The Emergence of a Process Tokenisation Model for the Public Sector: A Position Paper

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Abstract

Tokenisation denotes one of the most successful implementations of blockchain that concretes its benefits into practice, also in the public sector, where it can help to reverse the declining citizen trust in governments. Process Tokenisation is the possibility of adopting blockchain as infrastructure for a business process, measured by its level of "Tokenisability". Going towards a Process Tokenisation Model for the Public Sector, this position paper presents the context in which process tokenisation is necessary for the public sector and draws on Process Virtualisation Theory to propose constructs to help a public organisation identify the most suitable business process for tokenisation. Also, a European Blockchain Service Infrastructure use case description evaluates the model. As a result, the Process Tokenisation Model for the Public Sector demonstrated valuable, foreseeing sustainable potential benefits.

Keywords: *tokenisation; blockchain; public sector; process virtualisation theory; sustainability*

1. INTRODUCTION

In the context of the blockchain (BC), tokenisation describes transferring a tangible object, a real-world asset or a status, into a token on the blockchain (OECD, 2018), with growing adoption (Oliveira, Bauer, Zavolokina, & Schwabe, 2018). It stands as one of the most successful implementations of the blockchain that concretes its benefits into practice (Tian et al., 2020) being studied in the Information Systems (IS) field (Berdik, Otoum, Schmidt, Porter, & Jararweh, 2021; S. Kim, 2020), with the business process management approach (X. Li, Zheng, & Dai, 2021; Milani, Garcia-Banuelos, Filipova, & Markovska, 2021), and also applied in the public sector (Benitez-Martinez, Hurtado-Torres, & Romero-Frias, 2021; Datta, 2021). As advantages, tokenisation offers faster and cheaper transaction processing, flexibility, decentralisation, security, and transparency (Bashir, 2020). Considering its potential, tokenisation, applied to different business models, is expected to lead to a new economic paradigm in what has been called the token economy (Lee, 2019; Tian et al., 2020).

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Just as blockchain has disruptive potential in business and processes (Cagigas, Clifton, Diaz-Fuentes, & Fernandez-Gutierrez, 2021), tokenisation also has disruptive potential in business models and processes, which is why regulatory and corporate governance models will need to be re-examined in light of it (Morrow & Zarrebini, 2019), which opens up numerous new opportunities for businesses and governments (Babich & Hilary, 2020).

This position paper aims to present the context in which a process tokenisation model is necessary for the public sector, describe the process tokenisation model proposed from the public sector processes classification perspective, and evaluate the model by a use case of Education Credentials.

2. CONTEXT

Digital transformation outside the public sector raises citizen expectations of governments' ability to deliver high-value, real-time digital services (Escobar, 2020). Meantime, the trust and confidence of citizens in governments worldwide have been declining over the years (Mahmood, 2016; Tolbert & Mossberger, 2006). The lack of transparency contributes to this depreciation (Labarca, Arceneaux, & Golan, 2020).

With tokenisation in the public sector, the goal is not to replace legitimate political representatives with a new type of procedural legitimacy supported by BC, but to design systems that use BC capabilities to provide more transparency, equality of opportunity, and grander stakeholder control and participation in processes (Benitez-Martinez et al., 2021).

Consequently, the transparency and trust built into BC can rebuild trust in institutions (Tapscott & Tapscott, 2018). In this sense, through ex-post verifiability, BC could increase confidence in the operations of public organisations; also, through ex-ante automation, the use of BC could facilitate new forms of cooperation between organisations (De Filippi, 2021).

However, some concerns could hamper this process in the public sector (e.g., scalability, lack of laws and regulations, and energy consumption), and they need to be managed as risks (Escobar, Santos, & Pereira, 2023).

3. PROCESS TOKENISATION MODEL

Under the lens of Process Virtualisation Theory (PVT) (Overby, 2008) and the Extended Process Virtualisation Theory (ePVT) applied in the public sector (Barth & Veit, 2011), we are based on the premise that not all processes qualify to be tokenised, as some processes are more amenable to tokenisation than others (Overby, 2008). Therefore, we argue that process tokenisation can be assessed for any business process, in our case, any public sector business process, prior to implementation.

Process Tokenisation is the possibility of adopting a BC platform as infrastructure (Rukanova et al., 2021) for a business process to take advantage of blockchain in the public sector with gains such as automating administrative processes, reducing the cost of operations, increasing transparency and privacy, improving financial inclusion, enabling sustainability, and promoting innovation and economic growth (Mark, 2016; Medaglia & Damsgaard, 2020).

