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Blockchain as a driver for transformations in the public sector

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ABSTRACT

Blockchain architecture, originally designed for Bitcoin, has revolutionized finance through decentralized transactions and secured data management. It has been utilized to maintain private citizen records, allowing data owners to grant access via the blockchain for direct communication. Despite its potential, this technology remains relatively unexplored by both citizens and the public sector. By carrying out a thorough literature review, this article aims to shed light on this field. The research focus encompasses two key elements: (1) analyzing blockchain dimensions and (2) exploring its transformative impact on the public sector. The methodology involves an extensive meta-analysis of existing research on blockchain's analytical aspects and its role in reshaping public administration. Additionally, a questionnaire is administered to Information Technologies (IT) experts in public services, comparing their perceptions with established scientific studies. The research's core findings address various analysis dimensions, including regulatory risks, data management challenges, privacy concerns, and technological limitations. On the transformation front, organizations adopting blockchain technology anticipate enhanced networked services, fortified data security, operational efficiency, informed decision-making, and novel public services. The potential of blockchain to drive innovative services and safeguard data is widely acknowledged, yet organizations with blockchain are cautiously optimistic about its practical implications compared to those without.

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Public sector; blockchain; transformations; data security; citizens

1. Introduction

Blockchain technology was developed to track data from public records while upholding a high standard of privacy and anonymity (Ranjith Kumar and Bhalaji, 2021) (Aguilar-Alonso, et al., 2020). On one hand, there are several main advantages such as the possibility that that the owner of the data can approve access through the

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blockchain, allowing for direct communication between the blockchain and the destination. On the other hand, there are also several limitations indicated in the literature that need to be considered. Abdul-Moheeth et al. (2022) emphasizes the importance of improving transitions of care through blockchain applications in patient identity management in the healthcare sector. Another significant limitation is scalability, particularly with public blockchain networks like Bitcoin and Ethereum, which face challenges in handling large volumes of transactions in a cost-effective way (Alghamdi and Khan 2020). Additionally, regulatory and compliance challenges can lead to significant difficulties, as blockchain operates across borders, making it problematic to establish consistent regulatory frameworks (Bachynskyy and Radeiko 2019).

Privacy concerns are of utmost importance, especially in situations where data privacy is a serious problem, as blockchain's transparency may not align with required privacy requirements (Alimehaj et al. 2021). Furthermore, the intricate nature of blockchain technology can pose challenges to its adoption within the public sector, potentially due to a shortage of necessary skills (Amend et al. 2021). Another challenge arises from the substantial costs and resource demands associated with establishing and sustaining blockchain networks, which could potentially hinder their widespread adoption (Alkhwaldi and Aldhmour 2022).

Security concerns represent another significant limitation, as blockchain, despite its reputation for security, is still susceptible to security vulnerabilities (Anastasiadou, Santos, and Montargil 2021). Smart contracts, which are integral to blockchain applications, can raise legal challenges within traditional legal systems (Babu et al. 2022). The lack of understanding and awareness of blockchain technology within the public sector can also delay its adoption (Bwalya 2020).

Data migration and integration with legal systems can be complex and costly, making the transition to blockchain-based solutions difficult (Cagigas et al. 2021). Additionally, blockchain networks require decentralized governance models, which may not align with the hierarchical structure of many public sector organizations, leading to governance and decision-making challenges (Chatterjee and Qureshi 2022).

Despite these limitations, blockchain technology continues to evolve, and some of these challenges may be addressed over time, as the technology matures, and as public sector organizations become more aware of and prepared for its potential.

These opportunities and challenges give a purpose for this study to analyze the research that has been conducted on blockchain applications, especially on two multidisciplinary research subjects: (1) blockchain-related dimensions of analysis and (2) blockchain-driven transformations in the public sector. In this context, it is important to understand the concept of blockchain technology and its main goals.

