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BLOCKCHAIN INTEGRATION IN PUBLIC SECTOR: A COMPREHENSIVE REVIEW OF ECONOMIC AND LEGAL CHALLENGES

Integracija blokčejna u javnom sektoru – sveobuhvatan pregled ekonomskih i pravnih izazova

Abstract

This paper presents a comprehensive analysis of the benefits, obstacles, and ramifications of integrating blockchain technology into public sector functions, specifically focusing on economic and legal aspects. The discussion commences with an examination of the societal relevance of blockchain technology, as it is poised to dramatically enhance procedural efficiency within public sector organizations. Subsequently, the paper delineates the primary research objectives, which encompass identifying the multitude of benefits of blockchain technology for the public sector, investigating its legal and economic consequences, and scrutinizing the challenges that public sector organizations might face during implementation. Research methodologies employed to attain these objectives consist of an extensive literature review and qualitative primary data acquisition from field experts. Findings reveal that blockchain technology holds the potential to augment the swiftness and dependability of administrative procedures while bolstering data security within public sector organizations, albeit some legal and economic apprehensions persist. Regardless of these challenges, the authors maintain that the public sector is poised to reap significant rewards from blockchain technology deployment due to its capacity to modernize and streamline operations, as well as its capabilities for precise and verifiable data storage. Research limitations include a scarcity of available primary data and reliance on a singular data collection method. Suggestions for future research involve conducting additional studies addressing the questions raised in this research and supplementing the findings with user perspectives.

Keywords: *blockchain, public sector integration, legal challenges, economic ramifications, big data*

Sažetak

Ovaj rad predstavlja sveobuhvatnu analizu prednosti, prepreka i posledica integracije blokčejn tehnologije u funkcije javnog sektora, sa posebnim fokusom na ekonomske i pravne aspekte. Diskusija započinje ispitivanjem društvenog značaja blokčejn tehnologije, koja ima potencijal da dramatično poboljša proceduralnu efikasnost unutar organizacija javnog sektora. Zatim, rad definiše osnovne istraživačke ciljeve, koji obuhvataju identifikaciju mnogih prednosti blokčejn tehnologije za javni sektor, istraživanje njenih pravnih i ekonomskih posledica i proučavanje izazova s kojima se organizacije javnog sektora mogu susresti tokom implementacije. Istraživačke metodologije koje su korišćene za postizanje ovih ciljeva su opsežni pregled literature i kvalitativno prikupljanje primarnih podataka od stručnjaka iz polja. Rezultati otkrivaju da blokčejn tehnologija ima potencijal da poboljša brzinu i pouzdanost administrativnih procedura dok jača sigurnost podataka unutar organizacija javnog sektora, iako neke pravne i ekonomske bojazni i dalje postoje. Bez obzira na ove izazove, autori smatraju da javni sektor ima potencijal da ostvari značajne koristi od primene blokčejn tehnologije zbog njenog potencijala da modernizuje i pojednostavi operacije, kao i zbog njenih sposobnosti za precizno i proverljivo skladištenje podataka. Ograničenje ovog istraživanja je oskudnost dostupnih primarnih podataka. Predlozi za buduća istraživanja su sprovođenje dodatnih studija koje bi se bavile pitanjima postavljenim u ovom istraživanju i dopunjavanje nalaza sa perspektivama korisnika.

Ključne reči: *blokčejn, integracija u javni sektor, pravni izazovi, ekonomske posledice, veliki podaci*

Introduction

Blockchain technology, as described by Laroiya et al. [61], refers to an advanced digital ledger system enabling secure and immutable recording of transactions across a distributed network of computers. This decentralized characteristic ensures unchangeable transactions, protection against unauthorized access, and exceptional resistance to fraudulent activities or tampering [46], [42]. As a result, this technological innovation has led to a paradigm shift in data storage, sharing, and protection within the digital domain [20].

In the field of public administration, blockchain technology offers significant potential for improving government services and operations [83]. Key areas such as tax collection, land registry, identity verification, and asset registry can greatly benefit from its implementation [26]. By introducing innovative methods for managing, monitoring, and validating data, blockchain technology can enhance operational efficiency, strengthen security measures, and foster increased trust and integrity within the public sector [12].

As a distributed ledger technology, blockchain provides a wide range of potential applications within the public sector, encompassing government recordkeeping, financial services, digital identity, and public sector operations [23]. This technology's greatest strengths derive from its decentralized and distributed nature. Unlike traditional linear databases stored on central servers that are prone to data loss and vulnerable to cyberattacks, blockchain's infrastructure ensures robust security measures and resilience against data breaches, establishing a secure and efficient system for managing public data and information [31].

Many countries' public sectors face common issues such as bureaucratic inefficiency, corruption, and lack of accountability [58]. In this regard, blockchain technology offers a promising solution by providing a secure and transparent method of recording transactions and data. This technology has been employed due to its potential to streamline processes, reduce costs, and increase accountability in the public sector. This innovative approach could yield significant improvements in the quality of life by reducing corruption and protecting projects

from information manipulation. As literature explains, blockchain serves as a digital ledger that continuously updates economic transactions among numerous users, rendering it virtually immune to corruption. This continuous record of blocks guarantees the integrity and reliability of the data; consequently, blockchain's key features, such as immutability and decentralization, make it an effective tool for promoting transparency and combating corrupt practices [53].

