

**BLOCKCHAIN AND TOKENIZATION APPLIED TO ACCOUNTING AND AUDITING:
STUDYING THE COURTS OF ACCOUNTS OF BRAZIL AND PORTUGAL**

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Abstract

This work aims to evaluate the current stage of the blockchain technology application by the external control of the public sector in Brazil and Portugal, by identifying publications in documents and processes made available on the Courts of Accounts of both countries. We found 70 results distributed by 15 courts, leaving 19 courts without any reference, and only two effective application. Given the lack of practical applications in this field, we carried out a proof of concept referring to a previous study demonstrating the traceability of budget accounting represented by tokens in blockchain networks.

Keywords: Tokenization, Blockchain Technology, Audit, Public Accounting, Proof of Concept.

1 Introduction

The expansion of the use of computer networks has caused unavoidable changes in the market and in labor relations, in the professions, in short, in all areas of people's lives in recent decades. Nowadays, on the road to the new technological perspectives, the increasingly massive reality of the application of blockchain technology, smart contracts, and tokenization it has the potential to severely impact the reality of businesses and the public sector.

It has become common for digital robots to be tracking the preferences of people who access the internet, mapping interests to offer products and services to consumers. When an interested party accesses a page of airfare price searches for a particular destination, moments later, when accessing social networks, many other opportunities for events, car rentals, restaurants, hotels, and other options related to exactly the same location previously searched, for the same period of travel of the interested party are proposed.

Identically, the physical tracking of movements of property items begins to gain strength, as in larger-scale applications in the field of supply chains and logistics. Some ongoing pilot projects explore blockchain technology in supply chains, such as the maritime cases, Hyundai Merchant Marine (HMM) in South Korea, announced that in September 2017 it successfully completed its first pilot experience using blockchain technology by successfully completing its first pilot journey using blockchain technology for shipment reservation, cargo delivery and real-time container monitoring and management (Wang *et al.*, 2019).

In the food industry, Walmart, using IBM's blockchain software, reduced to 2.2 seconds the tracking of mangoes shipped from farms in Mexico to all U.S. stores. Typically, Walmart's IT system can take up to 7 days to identify the source of a bag of mangoes with some kind of contamination (Kamath, 2018).

This technology allows all products – food, medicines, vehicle parts, computers, mobile phones – to have their "life" tracked from "production/birth" and at all times of their circulation in the market to consumption or use through tokens created in distributed systems.

As noted, there are already systems capable of tracking even people and physical property items that are not connected to computer networks. Even more advanced is the stage of searching, tracing, and processing data available on internet-connected computer networks. To do this, it is enough that software (oracles – programs that have true and confirmed information from various reliable sources) obtain the necessary information and are able to transmit it to other programs that ensure its treatment and the database organization in blockchain networks.

Thus, the financial, budgetary, and accounting information of companies and governments constitute digital databases ready for exploitation by computerized software and systems, notified by oracles and smart contracts, which have enormous potential for use by digital intelligences such as systems developed in blockchain, which should increasingly impact the performance of accounting and auditing professionals of the public and business sectors.

Through the use of tokenization and smart contracts in the systems of execution and control of public spending in a blockchain network, it will be possible for governments to make identical traces by monitoring the path of public resources throughout their stages of planning, execution, and control of public budgets, with significant impacts on audit procedures, with great potential for disclosure and control.

In this context, this study aims to evaluate the current stage and perspectives of application of blockchain technology in the control of public spending, through an analysis of publications on the electronic pages of all the courts of accounts in Brazil and Portugal (BR-PT), in order to investigate the initiatives in dealing with the theme in the public sector.

Adding possibilities of use of tokenization and other aspects are proposed by scientific publications around the theme, since the emergence of blockchain technology proposed by Nakamoto (2008) has linked it to the field of accounting and public auditing. In view of this relationship between accounting and blockchain technology, a proof of concept is developed to demonstrate the transactions carried out in a public blockchain, as a way to highlight traceability and highlight the possibility of controlling and auditing accounting operations in the distributed ledger, in terms of transparency and public control.

From this point of view, the research was organized according to the following path: chapters 2 and 3 deal with a bibliographic review on the decentralized consensus protocol of blockchain technology and Distributed Ledger Technology (DLT) applied to the field of accounting and auditing; in chapter 4, the methodology is presented; in chapter 5, the initiatives for the application of blockchain technology in the Courts of Auditors of Brazil and Portugal are

shown, chapter 6 is about the future of accounting and public audit in system tokenized with the application of blockchain technology; and Chapter 7 presents the conclusions.

