

Blockchain Potential Contribution to Reducing Corruption Vulnerabilities in the Brazilian Context

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Abstract - The recent popularization of distributed ledger technologies, which is better known in the financial sector due to digital currencies, has led to the appearance of numerous applications developed for the blockchain environment. The goal of this research is to investigate how a blockchain can contribute to the reduction of the vulnerabilities to corruption in the Brazilian context. Two stages of a literature review have been performed. The first identified the vulnerabilities to corruption in the Brazilian context and the second one identified the effective uses of blockchain characteristics. Subsequently, a deductive analysis was performed, aiming to verify which of the Blockchain initiatives presented could be potentially applied in the fight against corruption. This study points out ways to mitigate fraud and other causes of corruption to help regain society's trust in state institutions in Brazil, which has been suffering over the years from corruption scandals. Additionally, a research agenda leading to anti-corruption studies has been discussed.

Keywords - *blockchain, smart contracts, corruption levels, literature review.*

I. INTRODUCTION

Corruption may take different forms, ranging from petty frauds to grand illicit transactions. It happens in both the private and public sectors, but it is under the state apparatus where the more harmful effects are perceived. These effects present several consequences, namely: a lack of efficiency due to the misapplication of resources, equity loss due to benefits for select groups of stakeholders, bias on reward policies, as they can stimulate misbehavior among civil servants.

Corruption in public administration is related to the lack of control and governance, especially in governments where rules of internal controls are unclear, the accountability system is unable to uncover corruption, and the lack of transparency prevails [1]. Furthermore, transparency and accountability are paramount to confronting corruption in contemporary representative democracies and a way to monitor the discretionary power of the public agents, fostering responsibility and social control [2].

Most efforts related to the gradual reduction of corruption levels in organizations are focused on legal measures. From a legal point of view to a certain extent, the current levels of corruption are a consequence of the lack of laws; the more laws there are, the less corruption exists [3]. Additionally, legal measures are more focused on the punishment of those implicated in wrongdoing. However, a complex subject such as corruption needs an equally complex discussion, considering several dimensions such as legal, cultural, economic, political as well as administrative and governance ones. The

administrative and governance dimensions are the focus of this study. These dimensions involve increment in the management capacity, focusing on performance, better controls, and governance mechanisms [4].

Initiatives in the administrative and governance dimensions are, but not limited to, bureaucracy reduction, provided it involves public policies, fraud preventive measures, public transparency, participation, and social control [5]. These initiatives present a fundamental contribution; however, to fight corruption effectively, it is necessary to go further and use the contributions of new technologies.

Blockchain is related to the bitcoin cryptocurrency, a new financial transaction technology that has been considered an extremely innovative method of exchanging money, assets, shares, or any valuables [6]. Bitcoin and blockchain work together, as blockchain is a safe environment for financial transactions using bitcoin. Blockchain works like a ledger, where transactions are recorded in blocks and distributed to all interested parties with encrypted security, making your information virtually immutable, due to the need for validation by the previous block and registration on all nodes in the network [8].

The blockchain technology was developed to be virtually fraud-proof, presenting unique cryptography and security characteristics. Created in 2008, blockchain has recently claimed attention from both the organizational and the academic worlds. Furthermore, it is a completely digital process, which is controlled by an application layer protocol that validates transactions through a peer-to-peer network (P2P), having its operation and governance distributed and non-regulated by any central, private, or state organization [7].

This paper aims to discuss how blockchain can contribute to the reduction of the vulnerabilities to corruption in the Brazilian context. Given the contextual differences among countries, only the papers that have studied corruption in Brazil have been considered. It seeks to answer the following research question: Does blockchain have the potential to reduce corruption?

The structure of this research follows the recommendations of [8]. This first section discusses the subject and the research problem as well as the goals and motivations. Section II explains the methodological procedures. Section III presents the results and their discussion, followed by the final remarks in Section IV.

