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A Hierarchical Framework of Challenges for Blockchain Adoption in Public Services

Implications for decision-makers

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Abstract. This study attempts to identify critical challenges for blockchain adoption in government, particularly public-service delivery in India, a developing country context. Through an extensive literature review and focus-group discussions with policymakers and blockchain experts, we have identified 12 adoption challenges for Blockchain in public service delivery. We then collected data and analysed using interpretive structural modeling and Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) Analysis to develop a hierarchical framework of the challenges. Our findings indicate that governments must first ensure legislative support for blockchain-based transactions. This

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research contributes to information systems strategic planning literature and provides a framework for policymakers to craft a strategic approach to facilitate blockchain adoption.

Key words: Blockchain, interpretive structural modeling, hierarchical framework, public service delivery.

1 Introduction

Blockchain, the technology underpinning Bitcoin (Nakamoto, 2008), can transform organizations, governments, markets, and society (Hughes et al., 2019; Rossi et al., 2019). Gartner's (2019) report shows that the business value added by Blockchain is expected to grow to more than US$176 billion by 2025 and US$3.1 trillion by 2030. Companies around the globe, such as IBM and ConsenSys, are building solutions using Blockchain for banking and insurance, supply chain management, shipping, digital identity, education diploma verification, notarization, and others. By leveraging cryptography and distributed ledgers, it offers unique capabilities such as data immutability, security, and reliability. It can alter the fundamentals of organizational operations by providing a trustless ecosystem with no intermediaries (Iansiti & Lakhani, 2017). It enables the use of smart contracts for the execution of contracts on the fulfilment of certain conditions without human intermediaries (Rossi et al., 2019). These characteristics lead to the development of immutable and tamper-proof blockchain applications, resulting in higher trust and increased efficiency (Spahiu et al., 2022). For governments, such applications can help solve citizens' trust and privacy issues. In addition, Blockchain helps reduce transaction costs and improves the efficiency of government processes (Scholz & Stein, 2018).

Researchers (Verma & Sheel, 2022 Ølnes et al., 2017) argue that blockchain applications offer multiple benefits to public service delivery. Despite well-understood benefits, it is interesting to note that governments have slowly adopted blockchain technology. Even though it has been more than a decade since the bitcoin (and consequently blockchain technology) came into being, rarely has any government deployed Blockchain at an enterprise scale. The only exception has been Estonia (a relatively small country with 1.33 million population), where most of the government services (99%), including voting and digital courts, are offered online using Blockchain (E-Estonia, 2020). The efficiency and cost savings shown by blockchain implementation in Estonia are phenomenal. For example, a report published by the Estonian government indicates that X-Road (a distributed data exchange platform) by over 1000 organizations and enterprises saves about 844 years of working time yearly (E-Estonia, 2020). In the background of such phenomenal savings and process improvements in Estonia, it is pertinent to explore why other governments have been slow to adopt blockchain technology.

An exciting dichotomy emerges when we consider blockchain applications vis-a-vis other standard Information Technology (IT) applications, such as enterprise resource planning (ERP) and supply chain management (SCM) in government processes. First, while traditional IT systems call for centralized control, centralized storage, and password-based central access, blockchain-based applications work on distributed and decentralized models. Second, while the governance frameworks (responsibilities and decision rights) for traditional IT systems are well-defined, they are still evolving for blockchain-based systems (Ziolkowski et al., 2020). Third, while Blockchain uses sophisticated cryptographic techniques, traditional IT does not (Iansiti & Lakhani, 2017). Finally, while traditional IT systems are closed and subsumed within the organization, blockchain systems tend to be open and advocate for active collaboration with the organization's external environment, such as legislations, standards, and new organizational processes (Gregory & Savic, 2019). As a result, the adoption challenges of blockchain systems are quite different from those of traditional IT systems in government processes. Overall, there is a need to address the multiple challenges associated with blockchain adoption in government processes (public services), specifically in the technical, social, and regulatory domains (Janssen et al., 2020; Toufaily et al., 2021; Upadhyay, 2020). At a technical level, blockchain technology takes multiple forms (public/private/hybrid/consortium). It involves primarily two critical design choices (permissioned/permission-less) that determine the benefits offered by blockchain technology (Janssen et al., 2020). In the context of public service delivery, permissioned Blockchain is the appropriate mode of technology (Toufaily et al., 2021).

At the societal level, Blockchain promises to profoundly impact how citizens interact with the government as it removes all intermediation and physical touch points. From the regulatory perspective, there is a need to create a legal framework to support smart contract-based transactions on blockchains that are sine qua non for resolving possible ownership disputes and enabling transaction reversal for blockchain transactions (Toufaily et al., 2021; Ziolkowski et al., 2020).

In response to this need, this study attempts to understand the challenges in implementing Blockchain in a government setting in India, a developing country, using the technological, organizational, and environmental (TOE) framework (Tornatzky & Fleischer, 1990). We want to understand these challenges and their interactions with each other to make blockchain implementation in governments smooth, efficient, and cost-effective.

We propose the following two research questions:

> *What are the critical challenges of blockchain adoption in government, especially in the public service delivery context?*

> *Are these challenges interrelated? If yes, how can we develop a hierarchical framework of blockchain adoption challenges, leading to smooth, efficient, and cost-effective adoption in public service delivery?*

This study responds to two objectives while contributing to the body of knowledge on information systems strategic planning. First, how adopting new information systems (blockchain-based applications) will help achieve organizational objectives such as reducing transaction costs and increasing transparency (Dubey et al., 2022). Second, providing a hierarchical framework to policymakers so that they can develop a strategy to overcome these challenges for greater blockchain adoption in government and public service delivery (Janssen et al., 2020; Toufaily et al., 2021).

The paper is structured as follows. Section 2 presents the literature on the Blockchain, including a definition of Blockchain, its use in governments, and a brief description of the TOE framework. We have introduced the research methodology in section 3. Further, Analysis and results are presented in section 4, and section 5 presents a discussion and implications of the findings. Finally, section 6 offers the conclusion and limitations and provides directions for future research.

2 Literature review

The literature on the Blockchain has grown considerably in the past decade. When we explore the definition of Blockchain in the extant literature, we find a number of them. Two of the prominent blockchain definitions are given below

> Blockchain can be described as a decentralized, transactional database technology that facilitates validated, tamper-resistant transactions that are consistent across a large number of network participants called nodes. (Beck et al., 2018)

> Blockchain as an open-source data set, distributed across millions of computers, utilizing avant-garde cryptography. (Clohessy & Acton, 2019)

We propose a generic definition of Blockchain that includes all key aspects of the blockchain technology:

> *Blockchain can be defined as a cryptographically secured, distributed ledger technology (DLT) that allows immutable transaction of an underlying asset between two possibly anonymous individuals without any centralized trust-creating or transaction-settling authority.*

To understand the types of blockchains, we have developed a blockchain classification matrix inductively by reviewing the extant literature (Beck et al., 2018; Karki, 2022; Upadhyay, 2020; Ziolkowski et al., 2020;), as presented in Table 1.

	Definition	*Advantages*	*Disadvantages*	*Use Cases*
Public	Non-restrictive and permissionless DLT.	Transparency Trust	Performance Scalability	Crypto-currencies Land records
Private	Restricted and permissioned DLT.	Performance Access control	Trust Anonymity	Digital identity Supply chain
Hybrid	Combine features of private and public DLT.	Performance Scalability	Transparency No incentives	Government Supply chain
Consortium	Semi-decentralized ledger technology managed by group of organizations.	Scalability Security	Transparency Security	Banks Insurance firms

Table 1. Blockchain types

From a governance perspective, blockchain technologies can be classified by the nature of access they offer or the level of control over block validation. The first refers to the question, who can read or write transactions on the Blockchain? The latter refers to the question, who is authorized to validate transactions?