2 Literature Review

2.1 The Decentralized Consensus Protocol of Blockchain Technology

Blockchain technology is related to the emergence of the first crypto and digital currency that marked the beginning of its development, from the article credited to an author (or authors) still unknown today, through the publication of Nakamoto (2008) in his whitepaper "Bitcoin: A Peer-to-Peer Electronic Cash System". However, the use of blockchain technology advances to very diverse areas, as it has been proposed in scientific articles, but still lacking practical applications with effective results in people's lives, both due to technological limitations and the financial costs of access to state-of-the-art development.

The important characteristic of consensus building among unknown people who do not necessarily need to trust the other party has expanded their employment possibilities in various fields. The features of using blockchain technology, summarized by (O'Leary, 2017), are presented below:

- each participant [of the computer network] maintains a replica of a digitally signed shared transaction book;
- there is an immutability of the distributed ledger, with transactions only being attached;
- each replica is maintained through a consensus synchronization process;
- the network is completely open about who can participate, execute the consensus protocol; and maintain the shared ledger [DLT].

Distributed accounting is a kind of eBook consisting of an asset database that can be shared across a network of multiple computers, websites, regions, or institutions, based on blockchain technology. All participants in a blockchain network now have their own identical copy of the corporate name and their immutability characteristic is precisely because the copies are not centered in the traditional form of backups, but are recorded with each new change in the devices of all network participants, which characterizes that the network consensus protocol attests to the reliability of the information automatically for each new network data insertion, e.g. after each constitution of the new blocks (Tapscott & Tapscott, 2016).

According to Drescher (2017), advocates of these systems claim that almost every aspect of our lives will be affected by the emergence of digitalization and peer-to-peer networks,

such as payments, loans, insurance, as well as issuing and validating birth certificates, driver's and ID cards, passports, degrees, and patents.

These records are verifiable because blockchain accounting is done using two keys (encrypted codes), one private (private access of the agents that register), and a public key (which allows confirmation of the record).

One way to use blockchain technology for asset tracking and relationship is through token creation. Li *et al.* (2019) demonstrates how to convert real and virtual objects into blockchain-backed tokens through a protocol called Open Asset Protocol (OAP).

The consensus protocol allowed in blockchain is what allows the linking of assets. Some kinds of tokens are already widely traded as species of crypto currencies representative of the assets themselves, such as gold, like the PAX Gold token (PAXG). Anyone holding the PAXG token holds the underlying gold held in custody by Paxon Trust Company, including being able to physically redeem it (Casarilla, 2019).

2.2 The Blockchain Applied to the Field of Accounting and Auditing

Humanity's progress is marked by the emergence of new technologies and the human ingenuity they release. This idea is contained in the preface to a report produced by the UK Government, dated December 2015. Quoted document states that DLT has the potential to create one of those bursts of creativity that catalyze exceptional levels of innovation. So, it describes that this technology has the potential to help governments collect taxes, deliver benefits, issue passports, register land records, secure the supply chain of goods, and generally ensure the integrity of government records and services (Walport, 2015).

Thus, considering that a wide range of public services can and should be implemented based on this blockchain technology, public spending and its consequent supervision and control should be done directly in purely distributed systems (peer-to-peer), and much research has been done in this sense in recent years. Emerging blockchain and Bitcoin literature is growing rapidly (O'Leary, 2017).

According to McCallig *et al.* (2019), the potential of blockchain to change the way business records are stored and interact with each other has been widely recognized.

Distributed accounting technology can provide government with new tools to reduce fraud, errors, and the cost of paper-intensive processes. It also has the potential to provide new ways to secure the ownership and provenance of property and intellectual property (Walport, 2015).

One of the blockchain networks available as an alternative to bitcoin and in broad growth of use is the Ethereum network, which serves to facilitate the exchange of data, information, voting, etc., indicating that there are possibilities of use far beyond simply serving

as a disruptor for current financial institutions. Virtual currency networks are used to create tokens for several user-defined purposes (D'Alfonso *et al.*, 2016).

Faccia *et al.* (2019) demonstrate that the combined use of big data, blockchain, artificial intelligence, XBRL language, electronic collection, digital signature in a single homogeneous system would make possible to obtain an integrated system capable of solving several challenges simultaneously. These authors state that this new approach can provide an innovation for accounting and financing of big data management.

