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Challenges of Blockchain Technology Adoption for e-Government: A Systematic Literature Review

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ABSTRACT

The ability of blockchain technology to record transactions on distributed ledgers offers new opportunities for governments to improve transparency, prevent fraud, and establish trust in the public sector. However, blockchain adoption and use in the context of e-Government is rather unexplored in academic literature. In this paper, we systematically review relevant research to understand the current research topics, challenges and future directions regarding blockchain adoption for e-Government. The results show that the adoption of blockchain-based applications in e-Government is still very limited and there is a lack of empirical evidence. The main challenges faced in blockchain adoption are predominantly presented as technological aspects such as security, scalability and flexibility. From an organizational point of view, the issues of acceptability and the need of new governance models are presented as the main barriers to adoption. Moreover, the lack of legal and regulatory support is identified as the main environmental barrier of adoption. Based on the challenges presented in the literature, we propose future research questions that need to be addressed to inform how the public sector should approach the blockchain technology adoption.

CCS CONCEPTS

• Applied computing ~ E-government • Computer systems organization ~ Peer-to-peer architectures • Information systems ~ Distributed database transactions

KEYWORDS

Blockchain; adoption, government, public service, literature review

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1 THE PROMISE OF BLOCKCHAIN FOR GOVERNMENT

Innovations and transformations across many aspects of the public sector can be driven by the use of new technologies by governments. The use of information technologies (IT) to improve the public sector is often captured by the label of e-Government [14]. The initial focus of e-Government to provide and maintain a technological environment in government has evolved into transforming the business model and organization, and is expanded to also cover the transformation of the relationships between government and citizens, businesses and other non-state actors [22]. Hence, the adoption of new technologies to improve public services delivery has become more critical for government organizations.

Blockchain technologies, which are (amongst others) at the core of cryptocurrencies such as Bitcoin, are presented as a major breakthrough with great potential in public sectors [6]. Blockchain has the potential to make government operations more efficient by improving the delivery of public services and increasing trust in public sectors [25]. Also, blockchain applications can be transformative, as it can change the way in which transactions are recorded [36]. Basically, blockchain is a distributed ledger that is shared among participating parties in a network, used to record transactions that are verified by a consensus mechanism that creates trust in the network [38]. The majority of the participants in the network have to agree to approve the transaction. Once a record is verified and stored, it will be very difficult to manipulate data on the blockchain, as changes are immediately reflected in all copies of the ledger across the network and they are linked with the previous transaction [33]. In this way, the distributed ledger provides an almost immutable record and ensures the traceability of transactions.

Governments around the world are starting the explore the potential benefits and concerns of integrating blockchain-based applications into the public-private sector [12]. It is believed that blockchain has great potential benefits for the government such as data integrity, data quality, transparency, avoidance of fraud and manipulation, reducing corruption, and enhancing trust,

security, and privacy [36]. These potential benefits attracted the attention of governments in many countries to improve transparency and to eliminate corruption [21]. Several countries such as the USA, the United Kingdom, the Netherlands, the United Arab Emirates, Estonia, Sweden and China announced blockchain initiatives to actively explore its uses in the public sector [46]. Some of the potential benefits such as trust and transparency can be especially beneficial for developing countries since they are more vulnerable to corruption, fraud, and lack of trust than developed countries [16]. However, most of the current research related to blockchain is focusing on its application for cryptocurrencies, such as Bitcoin, and only a limited number of research is targeted at exploring the utilization of blockchain in other environments [52]. The importance of interdisciplinary research in the potential use of blockchain technology for government was suggested by Ølnes et al. [36]. They argue for more research into the possibilities of using blockchain technologies in the public sector to improve public services and to solve some of current public sector governance problems such as inefficiency, fraud and corruption.

In this article, we analyze the state of the art in blockchain adoption in the public sector by performing a systematic study of peer-reviewed scientific literature. With this literature review, we provide an overview of the current research topics and challenges in blockchain adoption in the public sector that serves as insight for both practitioners and researchers in order to suggest areas for further research.

