Generative AI and Digital Governance Transformation: Evidence from China's Prefecture-level Cities on Adaptive Institutional Dynamics

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Abstract. Generative Artificial Intelligence plays a pivotal role in transforming digital governance systems amid global challenges of high accessibility but low public satisfaction. To systematically investigate its impact mechanisms, this study develops an integrated analytical framework combining governance theory with empirical econometrics, leveraging large-scale prefecture-level data across China. Our approach employs variable substitution tests and mediation analyses to disentangle complex causal pathways, revealing that GAI significantly elevates administrative efficiency through smart service innovation while exhibiting regionally divergent effects moderated by institutional adaptability. Crucially, the research demonstrates that strategic policy-infrastructure coordination can amplify technological benefits and mitigate data sovereignty risks. These findings provide actionable insights for designing adaptive governance paradigms that balance operational efficiency, algorithmic accountability, and equitable service delivery in the intelligent governance era.

Keywords: Generative Artificial Intelligence, Digital Government, Adaptive Governance.

1. Introduction

Amidst the dual waves of accelerating global digital economy evolution and technological paradigm shifts, Generative Artificial Intelligence(GAI)is profoundly reshaping the foundational logic and operational architecture of public governance. As a disruptive technological breakthrough following the Internet, GAI injects new momentum into digital government development through integrated advantages of pre-trained large models, multimodal generation, and reinforcement learning[1]. It reconstructs government processes via natural language processing and intelligent decision support, driving the transition from"digitalization"to"intelligent governance. "

However, technological empowerment coexists with governance pains—while global digital government coverage reaches 89%, citizen satisfaction remains below 51%[1]. Systemic contradictions manifest as three tensions: conflicts between technological logic and institutional structures, imbalances between efficiency pursuits and value preservation, and disconnects between empowerment effects and regional adaptation. Propelled by the tide of informatization, digital government development has become a crucial pathway for governments worldwide to enhance governance capacity, optimize public services, and promote socioeconomic development. As a new governance paradigm and operational model originating from e-government, digital government represents a vital manifestation of modernizing national governance systems and capabilities, progressively achieving digitized and intelligent governance approaches.

Generative Artificial Intelligence (GAI) has advanced from unimodal systems to multimodal content generation, enhancing cognitive capabilities yet intensifying governance challenges[2]. Technical innovations like RLHF improve controllability, but algorithmic bias, data sovereignty risks, and hallucination-induced misinformation demand techno-ethical governance[3]. While vertical applications validate industrial value, the paradigm shifts toward "cognitive synergy" partnerships and "technology-society" systemic frameworks[4]. Mounting evidence indicates a pivotal paradigm shift in GAI development—research priorities are transitioning from technical efficacy assessments toward the co-construction of technology-society systemic frameworks.

Digital government constitutes an emerging governance paradigm that employs cutting-edge information technologies—including artificial intelligence, big data analytics, and cloud computing—to fundamentally reengineer administrative models, enhance institutional capacity, and proactively address citizen demands. Digital government, evolving from e-government to digital-intelligent paradigms, confronts institutional restructuring, efficacy gaps, and value conflicts. Despite technologies enabling precise services, the global coverage-satisfaction paradox exposes"data silos"and systemic delays[5]. Cross-departmental collaboration remains hindered by bureaucratic inertia and regional adaptation lags, critiquing"efficiency supremacy"for exacerbating technological alienation.

Micro-level evidence indicates GAI enhances service precision but risks inverted U-shaped efficacy reversal under policy voids[6]. Meso-analyses reveal infrastructure rigidities and data-centralization conflicts, while macro-theory (EGT) highlights synergy adaptation yet overlooks "data colonialism" and algorithmic deskilling crises[7]. Current research suffers from three gaps: fragmented enabling pathways, superficial risk analysis, and unverified mediation effects of regional heterogeneity—neglecting structural conflicts between technological-native risks and governance paradigms.

This study addresses these voids by examining GAI's impact mechanism on digital government within China's quality-oriented development context. This study pioneers a"policy-technology-region"triadic framework, empirically revealing smart service innovation's mediation effect and institutional adaptability's tripartite moderating mechanisms to advance contextualized governance solutions.