A different development aimed at the treatment of large databases is addressed by McCallig *et al.* (2019). These accounting data records evolved into enterprise resource planning (ERP) systems, which now store a wide range of information, including accounting records.

McCallig *et al.* (2019) demonstrated how distributed systems can increase the fidelity of financial reporting in three main ways:

- information will be provided by many entities, regardless the reporting entity, which together retain the information necessary to confirm the entity's claims;
- the financial network and accounting process that support the entity's claims will be more transparent to users of the information; and
- the information will be stored on a blockchain that uses a transparent and public recording method and cannot be changed.

Commonly cited alternative applications of blockchain technology include the use of digital assets in blockchain networks to represent currencies and custom financial instruments, ownership of an underlying physical device (smart property), non-fungible assets such as domain names (name coin), as well as more complex applications that involve having digital assets directly controlled by code implementing arbitrary rules (smart contracts), or even decentralized autonomous organizations (DAOS) based on blockchain (Buterin, 2014).

Precisely because of the multiplication of applications of blockchain technology, several impacts are envisaged in the area of accounting and auditing of companies and governments, to the extent that digital assets become part of the audited assets, as well as due to the imminent possibility of the use of blockchain technology on a large scale by entities, such as the assets control and tracking, and the use of smart contracts in the automation of processes and operations.

The term 'smart contract' was initially used by Szabo (1994), who summarizes it as a computerized transaction protocol that executes the terms of a contract. The general objectives of the smart contract project are to meet common contractual conditions (such as payment terms, guarantees, confidentiality).

With blockchain technology, the execution of smart contracts becomes feasible as supervisory responsibilities are shared and distributed among the network member nodes that validate operations (Buterin, 2014; Dai & Vasarhelyi, 2017).

Several platforms allow the programming of smart contracts in blockchain, simply connecting to the network and bearing the costs of creating and moving tokens. Cong and He (2019) list some of these platforms, such as Bitcoin, Ethereum, Lightning (built on the bitcoin blockchain), Stellar (which has its own blockchain) and Ripple (XRP), but there are others on outstanding recent growth, such as Cardano, Solana and Polkadot.

In the audit, blockchain smart contracts can be used to autonomously perform internal control tests and analytical procedures, given their versatility for business application (Rozario & Vasarhelyi, 2018). The performance of autonomous conference and control procedures, or even the autonomous execution of assets payments and transfers, which can be carried out after the conference of the provision of a service, depending on pre-established conditions in smart contracts, signals that an evolution process that will seriously impact accounting and government auditing is underway.

2.3 The Public Accounting and Audit in a Tokenized System in Blockchain Technology

The token represents the right to do some compute operation, such as an access token to a specific platform or software, that can serve as a digital signature. In the blockchain environment, tokens also have economic properties. The token is not just currency, but the main component of Blockchain. Li *et al.* (2019) divide tokens into three types, utilities, security, and asset-backed tokens, respectively.

Thus, since tokens are kind of 'digital rights', they can represent both the assets and the ledger accounts that register them. Therefore, many proposals of token applications in several activities have emerged recently, using the platforms available in the market, in which any user can directly access and create them for the purpose of their interest, being possible to subdivide them in the amount they want and monetize them according to the possibility of generating value subscribed to them.

Tokenization can be performed on any open and public blockchain network, but precisely because of the specificities of the public sector, legislation regulating government activity as well as access needs and restrictions, data privacy laws should direct government systems to the production of their own blockchains.

As an example, the Ethereum blockchain network does this by building what is essentially the last abstract fundamental layer: a blockchain with a full Turing programming language, allowing anyone to write smart contracts and decentralized applications, where they can create their own arbitrary rules for ownership, transaction formats, and state transition functions (Buterin, 2014).

Tokenization is exactly one way to link assets to blockchain, i.e. the on-chain asset, by linking a token to the respective asset, which can be generated on a platform such as Ethereum, Waves, Tron, and many others open, distributed and available in blockchain codes, some of which allow the movement of assets through smart contracts, with the insertion of program codes to the taste and interest of the creator.

Although they are the most widely used today, financial instruments are just one type of contract that can benefit from blockchain code. As technology matures, other assets - for example, real estate or intellectual property - can be stored and traded on blockchain systems. Once new types of assets become "on-chain", the agreements used to govern them in the world today (such as a mortgage or licensing agreement) can benefit from blockchain-based analogues (Stark, 2016).