The structure of this article is as follows: section 2 lays the theoretical foundations concerning blockchain technology for government by exploring the potential benefits of blockchain for the government as well as presenting its implications. In section 3 we present our research methodology for the literature review, followed by section 4 in which we present the challenges for blockchain adoption based on the literature review. In section 5 we translate these challenges into future research topics. We finalize with a discussion of the practical implications and limitations of our literature review in section 6.

2 BLOCKCHAIN FOR GOVERNMENT

Blockchain was first proposed in 2008 by Satoshi Nakamoto [33]. Generally, blockchain is a combination of a set of existing technologies such as distributed ledgers, cryptography, hashing and consensus protocols. All transaction records in blockchain are stored in a chain of data packages (blocks) and distributed across a peer-to-peer network [38]. All involved nodes in the network hold a copy of the blocks. Each block consists of a unique block header, which cryptographically commits to the contents of the block, a timestamp, the previous block header and the transaction details (transactions can be records, contracts, cryptocurrencies or other information) [39].

Every transaction or digital event in the public ledger has to be validated using a specific consensus mechanism. The consensus mechanism consists of a set of rules and procedures that allow to maintain and update the ledger and to guarantee the trustworthiness of the records in the ledger [39]. Consensus varies across different blockchain technologies, every consensus mechanism brings advantages and disadvantages based on different characteristics, e.g. the speed of transactions, energy efficiency, scalability, and censorship and tamperresistancy [44]. If a transaction is agreed upon by the majority of those participating nodes in the network by a specific consensus mechanism, a timestamp is applied, the transaction is recorded in a new block and linked to the previous chain of blocks with a hash pointer as a link to the previous block [3, 11]. In this way, blockchain provides a secure, decentralized, persistent, fault-tolerant and auditable transaction platform which allows for a transaction to take place in a decentralized fashion without the need of a central intermediary [8].

In general, blockchain has the following key characteristics [53]:

- *Decentralization.* Unlike a traditional transaction which is validated through a central trusted agency, every node in the network can validate transactions and has an identical copy of the ledger [26]. This mechanism causes transactions in a blockchain to have advantages in fault tolerance, data consistency, higher user control, attack resistance, transparency and it also enables the removal of third-party intermediaries, such as a notary or financial institutions;
- *Persistency.* The use of a consensus mechanism, a time-stamp, and a cryptographic seal means that invalid transactions will not be admitted and it becomes impossible to edit, delete or copy transactions that are already recorded in the blockchain [38]. These blockchain features provide for data consistency, fraud protection, ownership assurance and immutable records of the transactions;
- *Anonymity.* Interactions based on blockchain technologies take place between two individuals using public-key cryptography, by which their identities are covered by pseudonyms [26]. In this way, user privacy will be better protected than in classic electronic transactions;
- *Auditability.* All transactions in a blockchain are stored in chronological order, including the previous block's hash and storage of the hash of the current transaction which is meant to connect the next block when added. With this mechanism, transactions can be easily verified and tracked.

These key characteristics of blockchain technology provide some potential benefits to be utilized in the public sector to improve public services. Some of the benefits such as the distributed architecture, the immutability and transparency may be useful to eradicate fraud and corruption in the public sector [8, 20, 26]. With the use of the technology, every transaction in public services can be recorded without manipulation and enables better transparency and subsequently can improve trust in public services.

If the promised benefits of blockchain technology could be proved, it is possible that the technology reaches an inflection point and start gaining widespread acceptance by governments around the world in the near future. However, Ølnes et al. [36] point out that those potential benefits have not been proven by empirical evidence as of yet. Consequently, further

interdisciplinary research in broader aspects of blockchain such as governance models, design variables, impact and risks are needed [36]. Therefore, we used a literature review to map the challenges of blockchain adoption in the domain of government. In the next section we present the method that we followed for finding the literature.

