

Digital Revenue Governance and Subnational Fiscal Autonomy: A Mediated Principal–Agent Analysis of Federated Tax Digitisation

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Abstract: *This study investigated the impact of Digital Revenue Governance on Subnational Fiscal Autonomy within a federated fiscal system and modelled the institutional mechanism through which this relationship operated. A quasi-experimental design was employed using state-level monthly panel data from Nigeria's 2025 digital tax reforms. The analysis applied difference-in-differences, event-study, instrumental-variable, and sequential mediation techniques to establish causal and transmission effects. The findings indicated that Digital Revenue Governance did not exert a direct effect on fiscal autonomy but operated through a sequential pathway. Specifically, digital adoption enhanced Subnational Fiscal Efficiency, which strengthened Accountable Revenue Mobilisation and subsequently consolidated Fiscal Autonomy. The direct effect attenuated after incorporating mediating variables, suggesting that fiscal autonomy emerged as a performance-based and lagged institutional outcome. The study concluded that digital tax reforms influenced fiscal decentralisation through improvements in administrative efficiency and revenue credibility rather than immediate structural changes. A key limitation was the short post-reform observation period. The study contributed by integrating principal–agent and fiscal federalism perspectives within a unified digital governance framework.*

Keywords: digital governance, fiscal autonomy, principal–agent theory, revenue mobilisation, tax digitisation

INTRODUCTION

Digital monitoring technologies are fundamentally transforming tax administration by embedding transaction-level verification, third-party reporting, and automated reconciliation into fiscal systems. A substantial body of empirical evidence demonstrates that enhanced information visibility increases detection probability and reduces tax evasion by limiting opportunities for misreporting (Kleven et al., 2011; Pomeranz, 2015). Electronic invoicing systems, cross-matching algorithms, and financial account integration further reinforce compliance by narrowing informational rents and improving traceability of taxable transactions (Bellon et al., 2022; Okunogbe & Santoro, 2021). These developments establish that digital reporting can reshape taxpayer behaviour through improved monitoring precision. However, scholars have predominantly focused on behavioural compliance effects, leaving unresolved how digital information architecture influences broader institutional outcomes. In particular, limited attention has been paid to whether digital monitoring transforms the structural foundations of fiscal authority within federated systems where governance is distributed across multiple tiers.

Within federations, revenue authority is constitutionally fragmented across levels of government, creating inherent informational asymmetries between central and subnational actors. Subnational fiscal autonomy depends not only on statutory tax assignments but also on the credibility, predictability, and stability of own-source revenue realisation. Nationally coordinated digital infrastructure alters these dynamics by standardising taxpayer identification, synchronising reporting mechanisms, and centralising data visibility across jurisdictions. Digital revenue governance extends beyond procedural digitisation to constitute a structural reconfiguration of fiscal administration, embedding monitoring and enforcement within integrated information systems (Akininyi, 2026). While such integration enhances administrative precision and enforcement capability, it may also reshape the distribution of effective fiscal authority by altering informational control. This raises a fundamental institutional question: does embedded digital monitoring strengthen subnational fiscal autonomy by improving revenue performance, or does it merely intensify oversight without consolidating decentralised fiscal capacity? Addressing this question requires moving beyond compliance analysis toward a structural understanding of how information systems condition fiscal governance outcomes.

Global tax policy debates further underscore the structural importance of information architecture in determining fiscal authority. The digitalisation agenda advanced by the Organisation for Economic Co-operation and Development (OECD) highlights that effective taxing rights increasingly depend on the ability to identify and verify digitally mediated transactions rather than traditional notions of physical presence (OECD, 2015, 2018, 2020, 2021). Although these reforms are primarily designed to address cross-border tax allocation, they reveal a broader institutional principle that fiscal authority is inherently linked to monitoring capacity and informational visibility. Despite this insight, the implications of digital information restructuring for intergovernmental fiscal relations within federations remain underexplored. Existing research has not sufficiently examined how similar

informational transformations may recalibrate fiscal equilibria between central and subnational governments without formal constitutional changes.

The theoretical foundations relevant to this inquiry are well established but remain analytically fragmented. Principal–agent theory posits that improved signal informativeness reduces hidden action and enhances incentive alignment between principals and agents (Holmström, 1979; Holmström & Milgrom, 1991; Jensen & Meckling, 1976). Fiscal federalism theory, in contrast, emphasises that decentralised authority is sustainable only when subnational governments possess credible own-source revenue and operate under hard budget constraints (Oates, 1972; Weingast, 1995). Parallel contributions from digital governance literature document efficiency gains arising from interoperable systems and automated administrative processes (Dunleavy et al., 2006). However, these strands have not been integrated into a unified framework capable of explaining how digital monitoring precision conditions the performance-based foundations of fiscal autonomy. Consequently, the transmission mechanism linking digital adoption to decentralised fiscal authority remains theoretically underdeveloped. This study departs from prior research by explicitly modelling the institutional transmission mechanism through which digital monitoring architecture influences fiscal autonomy within a federated system.

This study addresses this gap by developing and empirically testing a mediated principal–agent model in which digital adoption enhances monitoring precision, improves subnational fiscal efficiency, strengthens revenue credibility, and ultimately consolidates fiscal autonomy. Digital Revenue Governance is conceptualised as an embedded monitoring architecture that restructures informational signals across tiers of government. Improvements in assessed-to-paid conversion, reconciliation integrity, and audit productivity increase the reliability of revenue flows, thereby reducing volatility and enhancing predictability. Within this framework, fiscal autonomy is not treated as an immediate consequence of digital adoption but as a lagged institutional equilibrium outcome that emerges from sustained improvements in revenue credibility. This conceptualisation shifts the analytical focus from statutory authority to performance-based decentralisation grounded in informational precision.

