

Article

A Study on the Logic and Pathways for Enhancing Public Service Quality in Haikou Against the Background of Digital Empowerment Driving Border Closure Operations

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Abstract: The launch of the full-island customs clearance operation at the Hainan Free Trade Port has ushered in a critical transition phase for Haikou's public service governance, shifting from a basic needs guarantee approach to one focused on optimizing services, mitigating risks, and promoting openness. As a central driver in reshaping the delivery of public services, digital technology offers new possibilities for addressing challenges such as population agglomeration pressures, the evolving structure of service demand, and the lag in transforming governance effectiveness within the context of customs clearance operations. This paper introduces the Digital Empowerment Theory into the context of customs clearance operations and constructs a four-tier analytical framework comprising data infrastructure, platform integration, scenario-based application, and smart decision-making. Based on official statistical data from Haikou City, the paper conducts a multi-dimensional assessment of the digitalization level of public services. The study finds that digital platforms such as HaiYiBan and HaiZhengTong have initially established a digital infrastructure for government services; however, challenges including cross-departmental data silos, the digital divide, fragmented scenario-based applications, and lagging effectiveness transformation continue to hinder the systematic improvement of public service quality. In light of these findings, this paper proposes an optimization pathway that involves coordinated efforts across three dimensions: data integration, scenario-driven approaches, and smart decision-making, aiming to provide theoretical insights and practical guidance for Haikou's development as a core pilot zone for the Hainan Free Trade Port.

Keywords: digital empowerment; public services; customs clearance; smart governance; hainan free trade port

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1. Introduction

On December 18, 2025, the full-island customs clearance operation for the Hainan Free Trade Port was officially launched, marking the transition of the Hainan Free Trade Port's development phase from a "transition period" to a "customs clearance phase." As the core pilot zone of the Free Trade Port, Haikou bears multiple responsibilities—including institutional opening-up, factor aggregation, and governance innovation. The implementation of the customs clearance operation represents not merely an adjustment in regulatory approach, but a systematic institutional reconfiguration encompassing the flow of multidimensional elements—such as trade, investment, personnel, capital, and data [1]. Against this backdrop, Haikou's public service system faces three converging pressures: first, increased total demand arising from nonlinear changes in population size and composition; second, evolving service demand structures driven by the influx of diverse stakeholders, including foreign professionals and international visitors; and third, elevated expectations for governance responsiveness and precision under the "first-line liberalization, second-line controlled management" framework. The traditional department-centered public service delivery model has revealed structural limitations—

such as delayed responsiveness, insufficient interdepartmental coordination, and slow adaptation of service outcomes—when addressing these dynamic and complex scenarios; therefore, there is an urgent need to leverage digital technologies to advance fundamental improvements in both service delivery mechanisms and governance logic.

Digital empowerment, as a central theme at the intersection of the new wave of technological advancement and governance evolution, offers novel theoretical perspectives and practical tools for enhancing the quality of public services [2]. Digital empowerment emphasizes reengineering public service delivery processes, decision-making mechanisms, and evaluation systems through the circulation of data as a factor of production, the integration of digital platforms, and the application of intelligent algorithms. This approach facilitates a transformation in service delivery—from being "experience-driven" to "data-driven," from "passive response" to "proactive forecasting," and from "fragmented provision" to "integrated collaboration." Introducing the digital empowerment framework into the context of customs clearance operations helps clarify the underlying digital logic guiding Haikou's public service sector during its transition toward open governance, identifies gaps and bottlenecks in digital governance capability, and establishes actionable pathways for optimization. The core contributions of this paper are as follows: First, it constructs a four-tier analytical framework—"Data Foundation – Platform Integration – Scenario Application – Smart Decision-Making"—to systematically elucidate the mechanisms through which digital empowerment supports improvements in public service quality; Second, based on official statistical data and policy documents from Haikou City, it conducts a multi-dimensional assessment of the digitalization level of public services during the initial phase of the customs clearance operation; Third, it proposes a synergistic optimization pathway encompassing three dimensions—data integration, scenario-driven approaches, and smart decision-making—providing a reference for Haikou's efforts to establish itself as a core leading zone within the Free Trade Port.