3 METHOD

Given the importance of the potential use of blockchain in the public sector, we carried out a systematic literature review to identify current research and potential use of blockchain technologies in e-Government applications. To achieve this aim, we formulated the following research question: *What is the current state of the art in research and which are the main challenges faced in adopting blockchain technologies in the domain of e-Government?*

In this work, the guidelines for a systematic literature review provided by Kitchenham and Charters [24] are followed. We used the following search terms, derived from the major terms in our main research question:
(blockchain OR "block chain" OR "distributed ledger") AND (government OR "public service" OR "public sector")

We used three electronic database resources to find research articles: Scopus, ScienceDirect, and SpringerLink. Title, abstract and keywords were used to search published journals papers, conference proceedings, workshops, and symposiums. The literature search resulted in 354 articles up to 30 December 2017 (see Figure 1).

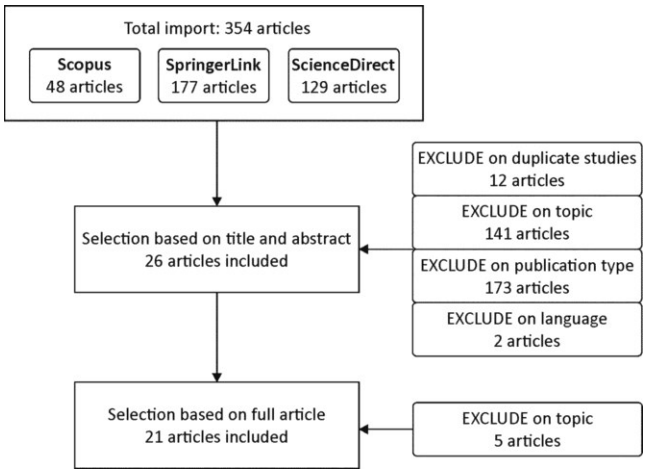

Figure 1: Search and study selection

A number of additional criteria were determined to select appropriate studies for inclusion in the review. To be included in the review, articles should: (a) be published in a peer-reviewed journal or conference proceedings, (b) present research about the use of blockchain technology in e-Government, (c) be presented in English, (d) be accessible in full-text, (e) not duplicate with articles from other databases.

After filtering, the article set was narrowed down to 26 articles. All 26 eligible publications were manually read to check the relevance for our literature review. An evaluation based on the full-text reading reduced the number of articles to 21 articles. The search and selection processes of this review are illustrated in Figure 1.

Furthermore, we synthesized the data by looking at the year of publication, type of publication, application domain, research process stage and challenges mentioned in the selected articles. We use the categorization of the systems development research process by Nunamaker et al. [34] to classify the research process stages. The research process consists of: conceptual framework, system architecture, system analysis and design, system (prototype) development and system evaluation. The full list of the selected articles is presented in Table 1.

In order to categorize the challenges, we adopted the technology - organization - environment (TOE) framework from Tornatzky et al. [45]. This framework has been extensively used by researchers to study information technology adoption. In this framework, three contexts are used to identify technological innovation adoption decisions, which are the technological, organizational and environmental contexts. The technological context describes the technological characteristics that are relevant to the adopting organization such as its availability. The organizational context refers to the organizational characteristics and resources of the organization such as the organizational readiness, managerial structure, and size that are relevant to the adoption of a technology. In the environmental context, the environmental characteristics in which the organization conducts its services such as the structure of the industry, the technology support infrastructure, and the regulatory environment are analyzed. By using these three contexts, we identified and categorized the adoption challenges presented in our literature review.

In the next section we present a description of the selected articles and analyze them to find the challenges they present for blockchain adoption in government.

4 RESULTS

In this section, we present the results of our literature review. We start by presenting a descriptive overview of the selected articles. Subsequently, we present the challenges found in the selected articles.

4.1 Overview of selected articles

Some pioneering works were published in efforts to explore blockchain adoption for e-Government systems and services. There were 21 scientific articles published proposing blockchain integration within e-Government, in which 15 articles were published in conference proceedings and only 6 articles appeared in scientific journals. Furthermore, of these 21 articles 3 of them were published in 2016 and 18 articles appeared in 2017. This suggests that efforts to utilize blockchain technology in the public sector have only just begun. This comes not as a surprise

as noted by Ølnes [35], who shows that the potential use of blockchain in the public sector has not been widely realized and reported upon so far.

