Generation of public value through the adoption of government blockchain networks: The analysis of the Brazilian federal government

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Abstract. This paper analyses the generation of public value through the adoption of government blockchain networks by different entities of the Brazilian federal government. To this end, the theory of Public Value in Electronic Government is used, with the approach proposed by Twizeyimana & Andersson (2019) with six dimensions of analysis. The method is a multiple case study with the three Brazilian blockchain networks: RBB, RNDS and PIER, which are at different stages of development. The results indicate the governance is a common challenge identified, and exchanging information with other networks is seen as a way of learning and developing the own models. Indeed, the already implemented government blockchain networks (RNDS and PIER) generate public value in the six dimensions and that the RBB has the potential to generate public value in the same dimensions. Furthermore, the choice of blockchain technology was an efficient solution for PIER and RNDS when compared to other technologies available at the time. The RBB was created to be an infrastructure for the development of other blockchain artifacts, to later house applications using the same technology. Governance challenges and balance between participants are crucial aspects in the development of networks. While RBB, a top-down initiative (governance development prior to applications) seeks a stable balance, the hierarchical deployment of PIER and RNDS allows for faster progress of deployment and development of applications on these networks. The paper has limitations in analysing public value from the perspective of public managers and not from co-creation with citizens. As future research, we suggest approaching the cases from the perspective of innovation theories and an investigation of the blockchain ecosystem in government in Brazil.

Keywords. government blockchain network, public-value, e-government, case study.
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1. Introduction

The 2008 financial crisis, among other things, sparked a global sense of distrust (De Filippi et al., 2020). In the same year blockchain technology was introduced to the world with the launch of Bitcoin, and it was quickly identified that beyond its use in digital currencies, the technology had potential applications in electronic documents, such as identities, smart contracts, and property titles (Ølnes, Ubacht & Janssen, 2017).

Bitcoin and other blockchain-based systems were presented as a reliable alternative to existing financial institutions and even governments (De Filippi et al., 2020). In other words, the technology emerged as a mechanism for generating trust between people, regardless of any institution. Studies show the potential for use in governments, with the possibility of gains in efficiency, effectiveness, increased transparency, greater public participation, higher data reliability, among others (Ølnes, Ubacht & Janssen, 2017; Khan, Arshad & Khan, 2020; Allessie et al., 2019; Aristidou & Marcou, 2019).

Governments worldwide have shown interest in the technology, especially for expected improvements in transparency, governance, and resource distribution (Batubara, Ubacht & Janssen, 2018). Beyond the applications and artifacts developed in blockchain, some countries have started to develop their own governmental networks, aiming to be platforms for blockchain applications.

Examples of these networks are the multi-country Alastria (mostly European states) and Lacchain (Latin America), BSN - Blockchain-based Service Network (China), and in Brazil, RBB (Brazil Blockchain Network), PIER (Regulatory Entities Information Integration Platform), and RNDS (National Health Data Network). In Academia there are studies on the characteristics of blockchain and potential applications in government, case studies, artifact design, and governance discussions (Christidis & Devetsikiotis, 2016; Ølnes, Ubacht & Janssen, 2017; Zheng et al., 2017; Batubara, Ubacht & Janssen, 2018; Allessie et al., 2019; Scholl & Rodríguez-Bolívar, 2019; Alketbi, Nasir & Abu Talib, 2020).

However, specific studies on governmental blockchain networks are still limited, demonstrating that research on this topic still does not cover the reality of seeking to implement the technology in governments. Additionally, papers on blockchain in government lack theories that help explain the phenomena, representing a significant gap in the Electronic Government literature (Atzori, 2018; Covarrubias & Covarrubias, 2021; Falwadiya & Dhingra, 2022).

In this context, the aim of this paper is to identify the public values generated through the adoption of governmental blockchain networks at the federal level in Brazil. With a positivist approach, this paper presents a multiple case study of the three federal governmental networks in Brazil that utilize blockchain technology: RBB, PIER, and RNDS. More specifically, the phenomenon under study is the blockchain networks of federal public administration entities in Brazil for their own and/or third-party applications, whether governmental entities or not.

The paper employs the theory of Public Value in Electronic Government utilizing the framework proposed by Twizeyimana & Andersson (2019), which suggests six dimensions associated with public value generation: Improved Public Services, Improved Administrative Efficiency, Open Government Capabilities, Improved Ethical Behaviour and Professionalism, Improved Trust and Confidence in Government, and Improved Social Value and Well-Being. Interviews were conducted with nineteen participants who worked on the implementation of the cited networks, and consultations were made to documents and institutional websites.

