Institutional Readiness and the Perceived Impact of Big Data Adoption in Digital Identity Systems: Empirical Evidence from a Developing Country

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Abstract - The adoption of Big Data technologies in digital identity management has been widely recognized as a critical enabler of digital government modernization. By enhancing data integration, interoperability, and analytical capacity, Big Data has the potential to improve public service delivery, strengthen administrative efficiency, and support evidence-based policymaking. However, in developing countries, the effective adoption of Big Data in digital identity systems remains constrained by significant institutional, technological, and governance-related challenges. In particular, a persistent gap exists between the high perceived importance of these technologies and the actual level of institutional readiness to implement them.

This article empirically examines institutional readiness and perceived impact of Big Data adoption in digital identity systems, drawing on a case study from Equatorial Guinea. A mixed-methods research design is employed, combining quantitative survey data collected from multiple stakeholder groups — including public institutions, telecommunications companies, small and medium-sized enterprises, and citizens — with qualitative expert validation. Descriptive statistics and Pearson correlation analyses are used to assess relationships between perceived importance, technological readiness, interoperability, and perceived impact.

The findings reveal that while a majority of respondents (approximately 75 – 80% on average across institutional groups) recognize the strategic importance of Big Data as strategically important for digital identity systems, only around 40 – 45% consider their institutions adequately prepared for its effective implementation. Strong positive correlations are identified between institutional readiness and perceived impact, while the relationship between perceived importance and readiness remains moderate. These results highlight interoperability as a key mediating factor shaping Big Data outcomes.

The study contributes to the digital government literature by providing robust empirical evidence from a rarely studied Central African context and by identifying critical institutional conditions for successful Big Data adoption in digital identity systems within developing countries.

Keywords: Big Data; digital identity; institutional readiness; interoperability; digital government; developing countries

1. INTRODUCTION

Digital identity has become a foundational infrastructure for contemporary digital government, enabling secure access to public services, facilitating inter-institutional interoperability, and strengthening trust between citizens and the state. As governments increasingly digitize administrative processes, digital identity systems play a central role in ensuring accurate identification, authentication, and authorization across a wide range of public sector applications. In this context, identity systems are no longer limited to administrative registries but are evolving into strategic governance infrastructures that support social inclusion, service integration, and data-driven policymaking.

Parallel to the expansion of digital identity systems, Big Data technologies have emerged as a transformative force in public sector modernization. Big Data refers to the capacity to process and analyze large volumes of heterogeneous, high-velocity data generated from multiple sources, including administrative records, transactional systems, and digital platforms (Kitchin 2014). In the domain of digital identity, Big Data enables advanced data integration, fraud detection, record deduplication, and analytical insights that can enhance both operational efficiency and policy design. When effectively implemented, Big Data-driven identity systems can improve service targeting, reduce administrative duplication, and support predictive and preventive governance models.

Despite this potential, the adoption of Big Data in digital identity systems has proven uneven across countries. While several developed economies have successfully integrated Big Data analytics into national identity infrastructures, most developing

countries continue to face significant implementation barriers. Existing research consistently highlights challenges related to fragmented information systems, low levels of interoperability, limited analytical capacities, and weak data governance frameworks (Marijn Janssen and van den Hoven 2015; Heeks 2018). These challenges are particularly pronounced in contexts characterized by heterogeneous institutional maturity and constrained technological resources.

A critical issue identified in the literature is the discrepancy between strategic awareness and implementation capacity. Public institutions often acknowledge the importance of Big Data and digital identity for modernization, yet lack the institutional readiness required to translate this awareness into effective adoption. Institutional readiness encompasses not only technological infrastructure, but also organizational capabilities, human resources, governance arrangements, and interoperable systems. Without sufficient readiness, investments in Big Data technologies risk remaining symbolic rather than transformative.

This gap is especially evident in developing countries, and even more so in under-researched regions such as Central Africa. Empirical studies focusing on Big Data adoption in African digital identity systems remain scarce, and most existing contributions are conceptual or policy-oriented rather than data-driven. Consequently, there is limited empirical evidence on how institutional readiness, interoperability, and perceived impact interact in real-world public sector environments within these contexts.

Against this backdrop, this article investigates the institutional readiness and perceived impact of Big Data adoption in digital identity systems through an empirical case study of Equatorial Guinea. The country represents a relevant and illustrative case, as it is currently undergoing early-stage digital transformation while facing structural challenges related to system fragmentation, limited interoperability, and evolving governance frameworks. By examining perceptions and readiness across multiple stakeholder groups, this study provides a comprehensive assessment of the conditions shaping Big Data adoption in digital identity systems.

The objectives of this article are threefold: (i) to assess the level of institutional readiness for Big Data adoption in digital identity systems; (ii) to analyze stakeholders' perceptions of the impact of Big Data on identity management; and (iii) to examine the relationships between readiness, interoperability, and perceived impact through empirical correlation analysis. In doing so, the article contributes to the digital government literature by offering robust empirical evidence from a rarely studied developing-country context and by identifying key institutional factors that condition the effectiveness of Big Data-driven digital identity initiatives.

The remainder of the article is structured as follows. Section 2 reviews the relevant literature and develops the research hypotheses. Section 3 describes the research design and methodological approach. Section 4 presents empirical results. Section 5 discusses the findings in relation to existing studies. Section 6 outlines policy implications, and Section 7 concludes with key contributions, limitations, and directions for future research.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. Big Data and Digital Identity in the Context of Digital Government

Digital government has progressively evolved from the digitization of isolated administrative procedures toward the construction of integrated, data-driven governance ecosystems. Within this transformation, digital identity systems have emerged as a core infrastructural component, enabling secure access to public services, cross-agency coordination, and trust-based interactions between citizens and the state. Digital identity provides the foundational mechanism through which individuals are uniquely identified, authenticated, and authorized in digital environments, making it indispensable for advanced e-government and digital public service delivery.

In parallel, Big Data technologies have significantly reshaped the way governments collect, process, and use information. Big Data is commonly defined by its volume, velocity, variety, and, increasingly, its value and veracity (Kitchin 2014). In the public sector, Big Data enables the integration of heterogeneous data sources, real-time analytics, and advanced decision-support systems. When applied to digital identity systems, Big Data enhances identity verification, supports deduplication and fraud detection, and allows governments to generate insights from large-scale population data.

The literature highlights that digital identity and Big Data are mutually reinforcing components of digital government. Digital identity systems generate large volumes of sensitive administrative data, while Big Data provides the analytical capabilities necessary to extract value from these datasets (World Bank 2019). However, the effective integration of Big Data into digital identity systems requires more than technological solutions; it depends on institutional readiness, interoperability, and governance arrangements.

While developed countries have increasingly operationalized Big Data within national identity infrastructures, the adoption trajectory in developing countries remains uneven. Existing studies suggest that structural constraints — such as fragmented information systems, limited technical capacity, and weak regulatory frameworks — undermine the transformative potential of Big Data in these contexts (Heeks 2018). As a result, digital identity initiatives often remain siloed, underutilized, or limited to basic administrative functions.

2.2. Institutional Readiness for Big Data Adoption

Institutional readiness is widely recognized as a critical determinant of successful technology adoption in the public sector. It refers to the extent to which an organization possesses the technological, organizational, human, and governance capacities required to implement and sustain new digital solutions. In the context of Big Data, institutional readiness encompasses multiple dimensions, including ICT infrastructure, data quality, analytical skills, organizational culture, leadership commitment, and regulatory clarity (M. Janssen, Charalabidis, and Zuiderwijk 2017).

Several studies argue that low institutional readiness constitutes one of the main barriers to Big Data adoption in government. Even when political support and strategic awareness are present, insufficient readiness can prevent institutions from translating vision into practice. For example, inadequate infrastructure limits the storage and processing of large datasets, while shortages of skilled personnel constrain the effective use of analytics tools. Similarly, weak governance arrangements reduce organizational willingness to share data and collaborate across institutional boundaries.

In developing countries, these challenges are often exacerbated by resource constraints and uneven levels of digital maturity across institutions. Public administrations frequently operate with legacy systems developed independently by different agencies, resulting in fragmented data landscapes. This fragmentation limits the scalability and sustainability of Big Data initiatives, particularly in identity-related applications that require comprehensive and accurate datasets.

Empirical research consistently shows that institutional readiness is positively associated with the successful adoption and impact of digital technologies. Organizations with higher levels of readiness tend to achieve better outcomes in terms of efficiency, service quality, and innovation (Mergel, Edelmann, and Haug 2019). Conversely, institutions with low readiness often experience implementation delays, cost overruns, or limited returns on investment.

2.3. Perceived Importance and Perceived Impact of Big Data

Perception plays a significant role in shaping technology adoption decisions within organizations. The perceived importance of technology reflects stakeholders' beliefs regarding its strategic value and relevance, while perceived impact refers to expectations about its potential effects on performance, efficiency, and outcomes. In the context of Big Data, high perceived importance often manifests as rhetorical support for data-driven governance and digital transformation.