2.1 Blockchain in government

The benefits provided by blockchain technology, such as fraud and manipulation avoidance, reduction of corruption, minimized third-party intervention, increased trust, transparency and auditability, data integrity and higher data quality, privacy, and reliability, make it attractive for use in government settings (Ølnes et al., 2017). For governments in developing countries, it is even more crucial as current e-governance solutions are siloed, standalone, and unable to communicate. As a result, despite using e-government services, public service delivery is sub-optimal as the services are not integrated and are inherently insecure and expensive. Owing to the broad applicability of Blockchain, the excitement around this technology is building, and the list of potential public-sector blockchain applications continues to grow (Hughes et al., 2019). Blockchain in government can enforce policies with the help of digital transformation processes that achieve goals faster by government departments in the secure ecosystem (Spahiu et al., 2022). Governments worldwide have expressed interest in implementing Blockchain due to its potential to lower transaction costs and build trust and transparency. In addition, blockchain technology can offer government solutions in information sharing where authentication is mandatory (Verma & Sheel, 2022). Blockchain's capabilities are particularly well-matched to meet the requirements of e-government services, especially in developing countries where governments are scaling up digital services. For services ranging from land record management and registry to issuance and validation of education and income certificates and driving licenses, Blockchain's characteristics—a decentralized distributed architecture, encryption, data immutability, and transparency—are appealing features for both governments and other stakeholders (Auffret, 2018). Recently, the Australian government announced funding of $6.9 million for two pilot blockchain projects$1.

In contrast, Dubai intends to become the world's first blockchain-powered government$2. According to the 2019 blockchain report by NASSCOM, India has rapidly adopted blockchain technologies, with total investments in blockchain projects reaching $20 billion across various industries. In India, the state governments of Tamil Nadu, Telangana, Kerala, Karnataka, and Maharashtra have begun to support blockchain start-ups and projects.

2.2 TOE framework

Prior research on IS suggests that the adoption and implementation of technology innovation are influenced by technological, organizational, and environmental factors (e.g., Poba-Nzaou & Raymond, 2011). The technological, organizational, and environmental (TOE) framework (Tornatzky & Fleischer, 1990) is one of the most extensively used frameworks for investigating the adoption of technology innovation (Venkatesh & Bala, 2012). Within TOE, the technological context portrays internal and external technologies pertinent to the firm and includes current and new technological innovation availability. Organizational context has characteristics such as firm size and the extent of resources available within the organization. Among other resources, slack resources refer to resources that are in excess when compared with an organization's current functioning needs. Environmental context is the field in which the firm operates, including the industry characteristics.

3 Research methodology

This study adopted a quantitative research method to develop a hierarchical model of Blockchain adoption challenges. We have explained our methodology in the following four sub-sections. In the first subsection, we describe the research context. We identified key challenges in blockchain adoption in the second sub-section. In the third sub-section, we provide an overview of Interpretive Structural Modeling (ISM)-Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) methods. Finally, in the fourth sub-section, we summarize the data collection process.

3.1 Blockchain adoption in public service delivery in India

In India, many state governments have shown interest in using blockchain technology for public service delivery. For example, Tamil Nadu has announced that it will roll out a state-wide blockchain network that will cover the state's entire population of 80 million residents at the cost of nearly US$ 6 million (Ashwin, 2019). This blockchain infrastructure will be shared amongst government agencies to create efficient public service delivery solutions. Each user will be allotted a blockchain-enabled digital wallet to store government-issued certificates such as income, residence, or community, school grade sheets (transcripts), college/vocational degree certificates, health insurance cards, and food security cards. It is envisaged that this infrastructure, operating as a technological backbone, will spawn a vibrant ecosystem for private players, especially start-ups, which will unlock value for citizens and the government. The Government of Telangana has started using Blockchain for land registration on a pilot basis (Variyar & Bansal, 2017). The Government of Karnataka has rolled out a program for using Blockchain for document attestation (Desai, 2018).

Notably, blockchain technology adds economic value in two ways: (i) it decreases the cost of verifying the state of a system, and (ii) it decreases the cost of networking (Catalini & Gans, 2016). In governments, the cost of networking is usually not a criterion for evaluating a blockchain solution's benefits. Instead, verification costs are a significant driver for adoption. Government agencies issue their citizens many documents, certificates, licenses, and registration certificates. Most government departments require the physical production of documents issued by other government departments as a necessary input for their services. Without a tamper-proof verification system, government agencies insist on producing the original document to verify the authenticity of the submitted copy. It is even more interesting to note that the issuing government organization first created the required document digitally. The verifying organization takes in a printed copy that is scanned and converted into a digital form as part of its process. This process creates several redundancies. Governments can significantly reduce verification costs by adopting blockchain-enabled e-verification (Catalini &Gans, 2016). Recently, Kumar et al. (2021) discussed delivering value using Blockchain while moving from physical food security to digital food security.

3.2 Key challenges in blockchain adoption

To identify challenges, we conducted an extensive literature review in databases such as Scopus, Web of Science, and Google Scholar with possible combinations of keywords such as "Blockchain + Factors + Implementation", "Challenges + Blockchain +Strategy", "Key + Inhibitors + Blockchain", "Blockchain + adoption", and "e-Government + Challenge + Strategy". In our search, 1,852 research papers, books, and reports were found. We further filtered the results using a three-step process:

1. Duplicate articles were removed, and books and reports were eliminated.
2. Title-based shortlisting.
3. Abstract-based shortlisting.

This study aimed to identify the challenges of blockchain adoption in government, particularly in public service delivery. We removed duplicate articles, books, book chapters, and reports in the first step. Next, we shortlisted articles based on the titles. Finally, we read all abstracts and retained articles relevant to blockchain adoption/implementation

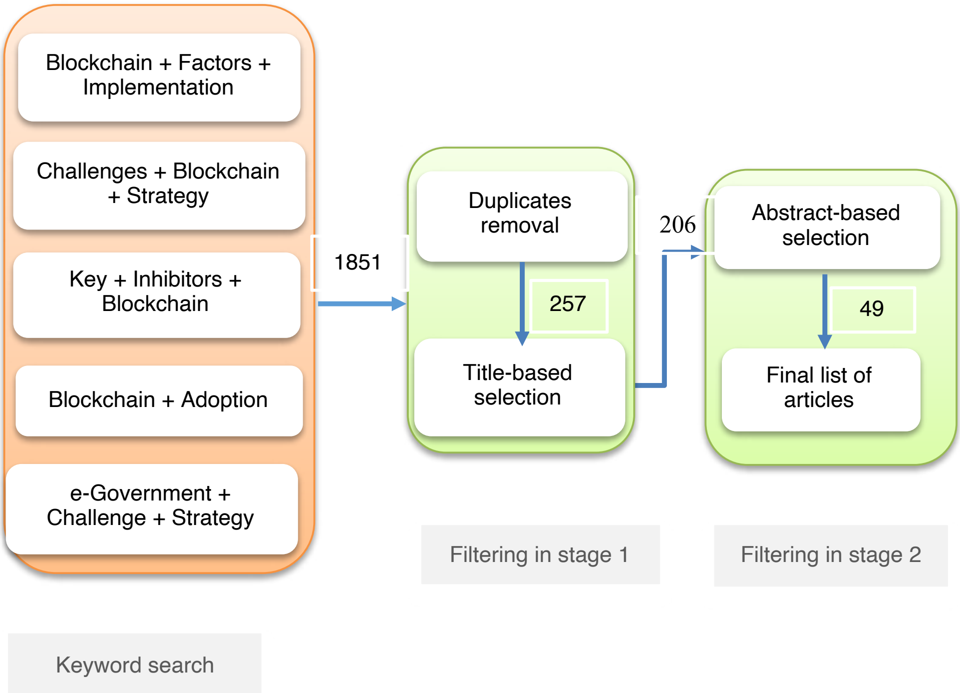

Figure 1. Literature selection process

challenges, blockchain strategy, blockchain governance, and e-government adoption challenges, which reduced the list to 49 articles. The literature selection process is given in Figure 1. We identified 15 key challenges through this process. In the next stage, we conducted a focus group discussion with seven stakeholders, including blockchain technical experts and policymakers with rich public service delivery experience.