The results indicate that blockchain governmental networks can generate public value even before their full implementation, as by bringing stakeholders together in the process, value generation can already be identified in the dimension of improvement in administrative efficiency, with greater collaboration, cooperation, and improved communication among entities. Other dimensions such as the improvement of public services, enhanced ethical behaviour and professionalism, increased trust in government, and better social value and well-being were also identified in the implemented networks PIER and RNDS.

The paper is divided into six sections. This first section introduces the topic, presenting the main concepts. In the next section, the Literature Review is presented, highlighting the main research gaps. Section 3 presents the Method, detailing the multiple case study. Next, Section 4 presents the description of each one of the cases. Section 5 shows the results analysis. The last Section presents the Conclusion, including final considerations, limitations, and suggestions for future research.

2. Literature Review

2.1 Public Value and Electronic Government

Just as New Public Management (NPM) supplanted traditional public administration in the 1980s and 1990s, the concept of public value emerged as the response that many scholars sought for a new approach to government management, incorporating the necessary aspects for its practical and theoretical implementation as a replacement for NPM (Bryson, Crosby & Bloomberg, 2014). Public Value, as a public administration paradigm, was originated in educational disciplines at Harvard University, later gaining new interpretations with Mark Moore in the mid-1990s. Moore emphasized that public managers should make decisions while simultaneously acting collaboratively to generate outcomes that create value for the public (Hilgers & Ihl, 2010; Williams & Shearer, 2011; Cordella & Bonina, 2012).

Public value, in the context of public administration, can be understood as a counterpoint or alternative to NPM (Van Veenstra, 2012; Stoker, 2006). In NPM, the citizen is merely seen as a client; however, in the Public Value paradigm, individual preferences are considered essential for constructing the public interest, rather than being reduced to mere consumer preferences (Alford & O'Flynn, 2009).

To create public value, individuals must be able to express their preferences and needs, enabling the government

to leverage technology to enhance its capacity to deliver what citizens need and desire. In this process services are provided, and public value is created (Lopes, Luciano & Macadar, 2018). For the real perception of public value requires its creation first, which can be attained through the benefits derived from adopting a given service (Alshibly & Chiong, 2015). On the other hand, another perspective suggests that public value creation can be based on collective benefits rather than necessarily being of personal perspective (Alford & O'Flynn, 2009).

From a perspective in which public value creation is government-driven rather than necessarily co-created with citizens, Twizeyimana & Andersson (2019) conducted a literature review proposing six dimensions associated with public value and e-government: improved public services; greater administrative efficiency; Open Government (OG) capabilities; enhanced ethical behaviour and professionalism; increased trust in government; and improved social value and well-being. These dimensions can be categorized into three broader public value dimensions: enhanced public services, improved administration, and increased social value.

Regarding research on public value and e-government, Twizeyimana & Andersson (2019) identified a lack of studies on the value of e-government in developing countries, highlighting the need for further research at different levels of government. Additionally, Lopes, Luciano & Macadar (2018) assert that the topic of public value remains underexplored in Brazilian research and government services.

2.2 Blockchain and Government Networks

Regulatory and legal issues related to the principles of public administration must be respected to ensure the validation and proper use of blockchain technology by the public sector. Beyond digital currency applications, smart contracts enable government operations to benefit from increased transparency, trust, efficiency, reduced corruption, cost reduction, fraud prevention, decreased manipulation, and enhanced resilience and security (Ølnes, Ubacht & Janssen, 2017).

Blockchain is a distributed public ledger in which all transactions are stored in blocks, with new blocks continuously added. Security is based on asymmetric cryptography and distributed consensus algorithms, typically characterized by decentralization, persistence, anonymity, and auditability (Zheng et al., 2017). Blockchain technology is expected to play an increasingly important role in global economic recovery and the development of the digital economy following the pandemic (Yang et al., 2022).

Ølnes, Ubacht & Janssen, 2017 (2017) argue that blockchain technology can be applied beyond the private sector to government operations. They compiled a list of the primary benefits of adopting blockchain applications in government, which include transparency, trust, efficiency, reduced corruption, cost reduction, fraud and manipulation prevention, increased resilience, and improved security. However, the authors emphasize that these benefits are unlikely to be achieved simultaneously.