Figure 1 depicts the Process Tokenisation Model for the Public Sector, comprising the requirements and the capabilities (both from PVT and ePVT), as well as the proposed sustainable incentives and the desirable outcomes for blockchain adoption in the public sector, both derived from extensive bibliographic research – all they are described as follows.

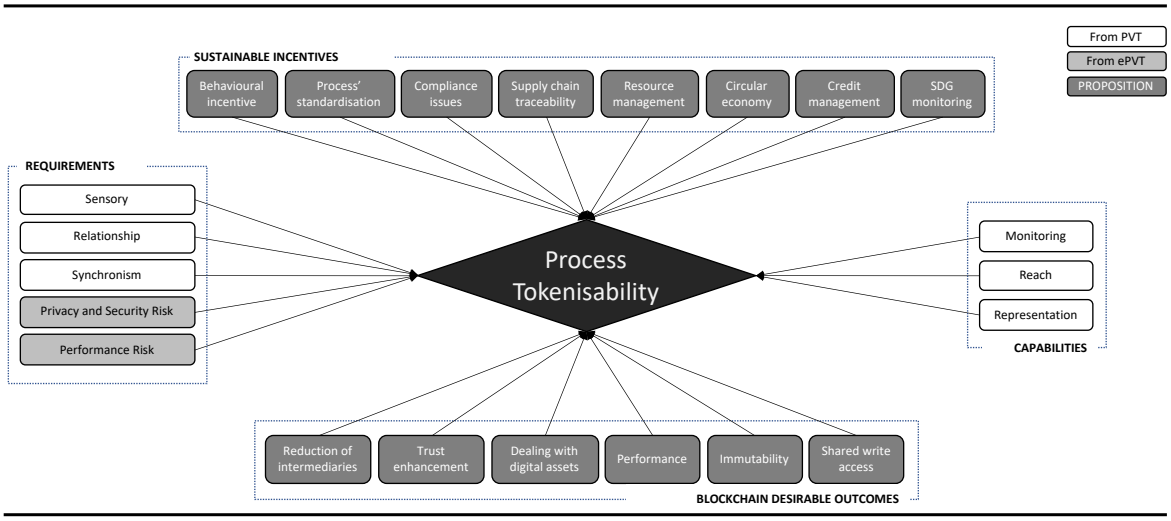

Figure 1 – Process Tokenisation Model for the Public Sector

3.1. Requirements

By default, the following requirements negatively affect the process's virtualisation (Alarabiat, Hujran, Soares, & Tarhini, 2021) and must be addressed by any solution aiming to implement it. BC's capabilities are expected to positively impact its adoption for a business process to take advantage of BC in the public sector.

Sensory. The perception of trust derived from adopting blockchain (Tan, Mahula, & Crompvoets, 2022; Tapscott & Tapscott, 2018) increases sensory perception (Srivastava, Vishnoi, & Srivastava, 2017).

Relationship. The trust embedded in blockchain (Tan et al., 2022; Tapscott & Tapscott, 2018) contributes to establishing a relationship of trust in the public sector (Barth & Veit, 2011), just as smart contracts can improve the relationship between parties (Lopez-De-Ipina, El Busto, Lauzurica, & Casado, 2021).

Synchronism. Performance, transaction duration, and latency are critical aspects of blockchain-based solutions (S. K. Kim & Huh, 2020; Lopez-De-Ipina et al., 2021) and must be addressed by design choices (i.e., typology and consensus mechanism) (Aysan, Bergigui, & Disli, 2021), considering the process synchronism requirements (Leng et al., 2020).

Privacy and security risk. Cryptography is one of the core technologies that integrate BC (Tasca & Tessone, 2017), namely with digital signatures and hash values; BC achieves the goal of maintaining user anonymity and privacy (Dai, Shi, Meng, Wei, & Ye, 2017) which mitigate, by default, privacy and security risk (Pournaras, 2020). Once again, design choices are primordial to address these issues (Pournaras, 2020; Zambrano, 2020), observing the European Union's (EU) General Data Protection Regulation (GDPR) (or other countries' equivalent legislation) compliance (Haque, Islam, Hyrynsalmi, Naqvi, & Smolander, 2021).