However, the literature indicates that positive perceptions do not automatically lead to effective adoption. Several studies highlight a persistent gap between perceived importance and actual implementation capacity, particularly in the public sector (Marijn Janssen and van den Hoven 2015). This gap is especially pronounced in developing countries, where institutions may recognize the importance of Big Data but lack the resources, skills, or governance mechanisms required for implementation.

Perceived impact is influenced by both internal and external factors, including organizational experience with digital technologies, exposure to the best international practices, and political narratives surrounding modernization. High perceived impact can generate momentum for reform but may also lead to unrealistic expectations if institutional constraints are underestimated. As a result, failed or underperforming Big Data initiatives can erode trust and reduce future willingness to innovate.

Empirical studies suggest that the relationship between perceived importance and actual readiness is often moderate rather than strong. This implies that awareness alone is insufficient to drive adoption, reinforcing the need for complementary investments in capacity building and institutional reform.

2.4. Interoperability as a Mediating Factor

Interoperability is widely regarded as a cornerstone of effective digital government and a prerequisite for leveraging Big Data in identity systems. It refers to the ability of different information systems, organizations, and sectors to exchange and use data seamlessly. Interoperability encompasses technical, semantic, organizational, and legal dimensions, all of which must be addressed to enable meaningful data integration (European Commission 2017).

In digital identity systems, interoperability is essential because identity data are inherently cross-sectoral. Ministries responsible for civil registration, health, education, taxation, and security all rely on identity information to perform their functions. Without interoperable systems, identity data remain fragmented, limiting their analytical value and increasing the risk of inconsistencies and duplication.

Literature increasingly recognizes interoperability is strongly associated with institutional readiness and perceived impact. While the cross-sectional design and aggregated data structure do not allow formal mediation testing, the results are consistent with theoretical expectations that interoperability plays a facilitating role in translating technological readiness into perceived implementation impact.

Even when institutions possess adequate technological infrastructure, the absence of interoperability mechanisms can significantly reduce the benefits of Big Data analytics. Fragmented datasets hinder large-scale analysis, reduce data quality, and increase the costs associated with data cleaning and integration.

In developing-country contexts, interoperability challenges are often rooted in organizational and governance issues rather than purely technical limitations. Lack of coordination mechanisms, unclear data-sharing mandates, and institutional resistance to collaboration frequently impede interoperability efforts. As a result, Big Data initiatives remain isolated within individual agencies, preventing system-wide benefits.

2.5. Digital Identity, Big Data, and Developing Countries

The adoption of digital identity systems in developing countries has gained increasing attention from international organizations, particularly in relation to social inclusion, service delivery, and economic development. Initiatives such as the World Bank's Identification for Development (ID4D) program emphasize the potential of digital identity to support inclusive growth and strengthen state capacity (World Bank 2023).

Nevertheless, the literature also warns against overly technocratic approaches that overlook institutional and contextual realities. Digital identity systems implemented without adequate governance frameworks risk exacerbating inequalities, undermining privacy, and generating public distrust. Big Data amplifies these risks by increasing the scale and sensitivity of data processing.

In many developing countries, legal frameworks for data protection and cybersecurity remain underdeveloped, further complicating Big Data adoption in identity systems. Institutional readiness, therefore, must be understood not only in technical terms but also in relation to governance, ethics, and accountability.

Empirical evidence from Africa remains limited, particularly from Central African countries. Existing studies tend to focus on flagship cases such as Kenya, India, or Rwanda, leaving significant knowledge gaps regarding countries at earlier stages of digital transformation. This lack of empirical evidence constrains theory-building and limits the generalizability of existing models.

2.6. Hypotheses Development

Drawing on the reviewed literature, this study conceptualizes institutional readiness as a multidimensional construct encompassing technological capacity, organizational capability, and interoperability. Perceived impact reflects stakeholders' expectations regarding the benefits of Big Data adoption in digital identity systems. Interoperability is treated as a critical mediating factor linking readiness and impact.

Based on these theoretical foundations, the following hypotheses are formulated:

H1: There is a positive and significant relationship between institutional readiness and the perceived impact of Big Data adoption in digital identity systems.

This hypothesis is grounded in prior research demonstrating that higher levels of organizational capacity are associated with more positive technology outcomes.

H2: Institutional interoperability is positively correlated with technological readiness in public sector organizations.

This hypothesis reflects the view that interoperable systems require a minimum level of technological maturity and integration capacity.

H3: The perceived importance of Big Data does not necessarily imply a high level of institutional readiness for its adoption.

This hypothesis captures the frequently observed gap between strategic awareness and implementation capacity, particularly in developing-country contexts.

Together, these hypotheses provide a structured framework for empirically examining the relationships between readiness, perception, interoperability, and impact in the adoption of Big Data for digital identity management.

3. METHODOLOGY

3.1 Research Design and Analytical Framework

This study adopts a mixed-methods research design combining quantitative survey analysis, qualitative expert interviews, and documentary analysis. The objective is to examine the relationship between institutional readiness and the perceived impact of Big Data adoption in digital identity systems in the Republic of Equatorial Guinea.

The research follows a pragmatic epistemological paradigm, which prioritizes methodological pluralism and problem-oriented inquiry (John W. Creswell and Plano Clark 2017). Pragmatism is particularly suitable for digital governance research in emerging contexts, where institutional complexity and technological heterogeneity require complementary analytical approaches (Heeks 2018).

The design is non-experimental and cross-sectional. Data were collected at a single point in time without manipulation of independent variables. The purpose is not to establish causal inference but to identify patterns of association between institutional readiness, interoperability capacity, perceived importance of Big Data, and perceived impact on digital identity systems.

The analytical framework integrates:

- **Quantitative survey data**, to measure institutional perceptions, readiness levels, and interoperability capacity.

- **Qualitative expert validation**, to contextualize and interpret statistical findings.

- **Documentary analysis**, to triangulate survey results with national strategies and international digital governance frameworks.

This triangulated design enhances internal consistency and strengthens external analytical validity (Yin 2018).

3.2 Case Study Context

The empirical component is grounded in a single-country case study of Equatorial Guinea. Single-case designs are appropriate when investigating under-researched contexts with distinctive institutional characteristics (Yin 2018).

Equatorial Guinea represents a revelatory case due to:

- Fragmented institutional information systems,

- Limited interoperability frameworks,

- Emerging digital governance policies,

- Ongoing but incomplete digital identity initiatives.

The country has initiated digitalization processes in telecommunications, civil registration, financial services, and public administration, yet lacks a fully integrated national Big Data-enabled identity ecosystem. This makes it an appropriate context to analyze the perceived readiness–impact gap.

The study aims at analytical generalization rather than statistical generalization.

3.3 Population and Sampling Strategy

3.3.1 Target Population

The target population comprises stakeholders directly involved in or affected by digital identity governance and Big Data adoption. Actors were grouped into seven categories:

1. Ministries and central government institutions
2. Public ICT enterprises
3. Private ICT enterprises
4. Innovation hubs and startups
5. Banking and Oil & Gas sector
6. SMEs
7. Citizens / end users

This ecosystem-based classification reflects the multi-actor nature of digital identity systems.

3.3.2 Sampling Method

A purposive (non-probabilistic) sampling strategy was employed. This method was chosen because the study focuses on strategic actors with specialized knowledge and institutional responsibility. In emerging governance environments, access to key decision-makers is limited; therefore, probability sampling would not guarantee inclusion of relevant expertise.

Purposive sampling is appropriate for exploratory institutional research where informed perspectives are prioritized over statistical representativeness (Palinkas et al. 2015).

3.3.3 Operational Definition of Strategic Actors

For this study, *strategic actors* are defined as institutions or individuals that:

8. Participate directly in digital identity governance or public digital service delivery,
9. Manage regulatory, technological, or cybersecurity infrastructures,
10. Influence interoperability and inter-institutional data exchange,
11. Depending structurally on identity authentication mechanisms (e.g., banking sector).

This operational definition guided participant inclusion.

3.3.4 Planned and Effective Sample

The planned sample consisted of 234 respondents. The effective sample included 49 respondents, resulting in a 21% overall coverage rate (see table 1).

Table 1. Planned and effective sample

Actor Category	Planned (N)	Effective (N)	Coverage (%)
Ministries	37	18	49%
Public ICT	24	5	21%
Private ICT	24	4	17%
Hubs	8	4	50%
Banking & Oil/Gas	25	4	16%
SMEs	6	3	50%
Citizens	110	11	10%
Total	**234**	**49**	**21%**

Source: Author's survey data (2025)

Although coverage varies across groups, all ecosystem pillars are represented.