We presented the identified blockchain adoption challenges to the focus group of experts. Due to the Covid-19 situation, we were constrained to do the focus group discussion via video call. In the first round of discussion, focus group participants were briefed about the methodology and were given a brief description of all 15 challenges we had identified and the reason for selecting them for inclusion in our list. In round two of the discussions, participants were divided and assigned to 2 breakout rooms for deliberations amongst themselves and proposed changes in the list as they deemed fit. Finally, in the third round, the research team, in the presence of all seven participants, consolidated the final list of 12 challenges based on the feedback from the breakout group discussions. All focus group members unanimously agreed with the final list of twelve challenges.

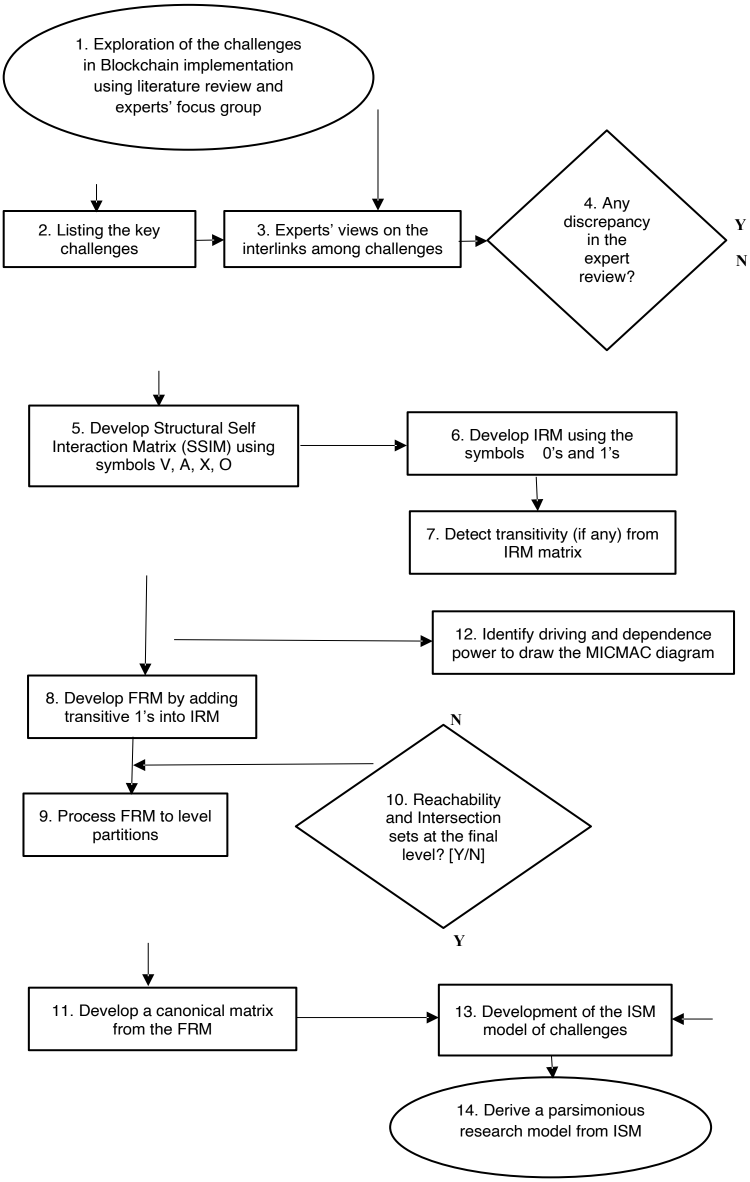

Figure 2. ISM flowchart (Adapted from Hughes et al., 2020)

Classification of challenges using TOE framework

We have classified all identified challenges using the TOE framework and summarized them in Table 2. In addition, a detailed description of the challenges is presented in Appendix A.

Technological challenges	*Organizational challenges*	*Environmental challenges*
Design issues Scalability Process change cost Low throughput rate Security	Resistance to change Capacity-building Technical skills	Enable legislative support Lack of awareness Legal issues Collaboration among government agencies.

Table 2. Key Challenges in Blockchain implementation in government services

3.3 ISM-MICMAC methods

ISM is a mathematically derived, methodical, and cooperative method that can simplify a complex problem by analyzing the interlinks between factors (Warfield, 1974). This method allows researchers to examine contextual relationships among factors identified through expert opinion and establish hierarchical levels of challenges (Mangla et al., 2018). MICMAC analysis complements ISM as it helps cluster identified challenges and provide decision-makers with deeper insights. In the literature, researchers (Janssen et al. 2018) have employed ISM-MICMAC analysis to address complex issues in various functional domains. For example, Ravi and Shankar (2005) analyzed the interrelationships among critical reverse logistics inhibitors to minimize inhibitors' impact on the automobile industry. In the recent past, Janssen et al. (2019) identified and analyzed challenges in adopting and implementing the internet of things (IoT) in the context of smart cities. Kamble, Gunasekaran, and Sharma (2020) also employed ISM to model the enablers of blockchain-supported traceability in the agriculture supply chain. Here, we use ISM to develop a model of the interdependencies between blockchain implementation challenges in public service delivery, underlining the impact they are likely to have on each other in the context of state governments in India. The ISM process requires experts to present a unanimous (majority) view regarding every pair of challenges through structured debate or independent brainstorming (Ravi & Shankar, 2005). There could be several factors that cause a problem or issue. If they are each explored individually, then the problems may be understood with far lesser accuracy than if the factors were considered to be directly or indirectly linked to each other (Jharkharia & Shankar, 2005). It is a conventional and extensively employed process in academic research due to its success in identifying interlinkages between similar factors and in representing areas of influence between them, which are then depicted in a final model (Janssen et al. 2018; Ravi & Shankar 2005; Rana et al., 2019).

We identified the key challenges facing blockchain implementation in public service delivery with the help of an extensive literature review and a focus group discussion, including key blockchain experts and policymakers. The flowchart of the steps involved in the ISM-MICMAC analysis is given in Figure 2.

SSIM

In ISM, we begin by compiling data received from respondents in the Structured Self-Interaction Matrix (SSIM). There are four possible ways of relating challenges of blockchain implementation in government, represented by 'V', 'A', 'X', and 'O' symbols (Hughes et al., 2020). We collect data from respondents using above mentioned symbols. The SSIM presented in Table 4 outlines the relationships between these factors in rows and columns indicated by 'i' and 'j', respectively (for both i and j = 1 to 13). The symbols are to be interpreted as:

V = Variable i influences variable j

A = Variable j influences variable i

X = Both variables i and j are influenced by each other

O = Variables i and j are not related to each other or are not influenced each other

The next step in the ISM process is the formulation of the Initial Reachability Matrix (IRM) and Final Reachability Matrix (FRM).

IRM and FRM

In the next step, the SSIM matrix is converted into an IRM and FRM. The symbols in the SSIM are converted into corresponding binary values using the following rules:

1. If (i, j) in SSIM is V, then (i, j) in IRM becomes 1, whereas (j, i) becomes 0.
2. If (i, j) in SSIM is A, then (i, j) in IRM becomes 0, whereas (j, i) becomes 1.
3. If (i, j) in SSIM is X, then both (i, j) and (j, i) in IRM become 1.