Performance risk. Blockchain in the public sector results in a complete revision of business processes and models (Cagigas et al., 2021); in conjunction with that, the fact that the BC is decentralised (Ølnes & Jansen, 2021) mitigates the performance risk, contributing to high availability and the benefit delivery.

3.2. Capabilities

The capabilities are the characteristics of the virtualisation mechanism and how they influence the relationship between the requirements constructs and process virtualisability (Overby, 2008, 2012). Hence, as capabilities, the BC's characteristics are presented along the constructs: monitoring, reach, and representation.

Monitoring. BC delivers "monitoring" capability by default as a chain of blocks formed by a continuous and incremental list of records where data is stored in a distributed, transparent, and tamper-resistant manner.

Reach. BC's decentralised characteristic supports the "reach" construct by ensuring the availability of information independent of location and time.

Representation. BC's immutable and tamper-proof characteristics support the "representation" construct by ensuring that data written in the ledger cannot be changed. Also, the design choice about what to write on-chain and off-chain expands the possibilities of formats to be stored and consulted later.

3.3. Proposed sustainable incentives

Based on extensive bibliographic research and validated with expert interviews, the proposed sustainable incentives for BC adoption in the public sector are described in the following, with effects on sustainability.

Behavioural incentive. Adopting any reward mechanism to help achieve the process' goals or other positive externalities contributes positively to process tokenisability.

Process' standardisation. The more standardised the public sector's business process to be tokenised, the more it contributes positively to process tokenisability.

Compliance issues. The more the public sector's business process to be tokenised runs into compliance issues, the less it contributes positively to process tokenisability.

Supply chain traceability. The public sector's business processes related to supply chains, or their interfaces, demand traceability and contribute positively to process tokenisability.

Resource management. The public sector's business process related to resource management contributes positively to process tokenisability.

Circular economy. The public sector's business process related to the circular economy or with incentives for its adoption contributes positively to process tokenisability.

Credit management. The public sector's business process related to credit management, or another environmental token, contributes positively to process tokenisability.

Sustainable Development Goals (SDG) monitoring. The public sector's business process related to SDG that needs to be measured reliably contributes positively to process tokenisability.

3.4. Proposed blockchain desirables outcomes

As technology influences the business model possibilities (Baden-Fuller & Haefliger, 2013), organisations seek advice to help decide where BC is a potential solution to their use case, with several distinct decision schemes proposed to assist in this decision (Shahaab, 2020). The six outcomes synthesised, with references, are analysed below based on extensive bibliographic research.

Reduction of intermediaries (Aysan et al., 2021; J. Li, Greenwood, & Kassem, 2019; Mulligan, Scott, Warren, & Rangaswami, 2018). BC contributes to reducing intermediaries in the process because it eliminates the need to rely on trusted parties. Thus, tokenisation can potentially reduce intermediaries, with operational efficiency and cost advantages. Therefore, if the public sector business process needs to reduce intermediaries, this construct is expected to impact tokenisation in the public sector positively.

Trust enhancement (Chowdhury, Colman, Kabir, Han, & Sarda, 2018; J. Li et al., 2019; Mulligan et al., 2018; Peck, 2017; Wüst & Gervais, 2018). In BC, trust comes from the network itself through cryptography, collaboration, and clever code. Tokenisation can potentially increase trust between parties without centralisation, increasing confidence in public organisations' operations. If the public

sector business process needs to enhance trust between parties, it is expected that this construct will positively impact tokenisation in the public sector.

Dealing with digital assets (Belotti, Božić, Pujolle, & Secci, 2019; GAO, 2022; J. Li et al., 2019; Mulligan et al., 2018). Tokenisation works well with assets that can be successfully represented digitally and to manage transactions (contractual relationships or value exchange) around digital assets. Therefore, if the public sector business process deals with digital assets (or that can be digitised), this construct is expected to impact tokenisation in the public sector positively.

Performance (Aysan et al., 2021; Chowdhury et al., 2018; J. Li et al., 2019; Mulligan et al., 2018). Blockchain performance requirements include throughput, latency, and scalability and must be addressed by design choices (e.g., typology and consensus mechanism). The speed required for the public sector business process will indicate if blockchain is the best answer. Thus, this construct is expected to have an equivocal impact on tokenisation in the public sector that depends on the context of the process.