The article aims to shed some light on the use of this technology in the public sector and for public services, as this remains an understudied subject, as there are several limitations in the literature (Cagigas et al. 2021; Ølnes and Jansen 2018). In this context, the study aims to contribute by identifying and understanding the importance of conceptual dimensions. These dimensions revealed through a literature review, may present challenges or barriers to the successful adoption of blockchain technologies. Additionally, the study analyzes potential transformations that may arise from the use of these technologies and how their implementation either affects (or may affect) public organizations.

In brief, a blockchain is a database that keeps track of the history of various pieces of information and allows for both the storage and validation of data transfers. This also allows for international trade (Huang et al. 2021). Information is encoded using an immutable chain, often known as a string of blocks, stacked one on top of the other. Ownership proofing is possible at any time thanks to the first blockchain, which is Bitcoin, which creates and maintains a record of all Bitcoin transactions.

Blockchain's primary point of differentiation is how its ledgers are distributed globally and mirrored over tens of thousands of nodes, or computers, without centralized management or involvement. This makes blockchain a decentralized database that enables data to be verified by decentralized communities, in contrast to centralized registries. The blockchain of Bitcoin is not just accessible to everyone but also reliable and safe, since nodes use complex applications of mathematics and computational brute force as part of their consensus procedures (Gonçalves and Domingos 2021). Because blockchain requires consensus procedures, it may be more challenging to create and implement apps that provide product traceability, conduct financial transactions (Yu et al. 2022), or transmit digital content when employing trusted intermediaries.

As a peer-to-peer network, the blockchain system's nodes share power and cannot be shut down by either a centralized authority or a single person. Even if a centralized authority blocks one or more individuals or groups, the system will still function even if more than half of the players attempt to overwhelm it (Yu et al. 2022). The system also possesses the capability to verify product authenticity and offers robust end-to-end traceability at the individual unit level, effectively preventing any potential disruptions in sensitive processes. The problem of centralized power can also be resolved via blockchain, which offers distributed and group power. However, before fully comprehending the logic of transparency, it is important to understand attribution, which is the most important aspect of both asset ownership and contracts (Liu et al. 2019).

Public organizations can use blockchain architecture to benefit from the distributed, decentralized ledger and enhance data exchange among the public organisms to obtain benefits. These benefits include lowered security expenses (Huang et al., 2021) and enhanced data security (Toapanta et al. 2018).

According to Hyvärinen, Risius, and Friis (2017), blockchain technology may be utilized to create a network that permits the sharing of big data, or metadata, and offers more accurate information on the prevalence and detection of fraud. Due to variations in the transmission of sensitive data among European public organizations, which lack uniformity and consistent security measures, there is an increased need for the development of standardized frameworks and procedures for effective data management.

Along with increasing trust and transparency, employing blockchain technology for identification, tracking, and verification has many other benefits. It can ensure total openness, confidence, and security for digital processes (Huang et al. 2021).

Additionally, it can be applied to resolve copyright issues and facilitate the transfer of sensitive data (Toapanta et al. 2018).

Nonetheless, some risks must be considered. Primarily, the integration of blockchain protocols poses challenges due to the intricate and novel nature of the technology, coupled with its limited market penetration. Additionally, the absence of standardization hampers swift implementation and advancement. The substantial energy consumption is another concern, contributing to the prohibitive cost of conducting or redoing data analysis tasks. Furthermore, navigating data privacy legislation proves to be an obstacle, encompassing concerns about data misuse and ethical considerations. These factors collectively contribute to a lack of complete trust in technology among managers and developers (Toapanta et al. 2018).

This study will make a significant contribution to the understanding of how blockchain technology is being utilized within public administration organizations. It combines a systematic literature review to strengthen the empirical approach, which not only enriches the theoretical knowledge about blockchain but also provides valuable insights into the practical experiences of experts working within organizations. It considers the perspectives of both, organizations that have implemented blockchain technologies, and organizations that have not, offering a comprehensive view of the impact and relevance of blockchain, in different contexts. This comparative analysis allows for an understanding of the challenges and opportunities associated with blockchain adoption in public administration.

Several key dimensions related to blockchain implementation are identified and analyzed, retrieved from the literature review, which serve as a structured framework for assessing the various aspects of blockchain adoption within public administration. This is a major contribution, as the proposed framework can be instrumental for organizations when adopting blockchain technology, providing a reference for understanding potential challenges.

