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National Data Center Innovation Strategy To Build Sustainable Big Data Governance In Indonesia

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Abstract: National Data Center Innovation Strategy to Build Sustainable Big Data Governance in Indonesia. Indonesia's digital transformation is accelerated through the establishment of the National Data Center as the core infrastructure for integrated government data management. This study aims to analyze innovation strategies required to build sustainable big data governance in Indonesia. The research object focuses on policy frameworks and implementation mechanisms of the National Data Center in supporting cross-agency data integration. A qualitative descriptive approach was employed through policy document analysis and literature review on data governance and cybersecurity. The findings indicate that national data center consolidation enhances interoperability, improves public service efficiency, and supports data-driven decision-making. However, major challenges include limited digital human resources, budget constraints, and cybersecurity vulnerabilities. Recommended strategies involve strengthening human resource capacity, reforming regulatory governance, implementing comprehensive risk and crisis management, and reinforcing data security architecture. Effective and sustainable integration of the National Data Center is essential to achieve accurate, transparent, and adaptive public services in the era of big data.

Keywords: National Data Center, big data, cybersecurity, One Data Indonesia, digital transformation, human resources.

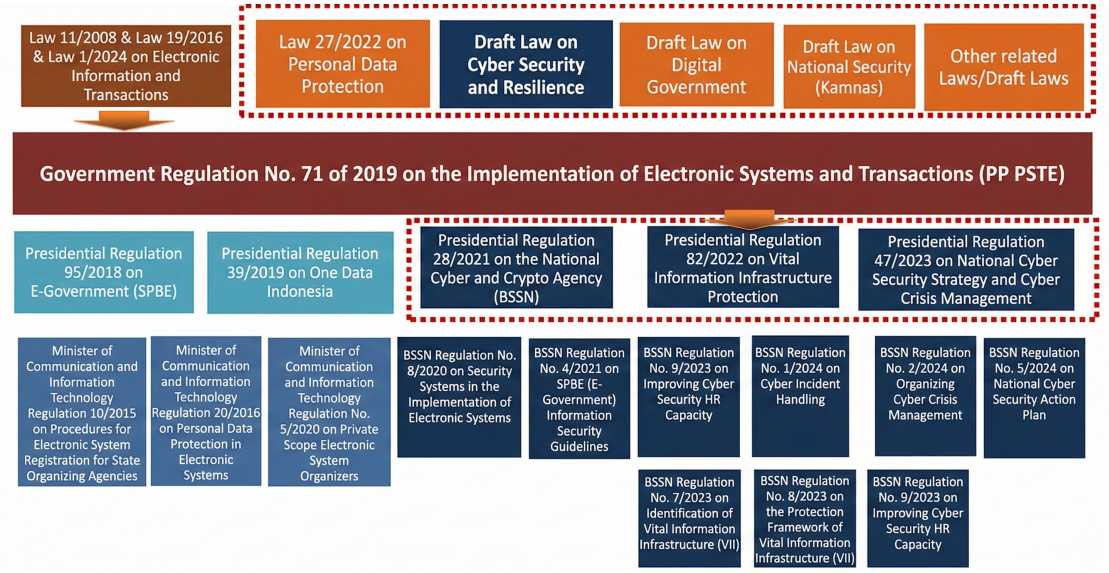
INTRODUCTION

The rapid advancement of the digital era has positioned data as a strategic resource comparable in importance to conventional resources such as energy and capital. Amid the growing complexity of governmental systems and increasing public demands for transparency and efficient public services, big data has emerged as a critical instrument for realizing evidence-based policymaking. The Government of Indonesia has responded to this need by establishing the National Data Center as one of the principal pillars of the Electronic-Based Government System (Iqbal et al., 2025). The National Data Center is expected to address data fragmentation across governmental institutions while fostering system

integration and interoperability throughout public sector administration. Nevertheless, its implementation continues to face substantial challenges related to sustainable big data governance, including infrastructure limitations, insufficient human resource capacity, budgetary constraints, and innovation strategies that remain fragmented and have yet to be institutionalized systematically.

