

Review

Revisiting big data governance: Insights from contemporary frameworks and emerging challenges

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Abstract

The rapid expansion of big data ecosystems has intensified demand for robust data governance frameworks that ensure data quality, security, privacy, and the creation of strategic value. Although numerous big data governance frameworks have been proposed over the past decade, they differ substantially in scope, maturity, and applicability, leaving critical gaps in addressing emerging technological, organizational, and ethical challenges. This study revisits the landscape of big data governance frameworks published between 2018 and 2025 through a comprehensive review and thematic synthesis of 13 peer-reviewed studies from high-impact journals and leading conferences. Unlike previous review studies that primarily collect governance dimensions or conceptual components, this study adopts a pattern-oriented analytical perspective to synthesize contemporary frameworks and identify recurring governance across contexts. The analysis identifies four major governance patterns, including fragmented governance approaches across sectors, context-specific frameworks without generalizable foundations, the growing intersection of AI and governance, and the imperative for adaptive and dynamic governance mechanisms. These patterns extend existing knowledge by explaining not only which governance elements are present in current frameworks but also how and why governance practices evolve in response to complex data ecosystems. The findings highlight the necessity of an integrated, adaptive, and context-sensitive big data governance framework that can respond to technological evolution and the complexity of the modern data environment. In addition, this study provides a structured roadmap for future research and offers actionable insight for organizations aiming to strengthen their data governance capabilities in increasingly data-driven environments.

Keywords: big data; data governance; big data governance; data governance framework; emerging challenges

1. Introduction

Since the beginning of the 21st century, numerous technological advancements have fundamentally transformed organizational operations and decision-making processes [1]-[2]. This trend gained momentum in the mid-2000s, when

many businesses and organizations developed information systems that leveraged these technological advancements to enhance efficiency and competitiveness [3]. Trierveiler [4] argued that this phenomenon is widely described as digital transformation. However, this transformation has continuously generated massive amounts of data at unprecedented speeds, strengthening the big data era [5]. The significance of big data is not only in its size but also in its complexity [6]. Typically, the features or characteristics of big data are commonly described by the 5Vs: volume, velocity, variety, value, and veracity [7]-[8].

Furthermore, the emergence of big data presents unprecedented opportunities for innovation, automation, and data-driven decision-making across organizational contexts [9]. It is changing the way organizations collect and analyze data, making organizations rely more on data analysis in strategic decision-making and gaining maximum value to achieve their competitive advantage and long-term sustainability [10]. Hence, data has been elevated to one of the most valuable strategic resources, with nearly all strategic business decisions made on the basis of insights derived from data [11]-[12].

However, the features that define big data also pose challenges related to data quality, interoperability, security, accountability, and ethical use. It necessitates the development of robust and adaptive big data governance frameworks [13]. Big data governance refers to the policies, standards, and mechanisms that regulate the collection, processing, sharing, and utilization of data across complex ecosystems [14]-[15]. Additionally, Al-Badi [16] argued that data governance requires a framework for managing information.

Over the last decade, researchers and practitioners have proposed numerous big data governance frameworks, each addressing distinct facets such as privacy, data quality, accountability, security, ethics, and regulatory compliance. Early studies focused on developing a structural governance framework [17]. Subsequent research has focused more on domain-specific frameworks [18]-[20]. Moreover, the evolution of data ecosystems further complicates the governance landscape. Emerging technologies such as artificial intelligence and machine learning have introduced novel risks and expanded the boundaries of conventional data governance. Therefore, recent developments in big data governance have incorporated AI-driven, automated, and self-regulating mechanisms [21]-[22]. This evolution reflects a broader paradigm shift from static governance mechanisms toward intelligent and dynamic ecosystems.

Although significant progress has been made, current research on big data governance continues to face challenges related to data quality, the ethical use of AI models, cross-organizational data sharing, and the governance of automated decision systems. These issues are becoming more prominent but remain inadequately covered in existing big data governance frameworks. Moreover, several existing big data governance frameworks remain conceptual or domain-specific, lacking empirical validation and scalability across heterogeneous environments [23]. This issue hinders many organizations from translating conceptual big data governance frameworks into practice, primarily due to limited resources, unclear responsibilities, and the absence of standardized metrics for assessing data governance maturity.