The organization of this article has been thoughtfully structured to explore the impact of blockchain-driven analysis and transformation within the public sector. It is divided in various consecutive sections.

The initial section of the article presents a systematic literature review to thoroughly examine the existing body of literature related to the role of blockchain technology in the public sector, using the PRISMA methodology. This includes protocol guidelines that delineate a series of steps researchers must follow to prepare their reviews and analyses through a stronger scientific approach. This comprehensive review covers various dimensions of analysis that become the basis of the empirical analysis.

Following the systematic literature review, the article transitions to the empirical methodology section, where an explanation of the research approach is presented. Furthermore, it delves into the specifics of the data collection technique used to gather empirical data. Moving forward, the article progresses to the data analysis section, presenting the results, interpreting and discussing the findings, to extract the main conclusions from the collected data.

In the final part of the article, the conclusion section summarizes the key findings and their significance. Additionally, this section highlights the main limitations of this study and the prospects for new research.

2. Systematic literature review

2.1. Methodology

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach is an evidence-based collection of items for reporting in systematic reviews and meta-analyses in various fields of research. It offers a thorough framework to guarantee the review process's openness, objectivity, and reproducibility, and it serves as the basis for the procedures used in this systematic review. The PRISMA methodology includes detailed recommendations for defining research questions, search strategies, study selection criteria, data extraction, risk of bias assessment, data synthesis, and reporting of results. All the steps of this study are covered by the PRISMA methodology.

2.2. Eligibility criteria – inclusion and exclusion criteria

At the end of April 2022, a thorough search of online scientific databases was carried out utilizing the scientific information research tool b-on. B-on stands for "Online Library of Knowledge," and it was developed by the Portuguese FCCN (Scientific Computation Unit of the Foundation for Science and Technology). It provides unrestricted and lasting access to comprehensive research and higher education resources, including complete texts from numerous scientific journals and online ebooks sourced from prominent scientific content providers. It stands as a prominent global source for accessing scientific information.

Multiple searches containing the terms "blockchain" and "public organi", or "public services", were conducted.

This study employed the following selection criteria: inclusion of studies involving the application of blockchain technology within public organizations or public services.

2.3. Findings from the article search

The number of publications found with the selection criteria is shown in Table 1, and the articles satisfying all set criteria with a $n = 72$, were selected for this study.

To address the research questions Rq1: "Which are the main dimensions of analysis of blockchain?" and Rq2: "Which are the main transformations driven by blockchain technology in the public sector?" A systematic evaluation of the literature was conducted.

The subsequent sections present and analyze the network of keywords and authors, addressing the research questions and initiating the exploration of the research agenda concerning blockchain in the public sector.

Table 1. Number of articles found per query.

Keywords "blockchain*", and "public organi*," or "public services"
Number of Scientific papers without other restrictions 159
Number of Scientific papers since 2018, (2018–2023) 150
Peer-reviewed journals: 136
Language English 127
Excluding conferences, 72

2.4. Data network and discussion

Mendeley (Elsevier) was used to assess each manuscript, and 72 articles made up the database that was stored in.ris format and uploaded by the VOSviewer software to examine the keyword's frequency (Figure 1).

As a result, the strongest link strength between the keywords, based on equal distance, is significant. The main keywords are "blockchain", and "public services".

The primary dimensions that serve as the foundation for the scale developed for the questionnaire, and shown in Table 2, were determined by an examination of the articles.

Table 2 concentrates on the blockchain primary dimensions of analysis (Rq1) and the transformations it drives (Rq2) to precisely respond to the previous research questions. These dimensions served as the framework and were the basis of the questionnaire to be evaluated by the experts. Both Dimensions of Analysis and Transformations were defined through an analysis of the articles and authors indicated in the table. These dimensions were defined to be analyzed by a group of experts, to obtain feedback and results, the process is explained in the following section.

The analysis of blockchain's primary dimensions of analysis (Rq1) allows us to understand the complexity of blockchain and the drawbacks and challenges of the development and adoption of technology.