2. The Theoretical Logic and Analytical Framework for Enhancing Public Service Quality through Digital Empowerment

2.1. Theoretical Implications and Operational Mechanisms of Digital Empowerment

Digital Empowerment arises from the deep integration of digital technologies with governance requirements and can be understood across three interrelated dimensions: technology, organization, and value [1]. Technologically, it entails capabilities for data collection, integration, analysis, and visualization; by dismantling information barriers, it supports transparency and traceability across the full public service delivery cycle. Organizationally, it transforms collaborative relationships among government entities and shifts hierarchical structures toward platform-based, networked models. From a value standpoint, it prioritizes citizen needs—improving fairness, accessibility, and satisfaction in public services through precise demand identification, timely response, and iterative feedback mechanisms. In contexts requiring enhanced operational continuity, Digital Empowerment must address both longstanding efficiency constraints in public service delivery and evolving governance expectations—including openness, interoperability, and proactive risk management.

The mechanism through which digital empowerment enhances public service quality comprises four interlocking dimensions: cost reduction, efficiency enhancement, collaborative integration, and systemic adaptability [3]. First, digital platforms substantially lower institutional transaction costs as well as administrative burdens on businesses and citizens by simplifying information flows and eliminating redundant approvals and documentation. Second, intelligent approval systems, integrated online service platforms, and mobile government applications reduce service response times and elevate operational performance. Third, cross-departmental data sharing and coordinated business processes dissolve information fragmentation and functional segmentation, enabling unified, end-to-end service delivery. Fourth, analytics-driven capabilities for

early risk detection, demand anticipation, and responsive coordination strengthen the capacity of public service systems to maintain functionality under dynamic conditions – supporting seamless transitions between routine operations and heightened operational modes.

2.2. "Data – Platform – Scenario – Decision" Four-Tier Analytical Framework

Building upon the integration of Digital Empowerment Theory and the New Public Service Theory, this study constructs a four-tier analytical framework—comprising "Data Infrastructure – Platform Integration – Scenario Application – Smart Decision-Making"—to elucidate how digital technologies drive the improvement of public service quality in Haikou under the relevant policy context [4]. As depicted in Figure 1, this framework takes the policy implementation as an external input and the enhancement of public service quality as the ultimate output, thereby establishing a closed-loop process of "Perception – Response – Execution – Optimization" across the four tiers.

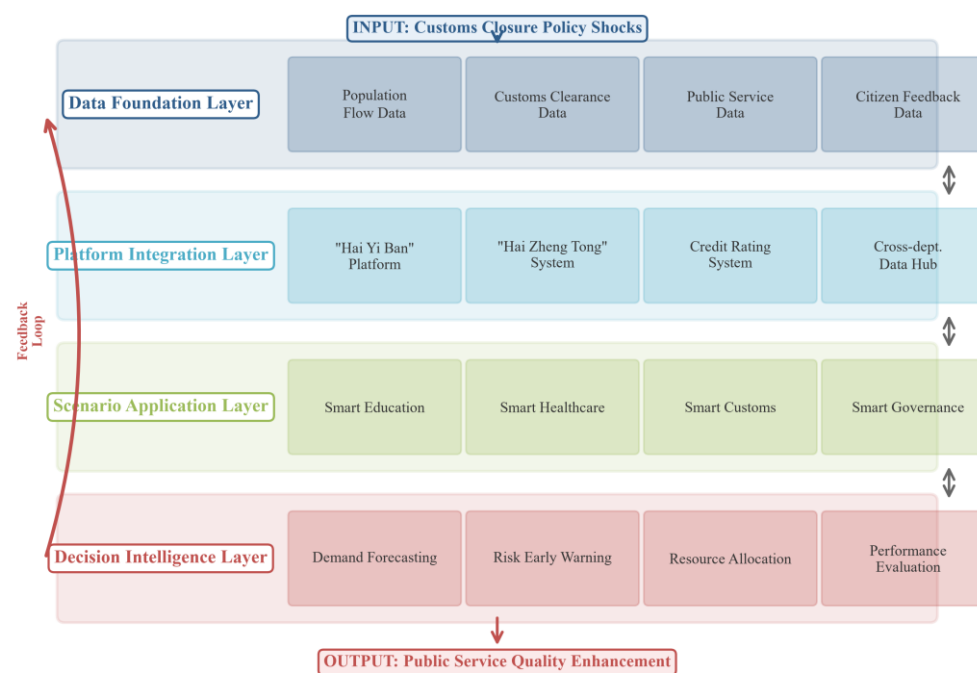


Figure 1. A Four-Tier Analytical Framework for Enhancing Public Service Quality through Digital Empowerment