In response to these limitations, this study aims to revisit and synthesize existing big data governance frameworks developed between 2018 and 2025. Specifically, this study provides a comprehensive synthesis of recent big data

governance developments by critically reviewing 13 big data governance frameworks to (i) illustrate how data governance mechanisms have evolved, (ii) identify unresolved gaps that persist, and (iii) outline how emerging challenges can be systematically incorporated into future big data governance framework development. Additionally, by adopting a comparative and integrative perspective that extends prior foundational studies by Al-Badi [16]. Thus, this study offers a consolidated and up-to-date understanding of big data governance, evaluates its applicability to modern data environments, and identifies critical directions for advancing both research and practice.

The remainder of this study is organized as follows: Section II presents the research methodology and selection process. Section III presents the selected big data governance framework reviewed in this study. Section IV synthesizes the evolution of big data governance frameworks, identifies persistent challenges, and highlights emerging patterns that shape future research directions. Section V concludes the study by summarizing key findings and implications. Collectively, this study underscores the growing importance of big data governance in ensuring data quality, reliability, and security within increasingly complex data ecosystems.

2. Materials and Methods

This study employs a comprehensive review methodology adapted from Okoli [24] to synthesize contemporary big data governance frameworks and identify emerging challenges across sectors and technological contexts. This methodology is suitable for domains characterized by conceptual fragmentation and rapid technological development, as it facilitates the consolidation of diverse theoretical, empirical, and domain-specific contributions into a coherent analytical big data governance framework.

2.1 Research Design

The review followed a structured and multi-stage process. It comprises literature identification, screening and eligibility assessment, thematic synthesis, and integrative analysis [25]. Each stage was executed systematically to maintain methodological coherence and reduce potential sources of bias. This design aligns with widely accepted review methodologies used in information systems and data governance research, ensuring transparency, replicability, and analytical precision.

2.2 Literature Identification

A comprehensive search strategy was implemented to capture the scope of contemporary development on the big data governance framework. Searches were conducted across prominent digital libraries, covering peer-reviewed journal articles and high-impact conference proceedings published between 2018 and 2025. Search strings employed combinations of the following keywords:

(“big data” AND “data governance” OR “governance framework” OR “data governance framework”)

2.3 Screening and Eligibility Criteria

Retrieved studies were screened using predefined inclusion and exclusion criteria.

Inclusion criteria:

- **Governance Focus:** The studies must explicitly propose, evaluate, or critique a big data governance framework or data governance mechanisms.
- **Relevance to Modern Data Environments:** Studies must address issues relevant to large-scale, complex, or distributed data ecosystems.
- **Conceptual or Empirical Contribution:** Papers offering conceptual models, practical frameworks, empirical examinations, or cross-domain governance insights were included.
- **Publication Quality:** Only peer-reviewed journal articles or reputable conference papers were selected to ensure methodological and conceptual robustness.

Exclusion criteria eliminated studies focused solely on technical algorithms, data analytics methods without governance components, or domain investigations unrelated to data management or governance.

2.4 Analytical Process

The analytical strategy employed a three-phase thematic synthesis consistent with qualitative review standards in information systems research [26]. This process enabled both convergence and divergence, including the synthesis of commonalities across studies and the identification of unique sectoral or technological needs by pinpointing context-specific needs and emerging concerns.

- **Open Coding:** Each study was systematically examined to extract governance components, conceptual definitions, scope, underlying assumptions, and contextual focus areas.
- **Axial Coding:** Codes were grouped to identify cross-cutting themes, recurring governance dimensions, sector-specific variations, and points of conceptual divergence. Special attention was given to identifying gaps, inconsistencies, and emerging governance challenges across the literature.
- **Selective Coding:** Themes were consolidated into four overarching governance patterns that inform the results and discussion section, including fragmentation of governance approaches, sector-specific governance discrepancies, rising demands for AI-driven data governance, and the need for a dynamic and adaptive governance framework.

Therefore, these methodological procedures provide a robust foundation for synthesizing contemporary big data governance development and identifying the key themes articulated in the results and discussion sections.

3. Results

Research on big data governance has expanded substantially over the past decade, driven by the growing recognition that the value derived from big data is inseparable from the mechanisms that regulate its quality, security, lifecycle, and responsible use. In this study, the literature selection process followed a multi-stage filtering procedure that combined keyword-based retrieval with content-relevance assessment, as presented in Table 1.

Table 1. Pattern of Big Data Governance Frameworks.

Sources	Retrieved	Studied	Excluded	Included
ScienceDirect	8422	3724	3719	3
IEEE Xplore	4176	273	271	2
MDPI	103	103	101	2
Google Scholar	7730	4920	4914	6

Through this process, 13 peer-reviewed journal articles and conference papers published between 2018 and 2025 were identified as meeting the inclusion criteria as summarized in Table 2. Although numerically limited, this quantity is analytically adequate and representative. It comprises highly cited, conceptually foundational works that explicitly articulate governance structures, principles, and mechanisms in big data contexts. In addition, the relatively small number reflects the review's selective, prioritized depth at the conceptual and framework contributions.