4. If (i, j) in SSIM is O, then both (i, j) and (j, i) in IRM become 0.

Table 5 presents the completed IRM, where the data in the SSIM are converted into binary digits using these four rules. The next step highlighting the extension of the IRM is FRM, where the transitive relations are checked if found to be represented by 1*. The transitive relations are described as:

If X is connected to Y (X→Y) and Y is connected to Z (Y→Z), then a transitive relationship exists between X and Z (X→Z). In this process, every zero across each row is investigated for transitivity using the following set-theoretical approach:

$\forall i\ \forall j\ \forall k$, if $\exists k$ such that $k \neq i$ and $k \neq j$ then

$(M[i, k]=1) \wedge (M[k, j]=1) \wedge (M[i, j]=0)$ then $M[i, j] = 1^*$

Next, we convert zeros in IRM to 1 based on the transitivity rule. If no such cases are observed, we consider IRM as FRM and continue with the next step in the analysis.

3.4 Data collection

The research team identified experts for the focus group by sending invites over emails about 200 senior executives of public/private organizations who have 10+ years of experience in planning IT adoption in their organizations and who are also involved in blockchain planning/implementation. We also reached out to scholars actively engaged

Designations	*Organization*	*Number*
IT secretaries of state governments	Public	01
CEOs of blockchain technology companies implementing government blockchain projects	Public	02
	Private	01
CTOs of blockchain technology companies implementing Government blockchain projects	Public	03
	Private	01
Principal architects, heads of blockchain units	Public	05
	Private	03
University professors and blockchain researchers	Public	03
	Private	02
Total		21

Table 3. Respondents' profiles

in blockchain research. We received voluntary consent to participate in this research from 21 respondents. Data were collected in the format given in Table 4, along with participants' demographic details (for summary see Table 3) through video calls.

In the following sub-section, we present the process by which we developed the ISM model. The first step to creating the ISM model is compiling all the responses in a Structured Self-Interaction Matrix (SSIM). The data summarized in Table 4 represents

E[i/j]		*13*	*12*	*11*	*10*	*9*	*8*	*7*	*6*	*5*	*4*	*3*	*2*
1	Resistance to change	A	A	A	V	A	A	A	A	A	X	X	A
2	Lack of awareness	A	X	A	V	X	A	A	A	X	V	V	
3	Process change cost	A	A	A	V	A	A	A	A	A	X		
4	Low throughput rate	A	A	A	V	A	A	A	A	A			
5	Design issues	A	X	A	V	X	A	A	A				
6	Capacity-building	X	V	X	V	V	A	X					
7	Technical skills	X	V	X	V	V	A						
8	Enabling legislative support	V	V	V	V	V							
9	Scalability	A	X	A	V								
10	Successful adoption of Blockchain in public service delivery	A	A	A									
11	Collaboration among agencies	X	V										
12	Security	A											
13	Legal issues												

Table 4. SSIM

the final decision (by the majority) of the respondents on a particular relationship between each pair of challenges. The empty cells represent duplicate pairs in Table 4.

4 Analysis and results

The next step in the ISM process is formulating the Initial Reachability Matrix (IRM) and Final Reachability Matrix (FRM) by converting V, A, X, and O into binary values as defined in sub-section 3.3.2. Next, the transitive relationship among challenges was checked, and found no inconsistency. Therefore, IRM/FRM are the same in this study and presented in table 5.

Element (i)/(j)	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1	1	0	1	1	0	0	0	0	0	1	0	0	0
2	1	1	1	1	1	0	0	0	1	1	0	1	0
3	1	0	1	1	0	0	0	0	0	1	0	0	0
4	1	0	1	1	0	0	0	0	0	1	0	0	0
5	1	1	1	1	1	0	0	0	1	1	0	1	0
6	1	1	1	1	1	1	1	0	1	1	1	1	1
7	1	1	1	1	1	1	1	0	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	0	0	0	1	1	0	1	0
10	0	0	0	0	0	0	0	0	0	1	0	0	0
11	1	1	1	1	1	1	1	0	1	1	1	1	1
12	1	1	1	1	1	0	0	0	1	1	0	1	0
13	1	1	1	1	1	1	1	0	1	1	1	1	1

Table 5. IRM/FRM

4.1 Partitioning of the FRM

The FRM is the same as the IRM. Therefore, this matrix is further used to assess each challenge's reachability and antecedent sets (Warfield, 1974). The reachability set R(Pi) includes the challenge and other challenges it may influence, whereas the antecedent set contains the challenge and other challenges that may influence it. Iteration I of the level partition compares the elements of the reachability set and the antecedent set for each challenge to find instances where both elements are the same. When found, these challenges are marked as 'I' under the 4th column in Table 6.

Element P(i)	*Reachability Set: R(Pi)*	*Antecedent Set: A(Pi)*	*Intersection: R(Pi) and A(Pi)*
1	1, 3, 4, 10	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13	1, 3, 4
2	1, 2, 3, 4, 5, 9, 10, 12	2, 5, 6, 7, 8, 9, 11, 12, 13	2, 5, 9, 12
3	1, 3, 4, 10	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13	1, 3, 4
4	1, 3, 4, 10	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13	1, 3, 4
5	1, 2, 3, 4, 5, 9, 10, 12	2, 5, 6, 7, 8, 9, 11, 12, 13	2, 5, 9, 12
6	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13	6, 7, 8, 11, 13	6, 7, 11, 13
7	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13	6, 7, 8, 11, 13	6, 7, 11, 13
8	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	8	8
9	1, 2, 3, 4, 5, 9, 10, 12	2, 5, 6, 7, 8, 9, 11, 12, 13	2, 5, 9, 12
10	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	10 (Level I)
11	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13	6, 7, 8, 11, 13	6, 7, 11, 13
12	1, 2, 3, 4, 5, 9, 10, 12	2, 5, 6, 7, 8, 9, 11, 12, 13	2, 5, 9, 12
13	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13	6, 7, 8, 11, 13	6, 7, 11, 13

Table 6. Level partition, iteration I

Using the above process, we found that the elements (i.e., 10) of the reachability set and the antecedent set are the same for challenge ten only. Hence, challenge ten is considered a variable at the highest level (i.e., Level I) in the ISM model. This process is repeated to identify the levels of other challenges. Once a challenge has been identified at a certain level of partitioning, its level and occurrence across other challenges are removed before repeating the same iteration process for the next level. A total of five iterations (due to paucity of space, not all matrices are provided here but are available upon request) were performed to determine the level of each challenge (Table 7).