II. RESEARCH METHOD

This exploratory-descriptive cross-section research and presents a qualitative approach due to the nature of the data and the analysis techniques employed. The literature review was the primary data collection technique used; it was applied. The first identified vulnerabilities to corruption were obtained through the analysis of 227 papers. Due to the contextual differences among countries, only the papers that studied corruption in Brazil were considered. The second one identified the key characteristics of blockchain, which is mentioned in the 65 papers that were analyzed.

Which are the vulnerabilities of corruption in the Brazilian public sector according to the literature? The Develop Review Protocol was: Scientific papers published in peer-reviewed journals, which are indexed on the following databases: Scielo, Ebsco, Sage, Wiley, Springer, Emerald, ProQuest, Spell, Scopus, and Web of science. Keywords: Corruption AND Brazil or corrupção AND Brasil. Language: English and Portuguese. Period: Any year (until January 2019). Field of knowledge: Any.

Performed by three other researchers on the field. Identify Relevant Research 525 papers. The duplicated papers within and among the databases were removed (127), as well as the ones that did not approach corruption, Brazil or public service (131), remaining 267 paper. The non-academic papers and book chapters were removed, remaining 227 papers to be analyzed.

Papers were extracted from their databases and imported onto Mendeley. All papers were read and categorized on NVivo (corruption causes identified a posteriori) the validate Report was performed by three other researchers.

The procedures to select papers on the blockchain. Specify Research Questions: Which are the main characteristics of blockchain according to the literature?

Scientific papers published in peer-reviewed journals, which are indexed on the following databases: Scielo, Ebsco, Sage, Wiley, Springer, Emerald, ProQuest, Spell, Scopus, and Web of science. Keywords: Blockchain. Language: English and Portuguese. Period: Any year (until January 2019). Field of knowledge: Social sciences (to avoid technical approaches).

Performed by three other researchers on the field. Identify Relevant Research 267 papers. The duplicated papers within and among the databases were removed (129), as well as the ones that did not approach the subject (43), remaining 95 papers. The non-academic papers and book chapters were removed, remaining 65 papers to be analyzed. Papers were extracted from their databases and imported onto Mendeley. All papers were read and categorized on NVivo (corruption causes identified a posteriori) and Performed by three other researchers.

Both stages were conducted by distinct researchers and reviewed by three others to guarantee data integrity and reduce researcher bias. Following this, a deductive analysis was performed, aiming to triangulate the data and verify which of the Blockchain initiatives can potentially be applied to fight corruption.

III. DATA ANALYSIS

The following sections present the results of the literature review on corruption vulnerabilities (A) and blockchain (B) as well as the crossed analysis of the two previous sections (C).

A. Corruption vulnerabilities identification

The analysis of the papers on corruption in Brazil shows that the number of papers has increased significantly; for instance, of the 227 articles, 141 were published in the last five years. The primary vulnerabilities identified are related to the lack of control, accountability, and transparency. The presents the results of the categorical analysis and the identified vulnerabilities, which are classified in descending order by the number of references found in the texts and the number of articles where they appear.

Non-effective management and control (67), (103); Public and political agents' corrupt behavior (67), (73); Overlapped bureaucracy and bureaucratic hoops (51),(65); Lack of proper accountability and audit (46), (61); Non-effective or lack of transparency (40), (60); Impunity (36), (53);Fragile electoral-political system (35), (52); Low citizen participation (28), (35); Non-effective compliance in public governance (26), (32); Bending the rules to take advantage at all costs (24), (27); Generalized corruption perception toward government institutions (22),(26); Public agents' discretionary power misuse (20), (26); High tolerance to illegal behavior (15), (22); Excessively gullible citizen-government relations (6), (7); Inequalities (5), (6).

Non-effective management and control constitute a vulnerability, given that the fight against corruption depends on good management practices [9]. The lack of effective planning is associated with extra last-minute investments and the necessity of claim urgency, consequently leading to buying or contracting without bidding [10]. It is necessary to improve systematized mechanisms focused on internal control [11] that operate preventively by establishing a hostile environment for fraud and corruption [12].