Specifically, blockchain technology has been identified as a potential solution to various positive economic outcomes [38], endorsing this technology as a potential game changer for the public sector with high promises of improving efficiency in administrative processes, reducing bureaucracy, and cutting costs. Numerous sources (see [17], [84], [59], [33], [29], [54], [100], [44], [40]) have reported that different countries, aiming to leverage the advantages and minimize the risks associated with this technology, are already witnessing the development of various blockchain solutions within public sectors and public administrations.

However, despite blockchain's immense potential in the public sector, its effective deployment necessitates careful reasoning and planning [92]. Implementing blockchain technology in public sector systems is often not a straightforward task due to significant challenges accompanying its implementation in real environments [66]. Although there are numerous advantages, such as security, transparency, and immutability, the public sector must be aware of the drawbacks of blockchain technology, including scalability and interoperability [109]. Furthermore, the relatively immature and complex technology may limit the effectiveness of its implementation in certain contexts. Hence, the appropriate implementation of blockchain in public service depends on the public sector's ability to assess the risks and rewards of the technology and ensure its effective and secure deployment [19]. Generally, the current state of blockchain-driven innovation in the public sector primarily focuses on automating transaction enforcement [51], [52], with limited but promising digital transformation of public services. Besides understanding how blockchain technology can bring economic benefits, recent literature also concentrates on reflecting on the

main issues and potential failures within the public sector that could result in economic challenges and costs [8].

In addition, without proper regulatory oversight and security measures, blockchain technology could pose a significant risk to the anticipated economic outcomes of its implementation, thereby maximizing positive effects of blockchain technology is inherently linked to the legal aspects of its implementation. Based on the primary insight into the literature, this study aims to provide answers related to the challenges and advantages of blockchain deployment in the public sector, specifically focusing on law and economy-related issues, thereby addressing the following questions:

RQ1: What has been the scientific production related to blockchain in the public sector from 2016 to 2022?

RQ2: What are the main topics examined by scientific inquiries related to the deployment of blockchain in the public sector?

RQ3: What are potential economy-related advantages, challenges, and risks related to the deployment of blockchain technology in the public sector?

RQ4: What legal implications, issues, and challenges exist when utilizing blockchain technology in the public sector?

Methodology

This study employs a systematic literature review methodology to trace and review the existing literature on the main topics related to blockchain technology in the public sector, analyzing the arguments presented by various manuscripts. To ensure the validity of the collected data, several factors were considered. First, the research included only peer-reviewed manuscripts from journals published between 2016 and 2022. Second, the search was conducted through a systematic approach, identifying reliable and valid information from key players in the field. Third, the inclusion criteria required the analyses to focus on the legal and economic aspects of blockchain in the public sector.

Regarding research design, this paper presents a systematic literature review methodology aimed at searching, selecting, reading, and evaluating existing

peer-reviewed manuscripts to identify emerging trends and discussion topics. The research was conducted in several steps, beginning with searching for manuscripts in the following databases: Scopus, Web of Science, EBSCO, Emerald, ScienceDirect, and Google Scholar.

The search terms used were "blockchain, law, economy, public sector, and governance." Subsequently, the selected manuscripts were read thoroughly and synthesized. During this step, relevant information was extracted, categorized, and grouped into sections related to legal, economic, advantages, and disadvantages. The final step involved conducting a qualitative analysis of the literature. This analysis entailed comparing and contrasting the various arguments presented in the chosen manuscripts to identify the main themes and major findings.

The selected manuscripts were comprehensively analyzed, and different aspects were categorized into four primary sections. This process allowed for a comprehensive evaluation of the most critical findings, answering the major research questions.

Results and discussion

RQ1: What has been the scientific production related to blockchain in the public sector from 2016 to 2022?

Between 2016 and 2022, an impressive 228 scientific papers were published on the topic of blockchain deployment in the public sector. Among these papers, 44 were open access, 21 were 'Gold' open access, 8 were 'Hybrid Gold' open access, and 20 were 'Green' open access. The most popular year for publications was 2022, with the number of publications nearly doubling those of 2020 (59 vs. 30), as seen in Figure 1.

The most popular subject area was Computer Science (139), followed by Engineering (60), Social Sciences (44), and Business, Management and Accounting (42), as depicted in Figure 3. The most common document types for these papers were Conference Papers (72) and Articles (60), as illustrated in Figure 2. The majority of these papers were sourced from the 'ACM International Conference Proceeding Series' (12) and the 'Lecture Notes in Computer Science, Including Subseries Lecture Notes in

Artificial Intelligence and Lecture Notes in Bioinformatics' (9). Leading outlets for blockchain research in the public sector are presented in Figure 5.

As expected, 'blockchain' (124) was the most popular keyword in the publications, followed by 'public sector' (65). Other recurring keywords included 'block-chain' (35), 'blockchain technology' (18), 'e-government' (18), 'bitcoin' (15), and 'distributed ledger' (13), as shown in Figure 6.