Iteration	*Challenges*	*Reachability Set*	*Antecedent Set*	*Intersection Set*	*Level*
I	10	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	10	1
II	1, 3, 4	1, 3, 4	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13	1, 3, 4	2
III	2, 5, 9, 12	2, 5, 9, 12	2, 5, 6, 7, 8, 9, 11, 12, 13	2, 5, 9, 12	3
IV	6, 7, 11, 13		6, 7, 8, 11, 13	6, 7, 11, 13	4
V	8	8	8	8	5

Table 7. Iteration I-V for challenges of blockchain integration in government

4.2 Driving and dependence power and MICMAC diagrams

Next, we develop the canonical matrix (see Appendix B), a restructured version of the final reachability matrix (FRM); the challenges are grouped to align with the level partition stage, starting with Level 1 and ending with the last partition at Level 5. The level column in Table 7 lists the challenges in the order in which they are represented in the ISM model. Converting an FRM into a canonical matrix also helps filter the 0s and 1s into separate sections. This arrangement helps researchers trace the links between the challenges at the same level and across other levels while creating the ISM model. The extended form of the canonical matrix with the driving and dependence power values of each challenge is given in Appendix B. The driving power is the total of all 1s of a challenge across a given row, and dependence power is the total of all 1s for that challenge down a given column. These totals reveal the nature of the challenges; their dependence and driving power values are shown in the MICMAC diagram (Dwivedi

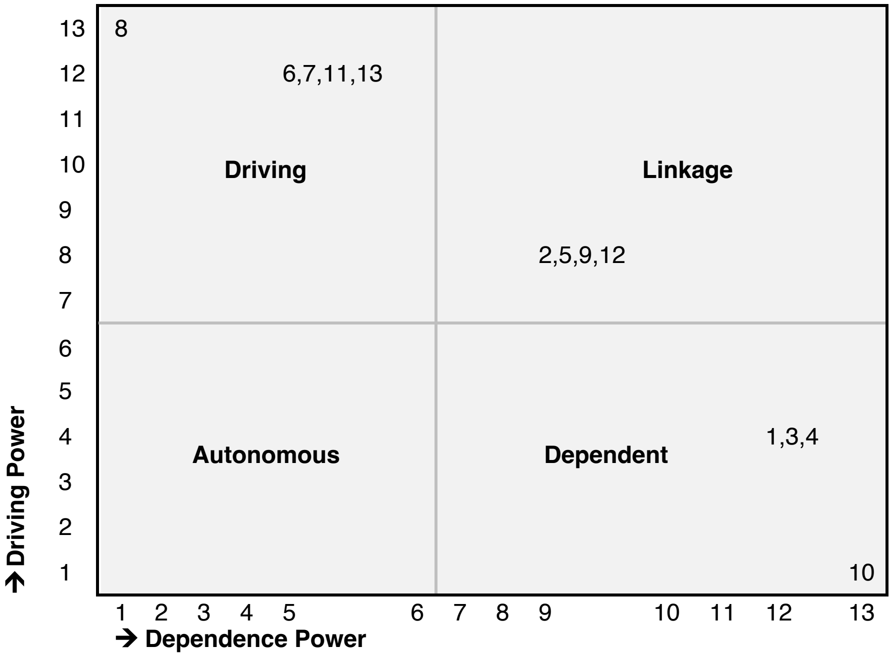

Figure 3. MICMAC diagram

et al., 2017). For example, the higher driving power of 12 or 13 challenges indicates that a challenge is driving in nature and would appear at the bottom of the ISM model.

In contrast, the lowest driving power of 1 indicates that the challenge is primarily dependent, which is justified by its high driving power. However, high dependence power, that is, 12 or 13, for a challenge indicates that it is a dependent challenge, which is significantly influenced by other challenges below it in the hierarchy of the ISM model. Therefore, it tends primarily to appear at the top of the ISM model.

The MICMAC analysis visually represents the challenges as per their dependence and driving power values along the *x*- and *y*-axis, respectively (Rana et al., 2019). This diagram highlights the drivers and dependents that influence blockchain implementation in the public sector in India. Figure 3 shows the challenges' positions in the MICMAC diagram's four quadrants. These four quadrants are classified as follows.

The *autonomous quadrant* includes challenges with weak driving and weak dependence power. Any challenge in this quadrant is a low-impact element, which means it is disconnected from the rest of the system. In this context, there are no challenges in this category.

1. The *dependence quadrant* identifies high dependence and low driving power challenges. There are four challenges, with numbers (1), (3), (4), and (10), in this category. These challenges are all positioned as dependent variables at the top of the ISM model.
2. The *linkage quadrant* identifies challenges with high dependence and driving power. Therefore, challenges in this category tend to be largely unstable. Any changes in these challenges will have a substantial impact on other challenges. These challenges, with numbers (2), (5), (9), and (12), fall between the bottom and top levels of the ISM model.
3. The *driving quadrant* identifies high driving and low dependence power challenges. These challenges are considered key factors in the ISM model and are largely positioned at the lowest level of the ISM model. These challenges, with numbers (8), (6), (7), (11), and (13), can be seen in the driving quadrant in Figure 3.

Figure 3 indicates that the challenges in the driving and dependence quadrants are divided into two clusters, whereas challenges in the linkage quadrant form a single cluster. The element with the highest dependence power (i.e., Challenge 10) in the dependence quadrant is positioned as a key-dependent challenge. In contrast, other challenges (i.e., 1, 3, and 4) in this quadrant are positioned at the level below. Likewise, the challenge with the highest driving power (i.e., Challenge 8) is positioned as a key driver. However, other clustered challenges (i.e., 6, 7, 11, and 13) in this quadrant are positioned at the level above. Due to high driving and dependence power, all challenges (i.e., 2, 5, 9, and 12) are clustered in the linkage quadrant and positioned in the middle.

4.3 ISM model

Developing the ISM model is the final step in the ISM process, as shown in Figure 4. The model spans five levels. The top level of the ISM model contains one challenge (i.e., successful blockchain implementation in government [10]), which was acknowledged using the Level I partition. This signifies that Challenge 10 has the highest dependence power. Below is Level II, which comprises three challenges, i.e., resistance to change (1), process change cost (3), and low throughput rate (4). These challenges have high dependence power (i.e., 12) and relatively low driving power (i.e., 4). This indicates that these challenges are largely dependence-oriented. Four challenges, including lack of awareness (2), design issues (5), scalability (9), and security (12), belong to Level III of the ISM model. All have relatively high driving power (i.e., 8) and high dependence

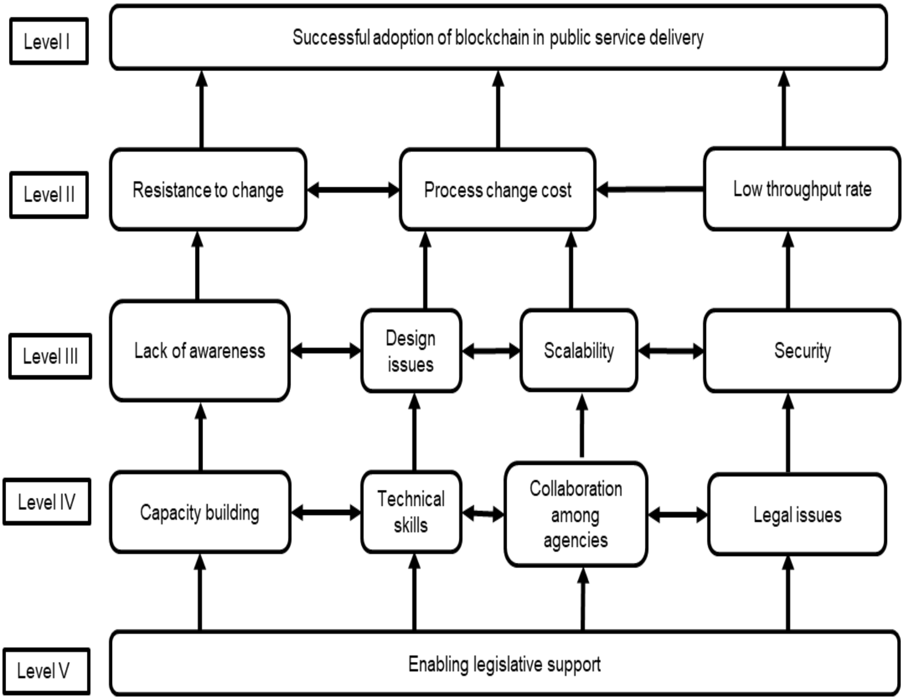

Figure 4. ISM model

power values (i.e., 9), which position them in the middle of the ISM model. Level IV contains four challenges, including capacity building (6), technical skills (7), collaboration among agencies (11), and legal issues (13). These challenges have relatively high driving power (i.e., 12) and low dependence power (i.e., 5). Finally, Level V contains only one challenge-enabling legislative support (8). This is the bottom-most element in the ISM model, with the highest driving power (i.e., 13) and the lowest dependence power (i.e., 1).