Blockchain technology presents a range of both novel and distinct risks that extend beyond traditional IT systems. These risks encompass various facets such as regulatory risks linked to legislation, taxation, data protection, immutability, automation, and decentralization (Bachynskyy and Radeiko 2019). The distinctive operational framework and inherent characteristics of blockchain contribute to these potential hazards.

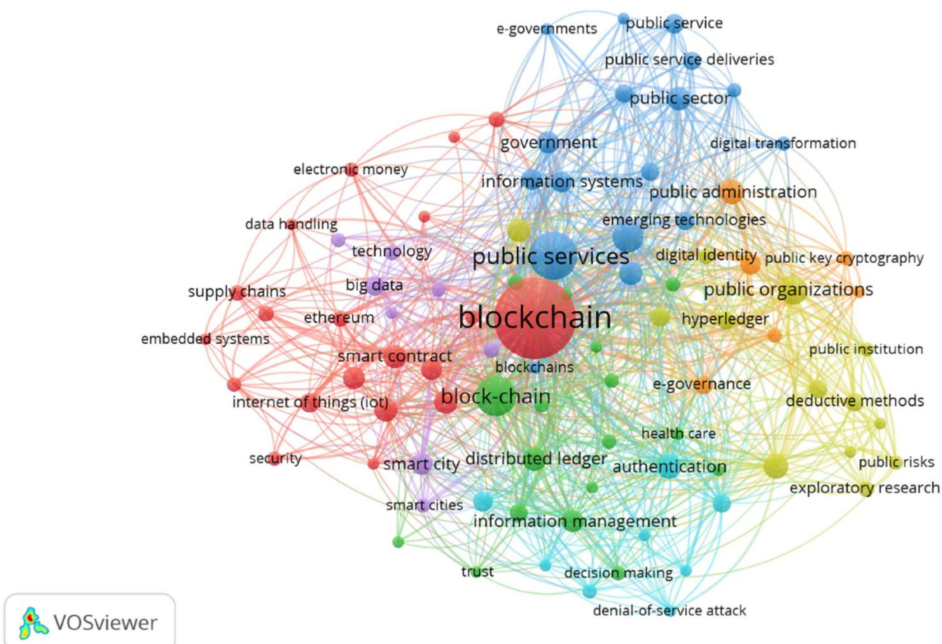

Figure 1. Keywords occurrence network.

Table 2. Blockchain dimensions of analysis and transformations in the public sector.

Dimensions of Analysis	Transformations	Authors	
Regulatory risks	Improved networked services	Abdul-Moheeth et al. (2022)	Niknezhad, Shokouhyar, and Minouei (2020)
Managing unstructured data	Improved data security	Alghamdi and Khan (2020)	Norström and Lindman (2020)
Data quality risks	Efficiency increase	Alimehaj et al. (2021)	Papadaki, Karamitsos, and Themistocleous (2021)
Availability of data	Better decision-making	Alkhwaldi and Aldhmour (2022)	Petroni and Pfitzner (2021)
Access rights to data	New public services	Amend et al. (2021)	Prager, Martinez, and Cagle (2021)
Data ownership issues		Anastasiadou, Santos, and Montargil (2021)	Prajapati, Dave, and Shah (2020)
Cost of data		Babu et al. (2022)	Rim (2023)
Lack of pre-processing facilities		Bachynskyy and Radeiko (2019)	Roth et al. (2023)
Lack of blockchain technology		Berdaliyeva et al. (2023)	Rusakova and Inshakova (2021)
Shortage of skills in blockchain		Brinkmann and Heine (2019)	Sadkov et al. (2021)
Privacy concerns		Bwalya (2020)	Schaffers, Vartiainen, and Bus (2020)
Security		Cagigas et al. (2021)	Shahaab et al. (2023)
Difficulties of data portability		Chatterjee and Qureshi (2022)	Shan et al. (2021)
		Cirillo et al. (2022)	Soares and Costa (2021)
		Criado and Gil-Garcia (2019)	Sobolewski and Allessie (2021)
		Datta (2021)	Sun, Lv, and Li (2021)
		Elisa et al. (2020)	Sung and Park (2021)
		Eluubek Kyzy et al. (2021)	Toapanta et al. (2020)
		Engin and Treleaven (2019)	Tsampoulatidis, Bechtsis, and Kompatsiaris (2019)
		Fathiyana, Yutia, and Hidayat (2022)	Tshering and Gao (2020)
		Fiorentino and Bartolucci (2021)	Turkanovic and Podgorelec (2020)
		Foschini et al. (2021)	Verma and Sheel (2022)
		Garcia et al. (2021)	Wamba and Queiroz (2020)
		Glavanits (2020)	Wang et al. (2022)
		Goldsmith et al. (2022)	Wei et al. (2022)
		Gonçalves and Domingos (2021)	Wheeler (2017)
		Grigoreva, Garifova, and Polovkina (2019)	White et al. (2019)
		Heckler and Kim (2022)	Wright (2020)
		Hujran et al. (2021)	Yfantis and Ntalianis (2022)
		Hussein, Taha, and Khalifa (2018)	Yue et al. (2022)
		Hyvärinen, Risius, and Friis (2017)	ZareRavasan and Jeyaraj (2023)
		Jha (2023)	Zhao et al. (2021)
		Kuo and Shyu (2021)	Zhuk et al. (2022)
		Leng et al. (2018)	
		Lin et al. (2021)	
		Lo et al. (2022)	
		Mahlaba et al. (2022)	
		Naik and Jenkins (2021)	