Notable universities involved in the research on this topic included the University of Bayreuth (5) and the University of Luxembourg (4), while major sponsors of the research included the European Commission (5) and the

European Regional Development Fund (3). Finally, India led in research with 25 papers published, followed by the United States with 17 papers, and the United Kingdom with 15 papers, as presented in Figure 4.

RQ2: What are the main topics examined by scientific inquiries related to the deployment of blockchain in the public sector?

As expected, the most frequently addressed topics within papers related to blockchain technology applications in the public sector included terms such as blockchain, distributed ledger, and electronic government. However,

Figure 1: Years of scientific production related to blockchain and public sector
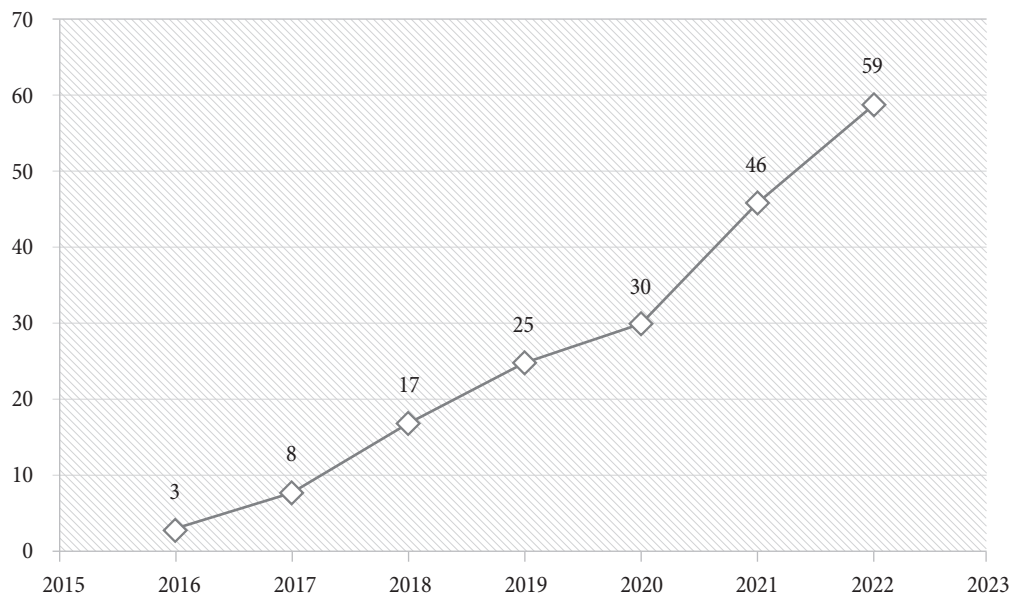
Figure 2: Types of scientific publications about blockchain and public sector
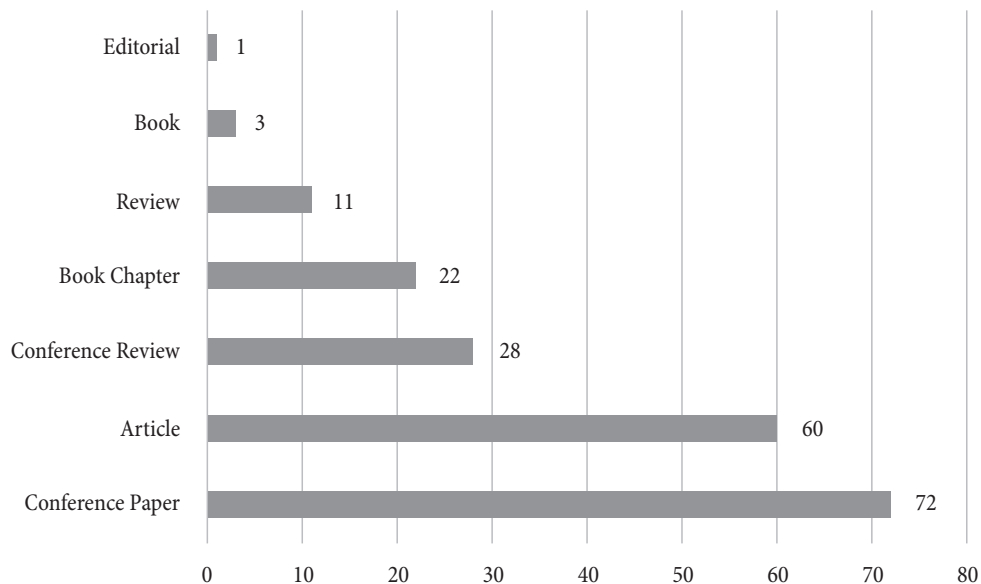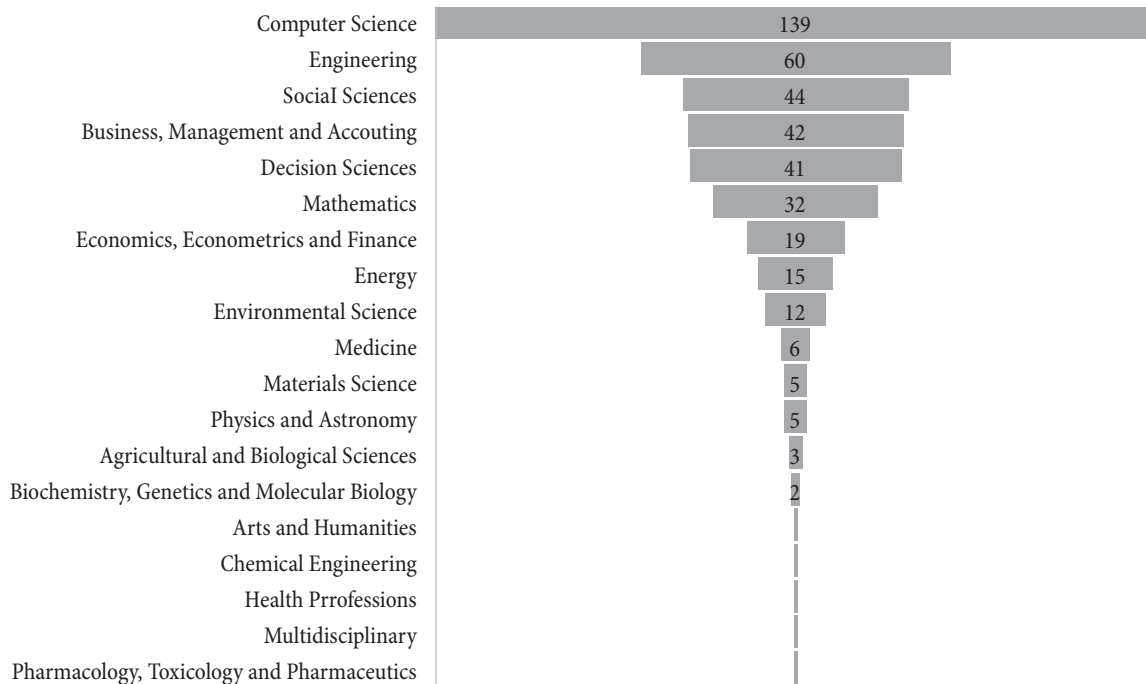
other prevalent topics encompassed the public sector, public administration, public services, and smart contracts. Given that the analyzed papers focus on implementing blockchain in the public sector to enhance public services, key themes that emerged include government service, electronic money, government transactions, government
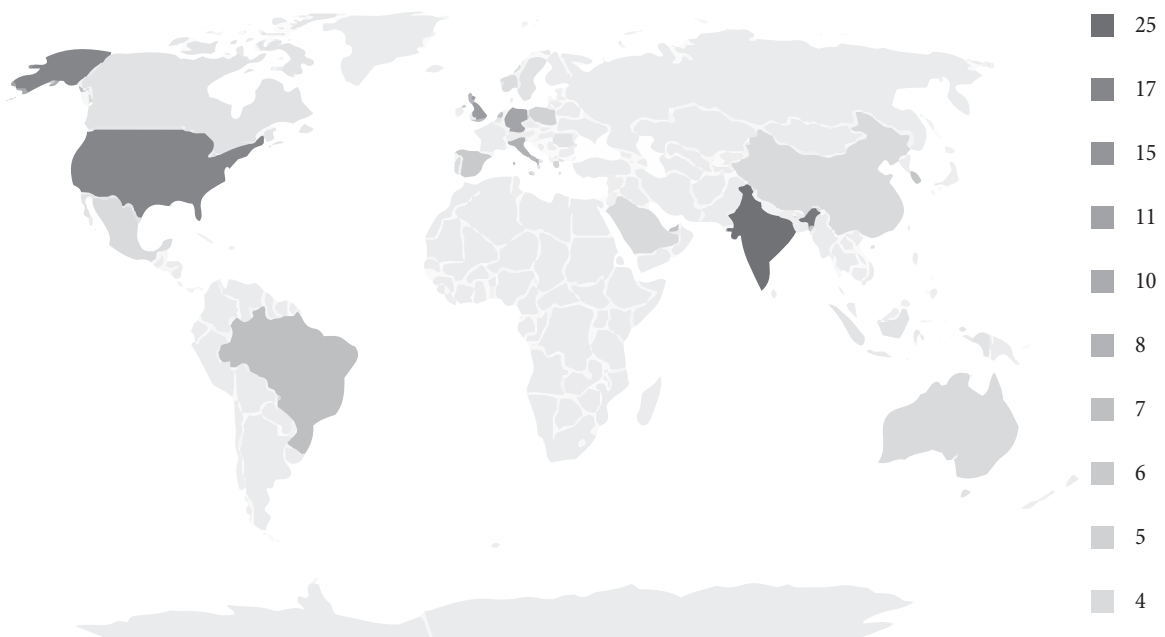
data processing, electronic data interchange, service industries, digital signature, and technology adoption.