Governments can leverage blockchain to transform how they manage data and interact with citizens. This technology is particularly suitable for the digitization of government services, and its potential to enhance efficiency is a key driver of adoption (Saxena et al., 2022). Although still in its early stages, efforts have been made by governments to implement blockchain in public services across different domains: government-to-government (G2G), government-to-business (G2B), and government-to-citizen (G2C). These initiatives aim to streamline processes, strengthen security, enhance transparency, and improve privacy in e-government services (Lykidis et al., 2021).

Governmental blockchain networks are characterized by an infrastructure developed by public entities, serving as a foundation for government-related applications. Such networks are being adopted in various countries worldwide. According to Stockton (2020), the main obstacle to blockchain adoption has been the cost and complexity of setting up a platform, making the emergence of networks such as China's BSN (Blockchain-Based Network) or similar solutions inevitable.

Some notable examples of these networks are listed as follow. Alastria is an association open to all types of companies and organizations, including public entities, with the mission to engage various sectors and contribute to the creation of a diversified innovation ecosystem. Participants collaborate on both network infrastructure and application development (Alastria, 2021). Another significant example is LACChain, a global alliance comprising various blockchain stakeholders and led by the Inter-American Development Bank's Innovation Lab (BID Lab). LACChain focuses on fostering blockchain adoption in Latin America and the Caribbean, promoting financial inclusion, consumer protection, and market integrity (Lacchain, 2021).

The European Blockchain Services Infrastructure (EBSI) is another relevant initiative. Established in 2018, EBSI connects blockchain nodes across 29 countries (EU member states, Norway, and Liechtenstein) along with the European Commission. Its vision is to leverage blockchain to develop cross-border services for public administrations and their ecosystems, ensuring information verification and reliable service delivery. Since 2020,

EBSI has been implementing a distributed blockchain network across Europe to support applications focused on various use cases (EBSI, 2021; Falwadiya & Dhingra, 2022).

The Argentinean Federal Blockchain Network (BFA) was created in 2018, with validation nodes operated by public institutions (such as universities) and private companies (Ramirez-Escudero, 2021). The BFA is an open, multi-service, and participatory platform designed to integrate services and applications that drive technological innovation and collaborative governance. Key use cases include public procurement, academic certificates, financial guarantees, and food trade (BFA, 2022).

Specifically in Brazil, three blockchain networks are under development at the federal level. PIER is an initiative launched in April 2020 by the Central Bank of Brazil (BACEN), the Superintendence of Private Insurance (SUSEP), and the Securities and Exchange Commission (CVM). Its objective is to facilitate the exchange of information among these institutions (BACEN, 2022; SUSEP, 2022). The RNDS, led by the Ministry of Health, serves as a repository for citizens' health records, integrating health-related data and supporting the management of healthcare services across different levels of care (Datasus, 2020). The RBB, developed through a Technical Cooperation Agreement between The Brazilian Development Bank (BNDES) and the Federal Court of Accounts (TCU) was designed as a nationwide infrastructure. RBB aims to serve as a platform for developing applications of public interest (BNDES, 2022).

This growing adoption of blockchain by governments highlights its potential to improve transparency, efficiency, and security in public administration. However, its successful implementation requires overcoming technological, financial, and regulatory challenges, as well as fostering collaboration between government entities, the private sector, and civil society.

3. Method

The method of this paper is the case study, incorporating document analysis and in-depth interviews with key participants involved in the implementation of blockchain government networks, which includes public managers, academics, market professionals, and other experts. The case study method fits for the objective of exploring contemporary phenomena within a societal context, and it is particularly relevant when the phenomenon under study is broad and complex, requiring a holistic and in-depth analysis (Yin, 2018). The methodological framework follows the approaches outlined by Yin (2018) and Eisenhardt (1989).

The object of study in this research is the phenomenon defined in this paper as governmental blockchain networks. Blockchain applications, by definition, are network artifacts; however, the mere adoption of a blockchain application by a government does not imply that it is using a network in its strictest sense or fully embracing the technology's main principles. Thus, this study focuses specifically on developments that explicitly identify themselves as networks. Consequently, blockchain applications confined to a single institution or lacking the intent to integrate multiple entities are not considered within the scope of this research. The study, therefore, examines self-declared blockchain networks in federal level of the public administration in Brazil, designed for both proprietary and third-party applications, whether governmental or non-governmental entities. Three blockchain networks at different stages of development were selected in the Brazilian context: PIER, RNDS, and RBB.