Table 2. Summary of Big Data Governance Frameworks.

Core Focus	Year	Sources
Foundational governance structure and principles	2018	[16]
Organizational framework and implementation case of National Pension Service in South Korea	2018	[17]
Governance for third-generation data platforms	2019	[20]
Big data governance in health information networks	2019	[18]
Cybersecurity-oriented governance	2019	[19]
Privacy and security framework for big data governance	2020	[27]
Data quality management for process mining	2021	[28]
Big data governance for e-government systems	2021	[29]
Strategic action framework for data governance	2022	[23]
Smart city data governance	2022	[30]
Institutional governance for official statistics	2023	[31]
AI-based and autonomous governance frameworks	2024	[21]
AI data governance in large language models	2025	[22]

Table 2 presents a summary of the existing big data governance frameworks developed, including author, year, and core focus, that were used in this study. Early contributions to this domain primarily focused on establishing foundational governance structures that could support large-scale data initiatives. For instance, Al-Badi [16] and Kim [17] highlighted the necessity of formalized governance processes to guide data collection, integration, and stewardship within technologically complex environments. It emphasizes persistent gaps in organizational readiness and capability development. Therefore, this initial framework development largely concentrated on structural elements, encompassing roles, policies, and control mechanisms, without fully addressing the dynamic and heterogeneous nature of big data ecosystems.

As technological ecosystems evolved, subsequent studies sought to expand the scope of governance to encompass technological and operational complexities introduced by emerging data platforms. Yebenes [20] proposed a governance

framework tailored to third-generation data platforms, highlighting challenges associated with distributed architectures, shared data assets, and hybrid data management models. Similarly, Li [18] advanced a framework to support regional health information networks in China, emphasizing that interoperability, privacy, and cross-institutional coordination are critical governance considerations. Their findings reflect the evolution of governance needs as organizations transition from traditional centralized systems to flexible, cloud-based, and real-time environments. Therefore, these contributions demonstrate growing attention to contextualized governance frameworks and also reveal difficulties in defining governance boundaries across sectors.

A parallel stream of research has examined governance requirements in specialized domains, such as cybersecurity and e-government infrastructure. Domain-specific frameworks proposed by Yang [19] introduced a big data governance perspective tailored to cybersecurity, advocating integrated mechanisms that coordinate threat intelligence, data protection, and real-time risk assessment. While Long [29] similarly developed a governance framework for e-government systems in the context of Industry 4.0, highlighting challenges related to interoperability, transparency, and digital service reliability. Although these studies offer valuable domain-specific governance insights, however, they also reveal the siloed nature of existing frameworks, which limits their applicability across diverse sectors and technologies.

Moreover, the development of the big data governance framework further underscores the growing importance of data privacy and security within it. Maniam [27] argued the need for governance frameworks that embed privacy-by-design principles, particularly in contexts where cross-border data flows and large-scale digital platforms create elevated risk environments. Thus, these studies demonstrate the insufficiency of regulatory compliance and should be complemented by organizational processes that ensure accountability, ethical use of data, and proactive risk mitigation.

Recent contributions indicate a shift toward integrating strategic and value-driven orientations within governance design. Zhang [23] proposed a strategic action framework that positions data governance as a central enabler of digital transformation, highlighting how governance practices enhance decision-making, innovation capability, and organizational alignment. Furthermore, Osu [30] implemented this approach in smart cities. Similarly, Hassani [31] emphasized the crucial role of comprehensive governance in enhancing the reliability and integrity of official statistics, underscoring the connection between governance maturity and institutional trustworthiness.

The growing integration of artificial intelligence and automated decision-making systems has introduced new governance challenges that traditional frameworks have been insufficient to address. Potdar [21] examined AI-based governance frameworks designed to support secure and compliant large-scale processing. While Pahune [22] highlighted the importance of data governance requirements across the AI lifecycle, including managing the training data, model accountability, and ethical considerations associated with large language models. Therefore, it collectively illustrates a shifting paradigm in which governance must evolve from static structures to adaptive frameworks.

Despite substantial progress in developing big data governance frameworks, a persistent limitation remains where many frameworks inadequately address the complexities associated with data quality management. For example, Goel

[28] examines data governance as a mechanism for improving data quality in process mining. It emphasizes that current approaches often overlook the lifecycle perspective required to prevent the accumulation of obsolete, redundant, and low-quality data. Consequently, it gives escalating costs, environmental implications, and analytic misrepresentations associated with unmanaged data creation.