Importantly, significant keywords that surfaced include legal regulation, financial fraud, data privacy, and security, highlighting the legal aspect of implementing blockchain and the importance of secure implementation

Figure 3: Subjects areas that are covered in scientific publications related to blockchain and public sector

Figure 4: Countries from which publications related to blockchain and public sector come from

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of this technology in the public sector [21]. Enhanced data security and verification can have numerous applications in the public sector [99]. For instance, blockchain can be utilized to securely store and transfer government data, such as sensitive documents, while also being employed to develop digital identities. This allows government agencies to issue digital certificates, which can then be authenticated by users on a trusted network [66]. Furthermore, blockchain can facilitate other government operations through efficient contract management [94]. By using smart contracts, legal agreements can be digitally recorded and tracked, allowing

parties to access data transparently and reducing the cost of dispute resolution [4].

The implementation of blockchain in the public sector can help increase transparency and participation by citizens, as blockchain-enabled applications enable them to access their data and make more informed decisions [10]. Moreover, with distributed ledgers and digital identity management, governments can enhance transparency in the usage of their funds by providing traceability and auditability to citizens [16]. In addition, the adoption of blockchain in the public sector allows governments to stay

Figure 5: Outlets in which the papers related to blockchain and public sector are published

Figure 6: Graphical depiction of keywords in publications about blockchain and the public sector

up-to-date with current technologies. By familiarizing themselves with applications, they can increase their internal capabilities and efficiency while developing more cost-effective solutions for their citizens [6].

In conclusion, scientific inquiries suggest that blockchain can revolutionize governments' capabilities through its distributed ledger and secure encryption, enhancing transparency, data protection, and efficiency in public operations [99]. Furthermore, researching the use of blockchain can enable governments to explore new avenues for revenue and cost-saving opportunities. For example, blockchain-enabled applications for revenue generation, grant management, or payroll can be explored to help public agencies save money in the long run. Therefore, the investigation of blockchain use in the public sector is a necessary and important area for research, as it holds the economic potential to deliver benefits to both the public sector and society as a whole.

RQ3: What are potential economy-related advantages, challenges, and risks related to the deployment of blockchain technology in the public sector?

The traditional public sector is a complex and multifaceted system responsible for governance and the provision of numerous public services. Despite its centralized accountability, it often faces challenges related to organizational fragmentation and information exchange capacity, resulting in disconnection and inefficiencies that are undesirable from an economic perspective. Blockchain technology is perceived as an innovative framework for governments to increase efficiency and improve their services (dos Santos et al. [27] and Sobolewski & Allessie [90] made a distinction between the quantitative and qualitative benefits of introducing blockchain technology in the public sector). Quantitative benefits encompass cost savings from reduced transaction processing costs without intermediaries compared to traditional systems and efficiency gains through reduced transaction completion time [89]. Qualitative benefits include reliability gains, decreasing the risks of cyber-attacks, system breakdowns, or data leaks, and transparency and accountability gains, characterized by increased oversight of the system's current state and transaction history. Blockchain technology provides tangible advantages beyond operational efficiency, including strategic benefits such as creating a competitive edge and generating improved or novel products and services. Blockchain corrects inefficiencies within the public sector by offering more efficient patterns and establishing prerequisites for the introduction of better public services.

From an economic point of view, blockchain technology's automation of processes and transactions can lead to significant time and cost savings for governments and their agencies. The automation of various administrative procedures can reduce costs and increase efficiency, leading to better outcomes for service providers and end-users alike [41]. Furthermore, a significant advantage of blockchain's application in the public sector is the reduction of bureaucracy, streamlining complex government processes. Blockchain technology can potentially lead to a reduction of operating costs, particularly those arising from fraud and error correction, as blockchain-based systems provide immutable and tamper-proof records that reduce the likelihood of fraudulent activities, minimize error rates, and enhance accountability. Successful implementation of blockchain technology can lead to decreased intentional or unintentional human errors, and improved reliability, resiliency, and audibility. Transactions processed within the public sector can be validated and authenticated by all participating nodes in the network, making the stored information authentic and of high quality. Embracing innovation and leveraging blockchain technology within the public sector results in process enhancement by eradicating errors, achieving standardization, offering improved services to citizens, ensuring trustworthy and efficient information sharing among institutions [77], reducing costs, providing faster services, and enabling 24/7/365 days a year service availability [14], [105]. Blockchain can enhance transparency, allow individuals to have direct control over their information [88], and increase public trust [108].

Considering other cost-related benefits, blockchain-based systems' transparency can improve the management of funds. Currently, there is a lack of traceability and transparency in the allocation of funds in the public

sector, with pervasive issues of corruption, leading to a lack of accountability and financial mismanagement [79]. In contrast, blockchain technology offers transparency in public money allocation, simplifies manual activities, reduces operational costs, and produces data to support aggregate analysis of benefits arising from the allocation of public resources [65]. Furthermore, blockchain-based systems can enable governments to boost tax revenues [46], reduce tax evasion [24], and curb the informal economy, leading to an overall increase in economic productivity. Specific sub-areas that blockchain could enhance are payroll [68], withholding taxes, value-added taxes, transfer pricing, and information sharing between federal, state, and local governments, as well as foreign countries [91], [55].

Data protection is a significant area where blockchain technology can provide advantages, which can also be related to reducing costs. Blockchain-based systems can offer secure data exchange and storage, enabling governments to manage sensitive data while minimizing costs related to data protection. Furthermore, blockchain technology can safeguard critical infrastructure, providing an additional layer of security and ensuring the continuity of services. Blockchain is viewed as a straightforward economic advancement, and efforts have been made to boost the efficiency of current services and maximize cost savings by implementing blockchain technology [66]. In addition to highlighting cost savings, some authors also emphasize increased resilience to spam and DOS attacks as an important benefit of using blockchain in the public sector [70].