, the study exploits the staggered implementation of Nigeria’s 2025 tax digitisation reforms across subnational jurisdictions. The phased rollout of unified filing systems, electronic invoicing, automated third-party reporting, and harmonised enforcement protocols generates plausibly exogenous variation in digital adoption intensity. Using monthly state-level panel data comprising 1,920 observations, the analysis employs difference-in-differences, event-study, instrumental-variable, and sequential mediation techniques to identify causal effects. The findings indicate that digital adoption significantly improves administrative efficiency and compresses revenue volatility. However, direct effects on fiscal autonomy diminish once efficiency and accountability channels are incorporated, supporting the hypothesised mediated pathway. The temporal dynamics further reveal that autonomy responds with observable lags, consistent with gradual institutional adjustment rather than immediate technological impact.

The study contributes to the literature in three important ways. First, it reconceptualises digital infrastructure as endogenous monitoring precision embedded within fiscal institutions, thereby extending principal–agent theory into the domain of digital governance. Second, it refines fiscal federalism theory by demonstrating that decentralised authority depends on revenue credibility generated through information architecture rather than statutory assignment alone. Third, it integrates insights from public finance, accounting, and digital governance by linking monitoring technology to institutional equilibrium within federated systems. By doing so, the study advances the understanding of how digital transformation reshapes the operational foundations of fiscal autonomy in contemporary governance environments.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Conceptualisation of Digital Revenue Governance and Fiscal Autonomy

Digital Revenue Governance (DRG) refers to the institutional integration of transaction-level verification systems, third-party reporting mechanisms, interoperable databases, and unified taxpayer identification frameworks within modern tax administration (Akininyi, 2026). Conceptually, DRG extends beyond process automation to represent a restructuring of informational architecture that enhances monitoring precision and reduces verification costs across fiscal systems. Within a principal–agent framework, such digital integration improves signal informativeness by reducing hidden action and narrowing informational asymmetries between fiscal authorities and administrative agents (Holmström, 1979; Jensen & Meckling, 1976). Subnational Fiscal Efficiency (SFE) captures the operational integrity of revenue administration processes, including assessed-to-paid conversion, reconciliation accuracy, and audit productivity, reflecting the extent to which administrative signals translate into realised outcomes. Accountable Revenue Mobilisation (ARM) represents the quality of realised inflows, operationalised through volatility compression, timeliness, and reconciliation credibility. Fiscal Autonomy (FA), in turn, denotes performance-based decentralisation, measured through credible own-source revenue capacity and reduced reliance on intergovernmental transfers, consistent with fiscal federalism theory (Oates, 1972; Weingast, 1995). The analytical distinction among DRG, SFE, ARM, and FA is essential, as digital integration influences autonomy indirectly through institutional performance channels rather than through formal reassignment of taxing authority.

Digital Revenue Governance and Compliance Behaviour

A substantial empirical literature establishes that improved information visibility significantly alters taxpayer compliance behaviour by increasing detection probability and reducing informational rents. Third-party reporting systems constrain opportunities for misreporting by introducing verifiable external information, thereby strengthening enforcement credibility (Kleven et al., 2011; Pomeranz, 2015). Digital reporting technologies, including electronic invoicing and automated cross-verification systems, further enhance compliance by lowering administrative costs while simultaneously increasing monitoring effectiveness (Kochanova et al., 2020; Bellon et al., 2022). Evidence from value-added tax systems indicates that transaction-level reporting leads to measurable improvements in declared liabilities and collection efficiency, particularly in environments characterised by high informational

opacity. Integration of tax systems with financial infrastructure also enhances traceability, although it introduces considerations related to financial inclusion and cybersecurity risks in emerging economies (Agur et al., 2020). Despite these advancements, the literature remains predominantly focused on micro-level behavioural responses, emphasising compliance elasticity rather than broader institutional transformations. Consequently, limited attention has been given to how improvements in monitoring precision translate into sustained administrative efficiency or influence intergovernmental fiscal dynamics within federated systems.

Digital Governance and Administrative Performance

Parallel scholarship in digital governance examines how information systems reshape administrative performance through enhanced coordination, reduced transaction costs, and improved data integration. Interoperable databases, unified identifiers, and automated workflows facilitate seamless information exchange across government agencies, thereby strengthening operational efficiency and institutional coordination (Dunleavy et al., 2006; Akinninyi, 2026). Public finance research conceptualises these developments as integrated fiscal platforms that improve reconciliation accuracy, reduce administrative fragmentation, and enhance enforcement consistency (Gupta et al., 2017; Junquera-Varela & Lucas-Mas, 2024). Digital systems enable transaction-level verification, which reduces reconciliation discrepancies and strengthens observability of revenue processes. Empirical evidence further suggests that digitalisation can generate broader economic benefits by improving resource allocation efficiency and firm-level performance through reduced informational opacity (He & Yi, 2023). However, administrative efficiency is often treated as a technocratic endpoint rather than as a dynamic mechanism influencing fiscal governance outcomes. Existing studies do not explicitly model how improvements in Subnational Fiscal Efficiency translate into Accountable Revenue Mobilisation or how these performance gains contribute to the consolidation of fiscal autonomy. This limitation highlights the need for a more integrated analytical framework linking digital governance to institutional outcomes within federated fiscal systems.