Sometimes, civil servants create vulnerabilities by selling their unethical services, focusing on their gain [13]. These corrupt behaviors can be perpetuated and socialized as a way of persuading newcomers to accept corruption acts as normal in some contexts [14]. However, extremely strict rules, which are established to avoid unlawful behavior, can affect the autonomy of the public managers regarding decision-making that best benefits the citizens [15]. Based on this, public and political agents' corrupt behaviors constitute a vulnerability.

Additionally, the lack of proper accountability and audit was identified as a vulnerability, which is related to the superficiality and an insufficient number of audits [16], the precariousness of supervision [17], and the difficulty of accessing public information through accountability [18]. This scenario generates vulnerabilities to corruption, especially when it becomes impossible to identify who is responsible for what, prior to whom, and when [19].

Audit influences public transparency and, as a result, contributes to the fight against corruption [16] and to the compliance with laws and regulations, which addresses another

vulnerability, namely non-effective compliance in public governance.

Although governance has improved in the public sector, it is still not enough to increase the quality of services or trust in public organizations [20]. Furthermore, it is necessary to implement more mechanisms of governance in the public sector [21], aiming at greater citizen participation. However, low citizen participation was also identified as a vulnerability because it is easier to commit and hide corruption when the population does not have the means to be aware of it. Society's effective participation in public management [22] brings citizens closer and improves democracy. The reduction of the distance between the government and its citizens can take place through technology [23], such as through the use of websites or social networks [24].

When sanctions are not consistently imposed, which may stem from the fact that the judiciary is susceptible to bribery or political influence [25], there is impunity, which is identified as a vulnerability. Brazilian laws do not adopt corporate criminal responsibility for crimes related to corruption, and thus, it occurs only under civil and administrative law [26]. Additionally, it contributes to a non-effective system, when "the probability of being punished is less than 5%" [27]. It is necessary to review current laws on corruption, especially about very ambitious norms, which are difficult to comply with or present extremely high costs [17].

Non-effective or lack of transparency is also a vulnerability because democracy is built on transparency and truthful citizen-government relations. However, the existence of just islands of transparency compromises its effectiveness. As a result, even if there is government data disclosure, which allows social participation, it does not mean it is effective against corruption. Furthermore, information needs to be accessible and timely [11] as well as comprehensible for all citizens [16].

The fewer citizens have access to information, the more they tend to exhibit excessively gullible behavior. Additionally, this behavior is a result of an inadequate educational background and can facilitate corrupted actions and the acceptance of popular sayings such as "he/she steals from the government, but he/she helps the population," which show a twofold negative/positive behavior, originating especially from patronage [28]. The acceptance of public agents who are corrupt but have a satisfactory administration is maximized by low educational background citizens [29], who usually present more gullible behavior. Consequently, excessively gullible citizen-government relations represent vulnerability, which is also connected to high tolerance for illegal behavior.

Too many regulations and excessive state bureaucracies called overlapped bureaucracy and bureaucratic hoops are common practices that encourage corruption [17]. For example, in the business area, the low speeds and high regulations involved in the process of opening a business can be a vulnerability, as corruption may be instigated to speed up the process [30]. The greater the bureaucratic apparatus, the greater will be the discretionary space in which a public servant can act according to his/her private interests [31], which addresses public agents' discretionary power misuse is another

vulnerability. Furthermore, misuse of the discretionary power of a public servant may involve misbehavior—from the selling of privileged information to economic reform exceptions [32]. When discretionary power is applied without proper assistance and the necessary control, it can contribute to bribery, fraud, and influence peddling [33].

In the midst of so many corruption scandals, disbelief and mistrust in public institutions and their personnel weaken democracy [34]. Therefore, it constitutes a vulnerability that is termed the generalized corruption perception toward government institutions. As a result, the perception that corruption is so widespread and deeply entrenched increases, threatening economic and social development [35] and becoming a vicious cycle. Thoughts such as "if everyone around me is corrupt and thus, has a more comfortable life, why will only I be left out?" creates the idea that the ones who do not take advantage are not smart, connecting it with another vulnerability—bending the rules to take advantages at all costs [36].