Immutability (Aysan et al., 2021; Belotti et al., 2019; Chowdhury et al., 2018; GAO, 2022; J. Li et al., 2019; Mulligan et al., 2018; Peck, 2017; Wüst & Gervais, 2018). Immutability is a core characteristic of blockchain guaranteed by consensus mechanisms. As a result, tokenisation offers permanent, tamper-proof, and shared data with historical states. Therefore, if the public sector business process needs to record data permanently and tamper-proof, this construct is expected to impact tokenisation in the public sector positively.

Shared write access (Aysan et al., 2021; Belotti et al., 2019; Chowdhury et al., 2018; GAO, 2022; J. Li et al., 2019; Mulligan et al., 2018; Peck, 2017; Wüst & Gervais, 2018). Decentralisation is another core characteristic of blockchain as a digital ledger shared among a peer-to-peer distributed network of independent parties. Because it is shared, only the different parties that have to write and commit privileges can add to the chain, depending on design choices. Suppose the public sector business process needs some/all of the network's members to write transactions. In that case, this construct is expected to impact tokenisation in the public sector positively.

4. PUBLIC SECTOR PROCESS CLASSIFICATION

A process classification framework can be used as a business process taxonomy (American Process & Quality Center, 2018).

Aiming to identify a public sector business process' classification framework to cover a wide range of public processes with varying characteristics (Barth & Veit, 2011), a systematic literature review (SLR) was conducted in April 2023 by querying Scopus, ACM Digital Library, IEEE Xplore, ScienceDirect, and Web of Science, using the query ("public sector" OR "government" OR "public service" OR "public administration" OR "e-gov" OR "eGov") AND ("process classification

framework" OR "Government Process Management" OR "business process hierarchy"). The SLR process was based on PRISMA (Liberati et al., 2009) and the approaches for Software Engineering proposed by (Kitchenham & Brereton, 2013), being in line with these references and adapted to the context of this research (Escobar, Almeida, & Varajão, 2023).

The query returned a total of 30 articles. After removing the duplicates, 24 unique articles remain. They were retrieved and fully read to identify process classifications specific to the public sector. During this step, six of them proved to be inaccessible and were excluded. Finally, three papers present or describe one or more public sector process classifications, as summarised below.

Two complimentary works reviewed the state-of-the-art eGovernment process domain models and grouped them into three categories: object, process, and holistic (Peristeras, Loutas, & Tarabanis, 2008; Peristeras, Tarabanis, & Goudos, 2009). In these works, inside the process category, with a focus on modelling generic processes common to many public sector organisations, two initiatives were listed: the SAP Public Sector Solution Map and the Government Process Classification Scheme.

SAP has developed a series of generic process models called "solution maps", covering various industries, including the public sector, at a high abstract and technology-independent level to be used as a blueprint and a reusable knowledge infrastructure for developing ERP systems for different kinds of governmental organisations, comprising top-level governmental processes (Peristeras et al., 2008). More recently, SAP updated and renamed the public sector approach as The Intelligent Enterprise for the Public Sector (SAP-SE, 2022). Figure 2 presents SAP's approach.

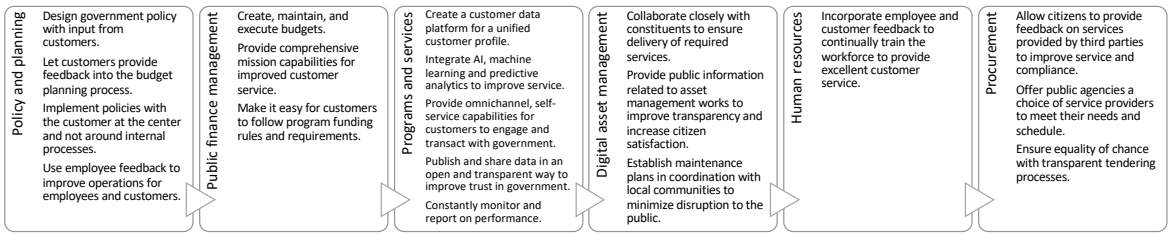

Figure 2 - The Intelligent Enterprise for the Public Sector – adapted from (SAP-SE, 2022).

The second initiative is the Government Process Classification Scheme (GPCS), resulting from a consortium comprising experts and representatives from various United States governmental organisations, which works as an information management tool to classify common governmental processes (Peristeras et al., 2008). Figure 3 presents the first two levels of the GPCS.