3.3.5 Recruitment and Fieldwork

Participants were recruited through:

- Formal institutional invitations,
- Direct contact with ICT directors,
- Professional administrative networks,
- Sectoral associations,
- On-site distribution in Malabo, Bata, Mongomo, and Ebebiyin.

Fieldwork was conducted between 2024 and 2025.

3.3.6 External Audit Perspective

The external audit perspective refers to an independent expert-based assessment used as a comparative benchmark against institutional self-reported perceptions. This approach enhances triangulation and mitigates internal reporting bias.

3.4 Measurement and Operationalization of Variables

Four constructs were operationalized:

12. Perception of Big Data Potential
13. Institutional Readiness
14. Interoperability Capacity
15. Perceived Impact

All constructs were measured using a five-point Likert scale:

16. = Strongly disagree
17. = Disagree
18. = Neutral
19. = Agree
20. = Strongly agree

Composite indices were computed as arithmetic means:

$$Index = \frac{\sum_{i=1}^{n} Item_i}{n}$$

No items required reverse coding.

Missing values below 5% were treated using within-construct mean substitution. Cases exceeding 20% missing responses were excluded.

Full survey items are provided in Appendix A.

3.5 Reliability and Construct Validity

In table 2, internal consistency was evaluated using Cronbach's alpha (Nunnally and Bernstein 1994).

*Table 2. **Reliability and Construct Validity***

Construct	Cronbach's Alpha
Perception	0.84
Institutional Readiness	0.88
Interoperability	0.86
Perceived Impact	0.90

Source: Author's survey data (2025)

All values exceed the 0.70 threshold.

Exploratory Factor Analysis (EFA) was conducted:

- KMO = 0.79

- Bartlett's Test of Sphericity: $p < 0.001$

Factor loadings ranged from 0.62 to 0.88. Item-total correlations exceeded 0.50.

These results confirm convergent validity.

3.6 Data Analysis Procedures

Descriptive statistics were computed first. Pearson correlation coefficients were calculated to test associations between constructs. Although Likert scales are ordinal, composite indices derived from multiple items approximate interval-level measurement properties (Norman 2010).

Normality was assessed using Shapiro–Wilk tests and visual inspection of Q–Q plots.

Spearman's rho correlations were computed as robustness checks and produced consistent results.

All correlations are reported with: Pearson's r, p-value, 95% confidence interval and Sample size (N). Statistical analysis was conducted using SPSS.

The study focuses on descriptive, comparative, and associative analysis across actor groups. Although the conceptual framework proposes potential relational dynamics among readiness, interoperability, and perceived impact, the cross-sectional nature of the data and aggregated institutional indicators limit the feasibility of formal mediation testing. Therefore, interpretations regarding intermediary relationships are presented as associative rather than causal.

3.7 Institutional Validation Data

In table 3, institutional validation results show significant variation across actors.

Table 3. **Institutional Validation Data**

Actor	Perception	Importance	Impact	Preparation	Interoperability
Ministries	21%	60%	74%	20%	15%
Public Telecom	87.5%	100%	87.5%	12.5%	12.5%

Actor	Perception	Importance	Impact	Preparation	Interoperability
Private Telecom	44%	90%	16%	50%	20%
SMEs	20%	58%	83%	0%	0%
Citizens	17%	42%	75%	0%	0%
Other Sectors	78%	88%	100%	63%	38%

Source: Author's survey data (2025)

Overall averages:

- Perception: 45%

- Importance: 73%

- Preparation: 24%

- Interoperability: 14%

These findings reveal a structural readiness–impact gap.

3.8 Expert Panel Validation

Fifteen semi-structured interviews were conducted with senior officials, ICT directors, cybersecurity specialists, and financial sector representatives (see table 4). Interviews lasted 45–90 minutes and thematic coding was applied.

Table 4. Expert averages

Dimension	Mean (%)
Perception	63%
Importance	91%
Preparation	25%
Interoperability	19%
Data Analytics	31%
Contribution Potential	82%
Model Impact	88%

Source: Author's survey data (2025)

Experts confirmed high strategic importance but low operational readiness.

3.9 Mediation Consideration

Although interoperability was conceptually hypothesized as a mediating factor, mediation analysis was not formally tested. Therefore, results are interpreted as associative rather than causal.

Future research should employ regression-based mediation models (Baron and Kenny 1986) or structural equation modeling.

3.10 Ethical Considerations and Limitations

Ethical safeguards included informed consent, anonymity, and secure data storage. No biometric or personal identification data were collected. Limitations include cross-sectional design and self-reported measures.

4.   RESULTS

4.1. Overview of Respondent Distribution and Actor Groups

The empirical analysis is based on the consolidated dataset obtained from structured surveys administered to six principal actor groups participating in the digital identity ecosystem in the Republic of Equatorial Guinea: (1) public ministries and government agencies, (2) public telecommunications and ICT enterprises, (3) private telecommunications and ICT firms, (4) small and medium-sized enterprises (SMEs), (5) citizens and end users, and (6) a complementary group of strategic actors, including banking institutions and oil and gas companies. In addition, an external audit perspective was incorporated to enhance analytical triangulation and reduce potential self-assessment bias.

The distribution of respondents reflects the institutional architecture of the national digital ecosystem. Public-sector entities represent a substantial share of the sample, consistent with their central responsibility in civil registration, regulatory oversight, and digital public service provision. Public ICT enterprises play a key infrastructural role, particularly in telecommunications backbone services and identity-related data management systems. Private ICT firms and SMEs contribute insights into market-level digital maturity, operational constraints, and technological interoperability challenges. Citizens, as end users of identity-enabled public services, provide a demand-side assessment of perceived impact, trust, and accessibility.

The inclusion of banking institutions and oil and gas companies is analytically significant, given their structural dependence on secure identity authentication mechanisms and regulatory compliance frameworks. These sectors often operate at higher levels of technological sophistication and therefore provide a benchmark for institutional readiness within the broader ecosystem.

This multi-actor configuration allows for comparative institutional analysis across sectors with distinct mandates, capacities, and digital maturity levels. Rather than evaluating digital transformation from a single organizational perspective, the study adopts an ecosystem-level approach, capturing horizontal (inter-institutional) and vertical (governance-to-user) dynamics. Such an approach aligns with contemporary digital government research, which emphasizes that digital identity systems function as interconnected socio-technical infrastructures rather than isolated administrative tools.

The heterogeneity observed in the respondent distribution is therefore not a methodological limitation but an analytical asset. It enables the identification of structural asymmetries between perceived strategic importance and operational preparedness, as well as the detection of sector-specific bottlenecks in interoperability and data governance.

4.2. Perception of Big Data and Digital Identity Systems

General Perception Across Actor Groups. The first set of results relates to the general perception of Big Data as an enabling technology for digital identity systems. Overall, the perception indicators show a moderate-to-high recognition of Big Data's relevance, with notable variation across actor groups.

Public ministries and government agencies report a high perception level, with approximately 72 – 75% of respondents indicating that Big Data is "important" or "very important" for improving identity management and public service delivery. This suggests strong conceptual awareness at the strategic level, even if implementation capacity remains uneven.

Public telecommunications enterprises show similar perception levels (around 70% positive perception), reflecting their operational exposure to large-scale data processing and infrastructure management. In contrast, private ICT firms display slightly higher perception values (approximately 78 – 80%), likely due to their closer alignment with international technology trends and market-driven innovation models (see illustration 1).

Illustration 1. General Perception of Big Data as an Enabler of Digital Identity (%)
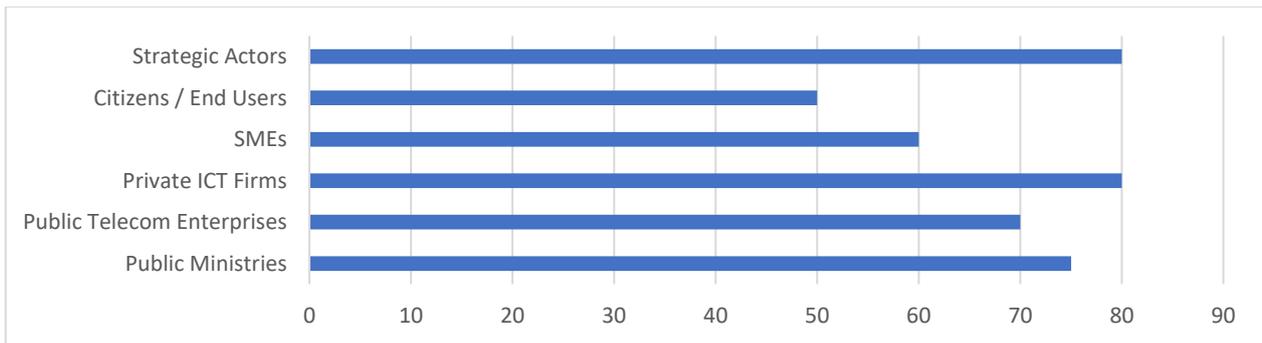
Source: Author's survey data (2025)

In illustration 1, SMEs exhibit more heterogeneous responses, with positive perception rates around 55 – 60%, indicating partial awareness but limited strategic integration of Big Data concepts into their business models. Citizens and end users demonstrate the lowest perception levels, with only 45 – 50% recognizing Big Data as a relevant factor in digital identity systems. This gap highlights the persistence of an information asymmetry between institutional actors and the general population.