A key challenge involves managing unstructured data within the blockchain environment. This intricate undertaking demands substantial effort to standardize and organize data, rendering it suitable for machine interpretation and analysis (Wang et al. 2022). Evaluating data quality risks becomes paramount within blockchain systems, particularly in the context of cybersecurity threats (Chatterjee and Qureshi 2022). Such evaluation encompasses considerations like endpoint protection, user confidentiality, and safeguarding private keys that enable access to digital assets.

The assurance of data availability within blockchain networks pertains to the accessibility and validation of complete transaction sets by all participating nodes for a given block. However, this doesn't necessarily guarantee perpetual data availability. Additionally, data retrievability pertains to the ability of nodes to retrieve historical data from the blockchain (Lo et al. 2022; Rusakova and Inshakova 2021).

Access rights to data within the blockchain network are confined to authorized entities, ensuring the security and transparency of stored data (Datta 2021). Data ownership issues focus on granting individuals control over their data, enabling them to manage, share, and determine access rights (Datta 2021; Soares and Costa 2021). This decentralized approach empowers individuals to exercise authority over their data.

Yet, blockchain systems come with notable drawbacks, including the high cost of data storage and associated expenses for accessing stored data (Soares and Costa 2021). Moreover, the lack of pre-processing facilities poses challenges for converting raw data into a usable format (Rusakova and Inshakova 2021).

The nascent stage leads to a lack of blockchain technology and the substantial processing resources required for transaction validation contribute to operational inefficiencies (Hussein, Taha, and Khalifa 2018). As user volumes and transaction frequency rise, the capability of blockchain networks to handle these demands becomes crucial.

A shortage of blockchain skills further compounds challenges (Cirillo et al. 2022). Skills encompassing blockchain architecture, cryptography, data structures, smart contracts, and distributed systems are in high demand, creating a scarcity of competent professionals.

Addressing privacy concerns, blockchain systems employ asymmetric cryptography to safeguard user-to-user transactions, with each user possessing a public and private key (Elisa et al. 2020; Wang et al. 2022). The decentralized nature of blockchain introduces security concerns, as control is jointly maintained by all users, preventing unilateral alterations (Huang et al. 2021).

Furthermore, data portability faces obstacles that might increase the risks of data exposure, loss, and network-based attacks (Toapanta et al. 2020). However, blockchain technology offers a solution by facilitating a secure, transparent, and intermediary-free exchange of information and value, simplifying the porting process.