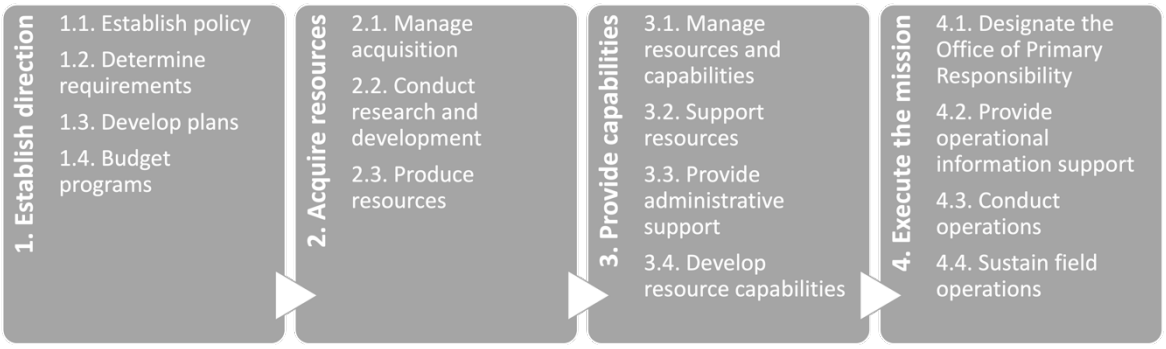

Figure 3 - The Government Process Classification Scheme – adapted from (Peristeras et al., 2008)

In another approach, a government business process classification framework was proposed, consisting of governmental business services (primary processes) and management of government resources and support processes (management and support processes) (Gökalp & Demirörs, 2014). Figure 4 presents the Government Business Process Classification (GBPC) Framework.

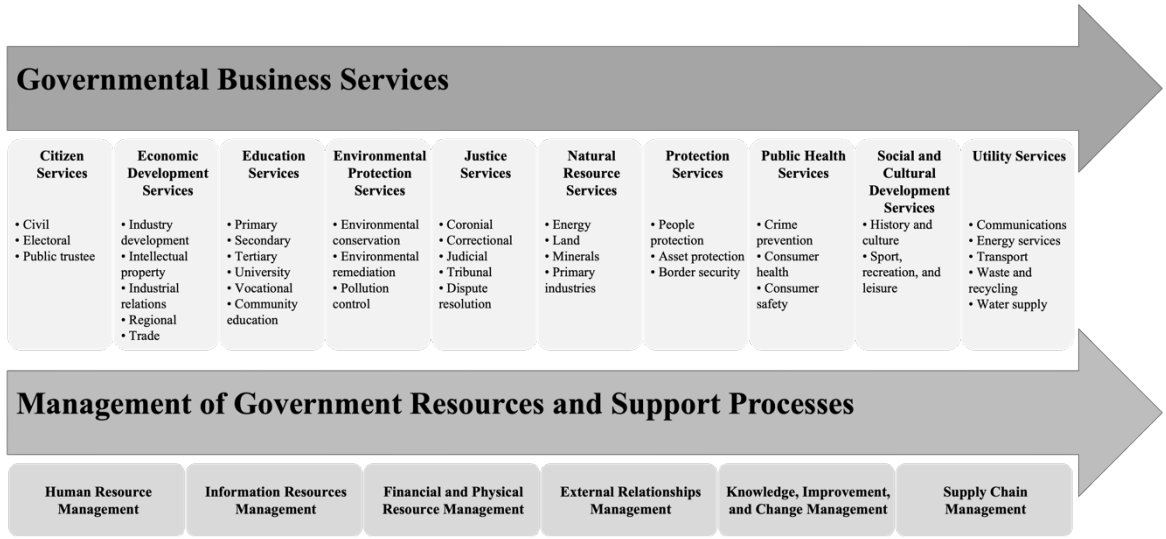

Figure 4 - GBPC Framework – adapted from (Gökalp & Demirörs, 2014)

To be the more comprehensive and processes-focused of the three classification schemes analysed, this work adopts the GBPC Framework (Gökalp & Demirörs, 2014) to classify the use case and to discuss the process tokenisation model.

5. THE EBSI CASE

The European Blockchain Service Infrastructure (EBSI) is an initiative of the European Commission and the European Blockchain Partnership. It aims to harness the power of BC for the public good (European Commission, 2023). As the first public-facing pan-European blockchain initiative, EBSI seeks to accelerate the creation and delivery of cross-border blockchain-based services for public administrations and their ecosystems to verify the information and make services trustworthy (Bosch, Tangi, & Burian, 2022). In this vein, the EBSI's ledger can hold information decentralised

and trusted, permitting new forms of verification, traceability, and transparency (European Commission, 2023).