From a logical perspective, the four layers form a progressive structure encompassing "technical infrastructure support – platform-mediated transformation – scenario-based value realization – continuous decision-making optimization." The Data Infrastructure Layer provides the entire system with informational raw materials, serving as the material foundation for digital empowerment; the Platform Integration Layer, through unified standards and interfaces, transforms disparate data resources into readily available service capabilities; the Scenario Application Layer directly serves the public and enterprises, demonstrating the tangible value of digital empowerment; and the Smart Decision-Making Layer leverages intelligent algorithms to advance governance efforts and enable precise decision-making, thereby creating a feedback loop that reinforces digital empowerment. It is important to note that the relationship between these four layers is not strictly linear or sequential; rather, they are dynamically coupled through data flows, business flows, and feedback loops, supporting the continuous improvement of public service quality [4].

The Data Infrastructure Layer serves as the material foundation for digital empowerment; by integrating multi-source data—including population mobility,

customs clearance and logistics data, public services, and citizen feedback—it provides the informational support necessary for subsequent analysis and decision-making. The Platform Integration Layer acts as the technical vehicle for digital empowerment; platforms such as "Haiyiban" and "Haizhengtong" leverage unified identity authentication, standardized data formats, and a centralized service portal to facilitate the transformation of government services from a model of "multiple visits" to a model of "one-stop online service." The Scenario Application Layer represents the phase where the value of digital empowerment is realized; it encompasses specific application scenarios—including smart education, smart healthcare, smart customs clearance, and smart governance—and directly delivers digital services to businesses and citizens. The Smart Decision-Making Layer constitutes the advanced manifestation of digital empowerment; through demand forecasting, risk early warning, resource allocation, and performance evaluation, it drives the shift in public service delivery from a "post-event remediation" approach to a "pre-event predictive" approach [5]. These four layers do not follow a linear, progressive sequence but are continuously optimized through a feedback loop, thereby forming a dynamically evolving digital governance ecosystem.

3. Assessment of the Current State of Public Service Digitization in Haikou Against the Background of Customs-Related Operational Frameworks

3.1. Achievements in the Construction of the Digital Government Service Platform

In recent years, Haikou City has steadily advanced its digital government initiative, establishing a digital government service platform system centered around the "HaiYiban" and "HaiZhengTong" platforms. According to official statistical data and information related to customs clearance operations in the Hainan Free Trade Port, by 2025, the online accessibility rate of municipal-level government service items in Haikou had increased significantly; registered users on the "HaiYiban" platform continued to grow, and government services showed a clear shift from desktop-based to mobile-based delivery [6]. In particular, in June 2026, the "Customs Clearance Operations Special Zone" was officially launched on the "HaiYiban" platform, integrating core customs clearance services—including the "Second-Line Island Exit Nuclear Release List Application"—into the mobile service portal, enabling a seamless "one-mobile-phone customs clearance experience." This milestone reflects Haikou's transition in public service digitalization from "window-based services" to "mobile-based services."

Regarding cross-departmental coordination, authorities including Customs, Market Supervision, Taxation, and Human Resources and Social Security have achieved initial data sharing and operational alignment through the Smart Regulatory Platform [4]. The Customs system applies a three-pronged approach—"intelligent document review," "preliminary automated inspection," and "risk assessment"—to precisely identify high-risk shipments while expediting the release of low-risk goods; over 100,000 foreign trade entities have been incorporated into a credit-based classification and tiered clearance management framework, allowing enterprises with strong integrity records to access streamlined customs clearance procedures. These digital initiatives support the balanced advancement of administrative efficiency and regulatory effectiveness, providing a robust technical foundation for the initial phase of customs clearance operations.