The development of information and communication technology has significantly transformed the manner in which governments interact with citizens. Beyond enhancing public service efficiency, these technological advancements enable large-scale data collection and analytics (Octaria et al., 2024). This transformation has been reinforced through several presidential regulations supporting Indonesia's digital transition, including Presidential Regulation Number 95 of 2018 on Electronic-Based Government Systems, Presidential Regulation Number 39 of 2019 on One Data Indonesia, and Presidential Regulation Number 132 of 2022. Collectively, these regulatory frameworks provide comprehensive guidance on data and information governance, including the mandate assigned to the Ministry of Communication and Informatics to manage the National Data Center as the central infrastructure for big data governance in Indonesia.

Presidential Regulation Number 95 of 2018 underscores the strategic role of electronic-based governance in strengthening transparency and governmental accountability. Specific provisions within this regulation emphasize the necessity of developing technological infrastructure that supports inter-agency data integration. Meanwhile, Presidential Regulation Number 39 of 2019 affirms the importance of a unified data framework as a foundation for data-driven decision-making. This principle is increasingly relevant in the big data era, where integrated datasets generate more comprehensive insights for public policy formulation. Furthermore, Presidential Regulation Number 132 of 2022 reinforces the institutional position of the National Data Center in managing strategic data assets, thereby facilitating more timely and accurate decision-making processes within government administration.



Source: Government Regulation No. 71 of 2019

Figure 1. Government Regulation

The Directorate of Government Application Informatics Services, operating under the Directorate General of Informatics Applications, is mandated to administer the National Data Center. An interim National Data Center program was initiated in 2020, with full physical development targeted for operation by 2025. At this stage, it is essential to examine how the National Data Center can function as a sustainable hub for big data governance in Indonesia.

According to data from Statistics Indonesia, the volume of data generated nationally is projected to increase by approximately 30 percent annually, underscoring the urgency of establishing effective and efficient data management systems (BPS, 2021).

Through the National Data Center, Indonesia's digital infrastructure and data governance architecture are expected to be strengthened, particularly in terms of data consolidation, national data management, and interoperability. Its establishment is anticipated to accelerate the realization of accurate, integrated, and accessible public services, while reinforcing the implementation of a unified national data framework. Furthermore, within the fifth directive of digital transformation, emphasis on completing primary legislation supporting the digital ecosystem, including the Personal Data Protection Bill and regulatory reforms in telecommunications and broadcasting, is expected to accelerate digitalization across sectors, including national broadcasting (Octaria et al., 2024). Consequently, the integration of government public services through national digitalization is approaching realization, supported by robust data infrastructure and adequate regulatory frameworks.

Empirical developments indicate that although the National Data Center infrastructure has been gradually developed, its sustainability remains uncertain. Numerous public sector information systems continue to operate in silos, lacking comprehensive integration and exhibiting dependency on foreign technology vendors. Simultaneously, data governance practices across ministries, agencies, and regional governments are not yet matched by adequate analytical and technical human resource capacities (Manaek et al., 2023). As a result, data that should function as a strategic asset has not been optimally utilized to formulate effective, efficient, and adaptive public policies. This condition suggests that sustainable big data governance in Indonesia extends beyond technological infrastructure and is closely tied to institutional innovation strategies implemented by data-managing entities, including the National Data Center (Basyo & Anirwan, 2023).

The sustainability of the National Data Center is inseparable from the quality of its human resources and the institutional environment in which they operate. One of the most persistent structural constraints within government institutions is the lengthy and bureaucratic recruitment and selection process, which reduces their capacity to attract highly qualified digital talent. In the highly competitive field of information technology, delayed hiring procedures often result in skilled candidates opting for private-sector opportunities that offer more agile and flexible mechanisms. This structural mismatch generates a recurring gap between institutional demand and the availability of competent professionals in data management, cybersecurity, and digital infrastructure. The challenge is further compounded by the limited availability of structured training and career development programs. Although cloud computing, big data analytics, and artificial intelligence have become integral to contemporary data governance, many public sector personnel have not received systematic capacity-building interventions. Without sustained investment in professional development, the adoption of advanced technologies risks becoming symbolic rather than transformative, thereby constraining the overall effectiveness of data center governance.