In the long term, blockchain technology has the potential to transpose comprehensive data from the public sector into trusted data marketplaces (see [82], [43], [28], and [39]). From a wider perspective, blockchain can enable secure data sharing among different stakeholders, including government organizations and agencies, citizens, businesses, academia, and others. Blockchain-based data marketplaces create a secure and standardized platform for stakeholders to share and access data while ensuring data privacy and confidentiality, leading to increased collaboration, innovation, and efficiency in the public sector [37].

Through a decentralized platform that validates transactions, data, and information independently and securely without any third-party control, and within a verifiable, secure, transparent, and permanent system, blockchain technology leads to the elimination of rent-seeking and other inefficient forms of resource utilization [57], [58]. For example, blockchain in public procurement can automate the management process and provide tamper-proof record-keeping, real-time audibility, and automated smart contracts, resulting in uniformity, objectivity, and transparency [22]. Additionally, within the procurement process, blockchain technology can prevent the deletion or modification of public comments and offers, leading to decentralized decision-making, oversight, and record-keeping [30]. Therefore, from the literature point of view, blockchain technology is considered a promising solution for public e-procurement [85].

Some empirical research has already confirmed the positive impacts of blockchain technology in the public sector (see [98], [64], [26]). This technology is being experimented with in various areas of public services, including but not limited to digital currency/payments, land registration, identity management, notarization, supply chain traceability, healthcare [74], education [78], [49], corporate registration, data management, auditing [11], energy markets, taxation, voting, and legal entity management [102]. Within the realm of blockchain technology adoption, the sectors with the highest number of records are public management and healthcare. Still, a diverse range of sectors, including international trade and customs, voting, environmental protection, food safety, digital identities, energy, social protection, and public procurement, among others, is also identified as having significant potential for blockchain applications [19]. Considering government domains with the largest blockchain applications so far, Maragno et al. [63] highlight general public services, economic affairs, health sector, data and documents management, traceability of products, digital voting systems, and digital identity management.

Although the application of blockchain in these domains brings the aforementioned economic benefits, some inherent challenges occur in blockchain implementation. The first obstacle relates to resources needed for blockchain

applications, as deploying and maintaining the technology is costly, and not all governments have the resources to do it (many confront digitalization issues) [18]. Other challenges related to the economic perspective primarily start with technological barriers to widespread adoption of blockchain technology in the public sector, such as scalability, interoperability, flexibility, and security concerns (see [13], [50], and [1]). There are also organizational issues that are often described as obstacles to blockchain applications. Organizational readiness for blockchain adoption has been explored in studies by Ølnes et al. [69] that investigated acceptability issues. Business model and organizational transformation implications of blockchain have been examined by Ahram et al. [2] and Ølnes et al. [69]. The risk of errors in complex business rules when implementing blockchain has been addressed by Engelenburg et al. [32].

A key concern is blockchain technology's scalability in handling high volumes of transactions. The public sector is characterized by diverse and complex service offerings spanning different departments, agencies, and levels of government, leading to a complex web of interdependencies and integration challenges. Integrating blockchain technology into these existing systems may require significant technical modifications and adaptations to ensure seamless interoperability, which can be time-consuming, costly, and challenging to implement [71]. Moreover, the high volume of transactions and interactions may not be handled by many existing blockchain networks, which can result in delays, inefficiencies, and bottlenecks in transaction processing that may hinder widespread adoption of blockchain in high-volume public-service contexts [62].

The fragmentation of public services across different departments, agencies, and levels of government can pose challenges in terms of standardization and coordination. Ensuring consistency, coherence, and interoperability across different public services can be challenging as it requires coordination, consensus building, and alignment among various stakeholders [72]. Additionally, a common challenge is the lack of long-term experience in blockchain implementation, which could lead to imperfect management [53].

While blockchain has the potential to enable secure and transparent collaboration among stakeholders, the practical implementation of such collaboration can be complex and challenging. Firstly, setting up stakeholder collaboration on a blockchain requires the establishment of a consensus mechanism among stakeholders, which can be time-consuming and may involve negotiation and agreement on various technical, operational, and governance aspects [97]. This process may require substantial effort and coordination to ensure that all stakeholders are aligned and committed to the collaborative effort. Secondly, scaling up stakeholder collaboration on a blockchain can be challenging due to technical limitations [34]. The technology currently faces scalability issues, as the processing speed and capacity of many blockchain networks are relatively limited compared to traditional centralized systems [1]. As a result, accommodating a large number of stakeholders and processing a high volume of transactions may pose technical challenges and hinder the scalability of stakeholder collaboration on a blockchain.

A neglecting challenge in blockchain application is interoperability with existing centralized systems, as integrating blockchain into established systems may require substantial technical modifications and adaptations [47]. Additionally, the need to develop new technical skills and infrastructure to support blockchain implementation can pose obstacles, as it may involve substantial investment in infrastructural upgrades. Establishing an entirely new framework within the public system may incur high costs, including initial setup costs and ongoing maintenance expenses, which could pose financial challenges for budget-constrained public entities [53]. These challenges highlight the complexities and costs associated with the adoption of blockchain technology in the public sector and underscore the importance of careful planning and strategic considerations in implementing blockchain solutions in a public service context.