B. Blockchain characteristics

The analysis of the 65 articles allows for the identification of blockchain technology characteristics, mainly due to the frequency with which their concepts were broached in the texts. Therefore, by observing the descriptions created by the authors of each paper, the characteristics were adopted as every effective action, eventual consequence, or practical result obtained through the implementation of blockchain technologies. The characteristics classified in descending order by the number of references found in the texts and the number of articles where they appear.

Decentralized model (50), (114); Distributed registers (47), (102); Autonomous actions provided by code (44), (101); Improved security (41), (78); Actions transparency but with preserved identity (39), (77); Decision consensus (42), (76); Content inviolability (36), (63); Bureaucracy and operation cost reduction (22), (52); Public and private services quality (25),(36); Fraud-proof (19), (34); Private data property (13), (32); Fast transactions (16), (26); Transactions auditability (12), (18); Fast technology evolution (7), (8).

The decentralized technology model is pointed out as the force that makes blockchain powerful in the modern context of internet architecture [37]. The decentralized model is required to ensure data integrity and transaction privacy [38]. Among the potentialities of this feature is the fact that there is no control head, such as a bank, to monitor transactions [39]. Trust is not granted to a single organ or individual but shared by all members of the population involved [40]. Additionally, all of these endorse the fact that this feature has the highest number of citations in the articles found.

A blockchain is a distributed ledger that is generally managed by a peer-to-peer network [6]. Among this distributed register are records of ownership and transfer of ownership, records of financial transactions, digital currency records, and food applications around the world, among many others. Under the right conditions, it can offer greater service availability and resilience to many digital services provided by distributed

storage, computing, and control [41]. Additionally, the distributed records functionality adds to the network the real-time management capability of each stage of the process; this reveals the importance of its recognition by a large number of citations.

Autonomous actions provided by code was the third characteristic that has been identified. The use of blockchain Ethereum allows the adoption of smart contracts as an independent decision-making algorithm, which is defined by predetermined rules. As a rule, smart contracts can assume exchange operations of any value without conflicts and in a transparent way, thereby avoiding the use of intermediaries [42]. On the other hand, they may contain unintentional or malicious failures, allowing hostile actors to control the performance of other users [41]. Nevertheless, the characteristic of autonomy of actions, provided by code has been recognized with merit, due to the improved performance of contract processes [43].

Another characteristic that has been identified is improved security. Blockchain technology can work with the latest and most efficient digital encryption methods. The correct application of security protocols makes the network virtually invulnerable. Additionally, participant identity must also be secured using state-of-the-art cryptographic technologies and protocols [38]. For instance, a key feature of a blockchain is the secure signing of transactions by each participant that wants to send digital money to another, as in the case of crypto-coins [37].

Blockchain offers the potential for greater transparency in combating crimes of tax evasion by allowing a more transparent view of transactions and by also protecting those involved from unjustified exposures of their financial affairs [39]. It is necessary to preserve the privacy limits of citizens, and both public and private blockchain present this potentiality [39]. Therefore, the characteristic of actions transparency, with preserved identity, can be well exemplified through e-voting implementation initiatives, where the integrity of the vote-counting is guaranteed by the traceability, transparency, and immutability of the ledger while maintaining the confidentiality of the voter identity [44].

Blockchain networks are designed to function independently of the conditions of the environment in which they are operating, and consensus algorithms are the warrantors of such decision-making, authorizing their modifications or helping identify irregular attempts to change the network. It constitutes the decision consensus characteristic. Blockchain technology imposes a distributed consensus and encrypted transactions, making it difficult to compromise the integrity of your records, without being noticed by an entire network [45].