Fiscal Federalism and Revenue Credibility

Fiscal federalism theory provides the normative foundation for understanding decentralised fiscal authority, emphasising that subnational governments achieve effective autonomy when they possess stable and credible own-source revenue streams. Classical formulations argue that decentralisation enhances allocative efficiency when revenue generation aligns with expenditure responsibilities (Oates, 1972). Institutional extensions further highlight the importance of hard budget constraints and predictable revenue mobilisation in sustaining fiscal discipline and preventing opportunistic behaviour (Weingast, 1995). Revenue volatility, administrative inefficiencies, and excessive dependence on intergovernmental transfers undermine fiscal autonomy by weakening budget credibility and reinforcing soft budget constraints. Despite these insights, the literature largely assumes fixed informational conditions and does not explicitly incorporate monitoring technologies as endogenous determinants of fiscal capacity. As a result, the role of digital information architecture in shaping revenue credibility and decentralised authority remains theoretically underdeveloped. Understanding how monitoring precision influences the stability and predictability of revenue

flows is therefore essential for advancing fiscal federalism theory in the context of digital transformation.

Integrative Gap and Theoretical Synthesis

The preceding literature reveals three interrelated but analytically disconnected strands. First, compliance literature demonstrates that monitoring precision reduces informational asymmetry and improves taxpayer behaviour (Kleven et al., 2011; Pomeranz, 2015). Second, digital governance research shows that information systems enhance administrative efficiency and coordination (Dunleavy et al., 2006; Gupta et al., 2017). Third, fiscal federalism theory establishes that credible revenue mobilisation underpins sustainable decentralised authority (Oates, 1972; Weingast, 1995). However, these strands have not been integrated into a unified framework explaining how digital monitoring architecture translates into institutional outcomes. Specifically, existing research does not model how improvements in monitoring precision enhance Subnational Fiscal Efficiency, how efficiency strengthens Accountable Revenue Mobilisation, or how mobilisation credibility consolidates Fiscal Autonomy. This omission limits the understanding of how digital transformation affects fiscal governance beyond compliance effects. Addressing this gap requires conceptualising digital infrastructure as an endogenous institutional mechanism within a principal–agent framework that links informational precision to decentralised fiscal equilibrium through sequential performance channels. To synthesise the theoretical relationships discussed, the conceptual framework illustrating the mediated and moderated pathways is presented in Figure 1.

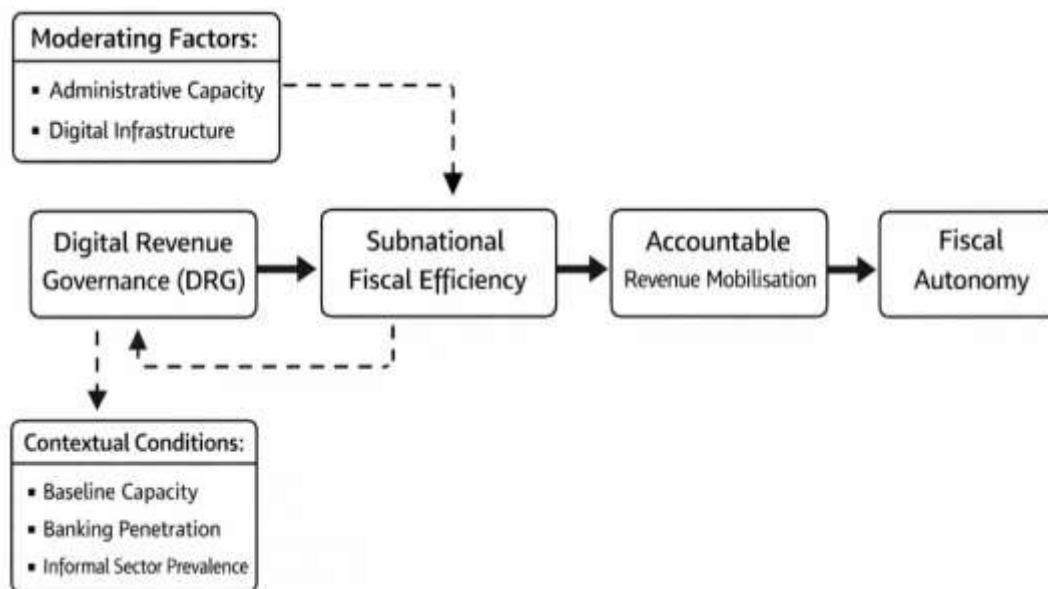


Figure 1. Conceptual Framework: Digital Revenue Governance and Subnational Fiscal Autonomy

Source: Author’s conceptualisation based on Jensen and Meckling (1976), Holmström (1979), Oates (1972), and Weingast (1995).

Hypotheses Development

Digital Revenue Governance and Subnational Fiscal Efficiency

Principal–agent theory attributes inefficiencies in organisational settings to hidden action, asymmetric information, and costly monitoring. Improved signal informativeness reduces these frictions by enhancing the observability of agent behaviour and aligning incentives with desired outcomes (Holmström, 1979; Holmström & Milgrom, 1991). In revenue administration, fragmented reporting systems reduce signal quality, allowing discretionary assessment practices and delayed reconciliation processes that weaken enforcement effectiveness. Digital Revenue Governance restructures this informational environment by embedding transaction-level verification, unified identifiers, and automated reporting systems within fiscal operations. These mechanisms increase monitoring precision while reducing verification costs, thereby strengthening the alignment between assessed liabilities and realised collections. Empirical evidence confirms that electronic reporting and third-party information systems enhance compliance by increasing detection probability and reducing opportunities for evasion (Kleven et al., 2011; Pomeranz, 2015). Extending this logic to administrative performance, improved monitoring precision should enhance assessed-to-paid conversion, reduce reconciliation discrepancies, and improve audit productivity. Accordingly, Digital Revenue Governance is expected to strengthen Subnational Fiscal Efficiency.