Regarding typology, EBSI is a public permissioned blockchain, where only approved nodes by the European Blockchain Partnership can write, but everyone will be able to read/verify (Escobar, Santos, & Pereira, 2023). This design choice aligns with the best practices for the public sector (Parmentola, Petrillo, Tutore, & De Felice, 2022; Zambrano, 2020).

One of the use cases developed by EBSI is the Education Credentials under the Verifiable Credentials initiatives (Bosch et al., 2022). In this sense, this work adopts the Education Credentials use case to evaluate the process tokenisation model. Furthermore, concerning the Government Business Process Classification Framework, Education Credentials can be classified as Education Services, potentially covering all educational services (i.e., primary, secondary, tertiary, university, vocational, and community education) with a cross-border perspective.

In the Education Credentials' use case, a holder (e.g., student) can request an educational credential (e.g., diploma) from an accredited issuer (e.g., university) and present it to a verifier (e.g., employer) using his digital wallet. The verifier can instantly check the accreditation of the issuing university on the ledger. This reduces the time and cost of verification while preserving personal data and preventing forgery (Bosch et al., 2022).

The Education Credentials are based on the European Self-Sovereign-Identity Framework (ESSIF), a pure SSI framework extended and tailored to European values and regulatory frameworks, namely the eIDAS Regulation and the GDPR directive (Grech, Sood, & Ariño, 2021). Under this new SSI paradigm, digital IDs will be issued directly to citizens (holders) for storage in their wallets. In the process, holders are assured complete control of their identities and data. No personal data will be stored on-chain except for the certificate of issuance or any other relevant change in the status of the digital identification. Furthermore, any third party (verifier) with whom the citizen has shared an identifier will be able to verify both the origin (for the holder and the issuer) and the status (i.e., valid, revoked, suspended, and expired) of the issued digital identifier (European Commission, 2022).

Regarding the constructs of the Process Tokenisation Model for the Public Sector, Table 1 discusses them in the EBSI case of Education Credentials.

	Construct	Discussion
Requirements	Sensory	Are addressed by the confidence the blockchain provides to Education Credentials, boosting their adoption and acceptance.
	Relationship	The trust between the actors (Issuer, Holder, and Verifier) is enhanced, each playing their role.
	Synchronism	The EBSI's design choice as a permissioned BC with a Proof-of-Authority consensus algorithm provides the necessary performance for the verified diplomas process.
	Privacy and security risk	By EBSI's design choice, only hashes are stored on-chain, and the solution complies with GDPR and eIDAS, among other regulations, which mitigate privacy and security risks.
	Performance risk	The distributed nature of EBSI provides the necessary performance for the solution once EBSI nodes are hosted across Europe, adhering to strict security standards and availability.
Capabilities	Monitoring	All transactions are recorded on the ledger via smart contracts called by EBSI's APIs by conformant applications, maintaining a tamper-proof record of all transactions.
	Reach	The distributed nature of EBSI also provides the availability of information independent of local and time.
	Representation	The holder has complete control of their identities and data, where no personal data is stored on-chain except the hashes and status of the credentials.
Sustainable incentives	Behavioural incentives	Not observed.
	Process' standardisation	The process is highly standardised and documented by EBSI, containing the Issuer, Holder, and Verifier actors and EBSI itself as the orchestrator. In addition, the solution provides APIs for interaction with EBSI and includes data standardisation through Class Descriptions to ensure broad adoption and compatibility.
	Compliance issues	The solution provided and documented by EBSI complies highly with the laws, regulations, and established standards, such as GDPR, eIDAS, ESSIF and W3C Verifiable Credentials and W3C Verifiable Presentations. Furthermore, the fact that it does not present any compliance issue from the point of view of the process and the implemented solution makes this construct neutral in this EBSI Case.
	Supply chain traceability	Not observed.
	Resource management	Recent works associate the adoption of BC for education credentials with resource savings and resource effectiveness (Ayub Khan et al., 2021; Z. Z. Li, Joseph, Yu, & Gasevic, 2022). In addition, EBSI's cross-border scope allows for regional and continental reach, maintaining data ownership with the holders, and enhancing the gains from its adoption in this specific case.
	Circular economy	Not observed.
	Credit management	The EBSI case does not deal with or interface with credit management or another environmental token in such a way that this construct could impact the tokenisation process.
	SDG monitoring	The EBSI case can contribute to SDG4, SDG8, SDG12, SDG15, SDG16 and SDG17, so their indicators need to be reliably measured.
Blockchain outcomes	Reduction of intermediaries	Giving the ownership of the data to the holder and the BC's characteristics of the EBSI case contribute to reducing intermediaries such as notary services.
	Trust enhancement	The EBSI's ledger can hold information in a decentralised and trusted way. Also, the BC's characteristics bring trust to this public sector business process, increasing the confidence between the parties (i.e., students, universities, and employers).
	Dealing with digital assets	The diploma is an official document that can be successfully represented digitally and with its status (i.e., valid, revoked, suspended, and expired) being handled as transactions.
	Performance	Verifying a diploma (or other credentials) is a non-transactional public sector business process in which performance is not critical. Nevertheless, the EBSI's design choice as a permissioned BC with a Proof-of-Authority provides the necessary performance for this process.
	Immutability	The validity of the diploma, which can be verified along with its status (past and current), is based on the immutability characteristic provided by BC.
	Shared write access	In the EBSI case, each of the accredited issuers (e.g., universities) must have shared written access to issue the diplomas and record them on the blockchain.

