redundant administrative costs, and improves the effectiveness of multi-agency coordination across domains. As a result, resource allocation and decision-making responsiveness can be substantially optimized.

Of note, strengthening grassroots governance units through empowerment should be considered to promote. We will establish a trinity governance framework that integrates "grids (for zonal

responsibility) + social organizations (for professional service delivery) + social workers (for frontline implementation)". Through regular training and the downward allocation of resources, the governance capacity of grassroots units can be systematically enhanced. In ethnic border regions, emphasis should be placed on cultivating local social organizations such as cultural heritage groups and community mutual-aid associations. These should be supported through targeted policies and digital skills training, and integrated into a unified digital governance network. This approach improves regional adaptability and encourages broader participation. At the community level, digital interfaces, such as mobile applications and online feedback systems, should be deployed to enable residents to participate in governance process design, voting, and supervision in real time. This ensures transparent solicitation of public opinions and facilitates a shift in governance mode from mere "technology embedding" (instrumental application) toward genuine "value co-creation" (multi-stakeholder collaboration and shared outcomes). Ultimately, these measures will synergize governance effectiveness and social satisfaction.

5.2.2 The Institutionalization of Algorithm Governance

The Algorithmic Impact Assessment (AIA) and Social Impact Assessment (SIA) systems should be established to systematically regulate high risk algorithm application scenarios, covering key areas such as financial credit, employment recruitment and public safety. This system mandates the full lifecycle management of algorithms in high impact scenarios. Pre-assessment focuses on risk identification and model validation to ensure that algorithm design complies with ethical norms. During the operation, real-time data tracking and abnormal warning mechanisms are used for monitoring to promptly identify algorithmic biases or operational malfunctions. Post-audit involves reviewing the effects and tracing responsibilities, generating detailed assessment reports to guide optimization and improvement. Meanwhile, algorithm developers are required to comprehensively disclose key parameter boundaries (including feature weights and decision thresholds), basic logical frameworks (covering algorithm principles and input-output mapping relationships) and model version information (including update logs) to ensure the interpretability and regulatory compliance of the decision-making process and prevent the black box operation from misleading users or stakeholders.

An algorithmic rights protection mechanism of "notification-explanation-appeal-correction" should be constructed to fully safeguard the legitimate rights and interests of users. Specifically, before the execution of algorithmic decisions, a clear notification obligation should be fulfilled, providing affected individuals or groups with clear decision-making basis and its potential impacts. The explanation standard requires developers to interpret the algorithm logic and result causes in an understandable way to avoid the barrier of professional terms. An online platform and hotline service should be set up for the appeal channel, with a response time limit of 7 working days after the decision. The correction mechanism allows users to correct wrong decision results through automatic system or manual

intervention after raising objections. In addition, an independent third-party review mechanism should be established, entrusting professional institutions or supervision committees to conduct neutral reviews of controversial decisions to ensure the fairness and objectivity of the handling process.

Particular attention should be paid to the differential impacts of algorithms on ethnic minorities and vulnerable groups (such as low income people and the disabled). Potential discrimination risks should be identified and mitigated through targeted assessments and sensitivity tests. It is necessary to avoid the substantial bias under the guise of technological neutrality, emphasizing the inclusion of diverse representative samples in algorithm training data and setting up a bias monitoring indicator system to ensure that algorithm output results do not reinforce social structural inequalities or exacerbate marginalization problems.

5.2.3 Enhancing Digital Inclusion in Multi-ethic Areas

A “low-threshold, multi-channel” approach should be adopted to make digital services more inclusive. Specifically, for groups with limited digital access or skills, a dual-track service model combining human and digital interfaces should be systematically developed. While intelligent online services are promoted, offline service counters must be maintained as a basic safeguard to ensure no one is left behind. In the development of mobile applications, emphasis should be placed on interface simplification. Age-friendly adaptations, such as larger font sizes and voice-assisted navigation, should be widely implemented. In addition, specialized digital literacy training should be strengthened for older adults and ethnic minority populations in border regions. Training activities should be based on real-life scenarios and cover practical skills such as smart device operation, accessing government services, and recognizing and preventing online fraud.

Moreover, local knowledge into technology frameworks and service ecosystems should be comprehensively integrated in multi-ethnic regions. To be specific, particular efforts should be made to preserve and leverage local cultural elements such as ethnic languages, traditional crafts and indigenous knowledge. This can be supported by developing intelligent multilingual processing systems and accurate recognition mechanisms for cultural symbols, thereby promoting the digital preservation and transmission of cultural resources. In key areas of frontier development, such as smart agriculture and cross-border trade, locally formed industry norms and community practices should be fully respected and organically integrated into technical solutions. This ensures that technology interventions are aligned with the local socio-cultural context, effectively avoiding the issue that the technological means fail to adapt to regional cultures and promoting project relevance and sustainability.