H₁: Digital Revenue Governance is positively associated with Subnational Fiscal Efficiency.

Subnational Fiscal Efficiency and Accountable Revenue Mobilisation

Administrative efficiency alone does not guarantee fiscal credibility, as the quality of revenue mobilisation depends on the reliability and stability of realised inflows. Revenue administration frameworks emphasise that reconciliation integrity, volatility compression, and timely reporting are critical indicators of effective fiscal performance (Junquera-Varela & Lucas-Mas, 2024). Within an information economics framework, improved efficiency increases the signal-to-noise ratio between assessed liabilities and realised collections, thereby enhancing predictability and reducing variance in revenue outcomes. Multi-task principal–agent models further suggest that improved measurement reallocates effort toward verifiable outputs, strengthening performance consistency (Holmström & Milgrom, 1991). In decentralised systems, predictable and credible revenue flows support budget stability and reduce dependence on external transfers. Consequently, improvements in Subnational Fiscal Efficiency should translate into higher-quality revenue mobilisation characterised by reduced volatility and enhanced reconciliation credibility.

H₂: Subnational Fiscal Efficiency is positively associated with Accountable Revenue Mobilisation.

Accountable Revenue Mobilisation and Fiscal Autonomy

Fiscal autonomy depends fundamentally on the ability of subnational governments to generate stable and credible own-source revenue streams. Fiscal federalism theory posits that predictable revenue mobilisation strengthens budget credibility, enhances planning capacity, and reduces reliance on intergovernmental transfers (Oates, 1972; Weingast, 1995). Revenue

volatility and reconciliation inconsistencies undermine fiscal independence by weakening the reliability of fiscal projections and reinforcing soft budget constraints. Accountable Revenue Mobilisation captures the extent to which realised inflows are stable, timely, and verifiable, thereby reflecting the operational credibility of fiscal systems. As digitalisation reshapes tax administration, the ability to sustain credible mobilisation becomes increasingly dependent on integrated information systems and monitoring precision (Devereux & Vella, 2014; Haslehner et al., 2019). Subnational governments that achieve higher levels of revenue accountability are therefore better positioned to strengthen their fiscal autonomy by increasing own-source revenue reliance and reducing fiscal fragility.

H₃: Accountable Revenue Mobilisation is positively associated with Subnational Fiscal Autonomy.

Mediated Institutional Pathway

The preceding hypotheses collectively imply a sequential institutional mechanism through which Digital Revenue Governance Influences Fiscal Autonomy. Rather than exerting a direct effect, digital adoption enhances monitoring precision, which improves Subnational Fiscal Efficiency. Efficiency gains strengthen Accountable Revenue Mobilisation by stabilising realised inflows, and credible mobilisation ultimately consolidates Fiscal Autonomy. This sequence reflects a mediated pathway in which digital infrastructure operates through performance-based institutional channels rather than through immediate structural changes in fiscal authority. Theoretical foundations in principal–agent and fiscal federalism models suggest that such adjustments occur gradually as informational conditions improve and incentives realign over time (Holmström, 1979; Weingast, 1995). The strength of this pathway is expected to depend on administrative capacity and governance quality, which condition the effectiveness of monitoring systems. Accordingly, the relationship between Digital Revenue Governance and Fiscal Autonomy is expected to be mediated by efficiency and accountability mechanisms.

H₄: The relationship between Digital Revenue Governance and Fiscal Autonomy is mediated by Subnational Fiscal Efficiency and Accountable Revenue Mobilisation.

METHODOLOGY

Research Design and Scope

This study adopts a quasi-experimental research design to examine the institutional effects of Digital Revenue Governance on subnational fiscal outcomes within a federated system. The empirical setting is Nigeria's 2025 Digital Tax Reform Programme, which introduced integrated electronic filing, mandatory value-added tax e-invoicing, automated third-party reporting, and harmonised enforcement protocols across subnational jurisdictions. Although legislated at the federal level, implementation occurred in staggered phases due to administrative readiness, infrastructure heterogeneity, and vendor sequencing constraints. This phased rollout generates plausibly exogenous variation in digital adoption intensity across states and over time. Nigeria provides an appropriate institutional context because its

fiscal system constitutionally allocates revenue authority across tiers of government, with subnational entities responsible for specific tax instruments while operating within nationally coordinated frameworks (Federal Republic of Nigeria, 1999; Suberu, 2001). This hybrid structure allows for the identification of how digital monitoring architecture affects fiscal autonomy through performance channels rather than formal reassignment of taxing powers. Nigeria provides a natural experimental setting due to the coordinated but staggered rollout of digital tax infrastructure across states, which generates exogenous variation in adoption intensity while maintaining a common institutional framework.

Data Description and Sample Construction

The empirical analysis is based on a balanced panel dataset comprising monthly observations for all Nigerian states across pre-reform and post-reform periods. The unit of analysis is the state-month, enabling the capture of both temporal dynamics and cross-sectional variation in digital adoption and fiscal performance. The observation window is sufficiently extended to allow for validation of parallel trends and assessment of dynamic treatment effects following reform implementation. Data are compiled from administrative and fiscal sources, including unified electronic filing systems, value-added tax invoicing registries, audit logs, bank disclosure records, treasury inflow statements, and official budget execution reports. These sources provide granular measures of digital adoption, administrative efficiency, revenue stability, and fiscal autonomy. Observations with incomplete reporting are excluded to ensure consistency and comparability across jurisdictions. The final dataset comprises 1,920 state-month observations, offering adequate statistical power for panel estimation and causal inference.