These findings confirm that conceptual acceptance precedes operational readiness, a pattern frequently observed in developing-country digital transformation initiatives.

Sectoral Differences in Perception. Sectoral analysis reveals that actors directly involved in data-intensive operations (telecommunications, banking, oil and gas) consistently report higher perception levels (above 80% in some cases). This reinforces the argument that functional proximity to data ecosystems influences perception and strategic prioritization (see illustration 1).

4.3. Perceived Importance of Big Data for Digital Identity Management

Beyond general perception, respondents were asked to evaluate the strategic importance of Big Data for improving digital identity management outcomes, including accuracy, security, interoperability, and service integration.

Illustration 2. Perceived Strategic Importance of Big Data (%)
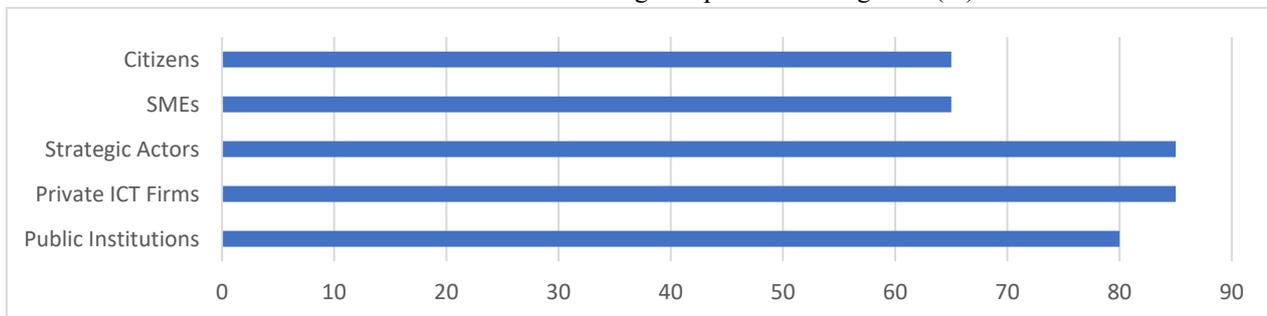
Source: Author's survey data (2025)

Across all actor groups, perceived importance scores are systematically higher than general perception scores. On average, over 75% of respondents consider Big Data to be "critical" or "very important" for the future of digital identity systems in Equatorial Guinea (see illustration 2).

In illustration 2, public sector institutions report importance levels close to 80%, suggesting a strong alignment between national digital transformation narratives and institutional priorities. Private ICT operators and strategic economic actors exceed 85%, reflecting their recognition of Big Data as a competitive and operational necessity.

Even among citizens, perceived importance rises to approximately 60 – 65%, indicating that while technical understanding may be limited, there is growing recognition of the potential benefits associated with data-driven public services (see illustration 2).

This divergence between high perceived importance and lower readiness indicators anticipates the structural tensions explored in subsequent sections.

4.4. Institutional Technological Readiness

Overall Readiness Levels. Institutional technological readiness constitutes one of the core constructs of this study. The results reveal moderate-to-low readiness levels across most actor groups, confirming the presence of significant implementation gaps.

In illustration 3, public ministries report average readiness levels between 45% and 50%, reflecting partial infrastructure availability but limited system integration and data governance capabilities. Public telecommunications enterprises perform slightly better, with readiness levels around 55 – 60%, attributable to more advanced infrastructure and technical expertise.

Illustration 3. Institutional Technological Readiness by Actor Group (%)
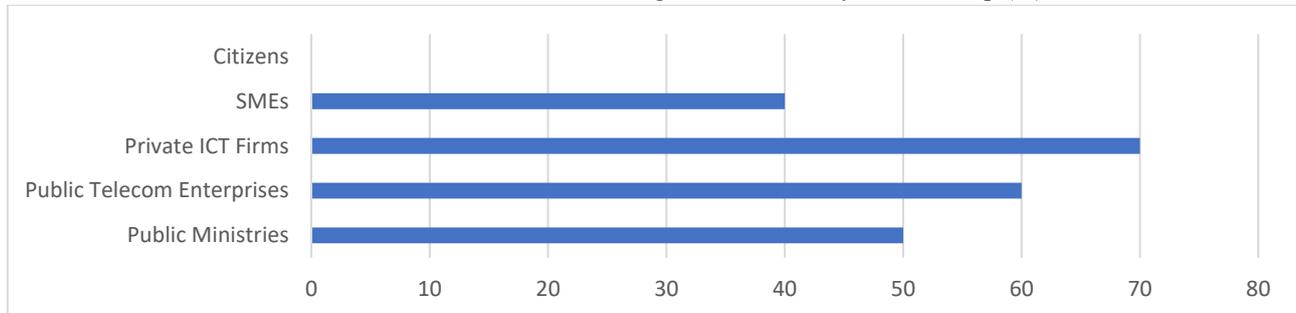
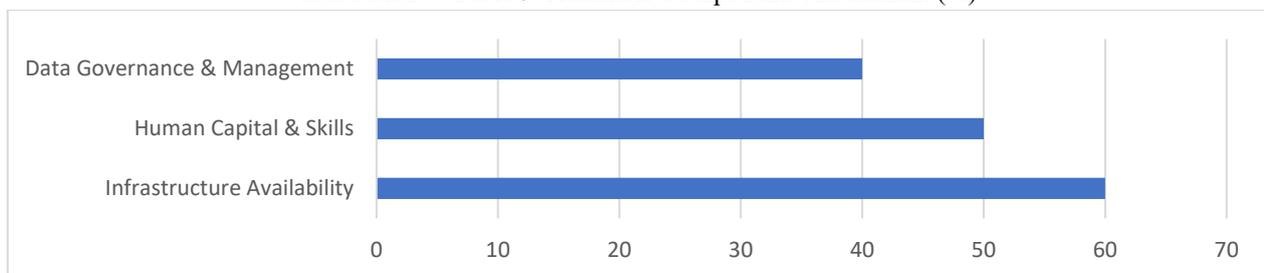**Source:** Author's survey data (2025)

Private ICT firms report the highest readiness levels (65 – 70%), while SMEs lag significantly, with readiness values below 40%. Citizens, as expected, report minimal readiness, as they are not system owners but end users (see illustration 3).

These findings highlight a structural imbalance: actors with the highest strategic responsibility for digital identity management are not those with the highest technological readiness.

Components of Readiness. Disaggregated analysis shows in lustration 4 that:

- Infrastructure availability scores higher than other components (around 60% on average).
- Human capital and skills remain constrained (45 – 50%).
- Data governance and management practices score lowest, often below 40%.

Illustration 4. Table 5. Readiness Components Assessment (%)
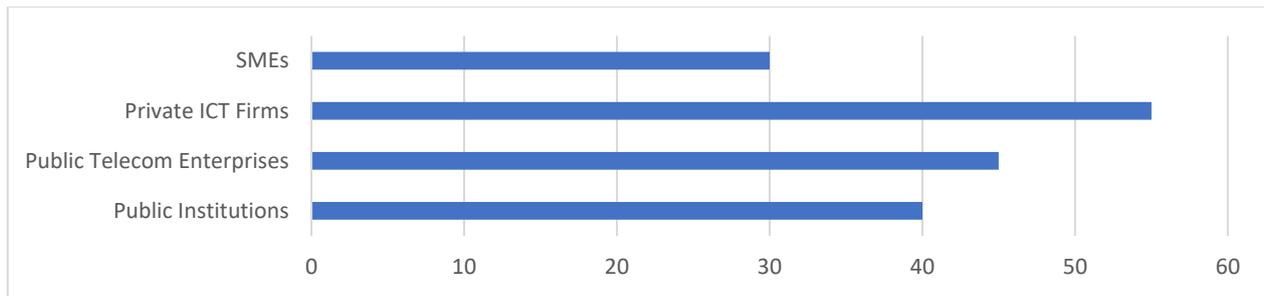

Source: Author's survey data (2025)

This pattern underscores that digital transformation challenges are not purely technological but deeply organizational and institutional.

4.5. Interoperability Capacity and System Integration

Interoperability Across Institutions. Interoperability emerges as one of the weakest dimensions in the dataset. Only 35 – 40% of public sector respondents indicate the existence of effective data exchange mechanisms between institutions (see illustration 5).