3.2. Progress on Digital Application Implementation in Key Areas

In the education sector, Haikou City has leveraged its Smart Education Platform to promote the digital sharing of educational resources; the coverage rate of digital teaching equipment in regular primary and secondary schools has been steadily increasing, while applications such as online education and smart classrooms have played a supplementary role amid growing demographic pressures on the school-age population. In the healthcare sector, applications including telemedicine, electronic health records, and internet-based hospitals have been gradually rolled out, laying a solid foundation for improving medical service accessibility and efficiency. In the social security sector, the digital transformation of social insurance administration services has been steadily advanced, enabling

networked management of enrollment data for various insurance schemes—such as the Basic Pension Insurance for Urban Employees, Work-Related Injury Insurance, and Unemployment Insurance [2]. In the port services sector, the smart customs clearance system has significantly reduced clearance time for imported and exported goods, thereby enhancing the efficiency of passenger and cargo flow at ports.

It is important to note that the depth and breadth of digital adoption across these sectors are not evenly distributed. The fields of public administration and customs clearance have seen relatively rapid advancement, driven by operational requirements for efficiency and standardization; in contrast, the sectors of education, healthcare, and social security remain largely focused on expanding infrastructure coverage and building foundational information systems; meanwhile, intelligent applications, data-driven precision services, and cross-departmental collaboration are still in their early stages. This imbalance represents both a current limitation in digital empowerment and a clear indication of priority directions for the future digital transformation of public services [7].

3.3. Measurement of Public Service Digitalization Level

To systematically assess the level of digitalization of public services in Haikou during the initial phase of its customs clearance optimization, this study draws upon established digital governance maturity assessment frameworks and constructs a Digital Maturity Index across six dimensions—government services, education services, medical services, social security, transportation services, and customs clearance services—with the index ranging from 0 to 100. As shown in Figure 2, the digital maturity scores for Haikou's government services and customs clearance services in 2025 were relatively high, at 78 points and 82 points, respectively, reflecting the significant achievements of the "HaiYiban" platform and the development of the Smart Customs initiative; however, the digital maturity scores for education services, medical services, and social security stood at 55 points, 48 points, and 62 points, respectively—still falling within the lower-middle range, indicating considerable room for improvement in the digitalization of public service equalization and universal access initiatives.

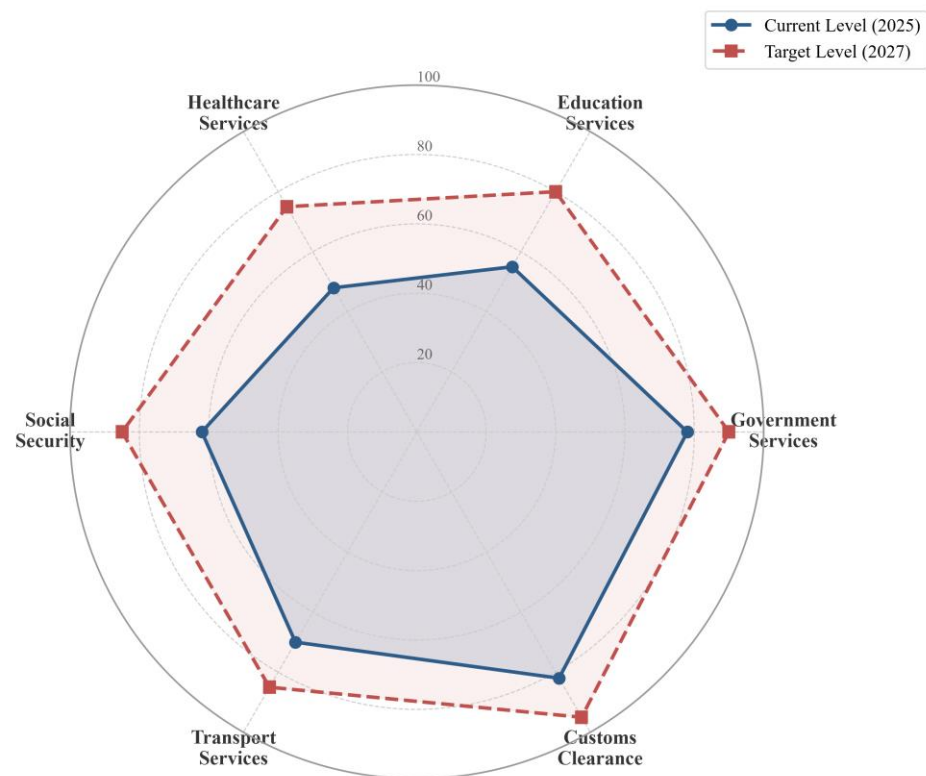


Figure 2. Digital Maturity Index of Public Service Domains in Haikou (2025)