5.2.4 Constructing a New Model of Regional Collaboration

Based on practical needs, diverse models of regional collaboration should be systematically explored and implemented. These include platform-based coordination, core enterprise-led collaboration and co-construction and sharing mechanisms. Such flexibility allows adaptation to different regions and

varying stages of development, thereby enhancing overall operational efficiency and regional competitiveness. To support these efforts, three key cross-domain mechanisms should be established and optimized: joint enforcement, joint evaluation and joint operations. These mechanisms will help ensure efficient coordination and seamless linkage across planning, implementation and supervision, facilitating the smooth execution of the overall strategy. Meanwhile, it is vital to improve the corresponding systems for benefit-sharing and risk allocation. This includes clearly defining the rights and responsibilities of all parties, designing a scientifically sound accountability distribution framework and establishing long-term incentive mechanisms. These steps, grounded in fairness and transparency, will help consolidate and deepen stable long-term strategic partnerships among stakeholders.

Given X City's unique position as a border area, policy priorities should focus on deepening dialogue and practical cooperation with neighboring countries. Key areas include coordinating digital economy governance rules, mutually recognizing standards for secure cross-border data flows and enhancing the interoperability of digital infrastructure. Concrete measures may include establishing regular high-level bilateral meetings, multi-level technical exchange platforms and specialized task forces for key issues. These mechanisms will help promote mutual recognition of technical standards, sharing of regulatory experience and complementary utilization of superior resources. Through these multi-level and multi-dimensional collaborative efforts, the ultimate goal is to jointly build a mutually beneficial "Digital Border Community". This framework will serve as an effective vehicle for advancing regional security, sustainable economic development and shared prosperity in a coordinated and efficient manner.

5.3 System Resilience: The Transformation of Adaptive Governance

5.3.1 Enhancing Structural Resilience: Building a Multi-Actor Emergency Cooperation Alliance

A collaborative alliance among government, social organizations and enterprises should be established to strengthen structural resilience. Clear roles and responsibilities for risk identification, resource allocation and crisis response must be defined. To illustrate, the government takes the lead in policy formulation and macro-level coordination; social organizations focus on community mobilization and volunteer services; and enterprises contribute technical expertise and material support. Additionally, a stable and efficient coordination network should be established, supported by real-time information-sharing systems based on cloud platforms and regular multilateral meetings. Meanwhile, standardized communication protocols will help ensure smooth information flow. Special emphasis should be placed on enhancing the mobilization capacity of social organizations. This can be achieved by developing volunteer databases and rapid response teams, while strengthening community self-governance as a buffer during crises. Encouraging resident participation in emergency drills and neighborhood mutual aid will further improve overall risk resilience.

5.3.2 Improving Spatial Resilience: Developing Digital Twin Communities

A "digital twin" system for communities or industrial parks should be established to enhance spatial resilience. This system integrates data from physical infrastructure (e.g., transport networks, energy supply and building structures), social organizational networks (e.g., population distribution and records of social organization activities) and information space governance activities (e.g., public event logs and social media dynamics). A coordinated "monitoring-simulation-response" process across these three spaces should be constructed, incorporating real-time sensor networks, AI-based predictive simulation and automated response mechanisms. This will improve the capacity to perceive and respond to complex risks in both time and space. For example, during extreme weather events, the system can quickly generate virtual scenarios and optimize evacuation routes, ensuring efficient deployment of resources.

5.3.3 Optimizing Process Resilience: Enabling Agile Governance through Four-Flow Coordination

Process resilience can be strengthened by aligning "event flow, data flow, decision flow and resource flow" within an agile governance framework. A closed-loop management process of "monitoring-analysis-response-evaluation-feedback-optimizatio" should be reinforced. Specifically, at the stage of monitoring, big data should be used to identify potential hazards; at the stage of analysis, multidisciplinary expert consultations should be organized, helping make feasible decision and enhance strategies' efficiency and professional; next, based previous adjustment and strategy, predefined contingency plans can be outlined and finally implemented; subsequently, after the problems have been addressed, an evaluation based on specific quantitative indicators needs to be carried out; in the process of feedback and optimization, the work of summarizing successful experiences and reflecting on deficiencies should be attached more importance, which plays a crucial role in refining and upgrading data system. In addition, emergency intervention mechanisms should be established to allow deviations from standard procedures during crises such as direct deployment of reserve supplies or activation of alternative command channels, ensuring flexibility and maximizing the efficiency of resource utilization.