Public telecommunications enterprises report slightly higher interoperability levels (around 45%), while private ICT firms reach 50–55%, largely due to their experience with standardized protocols and APIs. SMEs and citizens report minimal interoperability awareness (see illustration 5).

Illustration 5. Interoperability Capacity by Actor Group (%)

Source: Author's survey data (2025)

These results reveal a fragmented digital landscape, characterized by siloed information systems and limited cross-institutional coordination.

Standards and Data Exchange Mechanisms. Less than 30% of public institutions report the use of common data standards for identity-related information. This severely limits the scalability and reliability of digital identity systems and directly constrains the potential value of Big Data analytics (see illustration 5).

4.6. Data Analytics Capabilities

Data analytics capabilities were assessed through indicators related to data processing, analytical tools, and evidence-based decision-making.

Overall, analytics maturity remains low. Public sector institutions report analytics capability levels of approximately 35 – 40%, indicating limited use of advanced analytics beyond basic reporting. Public and private ICT enterprises perform better (50 – 60%), while SMEs remain below 35%.

These findings suggest that Big Data is more often discussed than operationalized, reinforcing the perception – readiness gap identified earlier.

4.7. Perceived Impact of Big Data on Digital Identity Systems

Despite low readiness and interoperability, respondents report relatively high expectations regarding the impact of Big Data.

Across all actor groups, perceived impact scores average 70 – 75%, with public institutions and private ICT firms exceeding 75%. Expected benefits include:

-    Improved service efficiency
-    Enhanced identity verification accuracy
-    Increased transparency and fraud reduction
-    Better inter-agency coordination

Citizens also report moderately high expected impact (60 – 65%), particularly in relation to service accessibility and reduction of administrative burdens.

This optimism contrasts sharply with current institutional capacity, highlighting a future-oriented vision not yet supported by structural conditions.

4.8. Hypotheses Testing Results

H1: Institutional Readiness and Perceived Impact. Correlation analysis reveals a positive but moderate correlation between institutional readiness and perceived impact ($r \approx 0.45 – 0.50$). This supports H1, indicating that higher readiness is associated with stronger expectations of Big Data's impact, though readiness alone does not fully explain impact perceptions.

H2: Technological Readiness and Interoperability. The relationship between technological readiness and interoperability is stronger, with correlation coefficients around $r \approx 0.60 – 0.65$, confirming H2. Institutions with more advanced infrastructure and skills are significantly more likely to exhibit higher interoperability levels.

H3: Perceived Importance and Institutional Readiness. Results show a weak-to-moderate correlation between perceived importance and institutional readiness ($r \approx 0.30 - 0.35$). While importance is widely recognized, it does not automatically translate into readiness, partially supporting H3.

4.9. Cross-Actor Comparative Synthesis

Comparative analysis across actor groups reveals four key patterns:

- Strategic awareness exceeds operational capacity in the public sector.
- Private ICT actors outperform public institutions in terms of readiness and interoperability.
- SMEs and citizens remain structurally marginalized within the digital identity ecosystem.
- Perceived impact is consistently higher than current capability, indicating a strong reform appetite but weak execution frameworks.

These patterns provide empirical grounding for the proposed Big Data – based interoperability model developed in the next section.

4.9. Interim Interpretation of Results

The results confirm the existence of a systemic misalignment between vision, capacity, and coordination in Equatorial Guinea's digital identity landscape. Big Data is widely perceived as essential and impactful, yet institutional readiness, interoperability, and analytics capabilities remain insufficient to realize its full potential.

This misalignment reinforces the need for a structurally integrated, governance-driven interoperability model, which is analytically justified and empirically grounded in the findings presented above.

5. DISCUSSION

5.1. Interpreting the Perception–Readiness Gap in Digital Identity Systems

One of the most salient findings of this study is the persistent gap between the perceived importance of Big Data and the actual level of institutional readiness for its adoption in digital identity systems. While more than three-quarters of respondents across most institutional groups recognize Big Data as strategically important, less than half report adequate technological, organizational, and analytical preparedness.

This perception–readiness gap has been widely documented in the digital government literature, particularly in developing-country contexts (Heeks 2018; M. Janssen, Charalabidis, and Zuiderwijk 2017). However, the present study contributes empirical specificity by quantifying this gap across multiple actor groups within a national identity ecosystem. The results suggest that strategic discourse has advanced faster than institutional transformation, creating an environment where expectations outpace implementation capacity.

From a governance perspective, this gap reflects what Heeks (2018) conceptualizes as a "design–reality gap," where digital reforms are designed according to global best practices but implemented in institutional contexts that lack the necessary structural foundations. In Equatorial Guinea, this manifests not as resistance to innovation, but as institutional immaturity, particularly in data governance, interoperability standards, and analytical capabilities.

5.2. Institutional Readiness as a Multidimensional Constraint

The results underscore that institutional readiness is not a monolithic concept but a multidimensional construct encompassing infrastructure, human capital, organizational processes, and governance frameworks. While basic ICT infrastructure appears partially available in several institutions, readiness deteriorates sharply when more advanced components — such as data governance mechanisms and analytical skills — are considered.

This finding aligns with Marijn Janssen and van den Hoven (2015), who argue that digital government reforms often fail not because of technological scarcity, but because of misalignment between strategic ambitions and institutional capabilities. In the case under study, infrastructure availability alone has not translated into operational Big Data capacity, highlighting the limits of technology-centric reform strategies.

Moreover, the uneven distribution of readiness across actor groups reinforces structural asymmetries within the digital ecosystem. Public institutions, despite their central role in identity management, exhibit lower readiness levels than private ICT firms. This

asymmetry risks outsourcing strategic control over identity data to actors whose objectives may not fully align with public value creation, a concern increasingly raised in digital governance debates.

5.3. Interoperability as the Central Bottleneck

Among all analyzed dimensions, interoperability emerges as the most critical bottleneck for the effective use of Big Data in digital identity systems. Low interoperability levels — often below 40% among public institutions — severely constrain the analytical and operational potential of identity data.

This result provides strong empirical support for the argument that Big Data without interoperability is structurally ineffective, particularly in identity ecosystems that depend on cross-agency data exchange. As M. Janssen, Charalabidis, and Zuiderwijk (2017) emphasize, interoperability is not merely a technical issue but a governance challenge involving standards, institutional coordination, and trust.

The fragmentation observed in Equatorial Guinea mirrors early-stage digital identity systems in other developing contexts, where ministries and agencies operate in silos, each maintaining isolated databases. In such environments, Big Data analytics cannot function as intended, since data volume alone does not compensate for lack of integration.

International experiences such as Estonia's X-Road, the European Union's eIDAS framework, and Rwanda's Irembo platform illustrate that interoperability infrastructures must precede or at least accompany Big Data initiatives. The present findings reinforce this sequencing logic and suggest that attempts to deploy advanced analytics without resolving interoperability constraints are likely to produce limited returns.

5.3.1. Interoperability as an Enabling Institutional Condition

The theoretical framework initially conceptualized interoperability as a potential mediating mechanism between institutional technological readiness and perceived model impact. However, given the cross-sectional design of the study and the use of aggregated institutional-level indicators, a formal mediation analysis (e.g., regression-based mediation or structural equation modeling) was not conducted.

Instead, the empirical findings demonstrate strong positive associations between technological readiness and interoperability levels across actor groups, as well as between interoperability and perceived impact of the proposed Big Data–based digital identity model. Actor groups with higher readiness scores, particularly public ICT enterprises and strategic institutions, also reported comparatively higher interoperability capacity and stronger expectations regarding model impact. Conversely, actors with lower readiness (notably SMEs and citizen groups) exhibited lower interoperability scores and more moderate impact expectations.

These results align with digital governance literature suggesting that interoperability functions as an institutional enabling condition that facilitates the translation of technological capacity into effective digital transformation outcomes. Rather than establishing a statistically tested mediating effect, the present study provides associative evidence consistent with the theoretical proposition that interoperability constitutes a structural bridge between infrastructure readiness and policy-level impact.

Future research employing longitudinal designs or structural equation modeling could formally test whether interoperability statistically mediates the relationship between readiness and impact within public digital ecosystems. Such analyses would allow estimation of indirect effects and strengthen causal inference. Nonetheless, within the methodological boundaries of this study, interoperability should be interpreted as an associated facilitating factor rather than a confirmed mediating variable.

5.4. Reassessing the Role of Perceived Impact

Interestingly, perceived impact levels remain high despite low readiness and interoperability. This apparent contradiction reflects a future-oriented optimism rather than evidence of current effectiveness. Respondents largely associate Big Data with anticipated improvements in efficiency, transparency, and service quality, even when such outcomes are not yet observable.

From a theoretical standpoint, this supports the distinction between symbolic adoption and substantive implementation of digital innovations. Symbolic adoption occurs when technologies are embraced rhetorically to signal modernization, while substantive implementation requires deep institutional change. The findings suggest that Big Data in digital identity systems in Equatorial Guinea remains closer to the symbolic end of this spectrum.