Although blockchain is often associated with strong security guarantees [7], its effectiveness depends on the size of the ledger. Smaller ledgers are more vulnerable to manipulation, so there is a risk that an entity or hacker could gain control of a majority of the ledger's node network (known as the "51 percent rule"), resulting in fraudulent transactions and misuse of public resources [31]. The lack of standards and regulations undermines

trust in the adoption of blockchain, ultimately impacting scalability and the full implementation of this technology in environments where it is expected to bring greater benefits. Thus, to achieve the widest possible advantages from the application of blockchain, it is necessary to establish an adequate institutional and regulatory framework for its application in the public sector.

RQ4: What legal implications, issues, and challenges exist when utilizing blockchain technology in the public sector?

The economic outcomes of blockchain applications within the public sector depend on legal aspects and regulations concerning the use of this technology. Legal contexts of blockchain applications are often associated with accountability in governance, referring to the regulation and enforcement of rules such as dispute resolution and change management. In blockchain governance, there are four forms of accountability mechanisms identified based on Treib's et al. [106] typology: coercion, voluntarism, targeting, and framework regulation. Coercion is manifested through "lex cryptographic," which involves legally binding regulations prescribing specific fixed standards implemented through code. However, converting law into code is a challenge since code-based rules must be predictable and leave no room for interpretation, limiting their applicability in contingent and conditional scenarios. By contrast, voluntarism relies on non-binding instruments exemplified by soft forks, while targeting uses detailed recommendations, often employed through community consensus. Framework regulation, embodied by hard forks, establishes binding rules while giving users the choice to accept or reject policy options, occasionally resulting in permanent splits if consensus is not achieved [102].

Developing countries frequently face challenges in public sector infrastructure projects, leading to delays and other issues. Blockchain-based project management promises numerous legal advantages for addressing these challenges. E-procurement, for example, allows organizations to save time and resources by moving processes online, ensuring prompt tendering and promoting transparency [95]. Additionally, blockchain technology facilitates improved accountability and addresses the issue of the lowest bidder by imposing consequences for vendors who fail to fulfill projects within their contracted time and cost without valid reasons [53].

Blockchain technology provides numerous services independently, without the need for direct interaction with specific businesses or organizations, made possible through the use of smart contracts [53]. Smart contracts automate tasks, increasing efficiency and accuracy in various processes and eliminating manual intervention after their creation.

Corruption, a widespread issue in the public sector, often arises from information manipulation, ambiguity, and uncertainty. Blockchain technology can help reduce corruption, serving as a digital ledger that records all transactions, ensuring data integrity and preventing double spending. The transparent, immutable, and decentralized characteristics of blockchain have the potential to mitigate corruption across diverse settings [38].

Online voting has gained momentum in modern society, reducing costs and increasing voter participation by eliminating physical ballots and polling stations. Blockchain technology offers decentralized nodes and end-to-end verification, providing a potential solution for legitimate, accurate, secure, and user-friendly electronic voting systems [48].

However, several challenges and limitations exist related to blockchain systems and failures in legal and regulatory frameworks. Interoperability challenges may arise when implementing blockchain technology, affecting its scalability and the establishment of a blockchain infrastructure in the public sector [102]. Concerns regarding government control, abuse of blockchain technology, and potential illegal activities such as money laundering, illegal trade, and tax evasion must also be addressed [58], [25].

Adopting automated solutions in public sector organizations must consider both embedded public values and existing capacities and practices regarding digital governance. The replacement of certain functions and organizations with non-human controlled Decentralized Autonomous Organizations (DAOs) or automated agents may face political challenges and raise concerns about accountability in public management [73].

Additional technologies like artificial intelligence may be necessary to facilitate automated decision-making and enhance the flexibility of blockchain systems. Public agencies involved in blockchain implementations should carefully evaluate and design decision-making processes, clearly defining the interfaces of formal and informal processes to prevent premature decisions from being added to the blockchain [16].

Conclusion

The Blockchain concept has become increasingly popular over the past few years, not only in the business world but also among potential investors and the public. The surge of interest has spurred significant research into the potential of blockchain to revolutionize the digital realm, specifically in the public sector (see [43], [12], and [36]. The previous research concluded that, when used correctly, pairing blockchain with digital systems has the potential to positively transform public services and enhance the trust of citizens while encouraging further political activity [9], [64]. However, beyond theoretical insights, empirical data is crucial to understanding how blockchain is used in the public sector and to identify associated benefits and challenges. Additionally, technological developments need to consider the privacy and confidentiality of data, ensuring the secure sharing of data between services and devices. To this end, designing a security model that combines digital assets within a blockchain could provide a trustless layer for protecting data, improving the security of data sharing [107]. At the same time, deploying blockchain technology requires adequate legal foundations, reliable infrastructure, public trust, and socio-economic conditions to be successfully implemented [86], [75], [56], [76]. Concretely, governments could benefit from pairing blockchain with modern information systems, such as AI, IoT, and blockchain technology, to provide innovative, faster, and more secure ways of accessing different types of data in public sectors. Furthermore, introducing a blockchain-based identity management system could also facilitate the delivery of public services, reduce the time and cost needed, and increase the efficiency of operations. Research is also needed in this field to provide insight into

the governmental adoption of such technology, exploring the implications of such adoption, and the preliminary application of models such as the technology acceptance model and adoption models for studying cryptocurrencies. Ultimately, the successful integration of blockchain into the public sector calls for broad and profound research that explores ttechnology from various perspectives and its various contexts of use.