There are some reasons for choosing these three networks. First, they are all existent government networks in Brazil at federal level, which can produce rich comparison, once they are at the same regulatory and legal environment and face common challenges. Second, as studies comparing blockchain networks are scarce in the literature, this movement seems to be prudent in the theorical contributions. Third, the authors had an easier access to the interviewers as they are residents in Brazil.

The PIER, developed by the Central Bank of Brazil (BACEN), was officially launched in April 2020 to facilitate the exchange of information between the Superintendence of Private Insurance (SUSEP), the Central Bank (BACEN), and the Securities and Exchange Commission OF Brazil (CVM). Its primary function is to integrate data from regulatory bodies and streamline authorization and registration processes within the financial system (SUSEP, 2022). PIER enables financial institutions to receive responses from regulatory agencies more swiftly and efficiently (BACEN, 2022).

The RNDS serves as a document repository for storing citizens' health information, establishing a federated interoperability layer that supports the development of various health applications, such as the Brazilian Electronic Health Record (Datasus, 2020). The RNDS represents an innovative approach to health data management, storing information in virtual cloud-based containers using blockchain technology. It works as a repository for retrospective, real-time, and prospective patient data in digital format (Datasus, 2020).

The RBB was originated as a project in the BNDES to establish a nationwide blockchain infrastructure. The network aims to integrate all three branches of government—executive, legislative, and judiciary—along with federal

agencies, state, and municipal entities. Its objective is to provide a robust infrastructure that enables both public and private actors to develop and operate blockchain-based applications of public interest (BNDES, 2022).

3.1 Respondents and coding

The respondents of the research were individuals involved in the implementation and management of the networks. More specifically, interviews were conducted with the technical managers responsible for each network, as well as the managerial staff overseeing these networks. This approach incorporated perspectives on both the execution and organizational aspects of the networks. Based on recommendations from some interviewees, individuals from entities associated with the networks were also interviewed, as they could provide clarifications on decisions that impacted the network. All interviews were conducted by the first author as the sole interviewer. The first interview took place on December 12, 2022, and the last on February 10, 2023.

All meetings were held virtually via the Microsoft Teams platform, with recording and transcription features enabled. The meetings were conducted individually, with an average duration of forty-six minutes. The only exceptions were the meetings involving teams from the Central Bank and SUSEP. In these two meeting the participants requested to join simultaneously. In total, 19 individuals were interviewed, each representing a specific network, holding mid-level management positions or high levels of technical responsibility.

The interviews were recorded, transcribed, and analysed using coding, thematic analysis, and data tabulation. The transcription was initially read with open coding, followed by a second stage where these codes were grouped into final categories, as outlined below:

i)Origin: This topic includes themes related to the emergence of each network, including the motivation behind its creation, the reasons for its specific structure, its objectives, and other relevant aspects.

ii) Background and conditioning factors: This section addresses the circumstances preceding the networks' emergence, such as the conditions in which they were developed, the antecedents that enabled their creation, the willingness and capacity of the teams, internal leadership, technical aspects, and internal decision-making.

iii) Interinstitutional relations: This item identifies the partnerships and interactions established among the network actors, such as the creation of connections and dialogues essential for network formation.

iv) Leadership: Although networks assume a balance between participating entities, network governance remains a critical issue. It was identified that the networks exhibited some form of leadership, making this aspect fundamental to understanding Brazilian networks.

v) Governance and technical aspects: In line with the literature review, governance emerged as a key issue in the interviews. Additionally, governance is often associated with specific technical choices, and this section explores the relationship between these two concepts. The analysis highlights the technical decisions made within the networks that relate to governance themes.

vi) Outcomes and lessons learned: benefits and other gains obtained through the networks, as well as the lessons learned so far and those projected for the near future.

vii) Associated costs and challenges: This item evaluates the financial and non-financial costs associated with the networks, as well as other difficulties encountered throughout their evolution.

viii) Current status: A summary of the current state and operational dynamics of the network.

Other cross-cutting themes emerged in the research, were coded and analysed, but are not presented in this paper.