The substantial number of nodes ensures content inviolability. For instance, in the case of the Ethereum smart contracts, there are globally more than 30,000 nodes in this network [46]. Consequently, to violate the content, simultaneous interventions on more than 51% of the nodes are required for the information to be compromised, which is extremely difficult to be implemented [47]. Furthermore, content inviolability is one of the most widespread and perhaps

the most questioned features due to some attacks that occurred recently, which allowed for the recording of altered data in a range of blocks—evidence of an already exploited vulnerability. However, the solution saved the integrity of the network by eliminating a range of records, which will forever be ignored [41].

Bureaucracy and operation costs reduction is also a category that was identified. The reduction of intermediaries defines this characteristic, as the simplification of processes brings greater agility and reduction of costs [48]. Nevertheless, to achieve this benefit, changes must occur in the technological structure of the institution [40].

The adoption of blockchain not only brings improvement in processes and cost reduction, as it allows for a greater ability to compete in the market [49] but also contains the potential to modify the way health institutions, for instance, relate to their patients through a more efficient viability and reliability of personal data [37].

The fraud-proof characteristic is the primary reason for its development; according to the seminal article by Satoshi Nakamoto [7], the blockchain prevents actions related to fraud in duplicate payments. The strong implementation of security mechanisms through encryption keys and the distributed nature hinders the action of hackers along with the fact that the information only aggregates definitively to the block if it is confirmed by the nodes of the network [50].

The private data property is one of the characteristics more linked to a business model than to a technical property, as its identification is based on blockchain radically altering the possibility of monetizing data records accesses to the extent that it is possible to demand a fee from marketing companies for their use [51]. Another peculiarity is the property that each person has to determine for the amount of identity information they will share as well as to define the ownership of the digital material that it produces and makes available [52].

The processes and intermediary agents' removal commonly result in fast transactions. Additionally, situations involving money property value transfers are solved faster when compared to traditional methods [53]. An international money transfer that would take days can be done in minutes through blockchain [45].

The secure and immutable nature attributed to well-implemented blockchain environments provides greater reliability to audit processes and transactions auditability. For social business operations, blockchain works as a digital accounting system, recording all data transfer transactions in an unalterable database, with time and date records, which allows for audit operations [53].

The least-quoted category identified in the paper analysis is fast technology evolution. Blockchain is an open-source environment, and its platforms have unlimited code development and enhancement features, which are constantly evolving, thereby promoting improvements in the speed of innovation and the growth of its use [37]. Furthermore, the emergence of new means of digital financing through initial coin offering (ICO), which captures financial resources for

emerging companies, represents the usability of this feature [6]. As open-source software, most of the blockchain is open to everyone's development, which will encourage incremental innovation and further enhance the robustness of the blockchain ecosystem [6].

Additionally, blockchain has also been used to reallocate traditional functions and innovations [54], publicly fund crowdfunding systems, perform transparent tracking of state expenditures, and monitor the integrity of voters of voter-based electoral [6].

C. Current and potential uses of blockchain in the fight against corruption

At this stage of the research, the characteristics and uses of blockchain are associated either with the possibility of mitigation or elimination of vulnerabilities to corruption. In both cases, they were identified in the literature through a two-stage literature review. Thus, the vulnerabilities to corruption were crossed with blockchain characteristics.

First, each of the authors performed the analysis individually, evaluating the possible crossings according to their perception and analysis of the literature. Then, the results of each of the authors were compared in a table. Each author argued their comparisons, and in the sequence, the similarities and differences found were discussed.

Considering that a blockchain network does not have a single point of management and control [48], presenting a decentralized model means that there is no authority governing the chain. It allows for the democratic sharing of the decision in an anonymous and safe but still traceable way, contributing to an increase and improvement in accountability and auditing. Blockchain transactions do not necessarily require proprietary data [44], which contributes to improving transparency mechanisms. The guarantee of authentic and simultaneously anonymous participation can make citizens more comfortable in participating in the decision-making processes, as there is no possibility of reprisal from public power or other citizens.