As shown in Figure 3, a comparative analysis of the period before and after the customs clearance adjustment reveals that Haikou’s public service digital service capabilities have experienced rapid growth across multiple key indicators. The number of online government service items increased from 1,200 in 2024 to 3,500 during 2025–2026, representing a growth of approximately 192%; the number of mobile government service users rose from 850,000 to 2,100,000, an increase of about 147%; the cross-departmental data sharing rate climbed from 45% to 78%, up by 73%; the integration rate of the Smart Education Platform grew from 35% to 68%, a rise of 94%; and the remote healthcare coverage rate expanded from 28% to 55%, an increase of 96%. These figures demonstrate that the implementation of the customs clearance adjustment has accelerated Haikou’s digital transformation of its public services, and digital empowerment is emerging as a key driver in enhancing the quality of public services [8].

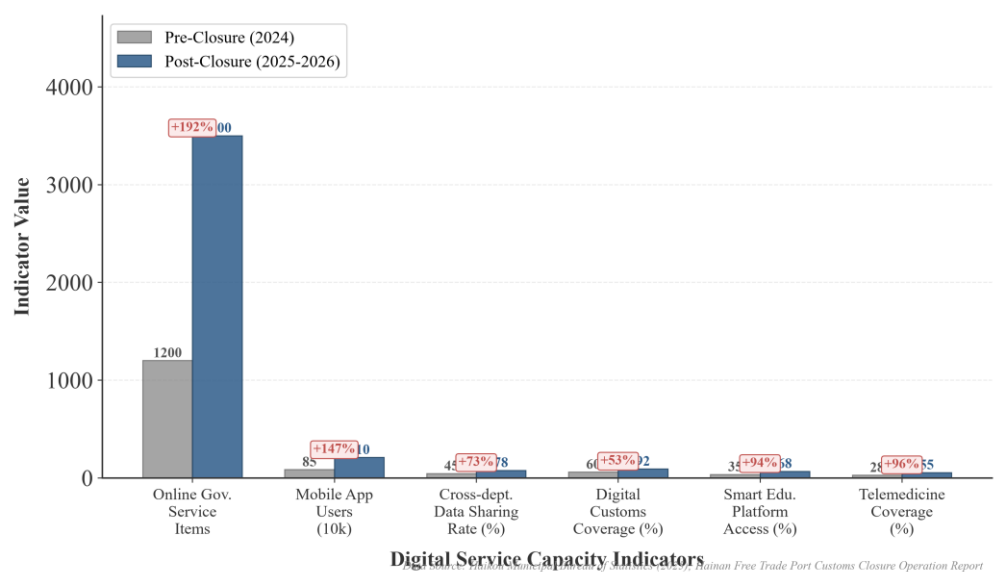


Figure 3. Comparison of Digital Service Capacity Before and After Customs Closure

From an international comparative perspective, as shown in Figure 4, Haikou still lags significantly behind mature free ports such as Singapore, Hong Kong, China, and Dubai in terms of digital governance maturity and public service quality. In 2025, Haikou’s Digital Governance Maturity Index stands at approximately 55, and its Public Service Quality Index is around 62, placing it within the "low maturity–low to moderate quality" range; in contrast, both Singapore and Hong Kong, China have digital maturity indices exceeding 88 and public service quality indices above 85, positioning them within the "high maturity–high quality" range. This indicates that Haikou still has considerable room to catch up in terms of digital empowerment of public services, while also suggesting that enhancing public service quality through digital transformation holds significant potential and feasibility [5].