4. Cases Description

The RBB emerged from BNDES initiatives in blockchain (BNDES, 2022). According to Interviewee 1, the first actions related to blockchain at BNDES began with the development of a Token and, over time, the possibility of the project evolving into the creation of a network. The network was founded based on a Technical Cooperation Agreement between BNDES and TCU, at an event held on May 30, 2022 (TCU, 2022).

The RNDS emerged as a solution to a data integration problem in the public health sector. Interviewee 6 highlighted that the choice of blockchain was due to the greater adherence of the technology to the proposed objectives for the health network. It was initially conceived to be a system to integrate patients' health data, giving them access to doctors and the government. But still in its development, it had to undergo a transformation in its conception, due

to the Covid-19 Pandemic crisis. Thus, the structure was first used for the national registry of Covid-19 vaccines and tests. Interviewee 11 highlighted that there was a demand from the Ministry of Health to integrate health data, and the team concluded that the blockchain solution would be the most appropriate. However, at the same time, it quickly ceased to be regional and became federal, without time for pilot tests. Due to this urgency, Interviewee 12 mentioned that in this environment of rush and need for quick responses amid the Pandemic, the network was put into operation.

The first experience with blockchain at the Central Bank was a positioning paper of the IT team. This division conducted research on DLTs analysing possible use cases and examining some of the platforms available to develop prototypes of a settlement system by the Central Bank (Burgos et al., 2017). Interviewee 7 mentioned that PIER emerged as an initiative of the Central Bank to share relevant information, such as company registration data, financial information, market information, and other information that may be useful for the supervision and regulation process of the regulatory entities of the financial system. The following table presents the comparison between the networks.

Tab. 1 – Case study comparative analysis

Theme/ Network	RBB	RNDS	PIER
Creation	Infrastructure for the development of blockchain applications by public interest entities.	Solution for healthcare data integration.	Solution for exchanging information from financial system regulatory entities – automation between regulators.
Blockchain use in the network	Technology as the center of the development strategy.	Better adherence to the proposed objectives. Blockchain as a central part of the network, but with other associated technologies.	Better adherence to the proposed objectives. Complementary technologies for participant interface.
Formalization of network constitution	Technical Cooperation Agreement between BNDES and TCU with the later adhesion of the other participants.	Enforcement through normative acts of the federal government.	Technology established based on the previous relationship between institutions.
Conditions for the emergence of the network	Internal innovation project, with institutional sponsorship from senior management, which allowed for deeper insights into the topic. Coordination with other entities interested in the topic. Institutional sponsorship from other public administration entities for a national blockchain network. Other government entities with technical knowledge of blockchain. BNDES expertise in relations with public and private entities. Possible role as BNDES financier.	Pre-existing digital strategy and identification of blockchain as a suitable technology for the development of activities. Previous failed technological attempts that brought knowledge for implementation.	Pre-existing digital strategy and identification of blockchain as a suitable technology for the development of activities. Production of technical knowledge by teams (positioning paper) analysing technology and its applicability in Central Bank actions. Prior knowledge of processes to be digitized.

Network Guiding Artifact	The network as a platform for developing other blockchain applications.	System for exchanging health information.	System for exchanging information from financial sector regulators.
Leadership	Shared.	Centralized.	Centralized.
Dialogue between network entities and power balance	Negotiation between entities for the best development of the network. Search for the lack of hierarchy between participants.	Guidance on the use of the Ministry for other entities and the respective provision of infrastructure. Existence of hierarchy among participants.	Negotiation between the Central Bank and other entities. Despite no hierarchy between entities, the conditions had a kind of enforcement for the adoption of the network by SUSEP and CVM. BACEN as the leader.
Development	Internal resources without hiring.	Internal resources: taking advantage of pre-existing cloud and service provision contracts.	Internal resources without hiring.
Governance	Public-permissioned network. Negotiation between entities to define by consensus how costs and resources will be shared. Technology presupposes another modus operandi of work, in which assets and operations are consensual and divided, which marks an opposition to the current centralization of involved entities.	Private network. Operating and sharing model defined by a single entity. Emergency implementation of the network meant that certain technical and governance aspects were left aside.	Private network. Operating and sharing model defined by a single entity. Network governance is more of a control by BACEN than a negotiation between the various parties that make it up, since the bank is the main actor and leader of the network.
Nodes	Distributed among participants physically. Each entity is responsible for its infrastructure. Exchange of knowledge between entities.	Even 3 for each participant, all in the same cloud structure. Ministry responsible for state infrastructure initially.	Distributed among participants, both physically and in the cloud. Each entity is responsible for its infrastructure. Central Bank with the role of technical advisor of other entities.