5 Discussion. Theoretical and practical implications

Recent scholarly work (Janssen et al., 2020; Toufaily et al., 2021) has proposed a comprehensive framework for the challenges in blockchain adoption based on various facets. In this work, we developed a framework for blockchain implementation challenges in governments. We have extended a simple framework to create a hierarchical framework that identifies the interrelations between challenges and presents them in multiple layers.

Before discussing the hierarchical relationship of the twelve challenges we have identified, it is essential to state that some may appear generic to any organization's technological interventions. However, in the blockchain context, they acquire a very different dimension and warrant a unique management response because of the complexity of the underlying technology. Unlike other technologies, Blockchain is complex and not well-understood technology (Hakak et al., 2020). One may argue that legal issues are a challenge for any new technology intervention. However, with other technological interventions, managing disputes and reversing transactions are simple tasks that can be accomplished with an administrative privilege password. In the case of a blockchain transaction, reversal is not possible and would require a sophisticated workaround that tags a new transaction along with the old one. Legal issues can also extend to ownership disputes (e.g., who owns a particular intellectual property right being traded on a blockchain) or change management disputes (Ziolkowiski et al., 2020). Compared to other technologies, there are no simple ways to respond to these challenges. Ziolkowski et al., (2020) have classified these decision problems into two categories: those that are similar challenges in other technologies (demand management, data management, system architecture design and development) and those that are blockchain-specific (membership, ownership disputes, transaction reversal). We developed table 8 inductively from the video call discussions with focus group participants and extended two categories proposed by Ziolkowski et al. (2020) to three categories (see Table 8), which are summarized below:

1. Category 1: Challenges that are similar to any other technological intervention.
2. Category 2: Challenges that are blockchain-specific.
3. Category 3: Challenges that are similar to other technological interventions but require a significantly more complex blockchain-centric response.

Category 1 (Challenges similar to other technologies)	*Category 2 (Blockchain-specific challenges)*	*Category 3 (Challenges similar to other technologies but requiring a blockchain-centric response)*
Process change cost Collaboration among government agencies	Low throughput rate Design issues Enabling legislative support Legal issues (ownership disputes, forking, governance change management)	Lack of awareness Capacity-building Technical skills Scalability Security Resistance to change

Table 8. Classification of blockchain challenges

For example, 'lack of awareness' in a blockchain context is a very different challenge from what it would be in another technology context. Here, it would require building public trust and educating the public, courts, and lawmakers about concepts like hashing, immutability, and widely witnessed events$3. A summary of such challenges and their implications for a blockchain context is given in Table 9.

The ISM model (figure 4) indicates a clear four-level hierarchy among the 12 identified key challenges. The foundation for blockchain adoption in public services rests on creating a legal framework that recognizes electronic transactions, digital identities, digital contracts, and the automated performance of contracts. These findings are corroborated by the experiences of countries such as Estonia and the United Arab Emirates (UAE) in implementing blockchain applications in governments. The government must amend existing laws to accommodate new ways of conducting transactions, authenticating users, and creating enforceable contracts. Let us examine each of these levels and their implications for governance.

5.1 Level 1 challenges

Legislative support is the first challenge that governments need to address before building any blockchain infrastructure or application. Blockchain-enabled transactions need legal backing and are recognized in court in disputes. This requires an enabling legislative environment. The Indian Contract Act 1872 and the IT Act 2000 have established an enabling foundation for blockchain implementation by formalizing electronic

S No	*Category 3: Challenges requiring a block-chain-centric response*	*Blockchain-specific dimensions that need to be addressed*
1	Lack of awareness	For the public, lawmakers, and judiciary—building public trust and educating people about concepts like hashing, immutability, and widely witnessed events
2	Capacity-building	For user organizations—concepts such as DLT, hashing, immutability, and widely witnessed events
3	Technical skills	Setting up a core technology team in user departments to handle technical issues; an error cannot just be erased or overwritten.
4	Scalability	Planning related to creating nodes and data distribution
5	Security	Decentralized nature; the autonomous nature of smart contracts
6	Resistance to change	A new level of transparency; doing away with any intermediation process; fraud prevention

Table 9. Blockchain-specific challenges and dimensions

contracts and e-signing. A few laws need to be amended to exploit the full potential of Blockchain. For example, the IT Act excludes land registration from its purview, which needs to be changed if blockchain-based land transactions are to be recognized. Another critical use case for Blockchain is digital asset transactions, which may require the amendment of the Negotiable Instruments Act 1881. For example, the governments of Estonia and UAE have taken the lead in blockchain implementation. Estonia has created a legal framework to support blockchain transactions. The UAE's Article 12 of Federal Law No. (1) of 2006 on Electronic Commerce and Transactions explicitly recognizes smart contracts and supports the automated performance of contracts.

5.2 Level 2 challenges

The level 2 challenges, *capacity-building, technical skills, collaboration, and legal issues* can only be tackled by addressing the Level 1 challenges. Successfully tackling Level 1 challenges would allow governments to handle Level 2 challenges. To illustrate this point further, we present the Level 2 challenges and understand how they relate to Level 1 challenges (legislative support, in this case).

Capacity-building and technical skills

These challenges refer to the lack of sufficient expertise in governments to deal with highly complex and mathematically advanced cryptographic technology such as Blockchain. Governments intending to use this technology must develop enough technical capacity to drive, guide, use, and interpret technical transactions and their outcomes. Governments not only need to have the executive (administrative) capacity to benefit from blockchain technology, but they also need to build the legislative and judicial capacity for it. This capacity-building exercise cannot happen in a vacuum. It needs to ride on the clear and demonstrated intent of the government to deploy and use blockchain infrastructure—i.e., the legislative support mentioned in Level 1. Capacity-building cannot occur without legal recognition of machine-driven smart contracts and mathematically complex hash functions. Departments and agencies that use paper or emails to exchange information would have to start dealing with automated zero-intervention transactions; instead of recording paper or electronic message trails, they would have to start accumulating chains of hashes. For this changeover to occur, an enabling legislative framework is a must. Training the government's administrative (executive) wing to use Blockchain for transactions would require a legislative framework that supports these transactions and enables administrators to modify their processes.

Collaboration among agencies and legal issues

To make a meaningful transaction on a blockchain—whether G2C (government to citizens), G2B (government to businesses), or G2G (government to government)—government departments and agencies need to interact and exchange information with one another. This interaction and exchange cannot happen unless the underlying enabling legal framework (Level 1 challenge) is in place. Departments and agencies need to share their internal processes and data structures with others to integrate them into the blockchain infrastructure meaningfully. Again, this collaboration cannot happen, and departmental siloes cannot be broken without legislative support from the government.

Legal issues refer to challenges arising from disputes about blockchain transactions. How do government agencies deal with such disputes? With paper-based systems, a paper trail is generated for every transaction. By tracing the decision trail, errors can be identified and corrected. However, in this new scenario, a separate standard operating procedure (SOP)-based resolution and auditing mechanism has to be established. This mechanism has to account for the technological complexities involved; for example, hashes are unique, but original messages cannot be recovered from a hash.

5.3 Level 3 challenges

The challenges at Level 3, *awareness, design issues, scalability, and security,* directly depend on the Level 2 challenges of capacity-building, technical skills, collaboration, and legal issues. Once these challenges are addressed, the challenges at Level 3 can be easily tackled. Let us examine these challenges in greater detail.