Due to the distributed registers of blockchain, all participating nodes provide network logs. This ensures a balance of computational resources for faster transaction times with full transparency. Additionally, it allows for greater control of the process steps and provides access to distributed information, thereby helping management and control. Furthermore, it can provide greater service availability and resilience for many digital services provided by distributed storage, computing, and control [49], thereby helping reduce bureaucracy.

Autonomous actions provided by code involve the use of blockchain Ethereum that allows for the adoption of smart contracts as an independent decision-making algorithm, which is defined to follow predetermined rules. Intelligent contracts are autonomous, self-contained, and decentralized agreements, which are controlled by programming codes that are executed automatically under certain conditions [45]. Smart contract can help in the management and control activities, accountability and audit as well as establish limits to the use of discretionary power by civil servants and reduce impunity, provided the

contracts are not only legal instruments but also a social tool; furthermore, expectations and relationships are as important in hiring as in legal obligations [55]; [56].

Blockchain offers the potential for greater active transparency in combating crimes of tax evasion, allowing for a more transparent view of transactions [39]. The fact that blockchain transactions remain anonymous can increase the population's participation in cases of dilation of corruption and high tolerance of illegal behavior of public and political agents. Furthermore, transparency strengthens citizenship and social control [16]. A clear example of this is e-voting implementation initiatives, where scrutiny and integrity are ensured by the ledger's traceability, transparency, and immutability [44].

The consensus algorithms are the guarantors of blockchain independence management and controlling decision-making, thereby authorizing its modifications or helping to identify attempts at illegal behavior [43]. Among the aspects related to this characteristic is the increase of compliance, which occurs due to the standardization of the decision attached to the network nodes [57]. It is necessary to establish a new way of government functioning, with bureaucratization, audits, productivity, efficiency, greater participation of the population in the decision-making process, and public management [22].

All nodes in the network receive a full copy of the data transparently and validate the entry of new operations—if there is a higher percentage of favorable readings, the information is aggregated. After the registration, information is disseminated to all nodes and can no longer be definitively changed, thereby ensuring the truthfulness and inviolability of what is registered [50] and increasing confidence in government institutions. How blocks are formed and chained makes a blockchain unalterable and irreversible [58]. Considering that operational difficulties and lack of managerial capacity in governments can lead to illegal transactions [33], the inviolability of blockchain content contributes undeniably to reducing tolerance to illegal behavior.

Reducing bureaucracy and operating costs decrease the chances of corrupt behavior on the part of the public agents because the reduction of intermediaries occurs, which brings greater agility to the process [48]. It affects the overlapped bureaucracy and bureaucratic hoops. For instance, the excess of bureaucracy can also lead to corruption due to public agents' discretionary power misuse. "In turn, this increase in discretionary power was often used to nourish their corrupt networks" [32].

The integrated application of blockchain technologies, in public and enterprise environments, can improve the quality of services and processes [38], thereby combating illegal behavior and improving trust in institutions. For governments, the potential for blockchain adoption is equally compelling, with a variety of uses that could help and protect democratic principles [38], especially control and management initiatives. Additionally, corruption in public administration is related to the lack of control, especially in governments, where internal controls are unclear [59]. Furthermore, the fight against these practices through the implementation of technologies, such as blockchain, can encourage greater citizen participation.

The strong implementation of security through encryption keys and the distributed nature hinders the action of hackers [45]. The consequence is the rise of confidence in the institutions that adopt blockchain. Moreover, due to the absence of the intermediary, third party, or central authorities, which may suffer from corrupt or illegal activities, this blockchain characteristic may reduce the risks and possible damages inherent to third parties [45], besides avoiding problems related to a public agent's abuse of power. For example, the transfer of federal resources to municipalities is associated with fraud in public purchases of goods and services, misappropriation of funds, and excessive billing of goods and services [60], which demonstrates a clear tolerance toward illegal behavior. This can be counteracted through the use of blockchain solutions.