Benefits	Infrastructure that allows application development. Possibility of sharing developments and reducing costs. Exchange of information between participants. Encouraging use for public administration, internal discussion in court, positive media and the message to public managers that they can seek innovation. Potential cost reduction due to the pre-defined environment and exchange of developments. Encouraging the use of blockchain for other public sector entities. Intra-institutional: positive media, internal debate with other departments and improvement of the image of the bodies (as supporters of innovation). Technological capacity, coordination with other entities and creation of an environment for innovation.	Application of blockchain in the context of health data in government. Federalization of distributed data: data is placed on the network according to local standards and the system allows the consolidation of information. Covid-19 crisis response tool. Availability of the national covid-19 vaccination card in a timely manner. Centralization of Covid-19 exam and vaccine data, with rapid consolidation of information. Taking advantage of previous developments for new applications. Data infrastructure. Provision of information to the end user. Greater auditability of health expenditure (verification by citizens of medication use, for example). Learning to use cloud technology. Decentralized data consolidation at lower cost than other technologies.	Greater speed of response to the end user when appointing people to positions in financial institutions, for example. Less bureaucracy between entities. Agile dialogue between entities. Availability of teams for other intellectual activities. Fewer manual processes and associated rework risks. Auditability of processes. Institutional learning of in-depth theoretical and new practical knowledge that could be used for regulation in the future. Learning about blockchain technology that can help the development of Real Digital.

Costs	No financial outlay, development by an internal team. Infrastructure costs assumed by each entity. Insignificant infrastructure values. Network with effective return in the medium/ long term.	Taking advantage of internal contracts for network development. Allocation of consultants who would already be available to the Ministry. Use of a pre-existing cloud contract. Blockchain costs approximately 1/3 of an alternative. High initial cost for the Ministry, but later each state would assume its infrastructure cost. RNDS cost around 10% of the costs of previous similar projects.	No financial outlay, development by an internal team. Infrastructure costs assumed by each entity. Insignificant infrastructure values. Insignificant deployment values.
Difficulties	Cultural: initial acceptance by different public administration bodies. Articulation between entities and assembly, governance and establishment of consensus for decisions. Convincing technical areas to business (and decision-making) areas to join the network.	Definition of standards for information exchange. Rapid system implementation requiring quick responses. Lack of time to make a pilot. Difficulty implementing the “undo” or reversal system. Lack of adequate testing environment.	Reduced team for development and deployment. Reduced budget of resources for developing innovation projects. Responsibility for maintenance and support in partner environments. SUSEP and CVM in lower stages the technology knowledge.
Current status	Network founded. Under development, with the definition of governance and adhesion of new partners.	After a hacker attack on the cloud where the network was hosted, the network was resumed using another technology, which is still in force today. There is no prospect of a resumption of blockchain technology.	Network in operation according to initial forecast.

Learned lessons	Training and education within the institutions themselves, leaving technical environments and passing through other areas aiming at embracing innovation. Better for government applications to run on non-full public networks. It also applies to the development of networks	Need for communication and awareness among other actors, even if the application is enforced. A hybrid solution, which has local and cloud servers, designed to work in multiclouds. Applications of the size of RNDS require a maintenance and support team available to support them.	Top-down systems with the provision of technical support increase the speed of implementation but can limit the knowledge transfer. In-house system for experimentation in other uses (real digital).
Expected results in the future	Applications' development. Robust governance model.	Reactivation of the blockchain network. Electronic medical record with patient history available in real time to network participants. Consolidated history of information for patients and doctors, available in real time.	Possibility for the network to receive other applications, such as the SUSEP system directly with the user Knowledge and mastery of technology for other applications. Practical, operational knowledge of technology.

5. Results Analysis

The following table presents the KPIs, and dimensions identified for each of the networks in this research, characterizing them as a subset of the complete framework of Twizeyimana & Andersson (2019). Due to the different stages of the networks, there is a distinction between the public values identified and the potential public values that may be generated in the future by the networks.