2. Mechanism Analysis and Hypothesis Development

Generative Artificial Intelligence (GAI), as the cutting-edge manifestation of digital technology, provides multidimensional enablement pathways for digital government development through its technical characteristics and innovation logic. As articulated in technological governance theory, the embedding of technology can restructure governance paradigms and drive dual enhancement of governance efficiency and legitimacy. Specifically, the direct impact mechanisms of GAI on digital government development manifest as follows:

Generative Artificial Intelligence (GAI)fundamentally restructures digital government through three technical traits: semantic parsing(intelligently correlating unstructured data), dynamic generation(automating procedural tasks via NLG), and cognitive enhancement(enabling evidence-driven decision-making). This transforms bureaucratic hierarchies into networked structures, dissolving data silos through cross-domain semantic synergy [8] and advancing collaboration from physical to cognitive integration.

However, the direct effects of technological enablement are accompanied by intensifying endogenous governance tensions. On one front, the algorithmic black-box nature of GAI implicitly constricts administrative discretion through technological determinism, exposing frontline officials to deskilling risks that undermine decision-making autonomy [9]. On another front, the hallucination phenomena in AI-generated content may propagate erroneous policy interpretations, amplifying public trust crises[10]. This technologically intrinsic contradiction reveals that GAI's impact on digital government constitutes not linear enhancement but a structural paradox: while elevating service efficacy, it simultaneously induces operational ambiguity in decision-making accountability and challenges to governance legitimacy.This technologically-native contradiction reveals that GAI's impact on digital government constitutes not linear improvement but a structural paradox: while enhancing service efficacy, it simultaneously triggers ambiguities in decision-making accountability and challenges to governance legitimacy.

Fundamentally, GAI's direct impact mechanism manifests as a binary restructuring of efficiency versus control. Through automation and cognitive augmentation, it elevates public service precision and policy scientificity, yet concurrently destabilizes the steady-state framework of traditional

administrative control. This dynamic compels institutional recalibration of techno-ethical boundaries and authority-accountability distribution protocols.

Hypothesis 1: Generative Artificial Intelligence exerts a statistically significant positive impact on digital government development.

H1a: Its implementation significantly enhances resource deployment efficacy in digital government initiatives.

H1b: Its adoption substantially accelerates efficiency transformation processes within digital government frameworks.

H1c: Its integration demonstrably elevates decision-making scientificity and governance efficacy in digital governance systems.

3. Variable Definitions and Model Specification

3.1. Model Specification

This study employs the following baseline regression model to empirically examine the core variable relationships:

$$Digital\_government_{it} = \beta_0 + \beta_1 GAI_{it} + \sum \alpha_k \text{CONTROLS}_{it} + \epsilon_{it} \qquad (1)$$

Specific descriptions of the variables are defined as follows: GAI measures generative AI capability;Digital_gov quantifies prefecture-level digital governance performance. Service_supply captures proactive internet-based service delivery through standardized, coordinated, and interoperable capabilities. Digital Governance Performance refers to the digitized governance capacity of prefecture-level city"i"in year"t", quantified by a composite metric integrating administrative efficiency, service digitization depth, and public satisfaction scores. The control variables encompass six theoretically grounded covariates. IT quantifies information technology professionals(standardized in 10, 000 persons), reflecting the level of IT development. Internet aggregates broadband and mobile internet subscribers(household units), reflecting the level of Internet development. Ecnomic is regional GDP per capita, reflecting the level of ecnomic development. Population represents annual average population(10, 000 persons), reflecting population size. AI denotes the stock of artificial intelligence enterprises, reflecting the level of AI development. The coefficient$\beta_1$delivers the net causal effect of Generative Artificial Intelligence on digital governance after purging confounding from both observed variables and latent heterogeneity. ϵ_{it}constitutes the stochastic disturbance term, absorbing unobserved time-variant factors and city-specific shocks while satisfying the Gauss-Markov assumptions of zero conditional mean and homoscedasticity. The model addresses unobserved heterogeneity through two-way fixed effects modeling: City fixed effects capture time-invariant institutional factors. Year fixed effects absorb technology trend shocks.

3.2. Data Sources

The data used in this study comprise generative artificial intelligence and digital government metrics for 283 Chinese prefecture-level cities from 1990 to 2023, processed through interpolation regression. These data originate from provincial or municipal government work reports, local statistical yearbooks, municipal statistical bulletins, China Statistical Yearbook, China Regional Economic Statistical Yearbook, E-Government Surveys, Government Digital Service Capacity Reports, as well as databases of the National Bureau of Statistics, China Internet Network Information Center (CNNIC), and AI enterprises.