Overall, the reviewed studies demonstrate substantial advances in big data governance. However, it remains fragmented across domains, technologies, and theoretical orientations. The widespread adoption of AI, distributed architectures, and cross-organizational data ecosystems continues to outpace existing frameworks, underscoring the need for integrated, adaptable, and value-driven governance approaches. Therefore, this study addresses these gaps by revisiting contemporary frameworks, synthesizing common patterns and divergences, and identifying emerging challenges that necessitate reconceptualizing how big data governance should be structured and operationalized in modern data environments, as discussed in the following section.

4. Discussion

The findings highlight substantial progress in the development of big data governance frameworks. It highlights the main challenges that constrain the maturity and effectiveness of existing frameworks. Therefore, this study synthesizes insights from contemporary big data governance frameworks and identifies four major patterns that reflect the current state of governance research and practice, as presented in Table 3.

Table 3. Pattern of Big Data Governance Frameworks.

No.	Pattern	Sources
1	Fragmented Governance Approaches Across Sectors	[16], [18], [29], [19]
2	Context-Specific Frameworks Without Generalizable Foundations	[18], [29], [27], [19], [20],
3	Growing Intersection of AI and Governance	[22], [21]
4	The Imperative for Adaptive and Dynamic Governance Mechanisms	[28], [31], [17], [30], [23]

Table 3 presents the four major patterns identified from existing big data governance frameworks, which are explained below.

4.1 Fragmented Governance Approaches Across Sectors

The development of big data governance frameworks varies significantly across sectors in terms of scope and focus. Some big data governance frameworks primarily focus on structural and procedural controls, such as standardized roles, policies, and data stewardship. Other frameworks emphasize privacy, security, or risk mitigation as core pillars of data governance. For example, Yang [19] proposed a cybersecurity-oriented big data governance framework that focuses on threat detection and resilience, whereas Li [18] developed healthcare big data governance frameworks that prioritize interoperability, data-sharing protocols, and privacy. Similarly, Long [29] introduced a big data governance framework for e-government initiatives that emphasizes transparency, scalability, and public service efficiency. Therefore, from a

practical perspective, as governance practices developed in isolation often lack interoperability and scalability, this fragmentation creates implementation challenges for organizations operating across multiple domains or regulatory environments. It implies that sector-specific governance solutions for practitioners should not be adopted wholesale but should instead be evaluated against a standard set of core governance dimensions.

This fragmentation contributes to inconsistent implementation and limited scalability across domains. The fragmented nature of current governance frameworks reveals a lack of consensus regarding the essential components of governance. The absence of consensus on essential governance components complicates the development of harmonized regulatory guidance for policymakers. Consequently, Al-Badi [16] argued that the lack of integrative frameworks inhibits organizations' ability to manage big data assets comprehensively. This presents an opportunity to develop a framework that strengthens the foundations of mature and sustainable governance ecosystems that not only harmonize governance practices but also enhance interoperability and facilitate cross-sector governance approaches.

4.2 Context-Specific Frameworks Without Generalizable Foundations

Although domain-specific frameworks provide essential insights, their limited applicability across different areas still impedes the development of a unified governance framework. For example, health-sector frameworks embed domain-specific regulatory requirements and clinical workflows [18], while cybersecurity models prioritize continuous threat monitoring and anomaly detection [19]. Similarly, public-sector models for e-government integrate transparency and accountability as core governance dimensions [29]. While these frameworks provide valuable insights, they often lack generalizable structures that can be applied seamlessly across industries.

In addition, Yebenez [20] argued that limiting cross-domain learning can hinder the development of universal governance standards. Organizations struggle to align their data governance practices with broader strategic objectives due to the absence of generalizable foundations, resulting in inconsistencies across data quality management, ethical compliance, and operational efficiency.

These findings highlight the need for a cross-domain synthesis that concentrates transferable data governance principles, such as shared standards, modular data governance components, and adaptable policy layers, and apply them across various environments. It presents an opportunity for practitioners to adopt modular governance designs that allow organizations to reuse core governance capabilities while tailoring domain-specific extensions. Additionally, policymakers can emphasize principle-based rather than prescriptive regulation, thereby promoting adaptability while maintaining governance consistency across sectors. Therefore, developing flexible big data governance frameworks for cross-domain synthesis is essential to facilitate adaptation to diverse organizational environments.