Once assets are represented by the token, both companies and governments can use tokenization as a digital representation of assets. To Li *et al.* (2019) asset-backed tokens represent real-world assets, which can be real estate, art, derivative markets, non-fungible assets, commodities, services, and even identity. As for the name of a specified token, it depends on what kind of things relate. As an example, the cited authors deal with a policy-backed token, called a policy-backed token.

Li *et al.* (2019) proposed the OAP for tokenizing assets with blockchain technology platforms. Unlike unfounded blockchains and "air currencies" (virtual currencies), cited authors linked each token with one thing in reality so that the value of tokens varies with these items. For example, a contract, a company, an insurance policy, as well as a car, a chocolate box, any object we could touch and see could be mapping things supported to a token on the blockchain. Thus, the assets of an entity or individual can be described in tokens, which can be searched by a blockchain address identified and computed under the authentication of the owner.

Advancing to concrete applications in the public sector, Silva *et al.* (2020) propose a possible model of tokenization of budget accounts capable of showing the phases of execution of public expenditure in the blockchain of the Waves platform, in which a token was created to serve as a budget marker in the simulator system of this research: a stable coin, composed of the name 'Budget + Municipality Name + year' , in the case on screen, 'BudgetAveiro2020', with the exact amount of the budget appropriation approved in the legislative power, which will be treated in the proof of concept of the following section.

After the tokenization of the public budget, as proposed by Silva *et al.* (2020), it is possible for the government to monitor and track the phases of forecasting and execution of the public budget, through the accounting accounts represented by tokens in the blockchain network, also accessible to society, depending on whether public blockchain is used.

3 Methodology

It is understood that this work is a type of descriptive research, which has as its primary objective the description of the characteristics of a given population or phenomenon (Gil, 2008).

The choice for the joint study of Brazil and Portugal occurred in view of the historiography of the Brazilian formation with the origin in Portugal and the existence of numerous bilateral governmental agreements between the two countries, in addition to the relations of formation and development of education provided by the congresses and joint scientific meetings, as reported by Fernandes & Xavier (2017).

In order to accomplish the work, a literature review was carried out by searching for the terms "accounting", "auditing" or 'audit' and "blockchain" or "smart contracts" (for searching in the titles of articles, keywords and abstract) on the Scopus platform. A total of 245 documents were selected, reduced to 62 papers in the fields of 'Business, Management and Accounting' and 'Decision Sciences', and 23 papers were finally studied according to the specific objectives of the theme, all of which were published between 2017 and 2020.

The choice of Scopus database took place because, currently, it hosts a wide range of works in various scientific areas. Besides, it has the merit and quality of publications indexed by this database by several scientific research institutions which are also widely recognized worldwide (Marques & Santos, 2017).

Considering that the literature review carried out and points to relevant impacts on the public sector, we sought to evaluate the level of adoption or discussion of the theme within the external control bodies of the two countries surveyed, since they are responsible for supervising the application of public money and the character that innovations such as the application of new technologies and the development of tools for the improvement of the public sector are always developed by the courts of accounts.

Thus, to evaluate the current stage of the application of blockchain technology in the control of public spending, a search was carried out on the electronic pages of all the courts of accounts in Brazil and Portugal (BR-PT), for the purpose of analyzing how the courts of accounts have addressed the theme and what is production on the subject.

The search on the electronic pages of the Courts of Accounts (*Tribunais de Contas – TCs*) were carried out to search for documents, processes and/or decisions and judgments that cited the term 'blockchain', 'smart contract' and 'smart contracts' (which were translated as the pages are written in Portuguese) on the websites of all 34 (thirty-four) Courts of Accounts existing in Brazil and Portugal.

Finally, considering the incipience of the subject, we seek to contribute to this evolution by a proof of concept, we chose to demonstrate internal transactions of a blockchain system, based on the practical example employed by Silva, Carvalho and Carvalho (2020), and that

the transactions carried out by the aforementioned authors were made on the Waves Blockchain (a public blockchain), demonstrating the tracking of the values and accounts represented of goods and rights, in which anyone can verify the occurrences, simply by having access to public keys and exploited blockchain blocks. In this case, it is important this analysis because the citizen can analyze the accounting of public expenditures, since the authors' proposal is that the records of budget accounting can be made through tokens representing the accounting accounts and the movements of expenditure amounts can become public and transparent.

These aspects related to the accounting and public audit in tokenized systems with the application of blockchain technology, as a proof of concept to demonstrate the traceability of items represented by tokens in blockchain networks follows the model established by Li *et al.* (2019).