This dynamic is not unique to Equatorial Guinea. Studies in other developing regions have documented similar patterns, where expectations of digital technologies exceed their realized impact due to institutional constraints (World Bank 2023). The present

study contributes by empirically linking high perceived impact to low interoperability and analytics capacity, clarifying why anticipated benefits remain largely unrealized.

5.5. Hypotheses Revisited and Theoretical Implications

The empirical results offer nuanced support for the study's hypotheses and generate several theoretical insights.

First, the positive correlation between institutional readiness and perceived impact (H1) confirms that readiness matters, but the moderate strength of this relationship indicates that other factors — such as political support, regulatory frameworks, and organizational culture — also shape impact perceptions. This suggests that readiness should be conceptualized as a necessary but insufficient condition for successful Big Data adoption.

Second, the strong correlation between technological readiness and interoperability (H2) reinforces the view that interoperability is both a technical and institutional outcome. Institutions with better infrastructure and skills are more capable of adopting shared standards and data exchange mechanisms. This finding supports ecosystem-based models of digital government, which emphasize coordinated capacity development.

Third, the weak correlation between perceived importance and readiness (H3) empirically demonstrates that awareness alone does not drive capability development. This challenges linear models of digital transformation that assume recognition of importance will naturally lead to investment and reform.

Together, these findings support a non-linear, institutionally grounded theory of digital identity transformation, where perception, readiness, and impact evolve at different paces and require deliberate alignment through governance mechanisms.

5.6. Implications for Digital Identity Governance in Developing Countries

Beyond the specific case of Equatorial Guinea, the results have broader implications for digital identity governance in developing countries. They highlight the risks of adopting technology-first strategies that prioritize system deployment over institutional capacity-building.

The evidence suggests that successful Big Data integration in digital identity systems requires:

- Early investment in interoperability frameworks,
- Clear data governance and accountability structures,
- Sustained human capital development,
- Incremental deployment aligned with institutional maturity.

These elements resonate with global policy frameworks such as the World Bank's Principles on Identification for Sustainable Development (ID4D), which emphasize inclusivity, interoperability, and governance over purely technical solutions.

5.7. Public–Private Dynamics and Power Asymmetries

The comparative results reveal that private ICT actors often outperform public institutions in readiness and analytics capability. While public–private collaboration is essential for digital transformation, this asymmetry raises concerns about dependency and control.

If public institutions lack the capacity to manage and analyze identity data independently, they may become overly reliant on private providers, potentially compromising sovereignty, data protection, and long-term sustainability. This underscores the need for governance frameworks that balance collaboration with capacity-building and public oversight.

5.8. Citizen Perspective and Trust Considerations

Citizens' lower perception and readiness levels reflect limited engagement with the technical dimensions of digital identity systems. However, their relatively high expectations of impact suggest that trust and service quality will be critical determinants of adoption.

Without visible improvements in service delivery, high expectations risk turning into dissatisfaction, undermining trust in digital identity initiatives. This reinforces the importance of incremental, user-centered implementation strategies that demonstrate tangible benefits early in the reform process.

5.9. Limitations and Directions for Future Research

While this study provides robust empirical insights, several limitations must be acknowledged. First, cross-sectional design captures perceptions and readiness at a specific point in time, limiting the ability to assess dynamic changes. Second, the analysis relies partly on self-reported measures, which may be subject to optimism or institutional bias. Third, the evolving regulatory environment introduces uncertainty regarding future governance arrangements.

Future research should prioritize longitudinal designs to track institutional maturation, deeper analysis of inter-agency data flows to assess actual interoperability, and comparative studies across countries with similar institutional profiles.

5.10. Synthesis: Why a Structured Interoperability Model Is Necessary

Overall, the discussion highlights that the challenges identified are systemic rather than isolated. High perceived importance and impact coexist with low readiness and weak interoperability, creating a structural imbalance that cannot be resolved through incremental or ad hoc interventions.

These findings provide strong empirical justification for the proposed Big Data–based interoperability model, which seeks to align perception, capacity, and governance within a unified institutional framework. The model responds directly to the gaps identified in this section and represents a necessary evolution from fragmented digital initiatives toward an integrated digital identity ecosystem.

6. POLICY AND STRATEGIC IMPLICATIONS / RECOMMENDATIONS

6.1. From Empirical Evidence to Actionable Policy

The empirical findings of this study highlight a critical paradox in the adoption of Big Data for digital identity systems in developing countries: high strategic awareness coexists with low institutional readiness and weak interoperability. This gap signals that policy responses must move beyond declarative digital strategies toward sequenced, capacity-oriented, and governance-driven interventions.

Unlike technology-driven reforms that assume infrastructure deployment will automatically generate value, the evidence from Equatorial Guinea demonstrates that Big Data adoption in identity systems is primarily constrained by institutional, organizational, and governance factors. Consequently, policy responses must address these constraints holistically, aligning technological investments with institutional maturation.

This section translates the study's empirical insights into concrete policy and strategic recommendations, structured around six interrelated dimensions: institutional readiness, interoperability governance, data governance and regulation, human capital development, public–private collaboration, and implementation sequencing.

6.2. Strengthening Institutional Readiness as a Policy Priority

Institutional Readiness Before Advanced Analytics. One of the central implications of the findings is that institutional readiness should be treated as a prerequisite, not a by-product, of Big Data adoption. The relatively low readiness scores observed across public institutions suggest that premature investments in advanced analytics platforms risk underutilization or failure.

Policymakers should therefore prioritize:

- Baseline digital infrastructure consolidation,
- Standardization of identity-related information systems,
- Internal process digitization and data quality improvement.

This approach aligns with international evidence indicating that Big Data initiatives yield meaningful impact only when institutions possess minimum operational and organizational capabilities (Heeks 2018; World Bank 2023).

Institutional Readiness Assessments as a Governance Tool. The results support the institutionalization of **periodic readiness assessments** as part of digital governance. Rather than relying on ad hoc evaluations, governments should adopt standardized assessment frameworks covering:

- Technological capacity,
- Data management practices,

- Interoperability maturity,
- Human and analytical capabilities.

Such assessments can guide resource allocation, prevent overambitious deployments, and enhance accountability by linking investment decisions to measurable institutional conditions.

6.3. Interoperability as the Backbone of Digital Identity Policy

National Interoperability Frameworks as a Strategic Imperative. Empirical evidence clearly positions interoperability as the single most critical bottleneck in realizing the value of Big Data for digital identity systems. Fragmented databases and siloed institutional architectures significantly undermine analytical potential and service integration.

As a result, national digital identity policies should explicitly designate interoperability as a core design principle, not an optional technical feature. This requires the development of:

- A National Interoperability Framework (NIF),
- Common data standards and identifiers,
- Secure data exchange protocols across institutions.

International cases such as Estonia's X-Road and the EU's eIDAS framework illustrate that interoperability infrastructures function as public digital utilities, enabling innovation while preserving institutional autonomy.

Governance of Interoperability Beyond Technology. Interoperability is fundamentally a challenge of governance. The findings indicate that technical compatibility alone is insufficient without:

- Clear institutional mandates for data sharing,
- Defined roles and responsibilities,
- Conflict-resolution mechanisms between agencies.

Therefore, interoperability policies must be embedded within broader public sector reform agendas, supported by political leadership and reinforced through administrative regulations.

6.4. Data Governance and Regulatory Frameworks

Establishing Coherent Data Governance Structures. The study highlights weaknesses in data governance as a key factor limiting Big Data adoption. Without clear governance frameworks, identity data integration risks generating privacy concerns, institutional resistance, and public distrust.

Policy frameworks should define:

- Data ownership and stewardship responsibilities,
- Access control mechanisms,
- Accountability and audit procedures,
- Ethical principles guiding data use.

These elements are essential to ensuring that Big Data strengthens, rather than undermines, trust in digital identity systems.

Aligning National Regulation with International Standards. While regulatory frameworks must be context-sensitive, alignment with international principles — such as data minimization, purpose limitation, and proportionality — is critical for sustainability and international interoperability.

The findings suggest that regulatory uncertainty discourages institutional engagement with data sharing initiatives. Clear, stable, and enforceable data protection regulations can reduce risk aversion and facilitate inter-agency collaboration.

6.5. Human Capital and Analytical Capacity Development

Moving Beyond Infrastructure-Centric Investments. The relatively low levels of analytical readiness observed in the study underscore the limits of infrastructure-centric digital strategies. Big Data systems require specialized skills that are often scarce in public administrations in developing countries. Policy interventions should therefore emphasize:

- Specialized training programs in data analytics,

- Institutional career paths for data professionals,
- Knowledge transfer mechanisms from private and academic sectors.