Variable Measurement and Operationalisation

Digital Revenue Governance (DRG) is operationalised as an index capturing the intensity of digital adoption across four core dimensions: proportion of filings processed through the Single Tax Window, share of value-added tax invoices issued electronically, percentage of financial accounts linked to verified taxpayer identifiers, and proportion of enforcement actions conducted under harmonised digital protocols. Each component is standardised to ensure comparability, and principal component analysis is employed to extract the dominant adoption factor. Subnational Fiscal Efficiency (SFE) is measured using indicators that capture administrative signal precision, including assessed-to-paid conversion ratios, audit yield per case, inverse refund cycle time, inverse cost-to-collect, and inverse reconciliation discrepancy rates. Accountable Revenue Mobilisation (ARM) reflects the quality of realised inflows and is constructed using measures of payment timeliness, inverse revenue volatility, reporting lag, and reconciliation completeness. Fiscal Autonomy (FA) is proxied by own-source revenue share relative to total inflows, supplemented by inverse transfer dependence and arrears ratios. Latent indices for SFE, ARM, and FA are derived using principal component extraction to ensure dimensional consistency and minimise measurement error.

Empirical Strategy and Identification Approach

To estimate the causal effects of digital adoption, the study employs a two-way fixed-effects difference-in-differences framework that exploits variation in reform timing across states. The baseline specification is expressed as:

$$Y_{it} = \alpha + \beta DRG_{it} + \mu_i + \lambda_t + \theta X_{it} + \varepsilon_{it}$$

where Y_{it} represents outcome variables including SFE, ARM, and FA, DRG_{it} captures digital adoption intensity, μ_i denotes state fixed effects controlling for time-invariant heterogeneity, λ_t represents time fixed effects capturing common shocks, and X_{it} includes time-varying controls such as economic activity and financial penetration. To examine dynamic treatment effects and validate the parallel trends assumption, an event-study specification is estimated:

$$Y_{it} = \alpha + \sum_{k \neq -1} \beta_k D_{i,t+k} + \mu_i + \lambda_t + \varepsilon_{it}$$

Insignificant pre-treatment coefficients support the identifying assumption of no differential trends prior to reform adoption. Given potential bias arising from staggered treatment timing, additional estimators proposed by Sun and Abraham (2021) and Callaway and Sant'Anna (2021) are employed as robustness checks. While the difference-in-differences framework relies on the parallel trends assumption, this study validates the assumption using pre-treatment event-study estimates and complementary estimators to mitigate bias associated with staggered adoption timing.

Instrumental Variable and Endogeneity Control

To address potential endogeneity in the timing and intensity of digital adoption, the study employs an instrumental variable approach using centrally coordinated vendor rollout sequences and pre-existing fibre connectivity infrastructure as instruments. These instruments are plausibly exogenous to state-level fiscal outcomes while strongly correlated with digital adoption intensity. First-stage regression results indicate strong instrument relevance, with Kleibergen-Paap rk Wald F-statistics exceeding conventional thresholds for weak identification. Instrument validity is further assessed using Hansen J-tests of overidentifying restrictions under heteroskedasticity-robust covariance structures. Failure to reject the null hypothesis supports joint instrument exogeneity. Limited-information maximum likelihood estimators are also employed to ensure robustness to potential weak-instrument bias. All first-stage estimates and diagnostic statistics are reported to ensure transparency and replicability of the identification strategy.

Mediation Model Specification

To evaluate the sequential institutional mechanism linking digital adoption to fiscal autonomy, the study estimates a system of structural equations capturing the mediated relationships among variables. The mediation structure is specified as follows:

$$SFE_{it} = \alpha_1 + \beta_1 DRG_{it} + \mu_i + \lambda_t + \varepsilon_{1it}$$

$$ARM_{it} = \alpha_2 + \beta_2 SFE_{it} + \beta_3 DRG_{it} + \mu_i + \lambda_t + \varepsilon_{2it}$$

$$FA_{it} = \alpha_3 + \beta_4 ARM_{it} + \beta_5 SFE_{it} + \beta_6 DRG_{it} + \mu_i + \lambda_t + \varepsilon_{3it}$$

The sequential indirect effect is computed as the product $(\beta_1)(\beta_2)(\beta_4)$, and statistical significance is evaluated using 1,000 bootstrap replications. Mediation is supported when indirect effects are statistically significant and the direct effect of digital adoption attenuates

after inclusion of mediating variables. This approach allows for explicit testing of the hypothesised pathway through which monitoring precision influences fiscal autonomy via efficiency and accountability channels.

Robustness Checks and Diagnostic Procedures

A series of robustness checks are conducted to validate the stability and reliability of the empirical results. Parallel trend assumptions are assessed using pre-treatment event-study coefficients and joint F-tests to ensure absence of anticipatory effects. Alternative index constructions, including equal-weight aggregation and pillar-specific measures, are employed to evaluate sensitivity to variable specification. Lagged treatment models are estimated to capture persistence and delayed effects of digital adoption. Standard errors are clustered at the state level to account for serial correlation, while Driscoll–Kraay corrections are applied to address potential cross-sectional dependence. Placebo tests using non-digitised revenue categories are conducted to confirm the specificity of reform effects. Instrumental-variable estimates are compared with baseline results to ensure consistency across identification strategies. Collectively, these diagnostic procedures reinforce the robustness of the findings and strengthen confidence in the causal interpretation of the estimated relationships.