4 Initiatives for the Application of Blockchain Technology in the Courts of Accounts in Brazil and Portugal

Considering that the courts of auditors carry out external control of the public administration, inserted in all public expenditures, a search was carried out on the electronic pages of all the Courts of Accounts in Brazil and Portugal, in order to evaluate the total number of documents, processes, references or news that met the search term "blockchain". Analysis and identification of the stage of involvement of the control body and/or public administration in the application of technology were carried out, and the summarized resulting data is shown in the following table:

Table 1. Search for the term 'blockchain' on the pages of the TCs (BR-PT)

Control Bureau	Search results (N° of documents)	Stage of involvement
TC PORTUGAL	1	1
TCU	4	2
	3	4
	2	5
	9	1
TCE-MG	17	1
TCM-SP	10	1
TCE-PR	6	1
TCE-CE	4	1
TCM-SP	3	1
TCE-RJ	3	1
TCE-BA	2	1
TCDF	1	2
TCE-ES	1	1
TCE-GO	1	1
TCE-PI	1	1
TCM-PA	1	1
TCM-RJ	1	1
19 Courts	0	-
TOTAL	70	-

Source: Elaborated by the author.

Stage: (1) quote/reference; (2) study; (3) working group; (4) pilot project; (5) practical application.

Caption: TCU – Tribunal de Contas da União (Federal Court of Accounts); TCE - Tribunal de Contas Estadual (State Court of Accounts); TCM – Tribunal de Contas de Município (s) (Municipality Court of Accounts); TC (Tribunal de Contas – Court of Account).

All documents identified in the search were analyzed individually to verify the level of involvement. The findings indicate that, of the 70 results, distributed by 15 courts, there are only 2 (two) references to effective applications of blockchain technology, in proceedings being processed at TCU and another 3 (three) cases of projects under development (pilot) with a view to implementation in relation to the documents of that same control entity.

As practical examples of those mentioned at the TCU, there is the data sharing protocol of the CPF¹ that uses Blockchain technology (*bCPF*), developed by the Brazilian Federal Revenue Office (RFB). Another tool called Pier was developed by the Central Bank of Brazil (Banco Central do Brasil - BACEN) in free software, as a decentralized and collaborative network, based on blockchain technology, which can revolutionize the way in which supervisory entities of the National Financial System (Sistema Financeiro Nacional - SFN) such as BACEN, CVM, the Superintendence of Private Insurance (Superintendência de Seguros Privados - Susep), and the National Superintendence of Supplementary Pension (Superintendência de Previdência Complementar - Previc) exchange protected information among themselves.

The Court of Auditors of Portugal reports the progress of the project with a view to the implementation of the Accounting Standardization System – Public Administration (Sistema de Normalização Contabilística para Administrações Públicas - SNC-AP) presenting a solution for conciliation and accounting processes through the DLT, in which a proof of concept was prepared, including presentation / discussion of the work leading to the prototype to be developed by the World Bank, with some software houses representative of public administration sectors (health, education).

In addition, it was identified that there is one (1) case of a scholarship granting for research in the area of blockchain (Tribunal de Contas do Distrito Federal - TCDF); and 4 (four) projects under study (TCU) with a view to implementation.

All the other 60 (sixty) documents identified deal with news, references in congresses and seminars, lectures, presentations of companies or meetings with technicians or researchers on the theme, without any indication of specific study, working groups, research, or pilot projects in development.

¹ Cadastro de Pessoas Físicas (CPF), which represents the tax identification of natural persons.

It is understood that it is worth highlighting the cases of TCE-MG (Tribunal de Contas de Minas Gerais) and TCM-SP (Tribunal de Contas do Município de São Paulo), with 17 and 10 references to the subject, respectively.

Finally, it was found that the other 19 (nineteen) websites of courts of accounts of Brazilian states and municipalities make no reference to lawsuits or report nothing about the term blockchain, distributed ledger technology or smart contracts.

For comparative purposes, some ongoing projects and information about technology published by external control entities from other countries in more advanced stages are cited, identified from the same search for the term "blockchain" in the respective countries.

In the USA, GAO developed a report titled "GAO-19-704SP BLOCKCHAIN & DISTRIBUTED LEDGER TECHNOLOGIES", published on 09/16/2019, which demonstrates the advantages, challenges, as federal agencies are evaluating and using DLT, including describing the existence of a document produced under the title "Virtual Currencies: Emerging Regulatory, Law Enforcement, and Consumer Protection Challenges, GAO-14-496" (GAO, 2020).