The transformations driven by blockchain (Rq2) are the following:

Blockchain technology brings about a multitude of advantages across various domains. One prominent area of impact lies in the improved networked services (Engin and Treleaven 2019). Its decentralized and immutable nature simplifies asset tracking, whether tangible assets like buildings or intangible assets like patents and intellectual property. Transactions are securely recorded within a network of businesses, fostering a more efficient and reliable framework.

Another key benefit is the substantial improvement in data security (Toapanta et al. 2018). By preventing loss, manipulation, and unauthorized access throughout the entire data lifecycle, blockchain technology ensures the integrity and confidentiality of sensitive information.

The efficiency of operations experiences a notable increase through blockchain adoption (Shahaab 2023). This is primarily attributed to the heightened traceability, security, trustworthiness, and transparency that blockchain introduces to shared data within a business network. Consequently, this comprehensive enhancement serves to reduce operational costs and streamline processes.

Furthermore, blockchain's influence extends to facilitating better decision-making for organizations (Toapanta et al. 2020). Leveraging blockchain's capabilities, organizations can establish a shared database that meticulously tracks assets, transactions, and interactions among participants. This wealth of data fosters informed decision-making, enabling organizations to respond more adeptly to dynamic circumstances.

The potential for blockchain to revolutionize new public services is also noteworthy (Engin and Treleaven 2019). This technology holds promise in addressing critical issues such as digital health records, online voting, specific intellectual property concerns, and secure government operations. Through its decentralized and transparent framework, blockchain presents opportunities to create new and more secure avenues for delivering essential public services.

3. Empirical methodological approach

By Cobianchi et al. (2021), this study's methodology is quantitative through empirical research, employing statistical tools for data analysis. For gathering primary data, a survey created on an internet platform was employed (Wang and Cheng, 2020). This is a cross-sectional study that collects information from a sample at a particular time (Wang and Cheng, 2020). The study was conducted with a non-probabilistic convenience sample (intentional and snowball type). Convenience analysis is a non-probability sampling method used in research, where participants or data points based on their ease of access and availability are selected, other than a random or systematic sampling process. This approach is often used for its practicality. On the other hand, the snowball-type approach is used in qualitative research to identify and recruit participants for a determined study. After selecting an initial participant, the researchers ask them to refer or "snowball" to other individuals who have relevant experiences.

For this study, a selection of individuals who have characteristics in common, whether demographic or behavioral, were selected to answer the questionnaire.

To answer the research question, a questionnaire was utilized to identify the importance of the dimensions of analysis of blockchain and transformations (see Table 2), between public organizations with and without Blockchain technologies. The information was gathered using a methodical questionnaire that was developed after the literature review. To maximize the representativeness of the data, the sample consisted of 173 public servants from public organizations in Europe (Portugal, Spain, Italy, France, and Ireland, all members of an international project), as shown in Table 3.

The respondents were blockchain technology experts in information technology who were employed by governmental organizations. The fieldwork was carried out between April and June of 2022, for a 5.8% proportional estimate, with a 95% confidence interval (and $p = q = 0.5$), and a rise in data errors. A summary of the data

Table 3. Distribution of the sample per country.

Portugal	76
Spain	14
Italy	22
France	34
Ireland	27
Total	**173**

Table 4. Fieldwork data.

Fieldwork	April through June 2022
Sample size	173 surveyed
Sample type	Convenience and geographic quota sampling
Survey type	Structured online questionnaire
Geographical area	Europe
Sampling error	5.8% assuming $p = q = 0.5$ and a confidence level of 95%

collection procedure and technical information relevant to the sample are shown in Table 4.

4. Data analyses and discussion of the results

For data analysis, the software IBM SPSS, version 24, was employed to conduct the necessary statistical analysis. This analysis aimed to assess the significance of the dimensions being studied for experts affiliated with public organizations, whether utilizing blockchain technologies or not.

To assess distinctions among organizations lacking Blockchain technology, an analysis of covariance (ANCOVA) was conducted. Despite the data's departure from normal distribution, the analysis remains robust due to the substantial and resilient sample size. Variance similarities persist despite deviations from normality (Blanca et al. 2017; Tabachnick and Fidell 2007).