Regulatory rigidity further reinforces these institutional bottlenecks. Procurement frameworks governing public goods and services often restrict collaboration with universities, research institutions, and private-sector technology firms in delivering specialized training or knowledge transfer programs. Consequently, access to cutting-edge expertise and adaptive learning ecosystems remains limited. This condition illustrates that sustainable big data governance is not merely a technological issue but a matter of institutional design and regulatory reform. In the absence of flexible and innovation-oriented governance arrangements, even substantial infrastructure investments may fail to yield optimal outcomes. The urgency of reform is underscored by empirical evidence indicating that only around 30 percent of public sector employees possess adequate digital competencies

to respond to current technological demands. Such data signal the need for a comprehensive human capital strategy aligned with long-term digital transformation objectives.

Simultaneously, Indonesia's experience with cybersecurity incidents, including the major breach affecting the National Data Center in 2024, demonstrates that infrastructure without resilient governance and skilled personnel exposes systemic vulnerabilities (Sumarno et al., 2024). These events highlight the interdependence between technological sophistication, human competence, and regulatory coherence. Within the broader paradigm of Industry 4.0 and the societal vision of Society 5.0, technological advancement is envisioned not as an end in itself but as an integrated ecosystem combining artificial intelligence, the Internet of Things, data science, and big data analytics to enhance societal problem-solving capacity (Lombardi et al., 2021). Therefore, the transformation of national data governance requires harmonization between digital infrastructure, institutional innovation, and human capability development.

In this regard, innovation strategy emerges as the conceptual bridge linking these dimensions. Innovation strategy can be understood as a systematic organizational approach to creating and implementing value-generating improvements in processes, services, and governance models. Within the public sector, it transcends technological upgrades by encompassing new policy mechanisms, procedural simplification, service enhancement, and optimized resource utilization (Rahman Hakim, 2023). Contemporary governance theory positions innovation strategy not as a supplementary initiative but as a core pillar of adaptive, inclusive, and sustainable administration (Gunawan et al., 2021). From a theoretical standpoint, innovation originates from the recombination and enhancement of existing practices to generate added value, whether economic or social. It may be stimulated by stakeholder aspirations, organizational feedback, or environmental dynamics, and may manifest in radical or incremental forms, each requiring distinct competencies and strategic alignment (Sumarsono et al., 2021).

Building upon these theoretical foundations, this study integrates empirical challenges and conceptual insights through a mixed-method approach. By quantitatively examining the relationships among strategic variables and qualitatively exploring institutional practices, the research seeks to capture the complexity of innovation strategy implementation within the National Data Center (Unaradjan, 2019). The novelty of this study lies in positioning innovation strategy as the intersection of technological infrastructure, governance structures, and human capital capacity, thereby conceptualizing it as a central determinant in constructing a sustainable national data ecosystem (Kurumbalapitiya, 2005). Ultimately, the research aspires to provide both conceptual clarification and practical guidance for policymakers in designing adaptive, performance-oriented, and collaborative strategies capable of ensuring that Indonesia's big data governance framework remains resilient, secure, and responsive to future challenges.

METHOD

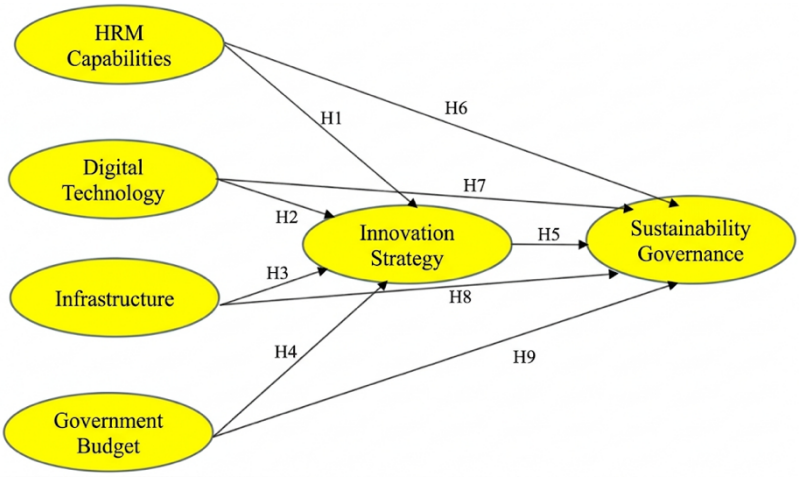
This study incorporates three categories of variables: exogenous, endogenous, and intervening variables. Referring to the conceptual framework illustrated in the research model, Human Resource Capability, Digital Technology, Infrastructure, and Government Budget are specified as exogenous variables, as they function as primary determinants influencing the system. Sustainability Governance is positioned as the endogenous variable, representing the ultimate outcome of the structural relationships examined in this study. Meanwhile, Innovation Strategy is conceptualized as an intervening variable that mediates the influence of the exogenous constructs on sustainability governance. By placing innovation strategy as a mediating construct, the model acknowledges that the transformation

of resources and structural inputs into sustainable governance outcomes is not automatic, but occurs through strategic and institutionalized innovation processes.