When looking into the application domain, most of the research (7 articles) discuss the application of blockchain for e-Government in general, discuss the idea, potential benefits, current issues, potential use, approach and evaluation of blockchain adoption [20, 25, 27, 29, 35–37]. Blockchain applications in public healthcare received the highest attention, with four articles looking into the possible use of blockchain to

Table 1: List of Selected Articles

Authors	Ref. No.	Title	Publication type	Research Process Stage
Ahram et al. (2017)	[1]	Blockchain technology innovations	Conference Paper	Concept
Angraal et. al (2017)	[2]	Blockchain Technology: Applications in Health Care	Journal Article	Concept
Biswas and Muthukkumarasamy (2017)	[5]	Securing smart cities using blockchain technology	Conference Paper	System architecture
Bore et al. (2017)	[7]	Towards Blockchain-enabled School Information Hub	Conference Paper	Prototype
Düdder and Ross (2017)	[13]	Timber tracking: Reducing complexity of due diligence by using blockchain technology	Conference Paper	Concept
Engelenburg et.al. (2017)	[15]	Design of a software architecture supporting business-to-government information sharing to improve public safety and security: Combining business rules, Events and blockchain technology	Journal Article	System architecture
Hou (2017)	[19]	The application of blockchain technology in E-Government in China	Conference Paper	Evaluation
Konashevych (2017)	[25]	The concept of the blockchain-based governing: Current issues and general vision	Conference Paper	Concept
Lander and Cooper (2017)	[27]	Promoting public deliberation in low trust environments: Australian use cases	Conference Paper	Concept
Liu (2017)	[28]	Medical Record System Using Blockchain, Big Data and Tokenization	Conference Paper	Concept
Maria-Lluïsa and Marsal-Llacuna (2017)	[30]	Future living framework: Is blockchain the next enabling network?	Journal Article	Concept
Margheri et al. (2017)	[29]	A Distributed Infrastructure for Democratic Cloud Federations	Conference Paper	Development
Moura and Gomes (2017)	[32]	Blockchain Voting and Its Effects on Election Transparency and Voter Confidence	Conference Paper	Concept
Ølnes (2016)	[35]	Beyond Bitcoin enabling smart government using blockchain technology	Conference Paper	Concept
Ølnes and Jansen (2017)	[37]	Blockchain technology as s support infrastructure in e-Government	Conference Paper	Concept
Ølnes et al. (2017)	[36]	Blockchain in government: Benefits and implications of distributed ledger technology for information sharing	Journal Article	Concept
Raju et al. (2017)	[40]	The Case for a Data Bank: An Institution to Govern Healthcare and Education	Conference Paper	System architecture
Sharples and Domingue (2016)	[41]	The Blockchain and Kudos: A Distributed System for Educational Record, Reputation and Reward	Conference Paper	Concept
Sullivan and Burger (2017)	[42]	E-residency and blockchain	Journal Article	Evaluation
Sun et.al. (2016)	[43]	Blockchain-based sharing services: What blockchain technology can contribute to smart cities	Journal Article	Concept
Wijaya et.al. (2017)	[50]	A new blockchain-based value-added tax system	Conference Paper	Design

improve patient medical records integrity [1, 2, 28, 40]. Meanwhile, three articles examined the use of blockchain in educational services to overcome the lack of data integration and integrity in the public education sector [7, 40, 41]. Moreover, blockchain adoption is proposed in the context of smart cities in 3 articles [4, 17, 30], two articles look into in the context of government to business supply chains [13, 15], and single articles are dedicated to digital identity [42], e-voting [32], and the tax system [50]. The state of the art in literature shows that the utilization of blockchain in the e-Government domain is still very limited. It is likely that not all typical applications to record transactional data such as ownership, important information and document records such as land and vehicle registry, certificates (birth, marriage, education), (business) licenses and others, as suggested by Ølnes et al. [36], have been explored. This descriptive overview indicates that applications based on blockchain technologies have not yet materialized in full in the public sector. The majority of the publications aims at conceptualization and does not link to actual implementations or evaluations in the empirical context. We therefore carried out another analysis of the literature by looking into the research process stages that are represented by the literature. This yields an extra indicator for the state of the art in the academic literature on blockchain adoption in the public sector.