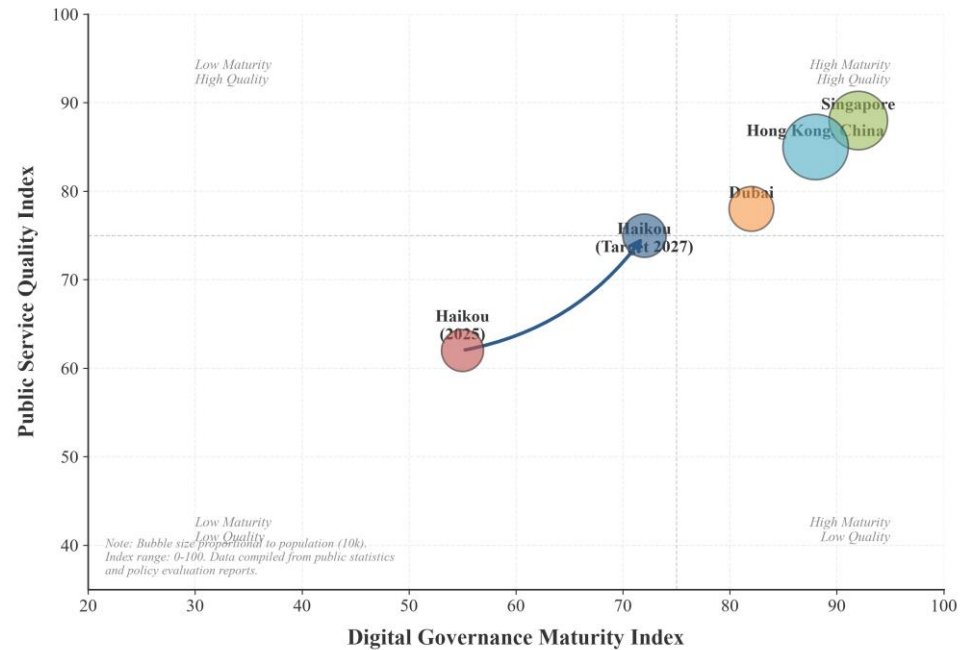


Figure 4. International Comparison of Digital Governance Maturity and Public Service Quality

4. Identifying Bottlenecks in Digital Empowerment within the Context of Customs Clearance Operations

4.1. Cross-Departmental Data Barriers and Collaboration Gaps

Although Haikou City has established digital platforms such as "HaiYiban" and "HaiZhengTong," cross-departmental data silos remain a core bottleneck hindering the effectiveness of digital empowerment. On one hand, data standards, interface specifications, and security requirements across departments—including public security, statistics, education, healthcare, human resources and social security, and customs—have not yet been fully harmonized; this results in limited data sharing scope and insufficient real-time capability, making it difficult to establish a comprehensive data foundation that covers population mobility, service demand, and resource allocation. On the other hand, departmental fragmentation and unclear delineation of data governance responsibilities have led to the persistence of "data silos," preventing the full realization of synergistic effects at the platform integration layer. In the context of tightly coordinated operational environments, the movement of people, goods, and capital imposes higher demands on real-time data sharing and cross-departmental collaboration; consequently, these data barriers directly undermine the responsiveness and accuracy of public services.

From a technical standpoint, issues such as non-uniform data interfaces, the absence of metadata standards, and varying data quality levels increase the cost and complexity of system integration; from an institutional perspective, incentive mechanisms for data sharing are inadequate—data-providing entities often bear significant security responsibilities and operational maintenance costs yet receive limited corresponding benefits or recognition, which reduces their motivation to share data. This challenge—characterized by low willingness, hesitation, and practical constraints in data sharing—has become a key barrier hindering the enhancement of public service quality through digital empowerment.

4.2. Digital Divide and Inclusive Development Challenges

The digital divide poses a significant challenge to fairness in the application of digital technologies for public service enhancement [9]. Among Haikou's permanent resident population, elderly individuals, rural residents, and low-income groups generally exhibit lower digital literacy; overreliance on online service channels risks excluding these populations from accessing digital public services. Additionally, considerations raised by

foreign nationals—including language accessibility of government service platforms, interoperability of identity authentication systems, and regulatory alignment for cross-border data transfers—require that digital public service transformation uphold both efficiency and inclusivity. Since adjustments to international travel policies, the demographic profile of public service users has diversified; without targeted measures to narrow the digital divide, disparities in service access may widen, compromising the equity and universal accessibility of public services.