Tab. 2 – Public values' KPIs

Public Value	**Identified**			**Potential**		
Improved Public Services	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
provision of services to citizens		**X**	**X**	**X**		
increased quality of public information and services		**X**	**X**	**X**		
enabled transparency, participation, and collaboration in the delivery of public services		**X**				
Improved Administrative Efficiency	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
cost-reduction		**X**	**X**			
reduced bottleneck and queues in the delivery of services to citizens		**X**	**X**	**X**		
better collaboration, cooperation, and better communication	**X**	**X**	**X**	**X**		
increased transparency, participation, and inclusiveness		**X**	**X**	**X**		
maintained accurate and durable records			**X**	**X**	**X**	

Open Government capabilities	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
improved public engagement and well-informedness		**X**		**X**		**X**
improved public control and influence on government actions and policies		**X**				
Improved Ethical Behavior and Professionalism	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
increased citizens' access to government information and services		**X**				
maintenance of accurate durable records			**X**	**X**	**X**	
Improved Trust and Confidence in Government	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
better delivery of public services		**X**	**X**	**X**		
increased quality of public services		**X**	**X**	**X**		
Improved Social Value and Well-Being	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
achievement of better outcomes in areas of peace, security, poverty reduction, **public health**, high employment, low crime rates, clean streets, improved environment and better educational achievements.		**X**				
a more flexible, pervasive, and cost-effective public sector (e.g., provision of online applications and transactions)		**X**	**X**	**X**		

In each dimension of the framework, at least two KPIs of public valuer were identified. From an initial perspective, it is evident that the RBB, due to not being operational and lacking any use cases in operation, only indicates achievement in one KPI within the dimension of Improved Administrative Efficiency. However, it is the network with the greatest potential for the development of new KPIs, as a total of eleven indicators were identified across all dimensions of public value.

Each of the networks, individually, has at least one KPI in each of the six dimensions. In all analysed networks it was identified the generation of public values across all six dimensions. This suggests that, potentially, once a government assesses the suitability of implementing a governmental blockchain network, it will generate public value.

In the dimension “Improved Public Services”, both the RNDS and PIER were able to deliver new services in e-government. The RBB considers this value as one of its objectives. Similarly, RNDS and PIER reported perceived improvements in the quality of the information provided about their services. PIER achieved this by centralizing data from different agencies onto a single platform, while RNDS managed to federalize health data. Regarding transparency and collaboration in public service delivery, only RNDS shows be able to deliver this value, allowing citizens to track their health data, including medications, and report any discrepancies within the system.

In “Improved Administrative Efficiency”, four KPIs were simultaneously identified by all three networks: reduced bottleneck and queues in the delivery of services to citizens, better collaboration, cooperation, and better communication, increased transparency, participation, and inclusiveness, and maintained accurate and durable records. This result suggests that enhanced administrative efficiency, characterized by quicker processes, team collaboration, and citizen participation, are public values that can be strongly achieved through blockchain networks.

The dimension “Improved Administrative Efficiency was the only one in which an already identified public value was identified for the RBB. Even in the pilot phase the communication among the parties already ensures greater collaboration, cooperation, and improved communication among the entities. This KPI is also considered potential for this network, because once implemented, these processes can take place within the network.

Regarding cost reduction, RNDS indicated that the blockchain solution was less expensive than previous attempts, and PIER stated that the system freed up analysts from handling bureaucratic tasks to engage in more valuable activities. Both RNDS and PIER have shown that the networks generated efficiency in processes, delivering more services with fewer resources employed. They utilized pre-existing resources, but this KPI does not account for additional associated costs, such as training and the allocation of teams or the work hours dedicated before the

network's implementation.

On the KPI of "reduced bottleneck and queues in the delivery of services to citizens ", according to interviewees, if it were not for RNDS, there would have been no timely response regarding vaccination data at the onset of the pandemic. For PIER, this KPI meant the reduction of bureaucratic hurdles between regulatory bodies. Throughout the interviews, it became clear that the network serves as an efficient means to exchange data and an excellent locus for collaboration among entities. In terms of transparency, RNDS managed to provide greater visibility of information among entities and to the public, consolidating federal data. In contrast, PIER achieved this only among the entities that are part of the platform.

Regarding the KPI of accurate and durable records, RNDS demonstrated how the principles of the technology must be respected, even in a pilot phase. A network based on technology that anticipates data distribution, which is strongly resistant to hacking attacks, suffered losses due to a cloud attack rather than an attack on the network itself. This could compromise the data related to COVID tests and vaccinations. From this experience, the potential of the network was identified should it resume using blockchain technology and implement distributed nodes. In contrast, PIER possesses data integrity and distributed backups.