In accordance with the categorization of the systems development research process by Nunamaker et al. [34], we identified 11 articles that are focused on providing conceptual frameworks of blockchain utilization in e-Government applications. Some of the articles discuss current issues, the potential benefits, the importance and general vision of adopting blockchain technology to improve public services delivery [20, 25, 27, 29, 35–37], and e-voting [12]. Furthermore, Sun et al. [43] analyzed the influence of blockchain technology on the smart city development while Maria-Lluïsa and Marsal-Llacuna [30] show how blockchain networks could disrupt the urban context. In the public education field, Sharples and Domingue [41] suggest an idea to exploit blockchain for a permanent distributed record of intellectual effort and associated reputational reward. In the field of public healthcare, Ahram et al. [1], Angraal et al. [2] and Liu [28] propose the integration of blockchain into the system of medical records. Moreover, Düdder and Ross [13] initiated the use of a digital tracking method based on blockchain technology to track timber products in a due diligence process for government to business supply chains.

In the system architecture development stage, three articles propose an architecture for security in smart cities [5], a citizen-centric data bank for public healthcare and education [40], and business-to-government information sharing in supply-chain processes [15].

Meanwhile, only a single article was found in the system analysis and design stage. Wijaya et al., [50] elaborate on a method to identify taxpayers, to transfer tax credits between taxpayers, and to create tax invoices through blockchain technology. Similarly, in the system (prototype) development stage, in one article a prototype for collecting and managing immutable school records for the Kenya school system was presented [7]. Furthermore, two articles evaluated the current implementation of blockchain-based applications for digital identity in Estonia [42] and e-Government in China [20].

Based on this overview we see that the majority of articles presented a conceptual framework. In contrast, only a few articles presented empirical evidence. Hence, blockchain adoption in the public sector seems to represent a more theoretical view than a practical approach or empirical evidence. Our analysis shows that the academic research in this field is still very nascent. It will take time to realize the benefits and strengths of the blockchain technology in the public sector before more empirical evidence can be analysed, evaluated and presented. In the next section we present a more in-depth analysis of the literature to discover the challenges for the empirical applications of blockchain based applications in the e-Government domain.

4.2 Challenges

In spite of the abundant potential benefits and application areas of blockchain technologies in government, the literature also presents various challenges that need to be addressed. In this section we identify the challenges faced in adopting blockchain technology for e-Government systems as presented in the selected articles. The challenges are categorized based on the TOE framework from Tornatzky et al. [45] as listed in Table 2 and visualized in Figure 2.

Challenges related to technological aspects clearly dominate the findings from the articles. Security, scalability and flexibility are identified as the main technological challenges. Interestingly, security as the main strength of blockchain technology [38] is still questioned by some scholars. Security challenges in the selected articles refer to cybersecurity issues and threats [1, 2, 32], blind trust on the part of blockchain developers, lawmakers, law enforcement and the general public, and the trade-off between security and performance [20]. Some scholars recommend that the benefits of blockchain adoption into public services must be identified carefully and should be higher than the cost of developing and running the system [2, 20, 30]. Some challenges that are highlighted in the selected articles are typical in blockchain technology, such as scalability, usability, interoperability, computational efficiency and storage size [52]. Ølnes et al. argue that design variables need to be determined carefully for e-Government systems in accordance with the needs and requirements of government organizations [36]. Moreover, Hou [20] argues that a general application platform for blockchain-based applications will provide rapid application development and can accelerate the adoption of blockchain in government services [20]. In general, the immaturity of the technology itself is at the base of all existing technological challenges in adopting blockchain. This can be understood as something that is common in all new technology introductions. Nevertheless, the research development to overcome these challenges is quite promising. For instance, regarding the scalability issues, several studies have resulted in breakthroughs

to improve scalability issues by providing techniques in consensus protocols that significantly reduce transaction time and computer power requirements [18, 31, 49].