5.3.4 Cultivating Cultural Resilience: Strengthening Social Cohesion through Narrative, Deliberation and Mutual Aid

Cultural resilience can be fostered by strengthening emotional bonds and social cohesion through community storytelling, deliberative negotiation and mutual-aid networks. To be specific, digital participation channels that incorporate ethnic cultural elements should be designed. For example, by developing multilingual community apps or virtual deliberation platforms, integrating local cultural features (such as traditional patterns or festival symbols) into digital interfaces can enhance cultural identity and social solidarity. In multi-ethnic regions, particular attention should be paid to building cross-cultural trust. Online cultural exchange activities and cross-cultural dialogue forums can be

organized to transform digital connectivity into cultural cohesion. For instance, shared narrative platforms can be used to document diverse community experiences, thereby strengthening the social capital underpinning digital collaborative governance and establishing a solid foundation for long-term resilience.

5.3.5 System and Method Innovation

To address the distinctive social governance and geographical characteristics of multi-ethnic border regions, innovations in digital systems and data application methods can be introduced to strengthen the systemic resilience of county-level digital economy platforms. Specifically, this system is built upon a complex systems theory framework and integrates two core technical approaches: System Dynamics (SD) and Agent-based Modeling (ABM). By combining the complementary strengths of SD in macro-level dynamic simulation and ABM in modeling micro-level agent interactions, a high-precision "digital twin" platform can be developed at the county level. This platform is designed to accurately map the structural and dynamic evolution of real-world county systems, incorporating detailed models of infrastructure networks, population distribution patterns and economic activity flows. It also simulates systemic responses, behavioral evolution paths and cascading effects under various extreme risk scenarios such as floods, earthquakes or disease outbreaks. Using this platform, multi-round and multi-scenario stress tests and simulation exercises can be conducted across different time scales and intensity levels. These can help to precisely identify potential vulnerability nodes - such as critical transport hubs or energy supply bottlenecks—as well as key systemic constraints. Based on these insights, targeted risk response plans can be formulated and optimized, including emergency evacuation route planning, rapid resource deployment mechanisms and personnel safety assurance protocols.

Building on this foundation, a specialized repository of contingency plans and a regular exercise mechanism should be established and continuously improved. This repository should include detailed operational procedures for critical scenarios such as natural disasters (e.g., snowstorms geological hazards and droughts) and sudden public safety incidents that include terrorist attacks or large-scale accidents. Furthermore, emphasis should be placed on risks that are frequent or unique to border regions. Hence, cross-departmental (e.g., emergency management, medical rescue, and public security), cross-level (county to provincial) and cross-jurisdictional coordination and joint training mechanisms should be strengthened. Regular tabletop exercises and field drills will help improve response efficiency. In addition, moderately redundant resource safeguards, such as emergency supplies (food, medical items, power generation equipment) and backup communication facilities (satellite communications, mobile base stations), should be deployed at key nodes like border posts or transport hubs. Alternative command centers and response channels, including multi-path information transmission and backup decision-making systems, should also be established. These measures can

help prevent systemic failure caused by single-point disruptions such as communication breakdowns or road damage and ensure both systemic resilience and functional continuity of the county system in extreme situations.

6. Conclusion and Future Directions

This study constructs a three-dimensional analytical framework of "element aggregation-collaborative evolution-system resilience" to systematically elucidate the internal mechanisms and underlying causes of obstructions in how the digital economy platforms in X City empower social digital governance. The findings reveal that the key challenges in county-level digital governance are not merely technical issues, but rather a systemic dilemma arising from the structural imbalance between data governance quality and scale expansion, institutional friction between platform logic and bureaucratic systems, and insufficient resilience in multi-stakeholder collaborative networks. The unique context of multi-ethnic border regions further amplifies these challenges, transforming technical adaptation issues into complex cultural-institutional adaptation problems.

The practice in X City demonstrates that addressing digital governance bottlenecks requires coordinated efforts across three dimensions: at the element aggregation level, it is essential to avoid a one-sided pursuit of data volume expansion and instead build a "trustworthy-usable-controllable" data governance ecosystem; at the collaborative evolution level, the challenges of algorithmic black boxes and asymmetric power-responsibility relationships must be addressed by establishing institutionalized platforms for multi-stakeholder co-governance; at the system resilience level, a shift from "rigid defense" to "adaptive governance" is needed, cultivating resilience across four dimensions: structure, space, procedure and culture. Only by achieving dynamic equilibrium among these three fundamental tensions (scale-quality-security, efficiency-equity and connection-solidarity) can digital technology be genuinely transformed into governance capacity.

Future research could advance along three directions: first, comparative multi-case analysis should be made to explore pattern differentiation and conditional constraints in digital governance practices across different types of counties; second, innovation in complex systems methodologies should be considered. System dynamics, multi-agent simulation and policy experimentation may be integrated to construct a circulation of "simulation-experimentation-evaluation" for digital governance; third, regional coordination mechanism innovation should be explored. We should systematically assess the institutional prerequisites and practical pathways for an integrated regional data factor market, thereby providing more inclusive border-region solutions for the development of Digital China. Through these explorations, China's county-level digital governance may achieve a remarkable progress from "tool embedding" to "system reconfiguration", offering Chinese wisdom for global border governance in the digital age.

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