For empirical analysis, this research employs SmartPLS version 4.1 as the analytical tool to estimate the structural equation model using a partial least squares approach. The evaluation process is conducted systematically in several stages. First, the outer model assessment is performed to examine the validity and reliability of measurement indicators, including convergent validity, discriminant validity, and internal consistency reliability. Second, the inner model evaluation is conducted to analyze the structural relationships among latent variables, including the assessment of path coefficients, coefficient of determination, effect size, and predictive relevance. Finally, hypothesis testing is carried out using the bootstrapping procedure to determine the statistical significance of each hypothesized relationship, as represented in paths H1 through H9. This sequential analytical framework ensures that both measurement accuracy and structural robustness are rigorously evaluated before drawing substantive conclusions.

The sampling technique applied in this study is total sampling, a method in which the entire accessible population is intended to be included as research respondents, thereby ensuring that each member of the population has an equal opportunity to participate. The target population consists of 500 civil servants within the Directorate General of Informatics Applications of the Ministry of Communication and Informatics, selected due to their direct relevance to the variables and institutional context under investigation. By adopting total sampling, the study seeks to minimize selection bias and enhance representativeness, particularly given the organizationally bounded nature of the research setting.

In practical implementation, however, the number of respondents successfully obtained was 160 individuals. These respondents comprise Team Leaders and Persons in Charge of specific activities within the Directorate General, as well as institutional representatives responsible for utilizing the National Data Center. Although the realized sample size does not encompass the entire population, it reflects those members who met the established research criteria and were accessible during data collection. Considering the descriptive and explanatory objectives of the study, the number of valid responses is deemed sufficient to represent the key characteristics of the population and to support robust statistical analysis using structural equation modeling.



Source: Processed by researchers, 2025

Figure 2. Research Framework

RESULT AND DISCUSSION

Outer Model Testing

Tabel 1. Outer Model Testing

Variabel	*Loading Factor*	AVE
HRM Capabilities		0,614
SDM 1	0,875	
SDM 2	0,861	
SDM 3	0,759	
SDM 4	0,863	
SDM 5	0,915	
Digital Technology		0,654
TD 1	0,859	
TD 2	0,822	
TD 3	0,866	
TD 4	0,851	
TD 5	0,875	
Infrastructure		0,865
Inf 1	0,808	
Inf 2	0,782	
Inf 3	0,736	
Inf 4	0,845	
Inf 5	0,715	
Government Budget		0,576
Ang 1	0,764	
Ang 2	0,728	
Ang 3	0,807	
Ang 4	0,788	
Ang 5	0,704	
Inovation Strategy		0,587
Ino 1	0,813	
Ino 2	0,782	
Ino 3	0,855	
Ino 4	0,759	
Ino 5	0,798	
Sustainability		0,873
BD 1	0,817	
BD 2	0,825	
BD 3	0,854	
BD 4	0,869	
BD 5	0,729	

Source: Research Data

Based on the table above, all measurement indicators satisfy the outer loading criterion, with loading values exceeding 0.70. This indicates that each indicator demonstrates strong convergent relationships with its respective latent construct and contributes adequately to explaining the variance of the construct it represents. High outer loading values reflect the robustness of the measurement model in capturing the underlying theoretical dimensions.

In addition to evaluating loading factors, convergent validity is further assessed through the Average Variance Extracted (AVE). The results presented in the table show that each construct achieves an AVE value above the threshold of 0.50. This finding confirms that more than 50 percent of the variance in the indicators is explained by their respective latent constructs, thereby satisfying the established criteria for convergent validity. Collectively, these results indicate that the measurement model demonstrates adequate validity and is suitable for subsequent structural model analysis.