RESULTS AND DISCUSSION

Descriptive Statistics and Identification Diagnostics

Table 1 presents summary statistics and pre-treatment diagnostics for the key variables. Digital Revenue Governance (DRG) exhibits substantial within-state variation, with a mean of 0.46 and sufficient dispersion to support staggered identification. Subnational Fiscal Efficiency (SFE) and Accountable Revenue Mobilisation (ARM) are standardised indices centred at zero, indicating balanced distributions across jurisdictions. Fiscal Autonomy (FA) averages 0.37, reflecting moderate variation in own-source revenue reliance among states. Correlation estimates reveal moderate associations between DRG and SFE (0.42) and DRG and ARM (0.31), while the contemporaneous DRG–FA relationship is comparatively weaker (0.18). The stronger ARM–FA correlation (0.47) provides preliminary support for the hypothesised mediation structure, suggesting that revenue accountability plays a central role in determining fiscal autonomy outcomes. These patterns indicate that digital adoption is more closely linked to intermediate institutional performance than to immediate fiscal independence.

Event-study lead coefficients further validate the identification strategy by testing the parallel trends assumption underlying the difference-in-differences framework. As shown in Table 1, pre-adoption estimates for both SFE and FA are statistically insignificant and exhibit no systematic trend across periods preceding reform implementation. Joint F-tests fail to reject the null hypothesis of no differential pre-trends, indicating that treated and untreated states followed comparable trajectories prior to digital adoption. This absence of anticipatory effects mitigates concerns regarding endogenous timing of reform implementation and strengthens the causal interpretation of subsequent estimates. The consistency between

descriptive patterns and identification diagnostics provides a robust foundation for evaluating the institutional effects of Digital Revenue Governance.

Table 1. Descriptive Statistics and Pre-Adoption Diagnostics**Panel A: Summary Statistics**

Variable	Mean	Std. Dev.	Min	Max	Obs.
DRG Intensity (Index 0–1)	0.460	0.210	0.050	0.920	1,920
Subnational Fiscal Efficiency (SFE)	0.000	1.000	-2.310	2.480	1,920
Accountable Revenue Mobilisation (ARM)	0.000	1.000	-2.040	2.260	1,920
Fiscal Autonomy (FA)	0.370	0.110	0.180	0.630	1,920
Own-Source Revenue Share	0.410	0.130	0.190	0.710	1,920
Revenue Volatility (CV)	0.290	0.120	0.100	0.620	1,920

Panel B: Correlation Matrix

Variable	(1) DRG	(2) SFE	(3) ARM	(4) FA
(1) DRG	1.000			
(2) SFE	0.420***	1.000		
(3) ARM	0.310***	0.550***	1.000	
(4) FA	0.180**	0.290***	0.470***	1.000

Panel C: Pre-Adoption Event-Study Leads (Dependent Variable: SFE)

Lead (k)	Coefficient	Std. Error	p-value
k = -4	-0.012	(0.021)	0.570
k = -3	0.008	(0.019)	0.670
k = -2	0.015	(0.018)	0.410
k = -1	0.000 (baseline)	—	—

Joint F-test (leads = 0): F = 0.830, p = 0.480

Dependent Variable: FA

Lead (k)	Coefficient	Std. Error	p-value
k = -4	0.003	(0.006)	0.620
k = -3	-0.002	(0.005)	0.710
k = -2	0.004	(0.005)	0.440

Joint F-test (leads = 0): F = 0.590, p = 0.620

Notes: SFE and ARM are standardised indices (mean = 0, SD = 1). Fiscal Autonomy (FA) is scaled between 0 and 1, with higher values indicating greater fiscal autonomy. Standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Source: Authors' computation (2026).

Baseline Effects of Digital Revenue Governance

Table 2 reports baseline two-way fixed-effects estimates corresponding to Hypotheses H1–H3. The results indicate that Digital Revenue Governance exerts a positive and statistically significant effect on Subnational Fiscal Efficiency ($\beta = 0.184$, $p < 0.01$), supporting the proposition that enhanced monitoring precision improves administrative performance. A one-standard-deviation increase in DRG is associated with a 0.184 standard deviation increase in SFE, reflecting substantial improvements in assessed-to-paid conversion and reconciliation integrity. These results reinforce the role of monitoring precision in strengthening administrative efficiency within decentralised fiscal systems (Kleven et al., 2011; Pomeranz, 2015), while extending the literature by showing that digital adoption strengthens institutional efficiency beyond taxpayer behaviour.

The results further indicate that Digital Revenue Governance positively influences Accountable Revenue Mobilisation ($\beta = 0.126$, $p < 0.01$), suggesting that administrative improvements translate into more stable and predictable revenue flows. However, the direct effect of DRG on Fiscal Autonomy is smaller in magnitude ($\beta = 0.052$, $p < 0.05$), indicating that digital adoption does not immediately translate into fiscal independence. Instead, the relative attenuation of the direct coefficient suggests that the influence of digital systems on autonomy operates through intermediate performance channels. In economic terms, the estimates imply that increased digital adoption reduces revenue volatility by approximately 8–11 percent and increases own-source revenue share by 2.4–3.1 percentage points over a medium-term horizon. These magnitudes underscore the material fiscal implications of digital governance for decentralised systems while reinforcing the importance of institutional transmission mechanisms.