This aligns with evidence showing that analytical capacity is a decisive factor in transforming data availability into policy impact.

Institutionalizing Data-Driven Decision-Making. Beyond technical skills, the findings indicate a need for cultural change within public institutions. Data-driven decision-making must be institutionalized through:

- Performance indicators linked to data use,
- Incentives for evidence-based policy formulation,
- Integration of analytics into routine administrative processes.

Without such cultural shifts, analytical tools risk remaining underutilized or confined to pilot projects.

6.6. Public–Private Collaboration: Opportunities and Risks

Leveraging Private Sector Capabilities. The higher readiness levels observed among private ICT actors suggest that public–private collaboration can accelerate Big Data adoption in digital identity systems. Private actors offer expertise, innovation capacity, and implementation experience that public institutions often lack.

Policy frameworks should facilitate:

- Strategic partnerships for system development,
- Joint innovation labs,
- Knowledge-sharing arrangements.

Managing Power Asymmetries and Dependency Risks. However, the study also highlights the risk of **asymmetric dependency**, where public institutions become overly reliant on private providers for critical identity infrastructure. This can undermine public control, accountability, and long-term sustainability.

To mitigate these risks, policies must ensure:

- Clear contractual governance,
- Public ownership of core data assets,
- Capacity transfer obligations in public–private agreements.

6.7. Citizen-Centered Policy Design and Trust Building

Trust as a Policy Outcome. Citizens' high expectations regarding the impact of Big Data contrast with their limited understanding of technical systems. This places trust at the center of digital identity policy.

Policies should therefore prioritize:

- Transparency in data use,
- Clear communication of benefits and safeguards,
- Mechanisms for citizen feedback and redress.

Trust cannot be assumed; it must be actively cultivated through inclusive and accountable governance.

Incremental Service-Based Adoption. The findings support a service-driven approach to digital identity implementation, where citizens experience tangible benefits early. Rather than deploying comprehensive systems at once, governments should:

- Start with high-impact services (e.g., health, education),
- Demonstrate value through improved service delivery,
- Gradually expand system scope.

This incremental strategy reduces implementation risk and strengthens public confidence.

6.8. Sequencing and Phased Implementation Strategies

Avoiding "Big Bang" Digital Reforms. The evidence strongly discourages "big bang" approaches to Big Data adoption in digital identity systems. Given institutional constraints, phased implementation offers a more realistic and sustainable pathway.

A recommended sequence includes:

- Institutional readiness assessment,
- Interoperability framework development,
- Data governance consolidation,
- Pilot analytics applications,
- Gradual system scaling.

Embedding Monitoring and Learning Mechanisms. Finally, policies should incorporate continuous monitoring and adaptive learning. Digital identity ecosystems evolve rapidly, and static policy frameworks risk obsolescence.

Embedding feedback loops allows governments to:

- Adjust strategies based on institutional performance,
- Identify emerging risks,
- Scale successful practices.

6.9. Strategic Synthesis

Taken together, these policies and strategic implications underscore that Big Data adoption in digital identity systems is fundamentally an institutional transformation process, not merely a technological upgrade. The empirical evidence from Equatorial Guinea illustrates that meaningful impact depends on aligning perception, readiness, interoperability, and governance within a coherent policy framework.

By grounding digital identity reforms in institutional capacity-building, interoperability governance, and citizen trust, developing countries can move beyond symbolic digitalization toward sustainable, data-driven public value creation.

7. CONCLUSIONS

7.1. Purpose and Scope of the Study

This article set out to empirically examine the **institutional readiness and perceived impact of Big Data adoption in digital identity systems** within the context of a developing country. Responding to persistent gaps in the digital government literature — particularly the underrepresentation of African and Central African contexts — the study focused on Guinea Equatorial as a critical and illustrative case.

Rather than approaching Big Data as a purely technological innovation, the research adopted a **socio-institutional perspective**, analyzing how technological preparedness, organizational capacity, interoperability, and governance structures shape the feasibility and impact of Big Data-enabled digital identity systems. By integrating quantitative survey data with qualitative expert validation, the study sought to capture both measurable institutional conditions and contextualized expert insights.

The findings confirm that the challenges associated with Big Data adoption in digital identity systems are **structural rather than cognitive**. While strategic awareness and perceived importance are high across institutional and societal actors, the underlying capacities required to operationalize Big Data remain uneven and, in many cases, insufficient.

7.2. Summary of Key Empirical Findings

The empirical analysis revealed several consistent and interrelated patterns.

First, the study demonstrated a **substantial gap between perceived importance and institutional readiness**. More than four-fifths of respondents recognized Big Data as essential for modernizing digital identity systems, improving service delivery, and strengthening administrative efficiency. However, fewer than half considered their institutions adequately prepared in terms of technological infrastructure, data management practices, and analytical capacity. This confirms Hypothesis H3 and reinforces earlier observations in the digital governance literature regarding "aspirational digitalization" in developing contexts.

Second, **interoperability emerged as a decisive mediating factor**. Across institutional groups, interoperability levels remained below 50%, significantly constraining the potential analytical value of identity-related data. The strong positive correlation between interoperability and institutional readiness supports Hypothesis H2 and underscores the systemic nature of Big Data adoption. Without interoperable systems, data remain fragmented, undermining both cross-sectoral service integration and evidence-based policymaking.

Third, the correlation analysis provided robust support for Hypothesis H1, revealing **strong and statistically significant relationships between institutional readiness and perceived impact** of Big Data adoption. Institutions with higher readiness levels consistently reported greater expectations of positive impact, suggesting that perceived benefits are closely tied to practical implementation capacity rather than abstract technological optimism.

Finally, expert validation reinforced the quantitative findings, emphasizing that **organizational and governance constraints outweigh purely technical limitations**. Experts consistently highlighted issues related to institutional coordination, data governance, legal uncertainty, and human capital deficits as primary barriers to effective Big Data deployment in digital identity systems.

7.3. Theoretical Contributions

This study makes several important contributions to the literature on digital government, Big Data, and digital identity systems.

Advancing Institutional Perspectives on Big Data Adoption. By empirically demonstrating that institutional readiness significantly conditions the perceived and potential impact of Big Data, the study strengthens theoretical arguments that position digital transformation as an **institutional change process rather than a technological substitution**. This finding extends existing models of e-government maturity by explicitly integrating Big Data readiness and interoperability as core explanatory dimensions.

Interoperability as an Analytical Construct. The study contributes to theory by empirically validating interoperability as a **mediating variable** between technological preparedness and Big Data impact. While interoperability is frequently acknowledged conceptually, it is rarely operationalized or tested empirically in developing-country contexts. This research provides evidence that interoperability is not merely a technical feature but a structural enabler of data-driven governance.

Contextualizing Digital Identity Research. Most empirical research on digital identity systems is grounded in developed-country experiences. By offering data-driven insights from Equatorial Guinea, this study contributes to **contextual diversification** in the literature, demonstrating that institutional conditions significantly shape the trajectory and outcomes of digital identity initiatives. The findings challenge the implicit assumption that models developed in high-capacity environments can be directly transferred to lower-capacity contexts without adaptation.

7.4. Methodological Contributions

Beyond its substantive findings, the study offers methodological contributions relevant to future research.

The mixed-methods, cross-sectional, and correlational design proved effective in capturing both **structural patterns and contextual interpretations**. The use of multiple actor groups — public institutions, private-sector entities, SMEs, and citizens — allowed for a multi-perspective assessment of readiness and impact, enhancing the robustness and external validity of the findings.

Furthermore, the integration of expert validation strengthened the interpretive depth of the quantitative results, demonstrating the value of triangulation in digital government research, particularly in contexts where institutional data may be fragmented or incomplete.

7.5. Practical and Policy Relevance

From a practical standpoint, the study underscores that **Big Data adoption in digital identity systems cannot be decoupled from institutional reform**. Policymakers should recognize that investments in analytics platforms, data centers, or artificial intelligence tools will not yield meaningful outcomes unless foundational capacities are addressed.

The conclusions reinforce the need for:

- Institutional readiness assessments,
- National interoperability frameworks,
- Coherent data governance structures,

- Targeted human capital development,
- Phased and adaptive implementation strategies.

Importantly, the study cautions against symbolic digital reforms that prioritize visibility over sustainability. Big Data should be positioned as a **means to institutional strengthening and public value creation**, not as an end in itself.

7.6. Implications for Developing Countries

Although grounded in the case of Equatorial Guinea, the conclusions of this study have broader relevance for developing countries with similar institutional characteristics.

The evidence suggests that:

- High political or strategic commitment does not automatically translate into implementation capacity.
- Interoperability deficits represent a common structural bottleneck.
- Data governance and institutional coordination are decisive for trust and sustainability.