The need for new governance models and issues of acceptability are identified as the most important challenges from an organizational point of view. As the blockchain platform requires the cooperation of multiple institutions and stakeholders, a new governance model is required [20, 25, 35–37]. In turn, this challenge might bring the need to transform the organization in order to reach benefits from the distributed nature and the need for making design choices for applications based on blockchain technology [1, 36]. Organizational transformation often leads to unfavorable reactions within the organization and as such become a new challenge in adopting the new technology. The acceptability challenge can also come from users who will use the application. This is mainly due to trust in the technology itself since the blockchain technology is relatively new and its reliability has not convincingly been proven yet [35–37, 41, 42]. In their research, Engelenburg et al. [15] translated laws and regulations to business rules. These business rules are then used in decision making systems. If the business rules are too complex, contradictions might arise during the reasoning process and pose a risk of error in the decision making process. The other challenges that need to be considered are the implications [30, 36], trust [36], and auditing of blockchain applications [36]. Overall, organizational readiness [37] plays an important role in blockchain adoption within the organizational context. In general, Heintze and Bretschneider [19] pointed out that technology adoption is aimed to transform the organization so that the organization can improve its level of performance or effectiveness.

Within the environmental context, laws and regulatory support were found as the most important factors. Laws and regulatory support are essential to ensure that a user has legal certainty as to the law to determine the rights and obligations of the parties to the agreement and which courts will handle any disputes [51]. Support infrastructure, including both technical and non-technical elements, may stimulate the development and

Table 2: Challenges of blockchain adoption

Aspects	Challenges	Authors
Technological	Security	Ahram et al. [1]; Angraal et al. [2]; Hou [20]; Margheri et al. [29]; Moura and Gomes [32]
	Scalability	Angraal et al. [2]; Biswas and Muthukkumarasamy [4]; Düdder and Ross [13]; Lander and Cooper [27]; Margheri et al. [29]; Sullivan and Burger [42]
	Usability	Düdder and Ross [13]; Ølnes [35]; Ølnes and Jansen [37];
	Interoperability/Compatibility	Biswas and Muthukkumarasamy [4]; Maria-Lluïsa and Marsal-Llacuna [30]
	Reliability	Hou [20]; Lander and Cooper [27]; Sharples and Domingue [41]
	Flexibility	Liu [28]; Wijaya et.al. [50]; Ølnes [35]; Ølnes et al. [36]
	Cost effectiveness	Angraal et al. [2]; Hou [20]; Maria-Lluïsa and Marsal-Llacuna [30]
	Computation efficiency	Düdder and Ross [13]
	General application platform	Hou [20]
	Storage size	Liu [28]
	Immaturity	Hou [20]; Ølnes et al. [36]
	Design variables	Ølnes et al. [36]
Organisational	Organisational readiness	Ølnes and Jansen [37]
	Acceptability	Ølnes [35]; Ølnes and Jansen [37]; Sharples and Domingue [41]; Sullivan and Burger [42]
	Business model/ Organizational transformation	Ahram et.al. [1]; Ølnes et al. [36]
	Risk of error for complex business rules	Engelenburg et.al. [15]
	New governance model	Hou [20]; Konashevych [25]; Ølnes [35]; Ølnes et al. (2017); Ølnes et al. (2017)
	Implications	Maria-Lluïsa and Marsal-Llacuna (2017); Ølnes et al. [36]
	Trust	Ølnes et al. [36]
	Auditing	Ølnes et al. [36]
Environmental	Laws and regulations support	Ahram et.al. [1]; Moura and Gomes [32]; Sullivan and Burger [42]
	Support infrastructure	Düdder and Ross [13]; Ølnes [35]
	Accessibility (the matter of the digital divide)	Lander and Cooper [27]

diffusion of new blockchain-based applications in the public sector [37].