The networks still do not appear ready to develop the capacities for open government. Only RNDS has a system for public engagement (allowing citizens to verify their data and access aggregated information), thereby facilitating greater public control. RBB and PIER have the potential to develop this capacity within their activities. Thus, in the dimension of Ethical Behaviour, RNDS meets the KPI of greater access for citizens to government information and services. As previously explained, only PIER has demonstrated the maintenance of durable and accurate records, but this is a desired capability for the other two networks.

In the dimension "Improved Trust and Confidence in Government" both RNDS and PIER deliver better services on the blockchain than when these same services were on other systems, providing better service and improved quality in outcomes. The RBB is indicated to have this potential in its actions. Regarding "Improved Social Value and Well-Being", RNDS and PIER, as observed, alongside RBB potentially, utilize online transactions, making the public sector more flexible. However, when analysing specific sectors, only RNDS delivers value in the KPI of better health outcomes.

6. Conclusion

Following the public value framework in electronic government presented by Twizeyimana & Andersson (2019), the implementation of government blockchain networks at the federal level can generate the following public values: improvement of public services; greater administrative efficiency; improving open government capabilities; better ethical and professional behaviour; greater trust in government; and improving social value and well-being.

Theoretically, between networks there should be a balance between all participants. But what was verified with the research is that they all developed with one entity being the driver of the network. This was seen in PIER, RBB and RNDS, with the driving forces, respectively, being the Central Bank of Brazil, BNDES and the Ministry of Health. PIER is the only one that proposes to be strictly for federal level entities, being specifically for regulatory entities of the Federal Executive Branch. However, both RBB and RNDS, from the beginning and in their objective, have a multilevel characteristic.

The RBB, more directly, was structured to encompass federal, state and municipal entities, with the desire for this institutional variability. The RNDS, on the other hand, positioned itself as a network led by the Union, through the Ministry of Health, centralizing data from the Union itself, the 26 states and the Federal District. It is important to highlight that connection with municipal entities would be desirable, but this would not fit into the network. In this way, the possibility would be for the state entity to replicate the data federalization structure for its municipalities.

Concerning the networks implementation, when conducted top-down (where governance defines the artifact rather than the artifact defining the governance of the network), there seems to be greater potential for balanced role evolution among participating entities, as observed in the development of RBB. Conversely, when implemented within a hierarchical structure (where a company defines governance, thus establishing the conditions of the network), implementation occurs more rapidly, as seen in PIER and RNDS. This issue of balance versus speed is an aspect that could be explored in future research. Additionally, the more decentralized aspects the network possesses, the greater the need for interaction to facilitate its creation. However, even when there is a central entity driving the network's development, it is essential to establish a communication system for information sharing and training of other elements.

This work developed the study of the generation of public value from the perspective of public managers, experts and those who worked on the creation of government networks. The results obtained are robust within the

Brazilian context, and the authors believe that these findings may be applicable in other countries or subnational entities. However, it is essential to conduct further research to determine whether such conditions are indeed confirmed in different scenarios. As a limitation, the paper doesn't consider the perspectives of public values being generated in joint creation between government entities and citizens. As a sequence, studies are suggested that encompass this perspective, in which citizens can be studied and the generation of values can be jointly evaluated. In this way, studies can be quantitative in nature, with the definition of indicators, which evaluate with the general population i) whether they have the same impressions as public managers or ii) whether the expected public values are in fact identified by the general population.

For future work the authors suggest the following research. This paper was developed through the theoretical lens of Public Value in Electronic Government, but during the process other opportunities were identified from other perspectives that were not explored in the literature used. For example, innovation theories can be used to analyse the development and implementation of technology in the public sector, including for the cases cited here. Furthermore, economic theories can also be evaluated for technology adoption. Finally, as this paper is restricted to the Brazilian case, future works can bring networks from other countries or even a cross-country analysis.

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Contributor Statement

Author 1: conceptualization, data curation, formal analysis, investigation, methodology, project administration, validation, writing the original draft, review, and editing).

Author 2: conceptualization, formal analysis, methodology, validation, writing – review, and editing).

Use of AI

During the preparation of this work, the authors used Open IA ChatGPT, Microsoft CoPilot and Google Translator to translate the text from Portuguese to English. After using these tools, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest.

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