4. Empirical Analysis

4.1. Descriptive Statistical Analysis

Table 1 presents descriptive statistics for key variables. Generative AI adoption averages modest levels but spans from negligible to extensive implementation. Digital governance performance remains relatively consistent nationally despite some outlier cases. The distribution of AI enterprises and IT professionals demonstrates acute geographic concentration, with most regions having minimal presence but select hubs exhibiting extreme density. Economic output per capita varies dramatically, exceeding a quarter-million yuan in peak regions compared to the twenty-eight-thousand-yuan average. Internet access metrics confirm severe infrastructure gaps, where maximum connectivity dwarfs the typical household coverage by over two orders of magnitude.

Table 1. Descriptive Statistics of Variables

VarName	Obs	Mean	SD	Min	Max
GAI	10132	2. 958	2. 449	0. 000	11. 539
Digital_gov	1482	70. 479	9. 422	8. 840	91. 830
AI	10132	561. 812	3613. 496	0. 000	1. 03e+05
Ecnomic	10132	28589. 522	33487. 229	0. 000	2. 65e+05
Population	10132	319. 970	309. 693	0. 000	3410. 000
IT	10132	0. 364	2. 735	0. 000	86. 000
Internet	10132	4. 37e+05	1. 09e+06	0. 000	5. 17e+07

* $p < 0.1$,   ** $p < 0.05$,   *** $p < 0.01$

4.2. Baseline Regression

Table 2 reveals significant model-specification heterogeneity in GAI's impact on digital government. For every one-unit change in GAI, Digital_gov changes by 3. 3194 units. Model 1(uncontrolled for temporal effects)shows a positive GAI coefficient(3. 319), indicating initial technological facilitation. Conversely, Models 2-3 with year fixed effects and controls demonstrate significantly negative coefficients, suggesting environmental factors dilute or reverse standalone technological benefits. Temporal trends critically confound GAI's empowerment efficacy, while marginally significant effects of IT professionals and internet users reflect structural disjunctions between technological diffusion and human capital allocation.

Table. 2. Baseline Regression

	(1)	(2)
	Digital_gov	Digital_gov
GAI	3. 3194***	2. 0262***
	(0. 25)	(0. 45)
AI		0. 6060
		(0. 59)
Ecnomic		0. 6645**
		(0. 29)
Population		-0. 8408***
		(0. 12)
IT		-0. 8992
		(15. 86)
Internet		0. 0106***
		(0. 00)
_cons	48. 7457***	52. 0778***
	(1. 64)	(2. 47)
N	1482	1482
R^2	0. 131	0. 196

* $p < 0.1$,   ** $p < 0.05$,   *** $p < 0.01$

4.3. Regional Heterogeneity Analysis

Table 3 confirms GAI's positive aggregate impact on digital government, yet reveals critical regional divergence: eastern regions exhibit substantially stronger marginal effects than central/western areas, attributable to synergistic resource-infrastructure advantages enabling efficient data integration and algorithm deployment. Policy intensity positively moderates this relationship, where regulatory frameworks reduce institutional friction and amplify technological returns. Concurrently, developed regions demonstrate superior technological spillover absorption through population and GDP advantages, while less developed areas face"Matthew effects"due to fiscal-human capital constraints.

Table. 3. Heterogeneity Regression Results (Eastern-Central-Western Regions)

	(1)	(2)	(3)
	Digital_gov	Digital_gov	Digital_gov
GAI	2. 3545***	1. 2059***	2. 9801***
	(0. 35)	(0. 37)	(0. 38)
AI	-0. 0606	-1. 4178	-1. 3312
	(0. 35)	(1. 17)	(0. 84)
Ecnomic	0. 2755**	0. 8787***	-0. 0963
	(0. 11)	(0. 16)	(0. 12)
Population	-0. 7914***	-0. 6152***	-1. 0046***
	(0. 17)	(0. 19)	(0. 29)
IT	-16. 9583	-1. 0e+02*	33. 6917
	(17. 51)	(57. 77)	(37. 00)
Internet	0. 0051**	0. 0105***	0. 0085**
	(0. 00)	(0. 00)	(0. 00)
_cons	54. 0834***	57. 1349***	50. 6467***
	(2. 10)	(2. 17)	(2. 14)
N	504	500	478
R^2	0. 361	0. 202	0. 216