Tabel 2. Composite Reability Testing

Variable	*Cronbach's Alpha*	*Composite Reliability*
Government Budget	0,816	0,822
Infrastructure	0,735	0,783
Inovation	0,820	0,834
HRM	0,833	0,884
Sustainability	0,877	0,880
Digital Technology	0,863	0,885

Source: Research Data

The results of the composite reliability assessment indicate that all latent variables achieve composite reliability values greater than or equal to 0.70. This finding demonstrates a high level of internal consistency among the indicators measuring each construct, confirming that the measurement items collectively provide stable and consistent representations of their respective latent variables.

Similarly, the Cronbach's alpha coefficients for all latent variables exceed the recommended threshold of 0.70. These results further reinforce the reliability of the constructs, indicating that the measurement instrument exhibits satisfactory consistency across items. Taken together, the composite reliability and Cronbach's alpha findings confirm that the constructs possess strong internal reliability and that the questionnaire employed in this study functions as a dependable and consistent research instrument.

Inner Model Testing

Goodness of Fit Model (GoF)

Tabel 3. Goodness of Fit Model Testing

Jenis Uji	Saturated Model	Estimated Model
SRMS	0,106	0,106
d_ULS	1,016	1,016
d_G	0,315	0,315
Chi-Square	221,987	221,987
NFI	0,485	0,485

Source: Research Data

The results presented in Table 4.13 indicate that the structural model demonstrates an acceptable level of fit. The Standardized Root Mean Square Residual (SRMR) value of 0.106 suggests that the discrepancy between the observed and model-implied correlation matrices remains within a tolerable range. Although ideal benchmarks commonly recommend values below 0.08, in variance-based structural equation modeling such as Partial Least Squares,

slightly higher SRMR values may still be considered acceptable, particularly when the model involves complex constructs and multiple indicators. Furthermore, the reported analysis value of 0.019 indicates that the average difference between observed and expected correlations is minimal, reflecting a relatively small residual discrepancy.

The d_ULS value of 1.016 and the d_G value of 0.315 are both below the 95 percent upper confidence interval threshold, indicating that the divergence between the empirical correlation matrix and the model-implied matrix can be attributed primarily to sampling error rather than model misspecification. This finding supports the overall adequacy of the structural model. Additionally, the Normed Fit Index (NFI) value of 0.485 indicates that the model explains approximately 48.50 percent of the covariance in the data relative to the null model. While this value does not approach unity, it suggests a moderate level of model fit within the context of exploratory and predictive modeling using Partial Least Squares. Collectively, these indices demonstrate that the proposed model possesses sufficient explanatory and predictive capability to proceed with hypothesis testing and structural interpretation.

Tabel 4. Hypothesis Testing

Path Analysis	Original Sample	T Statistics	P Values
Government Budget -> Innovation	0.497	4.845	0.000
Government Budget -> Big Data Sustainability	0.117	1.260	0.021
Infrastructure -> Innovation	0.096	0.908	0.036
Infrastructure -> Big Data Sustainability	0.129	1.430	0.015
Innovation -> Big Data Sustainability	0.464	7.207	0.000
HRM -> Innovation	0.142	1.169	0.024
HRM -> Big Data Sustainability	0.168	1.767	0.008
Digital Tech -> Innovation	0.232	2.186	0.029
Digital Tech -> Big Data Sustainability	0.022	0.252	0.008
Government Budget -> Innovation Strategy -> Big Data Sustainability		0.231	0.114
Infrastructure -> Innovation Strategy -> Big Data Sustainability		0.045	0.004
HRM -> Innovation Strategy -> Big Data Sustainability		0.066	0.009
Digital Tech -> Innovation Strategy -> Big Data Sustainability		0.107	0.024

Source: Research Data

The structural model results demonstrate that innovation strategy serves as the most influential determinant in building sustainable big data governance. The effect of innovation on sustainability governance yields a path coefficient of 0.464, with a t value of 7.207 and a significance level of 0.000, indicating a positive and highly significant relationship. This finding confirms that the sustainability of big data governance is not solely determined by the availability of organizational resources, but by the institution's ability to transform these resources through systematic and strategic innovation processes. Innovation therefore functions as the central mechanism that translates structural inputs into sustainable governance outcomes.