As such, the study supports the argument that **context-sensitive, incremental, and governance-driven approaches** are more likely to succeed than rapid, technology-centric reforms. Developing countries should resist the pressure to replicate advanced digital identity architectures without first consolidating institutional foundations.

7.7. Limitations of the Study

Several limitations should be acknowledged.

First, the study employed a **cross-sectional design**, which limits the ability to capture dynamic changes in institutional readiness and perceptions over time. Longitudinal studies would be valuable in assessing how readiness evolves as digital identity initiatives mature.

Second, while the sample included a diverse set of actors, some institutional groups were represented more strongly than others. Future research could expand the sample to include additional sectors, such as local governments or security agencies, which play critical roles in identity management.

Third, the study focused on **perceived impact rather than objectively measured outcomes**. Although perceptions are important predictors of adoption behavior, future studies could complement this approach with performance indicators related to service efficiency, fraud reduction, or cost savings.

7.8. Directions for Future Research

Building on these limitations, several avenues for future research emerge.

First, longitudinal and comparative studies across multiple developing countries could help identify **patterns of institutional maturation** and distinguish context-specific from generalizable dynamics.

Second, future research should explore the **causal mechanisms** linking interoperability, governance, and Big Data outcomes, potentially using experimental or quasi-experimental designs.

Third, deeper qualitative studies could examine how institutional cultures, power relations, and political incentives influence data-sharing practices and resistance to interoperability.

Finally, there is scope for research assessing the **citizen-level impacts** of Big Data-enabled digital identity systems, particularly in terms of trust, inclusion, and perceived fairness.

7.9. Final Synthesis

In conclusion, this article provides empirical evidence that the successful adoption of Big Data in digital identity systems in developing countries depends less on technological availability than on **institutional readiness, interoperability, and governance capacity**. The case of Equatorial Guinea illustrates that high strategic awareness alone is insufficient to drive meaningful digital transformation.

By empirically linking institutional readiness, interoperability, and perceived impact, the study contributes to a more nuanced understanding of digital government transformation in resource-constrained environments. It challenges deterministic narratives of technological progress and emphasizes the centrality of institutions in shaping digital outcomes.

Ultimately, the study argues that **Big Data should be understood as an institutional capability, not merely a technological resource**. When embedded within coherent governance frameworks and supported by sustained capacity-building efforts, Big Data has the potential to significantly enhance digital identity systems and, by extension, public sector performance and citizen trust in developing countries.

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9. APPENDIX ADDITIONS

Appendix A. Survey Instrument

A1. Overview of the Instrument

The survey instrument was designed to measure perceptions and institutional conditions related to the adoption of Big Data technologies in digital identity systems in the Republic of Equatorial Guinea.

The questionnaire consists of four multi-item constructs:

1. Perception of Big Data Potential (PER)

2. Institutional Readiness (IRD)

3. Interoperability Capacity (INT)

4. Perceived Impact on Digital Identity Systems (IMP)

All items were measured using a five-point Likert scale:

1. = Strongly Disagree
2. = Disagree
3. = Neutral
4. = Agree
5. = Strongly Agree

Unless otherwise indicated, higher scores reflect stronger agreement with the construct.

No items required reverse coding.

A2. Construct 1: Perception of Big Data Potential (PER)

Definition: The degree to which respondents perceive Big Data technologies as useful, strategic, and relevant for improving digital identity systems and public service delivery.

Table 5. ***Construct 1***

Code	Survey Item
PER1	Big Data technologies are essential for modernizing digital identity systems in Equatorial Guinea.
PER2	The use of Big Data can significantly improve the efficiency of public digital services.
PER3	Big Data enables better decision-making in identity management and governance.
PER4	Data analytics can enhance fraud detection and identity verification processes.
PER5	The integration of Big Data in digital identity systems is strategically important for national development.

Source: own elaboration

Composite index calculation: PER Index = Mean (PER1–PER5)

A3. Construct 2: Institutional Readiness (IRD)

Definition: The degree to which institutions possess the organizational, technical, regulatory, and human capacity required to implement Big Data in digital identity systems.

Table 6. ***Construct 2***

Code	Survey Item
IRD1	My institution has sufficient technical infrastructure to support Big Data applications.
IRD2	There are qualified human resources capable of managing Big Data technologies.
IRD3	Existing regulatory frameworks support data-driven digital identity systems.
IRD4	My institution has a clear strategy for Big Data integration.
IRD5	Financial resources are adequate to implement Big Data solutions.
IRD6	Data governance policies are clearly defined and operational.

Source: own elaboration

Composite index calculation: IRD Index = Mean (IRD1–IRD6)

A4. Construct 3: Interoperability Capacity (INT)

Definition: The degree to which institutions are technically and organizationally capable of exchanging and integrating data across systems and sectors.

*Table 7. **Construct 3***

Code	Survey Item
INT1	Information systems within my institution are interoperable with other public institutions.
INT2	There are standardized protocols for data exchange between institutions.
INT3	Technical platforms allow secure cross-sector data sharing.
INT4	Interinstitutional coordination mechanisms are effective for digital identity management.
INT5	Cybersecurity frameworks support safe interoperability practices.

Source: own elaboration

Composite index calculation: INT Index = Mean (INT1–INT5)

A5. Construct 4: Perceived Impact on Digital Identity Systems (IMP)

Definition: The extent to which respondents believe Big Data adoption will produce tangible improvements in digital identity systems.

*Table 8. **Construct 4***

Code	Survey Item
IMP1	Big Data adoption would improve the reliability of digital identity systems.
IMP2	Big Data would enhance transparency in identity verification processes.
IMP3	Big Data would reduce fraud and identity-related risks.
IMP4	Big Data would improve citizen access to digital public services.
IMP5	Big Data integration would strengthen national digital governance.
IMP6	Big Data would contribute to long-term institutional modernization.

Source: own elaboration

Composite index calculation: IMP Index = Mean (IMP1–IMP6)

A6. Validation and Importance Indicators (Descriptive Module)

In addition to Likert-scale constructs, respondents were asked to provide categorical or percentage-based assessments for validation purposes.

A6.1 Perceived Importance (Single-Item Indicator)

*Table 9. **Perceived Importance***

Code	Item
IMPOR1	How important is Big Data for the future of digital identity systems in Equatorial Guinea?

Source: own elaboration

Response scale:

1. = Not important
2. 2 = Slightly important
3. 3 = Moderately important
4. 4 = Important
5. 5 = Extremely important

A6.2 Institutional Preparation (Binary Indicator)

Table 10. Institutional Preparation

Code	Item
PREP1	Is your institution currently prepared to implement Big Data technologies in digital identity systems?

Source: own elaboration

Response options: 0 = No; 1 = Yes

A6.3 Interoperability Assessment (Binary Indicator)

Table 11. Interoperability Assessment

Code	Item
INTB1	Does your institution currently exchange digital identity-related data with other institutions?

Source: own elaboration

Response options: 0 = No; 1 = Yes

A7. Sociodemographic and Institutional Variables

The following control variables were included:

Table 12. **Sociodemographic and Institutional Variables**

Code	Variable
SECT	Sector category (Ministry / Public ICT / Private ICT / SME / Banking & Oil / Citizen / Other)
POS	Position level (Senior management / Technical / Administrative / User)
EXP	Years of professional experience
CITY	Location (Malabo / Bata / Mongomo / Ebebiyin)
EDU	Highest level of education completed

Source: own elaboration

These variables were used for subgroup comparisons and descriptive analysis.

A8. Interview Guide (Qualitative Component)

The semi-structured interview protocol included the following guiding questions:

1. How would you assess the current state of digital identity systems in Equatorial Guinea?

2. What role do you believe Big Data can play in improving these systems?

3. What are the main institutional barriers to implementation?

4. How effective is interinstitutional interoperability today?

5. What governance reforms are necessary to enable successful Big Data adoption?

6. How do you evaluate the feasibility of a national integrated digital identity platform?

Interviews were recorded with consent, transcribed, and coded using thematic analysis.

A9. Reliability Summary

Internal consistency statistics for multi-item constructs:

Table 13. **Reliability Summary**

Construct	Number of Items	Cronbach's Alpha
PER	5	0.84
IRD	6	0.88
INT	5	0.86
IMP	6	0.90

Source: own elaboration

All constructs exceed the recommended 0.70 reliability threshold.

Affiliations

1

Education:

Tech Technological University: PhD in ICT, master's in digital Transformation and Industry 4.0, master's in advanced management of Technological Projects.

University of Matanzas, Cuba: Master's in business management and computer Engineer.

Current Employment:

- Deputy Manager at the Telecommunications Infrastructure Manager (GITGE)
- Member of the Board of Directors of CCEIBANK GE

Place of Work: Equatorial Guinea

- GITGE: Malabo, Bioko Norte,
- CCEIBANK GE: Malabo, Bioko Norte,
- **Research Line:** Interoperability and Big Data applied to digital identity.