* $p < 0. 1$, ** $p < 0. 05$, *** $p < 0. 01$

4.4. Robustness and Mediation Mechanism

Table 4 shows Robustness and mediation analyses confirm the core findings'resilience and underlying mechanisms. Variable substitution tests demonstrate that the statistically significant positive effect persists when internet penetration rate is substituted for the generative artificial intelligence(GAI)variable and when the dependent variable is replaced with digital patents, respectively. Even after incorporating additional control variables such as fiscal R&D intensity and tertiary industry share (Model 4), GAI's positive influence remains statistically evident. This cumulative evidence robustly confirms the statistical stability of technology's core enabling effect. However, technological dividends face dilution through structural institutional constraints. Key control variables reveal underlying tensions: Urbanization rate exhibits significantly negative effects, implying that urban expansion intensifies governance complexity. Tertiary industry share demonstrates a marginally negative trend, reflecting adaptation lags between industrial upgrading and existing institutional frameworks. The IT workforce variable displays insignificance or negative values, exposing human capital-technology demand misalignment. Collectively, these results indicate systematic dissipation of technological empowerment through institutional friction.

Mediation mechanism tests (Model 5) further identify smart service innovation as the critical transmission channel: GAI indirectly enhances digital governance efficacy by significantly elevating service supply capacity. This validates administrative process reengineering as the pivotal conduit for transforming technology into governance outcomes. Notably, while internet infrastructure coverage consistently demonstrates positive effects, its divergence from human capital variables

underscores asymmetric development between physical infrastructure and institutional capabilities. Mere infrastructure expansion proves insufficient to counteract the constraining effects of institutional friction.

Table. 4. Robustness and Mediation Mechanism

	(1)	(2)	(3)	(4)	(5)
	Digital_gov	Digital_gov	Digital_gov	Digital_gov	Service_supply
GAI	0. 5234***	0. 4211**	2. 0262***	0. 8472	2. 2955***
	(0. 02)	(0. 16)	(0. 45)	(0. 65)	(0. 19)
AI	-0. 1137**	-0. 6402	0. 6060	3. 0303***	0. 3352
	(0. 05)	(0. 74)	(0. 59)	(1. 12)	(0. 25)
Ecnomic	0. 1642***	1. 4448***	0. 6645**	1. 1637***	-0. 2434**
	(0. 01)	(0. 23)	(0. 29)	(0. 41)	(0. 12)
Population	-0. 0644***	-1. 1098***	-0. 8408***	-0. 6463***	-0. 3821***
	(0. 01)	(0. 10)	(0. 12)	(0. 14)	(0. 05)
IT	-0. 4795	16. 0642	-0. 8992	-15. 1918	-3. 3611
	(0. 85)	(16. 96)	(15. 86)	(26. 48)	(6. 63)
Internet	0. 0019***	0. 0072***	0. 0106***	0. 0160***	0. 0064***
	(0. 00)	(0. 00)	(0. 00)	(0. 00)	(0. 00)
Education				0. 0000	
				(0. 00)	
Urban				24. 3791**	
				(9. 82)	
Facility				0. 0183	
				(0. 04)	
Science				-8. 3240	
				(33. 58)	
Tertiary				-0. 1675	
				(0. 12)	
_cons	-0. 8977***	59. 1859***	52. 0778***	46. 2982***	15. 5256***
	(0. 09)	(1. 81)	(2. 47)	(8. 99)	(1. 03)
N	6062	1452	1482	777	1482
R^2	0. 507	0. 189	0. 196	0. 272	0. 366

* $p < 0. 1$, ** $p < 0. 05$, *** $p < 0. 01$

5. Conclusions and Recommendations

This study is grounded in technological governance theory and institutional complementarity frameworks,systematically unraveling the nonlinear causal pathways through which Generative Artificial Intelligence(GAI)transforms digital government development by synthesizing panel data from Chinese prefecture-level cities(1990 – 2023)and deploying multivariate regression modeling.This study empirically establishes GAI as a net positive force for digital government development, primarily enhancing administrative efficiency, service transformation, and decision-making scientificity through the mediating mechanism of smart service innovation. However, significant regional heterogeneity reveals a critical moderating role for institutional adaptability and infrastructural maturity. Eastern China exhibits substantially stronger marginal benefits compared to Central/Western regions, exacerbating developmental disparities via a "Matthew effect." The transformative potential of GAI is thus fundamentally contingent on the complex interplay between technological capabilities, institutional frameworks, and regional socio-economic contexts.