The government of Tsukuba City, Japan, announced a system based on blockchain technology for the population to vote on social development projects. The aim is to increase the authenticity and security of votes. Called *My Number*, the system is the first that uses blockchain for voting in Japan. Each citizen receives a twelve-digit digital key, which serves as a digital ID linked to the decentralized blockchain network. The code prevents voting from being spoofed, duplicated, or used by third parties (Japan Times, 2018).

In Estonia, a small country in Eastern Europe, a maximum of 15 minutes is required to complete the entire process of selling a car; 30% of voters voted online in the last election; 98% of prescriptions are prescribed digitally between the doctor and pharmacist without any paper; people can access their bank account and make payments, as well as use public transportation with their blockchain-controlled identity card (Tapscot & Tapscot, 2016).

The benefits of the implementation of blockchain technologies, as provided by (Zemánková, 2019), are generally important to protect information, reduce errors, promote reliability and improve the effectiveness and integrity of the options, which is among the objectives of existence of the Courts of Accounts, so it can be said that much of what research and science has developed in the area of these new technologies should significantly and disruptively affect the ongoing activities in the area of external control and government audit.

5 Tokenization: a Proof of Concept

We use the example of the tokens created by Silva *et al.*, 2020, to verify what happens with transactions within the blockchain and what is evidenced openly so that everyone can see

the transactions and have an idea of the transparency and verifiability provided by blockchain technology.

Referred tokens is used to represent budget accounts, for traceability purposes, with the function of going all the way through budget execution, by budget agencies and units, according to the local administrative organization (Silva *et al.*, 2020).

The tokenization of a fictitious public budget, through the actual creation of tokens representing budget accounts, which are triggered according to the phases of public expenditure execution described in the following table.

(1)	<table border="1"> <tr><td colspan="2">Dotações Iniciais (BR/PT)</td></tr> <tr><td>50.000</td><td></td></tr> </table>	Dotações Iniciais (BR/PT)		50.000		(ORÇAMENTO TOTAL 50.000)	LEI ORÇAMENTÁRIA: autoriza a dotação inicial que se torna disponível para o gasto público.		
Dotações Iniciais (BR/PT)									
50.000									
(2)	<table border="1"> <tr><td colspan="2">Crédito Disponível (BR)</td></tr> <tr><td colspan="2">Dotações Disponíveis (PT)</td></tr> <tr><td>1.600</td><td>50.000</td></tr> </table>	Crédito Disponível (BR)		Dotações Disponíveis (PT)		1.600	50.000	(1)	<p>2º o crédito disponível é empenhado (compromisso do orçamento);</p> <p>3º o valor empenhado é liquidado (recebimento do bem/serviço e surgimento da obrigação de pagar);</p> <p>4º o bem ou serviço é pago.</p>
Crédito Disponível (BR)									
Dotações Disponíveis (PT)									
1.600	50.000								
(3)	<table border="1"> <tr><td colspan="2">Crédito Empenhado a Liquidar (BR)</td></tr> <tr><td colspan="2">Cabimentos/Compromissos (PT)</td></tr> <tr><td>1.200</td><td>1.600</td></tr> </table>	Crédito Empenhado a Liquidar (BR)		Cabimentos/Compromissos (PT)		1.200	1.600	(2)	
Crédito Empenhado a Liquidar (BR)									
Cabimentos/Compromissos (PT)									
1.200	1.600								
(4)	<table border="1"> <tr><td colspan="2">Crédito Liquidado a Pagar (BR)</td></tr> <tr><td colspan="2">Obrigações Processadas (PT)</td></tr> <tr><td>1.000</td><td>1.200</td></tr> </table>	Crédito Liquidado a Pagar (BR)		Obrigações Processadas (PT)		1.000	1.200	(3)	
Crédito Liquidado a Pagar (BR)									
Obrigações Processadas (PT)									
1.000	1.200								
	<table border="1"> <tr><td colspan="2">Crédito Liquidado Pago (BR)</td></tr> <tr><td colspan="2">Pagamentos Período (PT)</td></tr> <tr><td></td><td>1.000</td></tr> </table>	Crédito Liquidado Pago (BR)		Pagamentos Período (PT)			1.000	(4)	
Crédito Liquidado Pago (BR)									
Pagamentos Período (PT)									
	1.000								

Source: Silva *et al.* (2020).