Finally, the accessibility factor highlighted by Lander and Cooper [27] is related to the digital divide. According to UN e-Government Survey 2016 report by United Nation [48], digital access disparity between developed and developing countries was still very substantial. This disparity is based on the lack of internet infrastructure, lack of culturally-relevant content, levels of education and skills needed to use the technology and language barriers [47].

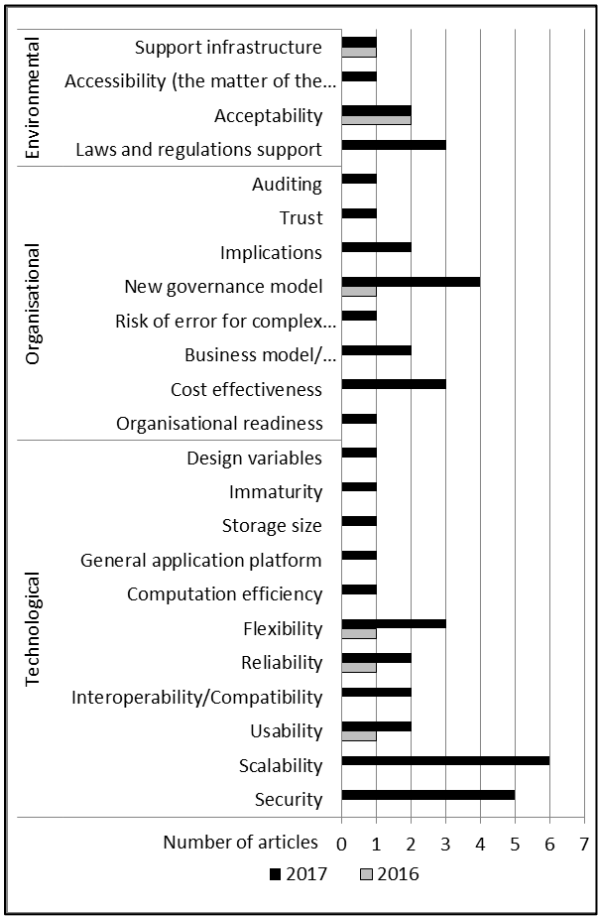

Figure 2: Challenges in adoption by year of publication

Additionally, we also mapped the challenges identified by the year of publication as shown in Figure 2. Only a few challenges were identified in 2016, and these were mainly in the technological and environmental context. In 2017, a significant growth in identified challenges is seen, mainly in the technological aspects. This corresponds to the growth of selected articles from three articles published in 2016 towards 18 articles published in 2017. Based on our analysis of the challenges as identified in the literature, we now identify the knowledge gaps to formulate future research topics in the next section.

5 FUTURE RESEARCH

Despite the immense publicity given to the potential use of blockchain technologies in many areas, research into the adoption of blockchain technology for e-Government still faces numerous challenges that need to be addressed. This provides vast opportunities for researchers to contribute and to explore potential research in this area.

The limited number of academic articles (21), with the majority of the articles (18) published in 2017 confirms that there is still limited interest in adopting blockchain in the public sector domain. This is also in accordance with the lack of empirical evidence presented by the researchers, causing many doubts regarding the benefits and capabilities of blockchain-based applications to improve public services. Therefore, more empirical research is needed to explore the (dis)advantages to inform governments on the adoption of blockchain technology in the public sector.

Given the limited issues presented by the selected articles, there are several unexplored issues in many aspects as identified in section 4. In addition, Charters et al. [10] suggested researchers to give more attention to issues that are fascinating practitioners. Accordingly, we recommend focusing on topics related to how organizations approach blockchain development and issues that could bring added value to practitioners.

This review confirmed that technological challenges are still the major issues such as security, scalability, interoperability and flexibility. However, it is still unclear at what level such technology issues need to be improved. Consequently, we need to develop blockchain technology standards in which the design variables are carefully determined in accordance with the needs and requirements of government organizations.