4.3 Growing Intersection of AI and Governance

The increasing integration of AI-driven processes into organizational workflows is fundamentally reshaping data governance initiatives, particularly in how data is produced, processed, and analyzed. It reveals an evolution away from traditional data-centric governance, which primarily regulates data access controls and data lifecycle management. These

mechanisms have become increasingly inadequate for governing automated decision systems characterized by opacity, adaptivity, and model driven. Consequently, recent studies emphasize the urgent need for algorithmic governance structures to address transparency and accountability challenges [21]-[22].

In addition, from a practical perspective, this shift necessitates organizations expand governance oversight beyond data assets to include models, algorithms, and decision outcomes. Currently, effective governance requires the deployment of model monitoring pipelines, explainability mechanisms, bias and fairness metrics, and auditable decision traces, as emphasized by Pahune [22]. These mechanisms enable organizations to detect governance failures in real time and demonstrate compliance with emerging AI regulations.

Moreover, the convergence of data and AI governance underscores the need for integrated regulatory frameworks that address both data stewardship and algorithmic accountability. As automated decision-making intensifies across sectors, organizations must adapt governance structures to address algorithmic opacity and evolving risk profiles. The rise of generative AI and large language models further underscores the need for dynamic, ethics-centered governance mechanisms that can effectively balance organizational objectives with societal expectations [22]. Thus, it suggests that AI governance should be embedded within existing data governance structures rather than treated as a parallel or isolated initiative.

4.4 The Imperative for Adaptive and Dynamic Governance Mechanisms

The rapid evolution of data ecosystems exposes the limitations of static and policy-driven governance frameworks. Many existing frameworks remain attached to fixed compliance policies that fail to respond to real-time technological, regulatory, or operational changes [17], [23]. It clearly demonstrates a critical need for adaptive data governance frameworks capable of continuous monitoring, iterative policy refinement, and responsive risk mitigation. Additionally, recent literature has highlighted the importance of dynamic governance for keeping pace with real-time data processes, emerging standards, and increasingly complex data interdependencies [31].

Data governance frameworks must shift from static policy enforcement toward continuous monitoring, iterative adaptation, and real-time control in response to the ongoing transformation of data ecosystems. It implies that adaptive governance frameworks should incorporate feedback loops, automated policy enforcement, and data quality intelligence to support continuous improvement. By applying these mechanisms, organizations enable proactive governance interventions to respond dynamically to emerging risks, regulatory changes, and data quality degradation. As a result, organizations can better manage uncertainty, sustain regulatory alignment, and ensure high-quality data across the lifecycle.

These findings indicate that significant progress has been made in developing big data governance frameworks. However, the diversity of approaches and the accelerating complexity of data ecosystems reveal a pressing need for more coherent, flexible, and forward-looking governance frameworks. Furthermore, the development of a unified framework,

combined with AI-aware and adaptive mechanisms, offers a practical pathway for organizations and policymakers to enhance the effectiveness of data governance. Such advancements can support governance systems that are not only rigorous and transparent but also resilient to rapid technological and regulatory change. This evolution is crucial for realizing the full potential of big data while ensuring the responsible and trustworthy use of data and AI practices across various environments.

5. Conclusions

This study revisits the current landscape of big data governance to clarify how effectively contemporary frameworks respond to the increasingly complex demands of modern data ecosystems. In response to this objective, the synthesis shows that substantial progress has been made in formalizing governance structures, particularly in security, privacy, and compliance. The significant gaps remain in data quality management, AI-driven decision governance, and cross-organizational data collaboration. Existing frameworks often lack the adaptability necessary to keep pace with rapidly evolving technologies and emerging ethical considerations, leading to fragmented and inconsistent governance practices.

The analysis underscores the need for more holistic, integrated, and context-aware governance frameworks. Future frameworks should incorporate multidimensional perspectives that extend beyond regulatory compliance to encompass strategic value creation, lifecycle-oriented data quality management, responsible AI oversight, and dynamic governance mechanisms that can evolve in collaboration with technological advancements. Additionally, empirical research is needed to validate governance constructs in real-world settings. Future research should focus on empirically evaluating the successful implementation of governance mechanisms by establishing benchmarks for governance maturity and identifying organizational capabilities to implement governance mechanisms that evolve in practice.

Finally, by consolidating insights from contemporary big data governance frameworks and emerging challenges, this study provides a foundation for advancing research on big data governance. Strengthening data governance remains essential not only for ensuring the trustworthiness and quality of data but also for maximizing the organizational value as a critical strategic asset in the big data era.

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