Lack of awareness

Creating awareness (Yasiukovich and Haddara, 2020) and public trust in the Blockchain is a prerequisite to its successful implementation. Awareness building is needed among the public, administrative machinery, judiciary, and legislature. This can only be achieved if the challenges in the previous layers have been successfully addressed; for example, there should be underlying legislative support for Blockchain and sufficient capacity within various arms of the government.

Design issues

The design challenge is closely linked to the capacity-building and technical skills challenges. If government agencies intending to use Blockchain have a clear idea of their needs, which they can translate to technical parameters, they can create a robust design for blockchain infrastructure. Key design parameters that need to be considered during the design phase of the blockchain infrastructure, among many others, are:

1. Nature of permission: Permissioned v/s permissionless architecture.
2. Blockchain technology: Hyperledger, Ethereum, Corda, Ripple, Stellar, or IOTA, and the right flavor of each.
3. Distributed ledger mechanism: what to distribute, and how much to distribute.
4. Data storage: On-chain v/s off-chain data .

Scalability

Scalability has been identified as one of the most difficult challenges associated with blockchain implementation (Zheng et al., 2018) and has much to do with how the system is designed. Key factors determining scalability include how much data are kept on- and off-chain, what consensus algorithm is used, and whether the network is permissioned or permissionless. While scalability appears to be a purely technical issue, it depends on multiple non-technical factors, such as the degree of collaboration, technical skills, and capacity within the government.

Security

Blockchains have some security challenges (Lin & Lio, 2017; Schlatt et al., 2022). Blockchains have been shown to have privacy issues depending on how they have been designed and implemented. For example, denial-of-service (DoS) attacks are possible on the Blockchain. Therefore, security and privacy challenges must be overcome to build a trusted blockchain solution for governments. Apart from robust technology, a secure blockchain solution depends significantly on legal backing and capacity-building efforts. Further, remedial actions in data loss need to be legally recognized. Blind trust in Blockchain may have profound implications (Hou, 2017).

5.4 Level 4 Challenges

This last set of challenges, *resistance to change, process change cost, and low throughput rate,* relates to processes. However, they are difficult to tackle unless all the challenges below this level have been addressed.

Resistance to change

This challenge is not new and is bound to come up every time there is an attempt at reformation or transformation within an organization (Ndou, 2004; Nurminen, 1997). Resistance stems directly from a lack of awareness among stakeholders. Design issues, scalability, and throughput rate will likely contribute to it. For example, blockchain infrastructure that is poorly designed and worse than the existing system could cause a quick erosion in public trust and resistance to the change. Those affected would include the public and street-level bureaucrats who interface directly with the public and are responsible for service delivery.

Process change cost

Financial costs have been identified as a critical challenge in implementing blockchain solutions, particularly in low-resource regions (Hou, 2017). The blockchain rollout must demonstrate that the government will save costs through improved efficiency, increased transparency, and enhanced trust. This challenge can be successfully overcome if the lower-level ones (design and scalability) have been effectively addressed. For example, CBDC can significantly reduce financial institutions' transaction costs (Financial Express, 2022).

Low throughput rate

A low throughput rate is one of the technical challenges in blockchain implementation (Bagaria et al., 2018; Kasireddy, 2017). This challenge is linked to design issues and scalability. Technological innovations minimize design issues and scalability challenges and improve the throughput rate of blockchain systems. Addressing concerns related to the throughput rate will help improve the efficiency of government systems.

5.5 Theoretical implications

This study makes four theoretical contributions. The first pertains to identifying and understanding the contextual challenges of blockchain adoption in public service delivery. Though there are studies on the technological aspects of the Blockchain (Behnke and Janssen 2020; Hakak et al. 2020), research on blockchain adoption challenges in the public services delivery context is scarce. To the best of our knowledge, this is the first study to collate knowledge from extant literature for identifying and contextualizing the blockchain adoption challenges in public service delivery in India. Second, this study attempts to classify the contextual blockchain adoption challenges using the TOE framework. From the theoretical perspective, this knowledge will help scholars develop new hypotheses toward a deeper understanding of blockchain adoption in public services. Third, this study adds a novel contribution to the extant literature by extending the blockchain challenges classification from two categories proposed by Ziolkowski et al. (2020) to three categories, namely category 1: challenges similar to other technologies, category 2: Blockchain-specific challenges, category 3: challenges similar to other technologies, but requiring a blockchain-centric response (see table 8). This new knowledge will extend the literature by comparing and contrasting blockchain adoption challenges with other IT systems. Finally, no existing literature classifies blockchain adoption challenges based on their nature, such as driving, autonomous, linkage, and dependent challenges. The fundamental theoretical contribution of this study is to identify interlinkages among the identified adoption challenges using interpretive structural modeling based on data collected from senior executives involved in the planning of blockchain adoption.

5.6 Practical implications

This study also provides some unique practical insights. First, this study offers the contextual meaning of generic blockchain challenges (such as lack of awareness and legal issues) to the public, administrative machinery, judiciary, and legislature. Second, it provides a quick visual reference for decision-makers to understand the interlinkages between blockchain adoption challenges and thus helps them prepare a risk mitigation strategy against adoption failure. The discussion presented in this study would help decision-makers build a priority list of challenges and an appropriate risk mitigation strategy. This knowledge would minimize decision-makers' cost, time, and effort in successfully adopting Blockchain in public service delivery. Third, this study classifies and groups various adoption challenges into four groups: driving, autonomous, linkage, and dependent. This knowledge would help public institutions build better public service delivery mechanisms using Blockchain and achieve greater citizen satisfaction. Finally, a deeper understanding of blockchain adoption challenges and their interlinkages will help the technical team develop economically viable and sustainable blockchain applications for public service delivery. This study provides valuable knowledge to the technical team in assisting them to create better blockchain-enabled applications and a ready strategy planning toolkit for decision-makers in government, helping them drive the successful adoption of blockchain applications in public services.

6 Conclusion, limitations, and future research avenues

In this study, we presented a framework of blockchain adoption challenges in public services in the Indian context. We began our research by identifying key challenges for blockchain implementation in public services with the help of a literature review and focus group discussion with experts. We employed ISM and developed a hierarchical framework of challenges to understand their interrelationships with decision-makers. In addition, we performed MICMAC analysis to cluster the challenges into groups to gain insights into how to overcome them. The proposed framework will help the decision-makers prioritize the blockchain adoption challenges from the mitigation strategy perspective.

This study has some limitations that future researchers can address. This study identified blockchain adoption challenges and developed a framework where we ranked challenges to provide deeper insights for decision-makers in the Indian context. Research transferability and generalizability are one of the shortcomings of this study. Researchers may extend this work using the single-context theory contextualization approach proposed by Hong et al. (2014). The single-context theory contextualization can be used in different countries by dropping/adding some context-specific challenges such as infrastructure-related challenges, lack of clarity about decision rights, risks related to cyber-attacks, lack of blockchain standards, and challenges associated with the integration of Blockchain with other emerging technologies. Second, researchers may use the identified challenges for future action design research (Baskerville et al., 2018; Sein et al., 2011). Action design research (design science and action research) reveals where IT artifacts are ensembled based on the organizational context and their use. The identified challenges would help create and evaluate ensemble IT artifacts (blockchain applications in government) using action design research. Third, researchers may use identified blockchain adoption challenges in clinical research (Schein et al., 2008) in the context of public services (Vassilakopoulou et al., 2022). Further, how fuzzy-set qualitative comparative analysis (fsQCA: Park et al., 2020) might be used to identify necessary and sufficient conditions for acquiring the required legislative support for blockchain-based transactions for successful blockchain adoption in the public sector? Finally, we have presented a theoretical framework of critical challenges faced in blockchain implementation in government in the Indian context. The challenges can also be explored in relation to emerging contexts such as impact of blockchain on climate change (Dwivedi et al., 2022a) and challenges of deploying blockchain for securing metaverse (Dwivedi et al., 2022b; 2022c). Finally, researchers may extend this work by proposing new hypotheses based on the developed framework and testing them empirically by collecting primary data from one country or across countries to generalize the findings.