Government budget shows a strong and significant influence on innovation, with a path coefficient of 0.497, a t value of 4.845, and a significance level of 0.000. This indicates that fiscal support plays a crucial role in stimulating institutional innovation. The direct effect of government budget on sustainable big data governance is 0.117, with a t value of 1.260 and a significance level of 0.021, suggesting a positive and significant contribution, although weaker compared to its effect on innovation. When moderated by innovation strategy, the total effect increases from 0.348 to 0.579. This substantial increase demonstrates that innovation strategy strengthens the effectiveness of government expenditure, ensuring that allocated funds generate transformative and sustainable governance improvements rather than merely supporting routine operations.

Infrastructure also exerts a positive influence on innovation, with a coefficient of 0.096, a t value of 0.908, and a significance level of 0.036, indicating a statistically significant but relatively weak effect. Its direct impact on sustainable big data governance is 0.129, with a t value of 1.430 and a significance level of 0.015. These findings suggest that infrastructure represents a fundamental prerequisite for sustainability, yet it does not function as a dominant driver. When innovation strategy moderates the relationship, the total effect increases from 0.084 to 0.129. This indicates that infrastructure becomes more impactful when integrated with innovative approaches such as cloud integration, system interoperability, and automation.

Human resource capability demonstrates a positive and significant influence on innovation, with a coefficient of 0.142, a t value of 1.169, and a significance level of 0.024. Its direct effect on sustainable big data governance is 0.168, with a t value of 1.767 and a significance level of 0.008. These results confirm that technical, analytical, and managerial competencies contribute directly to governance sustainability. When innovation strategy moderates this relationship, the total effect rises from 0.234 to 0.300. This enhancement indicates that innovation strengthens the role of human resources by enabling skill development, adaptive work practices, and the effective utilization of emerging technologies.

Digital technology has a significant positive effect on innovation, with a coefficient of 0.232, a t value of 2.186, and a significance level of 0.029. However, its direct effect on sustainable big data governance is relatively weak, with a coefficient of 0.022, a t value of 0.252, and a significance level of 0.008. This finding suggests that technology alone does not automatically produce sustainable governance outcomes. When innovation strategy intervenes, the total effect increases from 0.129 to 0.236. This result indicates that innovation enhances the effectiveness of digital technology through improved system integration, the development of new analytical tools, and the acceleration of digital transformation processes.

Overall, the empirical evidence confirms that government budget, infrastructure, human resource capability, and digital technology each exert positive and significant effects on both innovation and sustainable big data governance. Nevertheless, the strongest and most consistent effects occur through the pathway involving innovation strategy. These findings reinforce the conclusion that the sustainability of big data governance within the National Data Center depends not only on structural resources but fundamentally on the organization’s capacity to formulate and implement coherent, adaptive, and institutionalized innovation strategies.

CONCLUSION

Innovation strategy plays a significant role in ensuring the effective management and long term sustainability of Big Data within the National Data Center. The concept of innovation in this context extends beyond the mere adoption of digital technologies; it encompasses the strengthening of human resource capacity, the optimization of digital infrastructure, and the efficient allocation and management of government budgets. Through

a comprehensive and integrated innovation approach, the National Data Center is better positioned to deliver sustainable, accountable, and high quality public services that support national digital transformation.

Human resource capability emerges as a dominant factor influencing the effectiveness of the National Data Center's innovation strategy. A workforce equipped with adequate technical and managerial competencies is essential for maximizing the utilization of digital technologies and managing complex data infrastructure systems. Skilled personnel not only ensure operational efficiency but also facilitate adaptive responses to technological change, thereby reinforcing the broader objectives of digital governance and data driven policymaking.

Digital technology and infrastructure function as foundational pillars in the management of the National Data Center. Although their direct impact on Big Data sustainability is comparatively smaller than that of human resource capability, they remain indispensable components of an integrated governance ecosystem. Secure, adaptive, and efficient technological integration is necessary to enable measurable, transparent, and accountable public service delivery. Without reliable infrastructure and advanced technological systems, innovation efforts cannot be effectively institutionalized.

The successful implementation of innovation strategy is also highly dependent on long term and performance based budget management. Strategic and well planned fiscal allocation enables the National Data Center to maintain operational continuity while fostering continuous innovation. Effective budget governance ensures resilience and sustainability, even in the face of policy shifts or political dynamics, thereby safeguarding the long term stability of the national Big Data ecosystem.

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