Table 1 - Constructs of the Process Tokenisation Model for the Public Sector in the EBSI case

6. DISCUSSION AND CONCLUSION

Process tokenisation is more than desirable, being necessary, mainly in the public sector, to reverse the declining citizen trust in governments. But, if tokenisation can increase trust and confidence, it does not apply to all business processes – some processes are more amenable to tokenisation than others.

To help practitioners and public sector managers identify the most suitable governmental process to be supported by blockchain – what, besides the gain of trust, is essential to the best allocation of public budget on the right initiatives – the Process Tokenisation Model for the Public Sector demonstrated to be a valuable tool.

As demonstrated, the blockchain characteristics meet all the "requirements". But, more than that, the "capabilities" reinforce the fitting between the proposed model and BC. Also, these constructs, derived from PVT and ePVT, demonstrate the pertinence of these theories to the blockchain context.

Going further, with sustainable concerns, the "sustainable incentives" show light over considering aspects and benefits related to sustainability in selecting the most suitable public sector business process for adopting blockchain. This aspect allows us to conclude that blockchain in the public sector could also contribute to sustainability and Sustainable Development Goals.

Finally, the "blockchain outcomes" synthesised business processes' desirable outcomes that can help match these goals with blockchain characteristics. With tokenisation, they represent relevant enhancements for the public sector business processes, contributing not only with trust but also efficiency and efficacy to the process execution.

These conclusions were evidenced by the EBSI case of Education Credentials, which discussed each of the constructs proposed in the context of this Education Service following the Government Business Process Classification Framework, also presented in this study. Another point that deserves to be highlighted is the importance of design choices, described as essential in many of the constructs presented and confirmed by the EBSI case.

Regarding theoretical contributions, this work validated the PVT / ePVT constructs in the BC context – as demonstrated, the adherence of the requirements and capabilities constructs to an IS artefact, with the service provider's perspective, evidences the PVT's applicability in the context of an IT infrastructure. Moreover, regarding generalisation, researchers will find sustainable incentives and desirable outcomes for blockchain in the public sector that enrich the extant body of literature.

Concerning practical implications, decision-makers will find relevant elements to choose the most suitable governmental process to be tokenised, also foreseeing sustainable potential benefits. This approach is wanted to achieve the SDGs, especially in the public sector, where budgets are derived from taxes collected.

This paper has limitations. First, as a position paper, it lacks a deeper literature review. Second, the model description with only one use case can limit the analysis, compromising the generalisation potential. In this way, reporting other cases may present a more realistic picture for generalisation. Third, the proposed desirable outcomes were derived from extensive bibliographic research, taking care to, for each construct, highlight the works that referenced them. However, these desirable outcomes were not validated qualitatively or quantitatively. Moreover, the proposed Process Tokenisation Model for the Public Sector was not discussed, considering the challenges and concerns of blockchain in the public sector.

Future works, beyond exploring the limitations mentioned above, mainly involve the validation of each construct by qualitative empirical research and the evaluation of all of them to demonstrate the relationships between the variables; also, an in-depth study of the Government Business Process Classification Framework in the blockchain context demonstrates a potential to contribute to theory and practice.

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