Table 2. Baseline Two-Way Fixed Effects Estimates
Dependent Variables: SFE, ARM, FA

	(1) SFE	(2) ARM	(3) FA
DRG Intensity	0.184*** (0.041)	0.126*** (0.038)	0.052** (0.024)
Controls	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Observations	1,920	1,920	1,920
R² (within)	0.41	0.36	0.29

*Note: Standard errors clustered at the state level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$*

Source: Authors' computation 2026

Sequential Mediation and Institutional Pathways

Table 3 presents the mediation analysis corresponding to Hypothesis H4, providing direct evidence of the sequential institutional pathway linking digital adoption to fiscal autonomy. Consistent with baseline results, Digital Revenue Governance significantly increases

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Subnational Fiscal Efficiency ($\beta = 0.184$, $p < 0.01$). In the second stage, SFE exerts a strong positive effect on Accountable Revenue Mobilisation ($\beta = 0.428$, $p < 0.01$), while the direct DRG coefficient declines in magnitude and significance, indicating partial transmission through efficiency channels. In the final stage, ARM significantly predicts Fiscal Autonomy ($\beta = 0.273$, $p < 0.01$), while the direct effect of DRG becomes statistically insignificant. Subnational Fiscal Efficiency retains a smaller but significant association with FA ($\beta = 0.116$, $p < 0.05$), suggesting partial mediation alongside the dominant sequential pathway.

Bootstrapped indirect effects confirm that the primary transmission mechanism operates through the full sequence DRG \rightarrow SFE \rightarrow ARM \rightarrow FA (indirect effect = 0.022, $p = 0.012$). Partial pathways remain weaker and only marginally significant. The attenuation of the direct DRG coefficient following inclusion of mediators satisfies the conditions for mediation and validates the theoretical model. These findings demonstrate that digital adoption influences fiscal autonomy indirectly by improving administrative performance and revenue credibility rather than through immediate structural shifts in fiscal authority. The results therefore support a layered interpretation of institutional transformation consistent with multi-stage principal-agent models (Holmström & Milgrom, 1991).

Table 3: Sequential Mediation Estimates

Variables	(1) SFE	(2) ARM	(3) FA
DRG	0.184*** (0.041)	0.061* (0.032)	0.019 (0.018)
SFE	—	0.428*** (0.072)	0.116** (0.049)
ARM	—	—	0.273*** (0.067)
Controls	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Observations	1,920	1,920	1,920
Within R ²	0.41	0.49	0.46

Source: Authors' computation 2026

Indirect Effects (Bootstrapped)

Indirect Path	Effect	Std. Error	p-value
DRG \rightarrow SFE \rightarrow ARM \rightarrow FA	0.022	0.008	0.012
DRG \rightarrow SFE \rightarrow FA	0.021	0.010	0.041
DRG \rightarrow ARM \rightarrow FA	0.017	0.009	0.058

Notes: Standard errors clustered at the state level and reported in parentheses.

**** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*

Indirect effects calculated as the product of constituent structural coefficients.

Source: Authors' computation 2026

Dynamic Effects and Temporal Adjustment

Event-study estimates provide further evidence on the temporal sequencing of institutional adjustment. The results indicate that improvements in Subnational Fiscal Efficiency emerge within two to three post-adoption periods, reflecting relatively rapid gains in administrative performance following digital implementation. Subsequent improvements in revenue stability and payment timeliness occur with moderate lags, suggesting that enhanced efficiency gradually translates into accountable revenue mobilisation. In contrast, Fiscal Autonomy responds more slowly, with significant effects emerging only after sustained improvements in revenue credibility. This temporal ordering supports the hypothesised mediated pathway and indicates that fiscal autonomy is a lagged equilibrium outcome rather than an immediate consequence of digital adoption. The absence of significant pre-treatment effects further reinforces the validity of the identification strategy and confirms that observed dynamics are attributable to reform implementation rather than underlying trends. These findings are consistent with theoretical expectations that improvements in monitoring precision influence outcomes progressively as incentives adjust and administrative systems stabilise (Holmström, 1979). The dynamic evidence therefore strengthens the interpretation of digital governance as a process-driven reform that reshapes institutional equilibrium over time.

Heterogeneity and Moderating Effects

Table 4 reports heterogeneous treatment effects that highlight the conditional nature of the digital governance pathway. The interaction between Digital Revenue Governance and administrative capacity is positive and statistically significant ($\beta = 0.094$, $p < 0.05$), indicating that jurisdictions with stronger institutional capacity convert digital adoption into larger efficiency gains. This suggests that monitoring precision alone is insufficient to generate performance improvements without complementary administrative capabilities. Additional results show that governance quality moderates the relationship between Accountable Revenue Mobilisation and Fiscal Autonomy, with stronger institutional environments enhancing the translation of revenue stability into fiscal independence.

These findings confirm that the DRG \rightarrow SFE \rightarrow ARM \rightarrow FA pathway is capacity-contingent rather than uniform across jurisdictions. In lower-capacity environments, increased observability may not fully translate into enforcement optimisation or revenue consolidation. The results therefore highlight the importance of institutional complementarities in determining the effectiveness of digital reforms. Digital infrastructure provides the informational foundation for improved performance, but its impact depends critically on the administrative and governance context within which it is implemented

Table 4: Heterogeneous Treatment Effects

Variables	Model 1: SFE (Efficiency)	Model 2: ARM (Revenue Stability)	Model 3: FA (Fiscal Autonomy)
DRG	0.182*** (0.041)	0.136** (0.052)	0.118** (0.047)
Administrative Capacity	0.067* (0.038)	0.054 (0.043)	0.081** (0.039)
DRG × Administrative Capacity	0.094 (0.046)**	—	—
ARM	—	0.211*** (0.061)	0.174*** (0.058)
Governance Quality	—	—	0.089* (0.048)
ARM × Governance Quality	—	—	0.072 (0.031)**
Control Variables	Included	Included	Included
State Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Observations	1,512	1,512	1,512
Adjusted R ²	0.47	0.52	0.55

Note: Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Source: *Author's computations 2026.*

Robustness and Diagnostic Validation

A comprehensive set of robustness checks confirms the stability and reliability of the empirical findings. Instrumental-variable estimates using vendor rollout sequencing and pre-existing fibre connectivity as instruments yield coefficients comparable in magnitude to baseline estimates, with first-stage F-statistics exceeding conventional thresholds for weak identification. Hansen J-tests fail to reject the null of joint instrument exogeneity, supporting the validity of the exclusion restrictions. Limited-information maximum likelihood estimators produce consistent results, mitigating concerns regarding weak-instrument bias.