Blockchain's unique advantages, such as digital trust, immutability, and decentralization of data, have enabled it to enable governments to securely store & transfer data, enable secure, efficient, and transparent voting, enable citizens to own and control their data securely, enable improved coordination and accuracy with respect to service delivery, and create secure pipelines for the valuation and taxation of assets [5]. AI technologies such as machine learning & natural language processing can be used to enable governments to better predict market trends, manage their data, and realize cost savings in terms of human resources, by replacing manual labor with automated and data-driven processes [60], [45].

This paper seeks to summarize the current and potential applications of blockchain technology in the public sector, emerging trends and challenges, and the research done and proposed for their implementation by focusing on law and economic aspects related to the use of blockchain in the public sector. We hope to review the impact of blockchain on the public sector and offer potential recommendations for future research in this field.

So far, research has shown that the use of blockchain in the public sector has the potential to offer significant advantages to government operations that can help improve efficiency, reduce costs, and streamline processes. Also, blockchain has the ability to revolutionize the public sector by allowing more secure, transparent, and accountable systems. By researching the use of blockchain in the public sector, government officials can better understand its potential and how it can be leveraged to benefit their operations.

A growing belief is prevailing that blockchain creates an ecosystem that provides new economic opportunities in the public and private sectors alike [96]. The introduction of this new technology within the public sector improves

existing processes and creates innovative new services [62]. However, previous practices indicate that, so far, rationales for blockchain adoption in the public sector were primarily oriented toward reducing bureaucracy and the costs of administrative processes. By leveraging blockchain technology, governments can streamline transactions, eliminate intermediaries, and improve efficiency in record-keeping and financial management.

An economic perspective always captures the concept of efficiency, which takes into account the trade-off between the benefits and costs associated with implementing and managing blockchain networks in comparison to more centralized arrangements. While blockchain technology manages information in a decentralized manner, it often incurs higher costs compared to centralized architectures. Therefore, despite the desirable functions of blockchain networks, such as security, transparency, and immutability, the application of the blockchain framework within some public sector settings may still be considered less economically efficient [18].

In addition, the lack of standards and trusted hosting infrastructure poses obstacles to achieving interoperability, scalability, and security of blockchain networks. Gaps in essential functionality, such as smart contract capabilities, also hinder the full potential of blockchain in government services, inhibiting blockchain from unleashing the full economic benefits of its application in the public sector. Conversely, this leads to mistrust in the positive effects of technology and underscores the legal aspects of the blockchain application within complex public sector systems. The adoption of blockchain technology in public services brings about significant technological developments and changes. As such, the governance of public service should encompass the governance of blockchain as well [16].

Despite its potential benefits, blockchain governance remains a controversial aspect for public sector organizations. A systematic analysis tool is necessary to address governance challenges and ensure the effective design, operation, and maintenance of blockchain-based systems. As a technology that aims to build trust in governance processes without the involvement of a trusted third party, it is crucial to determine what to govern (or not to govern) and how to govern when adopting blockchain in the public sector [102].

To successfully implement blockchain technology in the public sector, several measures must be taken. Firstly, there is a lack of awareness and education about technology among policymakers, businesses, and the public, which poses a significant challenge. It is crucial to educate stakeholders about the technology's benefits, limitations, and potential use cases to build trust and understanding. Secondly, the regulatory framework for blockchain technology is still in its infancy, causing uncertainty in its further application within the public sector. Clear and consistent regulations are needed to ensure citizens' rights are protected, promote innovation, and encourage investment. Additionally, the technical infrastructure required for blockchain technology, such as high-speed internet and advanced computing power, may not be available to all parts of the public sector. Therefore, investment in infrastructure is necessary to support the technology's deployment. Moreover, adequate training and guidance for employers are required to ensure the technology is used effectively. This technology, like many others, is dependent on the human factor, and accurate and well-managed information is essential to provide satisfactory results.

The research was limited to exploring the use of blockchain technology in the public sector, specifically focusing on legal and economic aspects of their deployment and adoption. Furthermore, this research does not address the technological and organizational barriers to successful blockchain deployment or the potential socio-economic implications of their integration into public sector contexts. Despite mentioned examples, there is still a lack of empirical evidence to understand the actual benefits or drawbacks of blockchain technology in the public sector, as well as an absence of any publicly verifiable case studies or success stories. Additionally, more research is needed on integrating these technologies into existing public sector structures and developing a secure and reliable ecosystem for citizens' data ownership.

Overall, research has shown that the use of blockchain technology in the public sector offers numerous benefits ranging from improving data security to speeding up processes. Furthermore, the exploration of legal and economic aspects related to their use and adoption could

allow for their successful and secure deployment in the public sector. By researching the use of blockchain technology, governments can better understand the potential benefits and challenges so that they can be used to their full advantage. Ultimately, such research could help unlock the massive potential of blockchain and other emerging technologies within the public sector to revolutionize the digital realm and provide trust, transparency, and efficiency.

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