Additionally, there are many hypes around blockchain. Given the usability, cost-effectiveness and reliability issues, there is no clear guidance available to assess whether blockchain is the proper solution for specific application in e-Government systems. Therefore, an approach for assessing the suitability of blockchain technology as a solution is needed. This approach should be based on the specific properties of blockchain based applications and a clear understanding of the public processes in which they can be applied. This will lead to the formulation of design principles for blockchain applications that take the technological, organizational and contextual characteristics of these processes into account.

Moreover, the absence of a general application platform, in which security, scalability, interoperability, reliability and flexibility of blockchain technology for e-Government applications are addressed, raises the need for a proper design solution at the architecture level in accordance with the specific requirements from e-Government processes. Additionally, government organizations need guidance to solve their difficulties to unlock the value of blockchain technology. Hence we state the need to develop a reference architecture to provide architectural guidance for practitioners in the e-Government domain.

Furthermore, blockchain adoption might lead to organizational transformation, including changes in strategy, structure, process, and culture. This transformation requires organizational members' cooperation and commitment in order to enable the organization to improve the level of performance or effectiveness. A systemic approach towards the socio-technical implications of the adoption of blockchain-based applications within a governmental organization is required.

As blockchain technologies become more widely used, a proper legal framework within which blockchain can be utilized should be prepared. However, changes in legal frameworks and governance arrangements require careful considerations, especially in a changing environment with many uncertainties. This requires processes in which multiple actors need to be involved to find a balance between regulatory approaches on the one hand and the opportunities that the innovative blockchain technology offers for improving public services on the other hand.

Finally, a shared infrastructure, as suggested by [13, 37], needs to be established in order to provide for an ecosystem to support the development of blockchain based e-Government applications. Blockchain will likely evolve towards a general-purpose technology that can be used in many situations. A shared infrastructure that is secure and scalable and can be used by many organizations will ease control and maintenance and reduce costs. Yet, it is unclear how this should be established and governed.

6 CONCLUSION AND STUDY LIMITATIONS

In this article, we present the results of a systematic literature review into the current state of affairs in research and the challenges faced in the adoption of blockchain technologies in the domain of e-Government. Our findings show that academic research in this area has only just started and issues discussed in the selected literature are still very limited. Consequently, more intensive research in this area is still necessary to advance the maturity of this field of research. Particularly, empirical studies using rigorous research protocols should be enforced in government context to study the various potential benefits of blockchain adoption. Empirical studies will increase the reliability and clarify the validity and limitations of the advantages and potential benefits of blockchain technology. This is relevant for the government practice as well as academic research.

The contemporary literature shows that the main challenges in blockchain adoption are rooted in the technology aspects such as security, scalability and flexibility. Meanwhile, the need for new governance models and acceptability of this technology are the major challenges from the organizational perspective. Moreover, from the environmental aspect, laws and regulatory support present the biggest problem that needs to be addressed.

In order to resolve the technological challenges, we propose research into blockchain technology standards and a reference architecture for e-Government applications. Also, a systemic approach to study the transformational consequences with more emphasis on the organizational context in developing blockchain-based applications is needed. Moreover, an approach to find a balance between regulatory and legal frameworks and the applications of innovative blockchain technologies is needed. Finally, a shared, secure and scalable infrastructure to stimulate the development and diffusion of new blockchain-based technology is important to advance large-scale adoption.

The limitations of our literature review are linked to the choice of the search terms used, the journals included and the time period of the publication of the selected articles. Some important facts from publications that fall into the realm of grey literature might be missed since we did not include grey literature in our review. However, the articles discussed in this review provide an overview of the state of the art in academic research in blockchain technology adoption for the e-Government system. Annual repetition of the literature review will allow us to track and map the developments in this research area.

To conclude, the review in this study offers a useful starting point for future research themes for the development of blockchain-based e-Government systems for practitioners and researchers.

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