The multivariate design with covariates aims to mitigate the impact of other covariant variables, such as the skills variable influenced by blockchain on organizational transformations. This approach estimates the variance attributed to individual differences by regressing the dependent variable against the covariate. The scores in the dependent variable are statistically aligned with the covariate. Subsequently, an ANOVA is conducted on these adjusted scores to analyze the outcomes. (Tabachnick and Fidell, 2007). Thus, the analysis controls the effect of the covariable, so that it eliminates the variation due to the mismatch of the ANOVA error.

Each group's adjusted means are examined in Table 5.

The modified means, F statistics, and *p*-values are shown in Table 5. A 1–5 Likert scale was used, where 1 stands for "low importance" of the dimension and 5 stands for "high importance" when implementing the blockchain technology. The analysis reveals that there are statistically significant differences in all challenge-related variables (*p*-value .01 in all cases), with organizations without Blockchain technologies consistently scoring higher, considering the different dimensions used to analyze the perceptions of the experts. It's also possible to see what variables rate higher in F statistics when comparing organizations with and without Blockchain technologies. "Regulatory risks" is the dimension with the highest F rating, followed by "Access rights to data", and "Data ownership issues". On the other hand, the dimensions of the lower F rating are "Lack of Blockchain Technology" followed by "Shortage of Blockchain skills". The meaning of these findings is discussed further in this Section.

As for the effects of data-driven transformations, a four-point Likert scale was used instead, with 1 standing for "Does not create transformations" and 4 standing for "Creates transformations". This allowed us to examine how blockchain promotes or is expected to promote, transformations in the company. If there are significant

Table 5. Blockchain dimensions.

Variables	No Blockchain	Blockchain	*F*	*p*
Regulatory risks	4128	3153	102,385	.000***
Managing unstructured data	3987	3526	23,797	.000***
Data quality risks	4101	3631	14,633	.000***
Availability of data	4367	3614	62,34	.000***
Access rights to data	4358	3500	86,401	.000***
Data ownership issues	4377	3571	83,375	.000***
Cost of data	4278	3568	51,542	.000***
Lack of pre-processing facilities	4315	3613	45,606	.000***
Lack of blockchain technology	4119	3861	6,377	.012**
Shortage blockchain skills	4035	3738	7,934	.005***
Privacy concerns	4231	3912	15,069	.000***
Security	4288	3837	18,908	.000***
Difficulties of data portability	4445	3994	23,106	.000***

*=$p < .1$; **=$p < .05$; ***=$p < .01$.

Table 6. Blockchain transformation impact.

Variables	No Blockchain Mean	Blockchain Mean	*t*-student	*p*
Networked services	1.3	1.54	1.96	.051*
Improved data security	1.43	1.68	1.702	.090*
Efficiency increase	1.83	2.48	3.726	.000***
Better decision-making	1.4	2.58	7.681	.000***
New public services	1.463	2.15	4.968	.001***

*=$p < .1$; **=$p < .05$; ***=$p < .01$.

Table 7. Transformations and decision making.

Blockchain	Cramer test	*p*
Blockchain Influences transformations	0.391	.000***
Blockchain contributes to effective decision-making	0.335	.00***

*=$p < .1$; **=$p < .05$; ***=$p < .01$.

disparities between firms that use Blockchain technology and those that do not (Table 6), the continuation has been completed.

Table 6 shows that firms using Blockchain have statistically experienced more transformation than firms not using Blockchain in terms of efficiency increase, decision-making, and new public services and, to a minor extent, in terms of networked services and data security.

Finally, Cramer's test can be used to determine whether businesses involved in blockchain influence how transformations are created, as well as how effectively they contribute to decision-making. Considering this, it's possible to verify that businesses that use Blockchain tend to have a greater impact on changes and decision-making (Table 7).

This research seeks to contribute to the existing knowledge about the utilization of blockchain in public administration organizations, organizations that have implemented blockchain technologies, and organizations that have not implemented blockchain technologies yet. Through the empirical study, the experts who participated in this research scored several dimensions identified during the process of literature review, which is explained in Section 2.4.