Fig 1. Flow of budget account records (BR-PT)

Thus, budget control can be carried out by parallel and immediate monitoring of accounting account movements, both budgetary and equity and financial, because the blockchain network is opened for access by the block explorer available (As seen in the demonstration of this proof of concept) by the public blockchain, such as the Waves network cited in the example and the electronic addresses available in the referred paper.

Following this model is possible the construction (programming) of token (which can function as crypto currency species) and smart contracts in existing public blockchain networks such as Ethereum, Polkadot, Cosmos, Waves, among others. In fact, the same network can be employed by several users such as municipal, district, or central governments.

In order to demonstrate the access to a blockchain network and the traceability possible by the use of tokenization, we use the example of tokens created by the algorithm referred in Fig. 2, which can be viewed in the Waves Explorer when typing the account addresses seen in the paper cited in the blockchain block explorer.

This operation proves the traceability and transparency provided by the technology, since anyone can follow the budget represented by the token on screen, besides allowing the

confide of all the movements of resources already occurred in this account, as seen in the following table.

The screenshot shows the Waves Explorer interface. At the top, it displays 'waves Explorer' with a 'Mainnet' dropdown and a 'Back' button. The address '3PBLW2pvyetLhhymaGgVtbuZ8iaPYnRMUzN' is shown with a 'Copy' button. Below this, there are four balance sections: Regular Balance (1.029 WAVES), Generating Balance (1.029 WAVES), Available Balance (1.029 WAVES), and Effective Balance (1.029 WAVES). A table of transactions follows, with columns for ID / Type, Timestamp, Sender / Receiver, and Amount in / out. Four transactions are highlighted with colored boxes: 'Asset Transfer' (green), 'Asset Transfer' (green), 'Mass Payment' (red), and 'Asset Issue' (green).

Regular Balance	Generating Balance	Available Balance	Effective Balance
1.029 WAVES	1.029 WAVES	1.029 WAVES	1.029 WAVES

Transactions	Aliases	Assets	Non-fungible tokens	Data	Script
EzCMm1bLXMV9sBX17hWpfK27AizB67...					
Asset Transfer				↓ 3PHfBNo3uPo6QpXSARg1cGgg1vgLw...	1 READ attachment
Ff7nCbniatzg11S71CAYQdaPgA7LbQGEE...					
Asset Transfer				↓ 3PHfBNo3uPo6QpXSARg1cGgg1vgLw...	1 educacoin
CAdqt4XEoNMfy1Q9hXgZivp5jDT6VCME...					
Mass Payment				↑ 3PBLW2pvyetLhhymaGgVtbuZ8iaPYn...	50000 BudgetAveiro2020
3fEDG8ydDi59bhsLxEVU9M9CT9TYTBy...					
Asset Issue				3PBLW2pvyetLhhymaGgVtbuZ8iaPYn...	50000000000 BudgetAveiro2020

Fig. 2. Account 3PBLW2pvyetLhhymaGgVtbuZ8iaPYnRMUzN on the Waves Explorer

In the example described the address that refers to the token created to represent the general public budget account was used, (Budget – 3PBLW2pvyetLhhymaGgVtbuZ8iaPYnRMUzN), as well as any tokenized public budget account available to the citizen on a public blockchain such as Waves Platform, in which 4 transactions occurred between February 10, 2020 and July 26, 2020 were highlighted, leaving a balance of 1,029 Waves.

This accessibility can be verified at any public blockchain address by simply accessing the block explorers of each blockchain over the internet, such as the following:

- <https://wavesexplorer.com> - blockchain Waves (example of this paper);
- <https://www.blockchain.com> – Bitcoin - Bitcoin Cash – Ethereum;
- <https://etherscan.io> – Ethereum - tokens ERC-20;
- <https://tronscan.org> – Tron;
- <https://blockchain.com> – Bitcoin, Ethereum, Cardano, Ripple, Litecoin, Stellar, EOS, Monero, Tezos, Dash, Zcash, Mixin, Groestlcoin, Solana, other.

It is important to highlight that the operations described in each block of data of the public blockchain network is seen by all who access it, but without identifying the holder of the public key (account), but once known, all the inputs and outputs of the past and its future are now traceable, this being a striking characteristic and advantage of blockchain.

This has a direct implication on accounting and the public auditor, because the control and audit procedures can turn to the accounting accounts now treated as wallets that maintain their balances in the blockchain network, which can be intended to meet the budget categories of public expenditure (Administrative, Functional, Programmatic).