Notes

1. https://www.coindesk.com/australia-to-spend-575m-on-tech-including-blockchain-to-boost-pandemic-recovery
2. https://www.forbes.com/sites/suparnadutt/2017/12/18/dubai-sets-sights-on-becoming-the-worlds-first-blockchain-powered-government/#716fc884454b
3. Widely witnessed events are fixed length alphanumeric strings or hashes that are published daily in newspapers or television or on the internet to indicate the digital signature of all events captured on the government blockchain till that day. This is essentially a trust-building exercise and allows the auditability of government-owned blockchains).

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Appendix A. Description of blockchain adoption challenges in public services

Key Challenges	*Description*
Design issues	Government use cases require different feature support from the blockchain architectural design (Lacity, 2018; Mackey et al., 2019; Ziolkowski et al., 2020). We classify blockchain use cases in government into three types by the nature of underlying assets: non-transferable digital assets, transferable digital assets, and tokenized assets. Apart from these, there are use cases where certain privileges (e.g., write privilege) on the network would need to be permissioned and certain privileges (e.g., read privilege) would need to be permissionless (Hakak et al., 2020; Ziolkowski et al., 2020). Different types of blockchain technologies would optimally suit each of such use cases. Reconciling these varied needs and developing a standard design across the government would be a significant challenge and, if not carefully handled, could lead to an interoperability deadlock (Hakak et al., 2020; Morabito, 2017)
Scalability	Scalability is another blockchain adoption challenge (Biswas and Gupta, 2019; Beck et al., 2018). The bigger the scale, the larger the TPS demand (transactions per second), and this could choke the Blockchain with a transaction jam. Typically, a permissionless blockchain working on a PoW (proof of work) protocol has a lower throughput rate (transaction processing rate), whereas permissioned networks have much higher TPS (Chong et al., 2019; Kohad et al., 2020; Kouhizadeh et al., 2021).
Process change cost	Many existing government business processes and rules would need to change to accommodate the "blockchain way of transacting" (Allen et al., 2020; EY, 2019; Swanson, 2016). This would require the modification of existing systems and may result in a high cost for the government.

Low through-put rate	The fundamental block formation-based architecture of blockchains imposes limits on the throughput rate (Kasireddy, 2017; Zhou et al., 2020). This presents a challenge if the throughput rate desired by government use cases exceeds what the architecture permits (Bagaria et al., 2018; Li, 2019; Zhou et al., 2020)
Security	Blockchain, like other technologies, has vulnerabilities that malicious agents could exploit as data and information may be exposed to security risks (Lin & Liao, 2017; Schlatt et al., 2022; Wharton, 2018;). Since Blockchain is supposed to be a trusted, tamper-proof system, its vulnerabilities, if not patched carefully, would significantly erode public trust in it. There have been reports of hacking into blockchain systems and causing loss to individuals (Biswas & Gupta, 2019; Wharton, 2018)
Resistance to change	Resistance to change is a cause for concern more in public organizations than in private ones (Joshi, 1991). Whenever a new technology is implemented in government, officials show resistance initially (Marakas & Hornik, 1996; Nurminen, 1997 Ndou, 2004). Resistance will be low if it is an incremental change in the technology. However, with disruptive technologies like Blockchain, greater employee resistance is expected (Hughes et al., 2019; Janssen et al., 2020). One possible reason for resistance in governments is resistance to learning new technologies (Kouhizadeh et al., 2021).
Capacity building	Scholars (Edmiston, 2003; Ndou, 2004; Wamukoya & Mutula, 2005) argued that there is a strong need for capacity-building in the three branches of government (executive, legislature, and judiciary). They would need to either enforce contracts, adjudicate disputes, or provide enabling legislative support for blockchain-backed transactions and smart contracts (ACT-IAC, 2017). They need to be trained and made to acquire a sufficient appreciation and fundamental understanding of blockchain technology. Government capacity-building is always a challenge for every new technology (Ndou, 2004; Stewart, 2015), but it is a bigger blockchain challenge due to the high complexity of technology.

Technical skills	Technical skills such as programming skills, encryption skills, legal skills for smart contracts, architectural design skills, user experience design skills, and infrastructure development skills are required to support Blockchain in government settings (Angelis & da Silva, 2019; Hughes et al., 2019; IoT, 2017). In addition, there is a lack of skilled programmers who can continuously maintain data and software related to Blockchain and a lack of skilled resources with adequate managerial capabilities.
Enabling legislative support	Blockchain presents a new way of transacting without intermediaries (Werbach, 2018; Yeoh, 2017; Zachariadis et al., 2019). This is often in contravention with extant legal mechanisms that recognize the role of intermediaries and prescribe certain ways of conducting transactions—for example, central banks mandate that a regulated bank has to be an intermediary for payment settlements (Tiwari & Rautray, 2020; Warkentin & Orgeron, 2020). There is a need to align existing laws with the Blockchain transacting. Rules and regulations will also play a key role in the blockchain future.
Lack of awareness	Lack of awareness about new technologies is common (Ahmad et al., 2013; Jaeger & Thompson, 2003; Jaruwachirathanakul & Fink, 2005). However, in the case of Blockchain, lack of awareness of Blockchain among all four key stakeholders of government—namely, the executive, legislature, judiciary, and citizens—is a serious concern (Bahga & Madisetti, 2016; Yasiukovich & Haddara 2020)
Legal issues	Another critical challenge the government might face while implementing Blockchain is legal issues, as Blockchain will directly impact organizations' governance (Fulmer, 2019; Hughes et al., 2019). In India, state-specific regulations are likely to become a critical challenge.
Collab-oration among govern-ment agencies	To make blockchain system work effectively, government departments need to share information and collaborate with each other (Fridgen et al., 2018; Lacity, 2018; Mendling et al., 2018). This could be a challenge for departments that work in silos independently. Even if they do share information, there could be issues of compatibility, granularity, technology stack, and data structure (Behnke & Janssen, 2020).

Appendix B. Canonical Matrix

Elements	*10*	*1*	*3*	*4*	*2*	*5*	*9*	*12*	*6*	*7*	*11*	*13*	*8*	*Driving Power*	*Level*
10	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
1	1	1	1	1	0	0	0	0	0	0	0	0	0	4	2
3	1	1	1	1	0	0	0	0	0	0	0	0	0	4	2
4	1	1	1	1	0	0	0	0	0	0	0	0	0	4	2
2	1	1	1	1	1	1	1	1	0	0	0	0	0	8	3
5	1	1	1	1	1	1	1	1	0	0	0	0	0	8	3
9	1	1	1	1	1	1	1	1	0	0	0	0	0	8	3
12	1	1	1	1	1	1	1	1	0	0	0	0	0	8	3
6	1	1	1	1	1	1	1	1	1	1	1	1	0	12	4
7	1	1	1	1	1	1	1	1	1	1	1	1	0	12	4
11	1	1	1	1	1	1	1	1	1	1	1	1	0	12	4
13	1	1	1	1	1	1	1	1	1	1	1	1	0	12	4
8	1	1	1	1	1	1	1	1	1	1	1	1	1	13	5
Dependence Power	13	12	12	12	9	9	9	9	5	5	5	5	1	**Total = 106**	