Additional robustness checks demonstrate that results are not sensitive to alternative index constructions, lag structures, or error specifications. Driscoll–Kraay standard errors accounting for cross-sectional dependence do not materially alter statistical inference. Placebo regressions using non-digitised revenue categories yield insignificant results, confirming the specificity of reform effects. Across all specifications, a consistent pattern emerges: digital adoption improves administrative efficiency, efficiency enhances revenue accountability, and accountability consolidates fiscal autonomy. The robustness of these findings strengthens confidence in the causal interpretation of the estimated relationships.

DISCUSSION AND THEORETICAL IMPLICATIONS

The empirical results provide strong support for a mediated institutional pathway linking Digital Revenue Governance to Subnational Fiscal Autonomy. Digital adoption enhances

monitoring precision, which improves administrative efficiency and subsequently strengthens revenue credibility. Fiscal autonomy emerges as a lagged outcome of this process, rather than as an immediate effect of technological adoption. This interpretation extends principal–agent theory by conceptualising monitoring as embedded informational architecture rather than discretionary oversight intensity. Digital systems restructure equilibrium conditions by increasing observability and reducing informational rents, thereby aligning incentives across administrative agents.

The findings also refine fiscal federalism theory by demonstrating that decentralised authority depends on the credibility of revenue mobilisation rather than solely on statutory tax assignments (Oates, 1972; Weingast, 1995). Revenue stability and predictability emerge as key determinants of fiscal independence, shifting analytical emphasis from legal authority to performance-based outcomes. Furthermore, the study integrates digital governance scholarship with public sector accounting by linking system interoperability and data integration to macro-fiscal outcomes. Monitoring precision, administrative efficiency, and fiscal autonomy are therefore jointly determined within an embedded institutional framework shaped by digital transformation.

Policy and Institutional Implications

The results carry important implications for policy design in emerging economies. Digital tax reforms should be evaluated based on improvements in administrative performance and revenue credibility rather than on adoption metrics alone. Indicators such as assessed-to-paid conversion, reconciliation accuracy, and volatility compression provide more meaningful measures of reform effectiveness than aggregate revenue growth. Policymakers should prioritise interoperability, data integrity, and enforcement consistency to maximise the benefits of digitalisation. Investment in administrative capacity and analytical capability is essential to translate monitoring precision into sustained fiscal gains.

The findings also underscore the importance of institutional complementarities in digital reform implementation. Without adequate administrative capacity and governance quality, digital systems may improve observability

CONCLUSION AND FUTURE RESEARCH DIRECTION

Conclusion

This study investigates whether Digital Revenue Governance strengthens Subnational Fiscal Autonomy within a federated fiscal system by conditioning institutional performance through embedded monitoring architecture. The findings establish a sequential transmission mechanism rather than a contemporaneous revenue effect, demonstrating that digital adoption enhances Subnational Fiscal Efficiency, which improves Accountable Revenue Mobilisation and ultimately consolidates Fiscal Autonomy. The attenuation of the direct effect of digital adoption on autonomy after accounting for mediating variables confirms that fiscal independence emerges through performance-based institutional channels. These results indicate that digital tax integration restructures fiscal outcomes by increasing verification precision, reducing reconciliation frictions, and stabilising revenue flows. Fiscal autonomy is therefore best understood as a lagged equilibrium outcome grounded in credible and

predictable revenue realisation rather than as an immediate consequence of technological deployment or statutory authority.

Research Limitations

This study is conducted within a specific federated context, which may condition the institutional dynamics through which digital revenue governance influences fiscal autonomy. In addition, the analysis relies on administrative proxies to capture multidimensional institutional constructs, although these measures are grounded in established theoretical frameworks. The empirical window reflects an early phase of reform implementation, implying that the findings capture transitional dynamics rather than fully matured equilibrium outcomes. These factors do not undermine the validity of the results but define the scope within which the conclusions should be interpreted.

Future Research Directions

Future research should extend this analysis by examining the long-run institutional effects of digital revenue governance, particularly the persistence and stability of fiscal autonomy as an equilibrium outcome. A critical gap remains in understanding how political economy factors and institutional incentives interact with digital monitoring architecture to shape the durability of decentralised fiscal capacity. Addressing this dimension would deepen theoretical integration and provide a more comprehensive account of digitally mediated fiscal governance.

Contributions

This study determines whether Digital Revenue Governance strengthens Subnational Fiscal Autonomy and identifies the institutional mechanism through which this occurs. The findings demonstrate that fiscal autonomy is not a direct outcome of digital adoption but a mediated equilibrium arising from improvements in administrative efficiency and revenue credibility, thereby addressing a key gap in linking digital monitoring systems to decentralised fiscal outcomes. Conceptually, the study reconceptualises digital infrastructure as embedded monitoring architecture that enhances signal informativeness and reshapes incentive alignment, extending principal-agent theory while refining fiscal federalism around credibility-based decentralisation. Methodologically, it integrates quasi-experimental identification with sequential mediation modelling to capture institutional transmission pathways. Empirically, the results confirm that Digital Revenue Governance operates through Subnational Fiscal Efficiency and Accountable Revenue Mobilisation, with direct effects attenuating once these channels are introduced. The study therefore establishes fiscal autonomy as a lagged, performance-based outcome shaped by institutional credibility.

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