With tokenization, current spending on the public health function over a period of time of the COVID-19 pandemic, a public work, personnel expense, or an asset item such as a computer can be accompanied in specific wallets to accumulate the representative tokens of the respective accounting accounts, in order to control acquisition prices, asset allocations or comparison of execution with budget forecasting for control and audit purposes, including throughout the population.

As an example, in January 2021, it was announced that two British hospitals were using blockchain technology to keep tabs on the storage and supply of temperature-sensitive COVID-19 vaccines, in one of the first initiatives of that kind in the world. They use the Texas-based ledger Hedera Hashgraph, owned by firms including Alphabet's Google and IBM, which monitors vaccines and other treatments for Britain's National Health Service (NHS) (Wilson, 2021).

It should be noted that tokenization will bring news to the control and accounting websites in the public sector, in view of the possibility of instant audit procedures and great possibilities of disclosure and publicity of the performance of government managers, which can cause a significant reduction of costs and gains in efficiency in the application of public resources.

The above-mentioned references seem to indicate that auditing in blockchain systems maximizes the potential of concomitant control, contrary to the way in which they have always imposed themselves as an *a posteriori* (ex post) modality on the acts and facts already occurred, changing the focus for monitoring public spending for the time in which it occurs.

As stated by Rozario & Thomas (2019), at DLT business events are visible by customer accounting and near real-time auditing as soon as transactions are posted on the blockchain. This is a possibility provided by technology, to which Dai *et al.*, (2019) conceptualize as 'real time auditing' and Zemánková (2019) as 'automated audit process'.

6 Conclusions

This work aims to evaluate the current stage and the prospects of application of blockchain technology in the control of public spending, through an analysis of publications on the electronic pages of all the courts of accounts in Brazil and Portugal, in order to investigate the initiatives in dealing with the theme in the public sector, as well as the possibilities of

tokenization use and other aspects which are proposed by scientific publications around the theme, relating it to the field of accounting and public auditing.

The search for electronic pages in all TCs of Brazil and Portugal, in a total of 34 courts with the term blockchain returned 70 results, distributed among 15 Courts, it is stated that in the other nineteen there is no reference to processes or documents in which the term sought is included, indicating the Absence of technology approach in such control bodies.

It was shown that the Brazilian TCU is the Court with the most responses to the search (eighteen), with two references to effective applications in blockchain: three cases of projects under development (pilot) and four projects under study with a view to implementation.

In addition, it was identified that there is one case of a scholarship granting for research in the area (TCDF) and other sixty documents identified deal with news, references in congresses and seminars, lectures, presentations of companies or meetings with technicians in the thematic or researchers on the theme, without any indication of specific study, working groups or research or pilot projects in development.

The Court of Auditors of Portugal reports the progress of a project with a view to implementing the Accounting Standardization System – Public Administration (SNC-AP) with solution for conciliation and accounting processes through DLT, to be developed in partnership with the World Bank.

The literature review showed that the most modern applications should relate to the tokenization of assets linking them to blockchain, in line with the research of Stark (2016), Li *et al.* (2019) and Silva *et al.* (2020), as well as with the application of audit smart contracts (Buterin, 2014; Dai & Vasarhelyi, 2017; Clack, Bakshi & Braine, 2017; Zemánková, 2019; Cong & He, 2019).

Thus, the current stage in which the Courts of Auditors located in Brazil and Portugal are, concerning the development of projects that favor the application of blockchain suiting reveals, in most cases, only some interest and few effective implementation initiatives. This can be a field that requires much greater attention over time, mainly due to the possibilities that technology should provide for the public sector, such as the potential to help governments to collect taxes, deliver benefits, issue passports, register land records, monitoring the supply chain of goods and services to the population, and generally to ensure the integrity of government records and services.

The potential of blockchain to change the way business records are stored and interact with each other has been widely recognized in scientific research. Distributed accounting could provide the government with new tools in order to reduce fraud, errors, and the cost of paper-intensive processes. It also has the potential to provide new ways to secure the ownership and provenance of property and intellectual property.

A demonstration of the effective use of a blockchain network it was done in this paper, through the proof of concept able to highlight the possibility of traceability of assets and/or accounting accounts and monitoring of budget expenses through tokenization, which was carried out through tokens created on the Waves platform, with visualization of the block explorer of the designated blockchain, proving the transparency provided by the technology, accessible to anyone with internet access.

Thus, a wide range of public services based on blockchain technology, through the distributed ledger can and most likely should be implemented. Depending on this, public expenditures and their consequent supervision and control should be done directly in purely distributed systems, which requires research, study, and knowledge.

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