4.3. Fragmented Scenario-Based Applications and Lagging Efficiency Transformation

The current digital transformation of public services in Haikou exhibits isolated advances and sectoral fragmentation. Although initiatives such as smart education, smart healthcare, and intelligent customs clearance have achieved measurable progress individually, the lack of a unified service portal, standardized data protocols, and a consistent evaluation framework impedes cross-sectoral integration and synergistic outcomes. From an efficiency standpoint, several digital projects remain at the technology deployment or platform construction stage, without fully translating into concrete enhancements in administrative convenience or improved service satisfaction for enterprises and residents. Moreover, limited digital proficiency among frontline public service staff—coupled with inadequate embedding of digital tools into routine operational workflows—has widened the gap between technological investment and governance performance.

Specifically, smart education platforms primarily support internal teaching management functions but show insufficient linkage with public-facing needs such as enrollment processing and real-time alerts on degree program availability; in healthcare, telemedicine coverage remains narrow, and institutional mechanisms—including medical insurance reimbursement and cross-regional healthcare payment arrangements—have not yet been comprehensively harmonized; in social security, digital applications are largely restricted to information inquiry and transactional payments, while capabilities for intelligent service matching and precision policy delivery remain underdeveloped. This fragmented implementation landscape constrains systemic coordination through digital means and diminishes the perceived value of digital public services among the general population.

4.4. Risk Prevention and Control & Data Security Challenges

In the context of customs clearance-enabled operations, cross-border data exchanges, the collection of information concerning foreign individuals, and the centralized management of sensitive public service data have intensified demands on data security and privacy protection. On one hand, the 'frontline liberalization' policy facilitates broader cross-border data exchanges; however, regulatory mechanisms—including those for security evaluations of overseas data transfers and personal information protection—remain under development. On the other hand, the capability to prevent and respond to cybersecurity threats on public service platforms requires enhancement. Balancing efficient data circulation with robust security safeguards remains a pivotal challenge in the digital transformation of public services.

5. Optimal Pathways for Enhancing the Quality of Public Services through Digital Empowerment

Building on the theoretical framework of digital empowerment and the analysis of the current status and constraints in the digital transformation of public services in Haikou, this paper proposes an optimization pathway that integrates data unification, scenario-oriented implementation, and intelligent decision support to advance Haikou's public services from basic digitalization toward a digital-intelligent paradigm [10].

5.1. Data Integration: Building a Digital Infrastructure for Public Services

To overcome cross-departmental data barriers, it is essential first to establish unified data standards, data-sharing mechanisms, and a clear delineation of responsibilities and

authorities. It is recommended to leverage the "Haizhengtong" platform as a foundation to build a Haikou Municipal Public Service Data Middle Platform, integrating core data resources—including those related to population mobility, education, healthcare, social security, transportation, and customs—to create a dynamically updated public service data map. Secondly, incentive and restraint mechanisms for data sharing should be strengthened by incorporating data sharing into departmental performance evaluations, thereby facilitating a shift from "passive sharing" to "active sharing." Thirdly, a framework combining a negative list with security assessment for international data flow should be explored and established to enhance the efficiency of data circulation for services supporting foreign nationals, while ensuring data security. Finally, data quality management should be reinforced by establishing a full lifecycle management mechanism covering data collection, cleansing, updating, and utilization, ensuring the authenticity, completeness, and timeliness of the data [11].

Building upon data interoperability, efforts should be accelerated to transform data as a factor of production into tangible service capabilities [2]. On one hand, a unified public service data catalog and open data list should be established to clearly define the scope of data that can be shared, made available, or protected; on the other hand, mechanisms for authorized data utilization and market-oriented data development should be explored to unlock the economic and social value of data as a factor of production, while safeguarding public interests. By constructing a data value chain encompassing "aggregation – governance – sharing – application," a solid foundation for leveraging digital technologies to enhance public services can be established.

5.2. Scenario-Driven Approach: Building a "One-Stop Online Service" Ecosystem

To address the issue of fragmented scenario-based applications, the public service scenario framework should be restructured with a focus on the full lifecycle needs of both enterprises and citizens. First, deepen the functionality of the "HaiYiban" platform by integrating high-frequency services—such as school enrollment, healthcare insurance, social security inquiries, employment services, and foreign-related government affairs—into a single unified portal, enabling "single-point application and one-stop online service." Second, promote the age-friendly and internationalization of public services by providing multilingual support, simplifying operational procedures, and maintaining offline service channels to bridge the digital divide. Third, develop specialized application scenarios—including a "Foreign Nationals Service Zone," a "Cross-Border Medical Services Zone," and an "International School Enrollment Service Zone"—to enhance the convenience of foreign-related public services. Fourth, establish a user evaluation and feedback mechanism, using satisfaction data as a key basis for scenario optimization and creating a "Service-Evaluation-Improvement" closed-loop system.