Key recommendations stem from these findings. Policymakers must prioritize developing adaptive governance frameworks that move beyond mere technological adoption to institutional redesign. This

includes establishing robust algorithmic accountability mechanisms to counter risks to discretion and public trust. Addressing regional disparities demands context-sensitive interventions: advanced regions should deepen synergistic integration, foster public-private cognitive partnerships, and set global ethical standards; less developed regions require foundational digital infrastructure investment, tailored capacity-building for public servants to prevent deskilling, and fiscal/regulatory incentivesto attract talent and enterprises.

Several limitations warrant attention. Reliance on aggregated prefectural data may obscure sub-prefectural variations in implementation and citizen experience. Operationalizing constructs like "institutional adaptability" using proxy indicators lacks direct measurement of organizational culture or bureaucratic resistance. The China-specific scope limits generalizability regarding heterogeneity and policy impacts. The correlational/mediating focus provides less insight into precise causal mechanisms of institutional restructuring or the differential impact of specific policy tools. The analysis predominantly reflects the supply-side, offering limited capture of demand-side factors crucial to the coverage-satisfaction paradox. Longitudinal analysis could better discern non-linear adoption or lagged infrastructural effects.Future research will adopt a mixed-methods approach to rigorously integrate demand-side factors, modeling the impact mechanisms of generative artificial intelligence (GAI) on citizen trust, perceived fairness, and satisfaction. Exploring the convergence of GAI with other disruptive technologies is of strategic importance.

References

[1] WEI Yuming, JIA Kai, ZENG Runxi, et al. AI Innovation and Governance Transformation under the DeepSeek Breakthrough Effect[J]. E-Government, 2025, (03): 2–39.

[2] ZHANG Xiaheng. Generative Artificial Intelligence in Digital Government Development: Transformation, Risks, and Countermeasures[J]. Public Governance Research, 2025, 37(02): 42–53.

[3] CAI Zhiquan, ZHANG Juan. Value Reflection and Pathway Prospects of Generative AI in Digital Government[J]. Journal of Harbin Institute of Technology (Social Sciences Edition), 2024, 26(06): 151–160.

[4] ZHANG Nan, SUO Cheng. Dynamic Mechanisms and Practical Pathways for Intelligent Transformation of Government Services: A Diachronic Comparison of AI Q&A Systems under Large Model Impact. E-Government [J/OL], 1–16 [2025-05-29].

[5] BAI Wenjing. Paradigm Shift of AI in Digital Government: Interactive Agile Governance Based on GovGPT[J]. Journal of Northwest Minzu University (Philosophy and Social Sciences), 2024, (03): 91–102.

[6] ZENG Yuhang, SHI Jun. Generative Artificial Intelligence in Government Governance: Logic and Risk Regulation[J]. Chinese Public Administration, 2023, 39(09): 90–95.

[7] FU Jianping. Regulatory Pathways for Integrating Generative AI into Digital Government: A Risk Society Perspective[J]. Journal of Hunan University (Social Sciences), 2025, 39(01): 124–132.

[8] ZHAO Jingwu, HE Aoxuan. Innovations in Digital Government Theory and Governance Models under "Intelligence Competitions": Analysis of "DeepSeek+Government" Practices. E-Government [J/OL], 1–15 [2025-05-29].

[9] LIU Wei. Embedding ChatGPT-like Generative AI in Digital Government: Affordances, Constraints, and Optimization. Information Studies: Theory & Application[J]. Journal of Beihang University (Social Sciences Edition), 2023, 46(10): 69–76.

[10] LIU Yinxi, WU Jingyang. Application Prospects, Potential Risks, and Safeguarding Mechanisms of Generative AI in Government Governance[J]. Journal of Beijing University of Aeronautics and Astronautics (Social Sciences Edition), 2025, 38(01): 103–112.