Their perceptions indicate that the experts from organizations without blockchain technology attribute a higher importance to the main dimensions under analysis. This likely occurs because they lack close involvement in the implementation process and are not directly engaged with addressing the primary issues arising from technology usage. Consequently, they may not feel the need to be actively involved in seeking solutions and resolving challenges.

Regarding the dimension of "Regulatory risks", it has a high level of importance for both types of respondents, as the technology is novel and new regulations must be defined and implemented; the "Data ownership" dimension raises ethical issues, and managers, developers, and citizens tend to feel insecure about their personal and sensitive data; the "Availability of data" dimension is related to the quality of data. The quality of raw data relies on data sources, and the absence of pre-processing facilities hinders the establishment of precise data cleaning procedures. This situation contributes to elevated expenses associated with data processing and analysis when utilizing blockchain technology.

Among organizations already using Blockchain technology, there is high er awareness of the potential for transformative impacts that this technology can bring on dimensions such as efficiency growth, decision-making, and, new public services.

5. Conclusions

This study provides insights into the dimensions of Blockchain technology that experts find of higher or lower importance, shedding light on the underlying reasons. Notably, issues like regulatory risks, data ownership, and data availability emerged as prevalent concerns among respondents. By conducting a literature review and employing a specific methodology, this research collected and analyzed feedback from 173 specialists, aiming to unravel the advantages and drawbacks of implementing blockchain technology in public organizations.

The results offer valuable insights for researchers and practitioners, helping them understand the varying levels of complexity associated with different dimensions of blockchain when applied in public sector contexts. Key considerations include: (a) Assessing regulatory risks; (b) Developing strategies for managing unstructured data; (c) Ensuring and maintaining data quality; (d) Establishing frameworks for data availability; (e) Complying with access rights regulations and laws; (f) Addressing data ownership matters in alignment with legal requirements; (g) Evaluating the cost implications of data management; (h) Tackling challenges related to data portability; (i) Establishing solutions for the absence of pre-processing facilities; (j) Ensuring the availability of necessary blockchain technology; (k) Enhancing workforce skills to mitigate potential shortages in blockchain expertise; (l) Addressing privacy concerns; (m) Safeguarding data access and disclosure through robust security measures. By taking these factors into account, public organizations can navigate the complexities of blockchain implementation more effectively.

Furthermore, the implications of this research underscore the role of blockchain-driven changes as a catalyst for the emergence of new public services, products, and systems. Public organizations need to develop robust blockchain capabilities to facilitate this process, fostering heightened security, improved public knowledge management systems, and ultimately enhancing citizen services.

A significant correlation between the adoption of blockchain technologies by organizations and their influence on transformations and decision-making is apparent. These findings suggest that blockchain adoption is positively associated with transformations and effective decision-making among public organizations. Notably public organizations that havepted Blockchain technology show they perceive enhanced network services, fortified data security, streamlined efficiency, improved decision-making processes, and a broader array of new public services.

About the discovery that organizations adopting blockchain differ from those that do not, an alternative interpretation warrants consideration. It's possible that this disparity isn't solely attributed to blockchain adoption itself, but rather stems from other inherent structural attributes of these organizations that might influence their inclination toward innovation, including the adoption of blockchain technology. There can also be inherent dissimilarities, both observable and unobservable, between organizations employing blockchain and those abstaining from it.

For example, variations in risk perceptions of the technology among different organizations may not be a direct consequence of using blockchain or its impact on risk perceptions. Rather, it's plausible that organizations already employing blockchain have inherently more positive perceptions of the technology. These are questions to be tackled in future work.

As a core takeaway from this study, it becomes evident that public organizations should consider implementing blockchain technology. Such adoption may serve the dual purpose of safeguarding citizens' sensitive data and meeting the critical demand for new reliable public services. The challenge, however, lies in public servants' ability to effectively deploy blockchain technology, particularly in vital areas such as decision-making and data security processes.

Future efforts will involve conducting a survey among public employees to compare the collected information with the outcomes of this study. Furthermore, the scarcity of empirical research on blockchain in public organizations represents a notable drawback in the existing literature due to the novelty of the topic.

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