The key to scenario-driven approaches lies in integrating service resources in a demand-oriented manner. It is recommended to establish a digital profiling system featuring "one profile per individual" and "one profile per enterprise," leveraging user attributes and behavioral data to deliver targeted service information, thereby shifting the paradigm from "people seeking services" to "services finding people." Additionally, it is essential to drive business process reengineering across sectors such as education, healthcare, and social security, using specific use cases to facilitate data sharing and interdepartmental collaboration, break down siloed operations, and create an integrated service experience tailored for the public [12].

5.3. Smart Decision-Making: Establishing a "City Brain" Decision-Making Hub

Smart decision-making represents an advanced form of digital empowerment and serves as a key lever for enhancing the quality of public services. It is recommended that Haikou leverage its existing digital platforms to develop a "Sealed-Operation City Brain"—an initiative that integrates real-time data streams from areas such as customs clearance, transportation and logistics, public service feedback, and population mobility to establish a digital twin platform for resilient governance. First, a population mobility and service demand forecasting model should be developed to identify supply-demand

gaps in sectors—including education, healthcare, and transportation—based on historical data and real-time monitoring, thereby enabling proactive resource allocation before demand arises. Second, a risk early-warning and adaptive response system should be established; this would involve creating tiered response protocols tailored to low-probability, high-impact scenarios—such as peak passenger flows at customs checkpoints or cross-regional public health events—to strengthen the city's ability to transition smoothly between routine and non-routine operations. Third, a public service performance evaluation and resource allocation optimization model should be implemented to direct fiscal investments, staffing allocations, and infrastructure development toward sectors with the most urgent needs and the most significant gaps, thereby achieving targeted and precise delivery of public services.

The implementation of intelligent decision-making requires the synergistic support of algorithms, data, and institutional frameworks [13]. At the technological level, it is essential to actively integrate technologies such as machine learning, knowledge graphs, and natural language processing to enhance the accuracy of demand forecasting and risk identification; at the institutional level, transparency and accountability mechanisms for algorithmic decision-making should be established to ensure that intelligent decision outcomes are interpretable, traceable, and subject to oversight; at the organizational level, organizations should cultivate versatile professionals who possess both data literacy and domain expertise, thereby facilitating the transformation of intelligent decision-making from a mere "technical tool" to a "governance approach."

5.4. Institutional Safeguards: Refining the Digital Governance Framework

The effective implementation of digital empowerment relies on robust institutional safeguards. First, it is essential to strengthen the legal framework for digital government development by clarifying rights related to data ownership, usage, and revenue generation, thereby providing a legal basis for cross-departmental data sharing and international data transfers [2, 10]. Second, a standardized system for digital public services should be established to unify service processes, data formats, interface specifications, and security requirements, enhancing system compatibility and scalability. Third, efforts should be made to cultivate digital talent through training programs, recruitment initiatives, and collaborative partnerships to elevate the digital literacy of grassroots officials and public service personnel. Fourth, data security and privacy protection mechanisms should be implemented, including enforcement of the Cybersecurity Multi-Level Protection Scheme (MLPS) and refinement of personal information protection and data transfer security assessment procedures, ensuring the security baseline for digital governance.

6. Conclusion and Future Directions

This study's theoretical contribution lies in introducing "closed-off governance operations" as a key institutional variable into the analytical framework for examining digital empowerment and public service quality, thereby clarifying the logic of action and contextual conditions that shape the role of digital technologies in advancing open governance. At the practical level, the findings offer actionable guidance for Haikou to optimize its digital government service platform, bridge the digital divide, and improve the convenience of foreign-related public services. Due to limitations in data availability, this study does not incorporate micro-level survey data or satisfaction assessments from enterprises and residents; thus, quantitative evaluation of digital empowerment effects remains an area for refinement. Future research could integrate questionnaire surveys, in-depth interviews, and econometric analysis to examine the causal relationship between digital empowerment and public service quality improvement, and to investigate how digital empowerment mechanisms vary across distinct governance contexts.

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