The private data property feature is linked to a business model rather than to a technical property, as its identification was based on the fact that blockchain radically alters the possibilities of monetizing access to data records [51]. It is understood that this feature has great potential for commercial exploitation, but it does not apply to combat vulnerabilities to corruption.

Due to the reduction of internal processes and agents [45], situations involving the transfer of money or property values are faster than the traditional methods [47]. When applying this concept to administrative processes transfers, it can reduce the management and planning failures of the public machine. Additionally, the real-time transparency offered by blockchain technologies reduces the time gap, allowing homeowners to make preventive exit decisions [53] and improving the lack of effectiveness of compliance with public governance. Reducing bureaucracy through blockchain, which is, admittedly, a safe and fast method [54], should create greater citizen interest in government administrative decisions, as it can immediately verify the outcome of the transactions. An impact on the culture of corruption is expected, which allows the inspection of the discretionary power of the public agent and reduce illegal behavior.

The constant records made by blockchain [53] can provide data and contribute to reducing the vulnerabilities that occur in audit, control, and management and also make the information more transparent. In general, a good quality audit can contribute to compliance, thereby reducing the perception of widespread corruption in government institutions. Being audited, in the past, reduced future corruption by 8% but increased the likelihood of subsequent legal action by 20% [61].

Blockchain presents the last evolution and will encourage incremental innovation and further enhance the robustness of the blockchain ecosystem [37]. Furthermore, this feature can remove vulnerabilities to corruption by improving management and control through ICT and e-government systems, focusing on the generation of clear and transparent information from government data and thus, contributing to citizen participation. Besides, it is also important to be able to improve the electoral system by using greater security. The use of technologies mainly applied to e-government is useful tools in the global effort to reduce corruption [62]. The contributions of blockchain to increase trust and transparency in the regulatory

environment can be especially beneficial for developing countries [63], which justifies the proposal of this research.

Two behavioral-cultural variables that can be presented with just one connection, each using blockchain, can be perceived when verifying the vulnerabilities of excessively gullible citizen-government relations and bending the rules to take advantage at all costs. Furthermore, technologies are not enough to break behaviors derived from ingrained cultural variables and the *modus operandi* of a country. However, they can indirectly change after a period of living with higher levels of transparency and more participation of the citizen, whose contribution is amplified by blockchain. The potential contribution, though indirect, is perspective and forthcoming. The vulnerability of inequalities did not present any connection to the blockchain, and excessively gullible citizen-government relations and impunity presented just one.

Additionally, it is important to emphasize that combating vulnerabilities to corruption is extremely complex. Concomitantly, the use of blockchain technologies is relatively new in public administration and therefore, its acquisition and usage strategies must be carried out through incremental mechanisms. This indicates that at the end of each cycle of maturity, the evaluation of the impact in reducing the occurrence of corruption through the use of blockchain technologies must be allowed.

IV. FINAL REMARKS

Corruption is a socio-political phenomenon that can negatively affect the development of a country, affecting the social development and the quality of life of its population. Society and public agents must create efficient strategies and use all possible resources in the fight against corruption, including the new available technologies, such as blockchain. A set of 15 vulnerabilities were identified and classified into three groups (a) namely, behavioral-cultural, socio-institutional, and structural-socio-political. Another important result was the identification of 14 blockchain characteristics, (b) which were described and exemplified. After that, a from-to analysis was performed (a x b) as a way to identify which blockchain characteristics have potential or even real uses to contribute to the reduction of the vulnerabilities to corruption. Furthermore, considering the set of vulnerabilities, 10 presented a good relation with blockchain characteristics. The other five presented no relation or modest relation.

The main academic contribution was the identification of the vulnerabilities to corruption and the characteristics of the blockchain (and both can be used for other researches) as well as the identification of the relation blockchain/vulnerability to corruption. Another academic contribution is the initiative to co-create knowledge between academia and the public sector, seeking solutions for better management of public resources.

Blockchain is a new technology with both potential contribution and mistrust, and hence, it is important to identify possible practical applications on public management. Additionally, it constitutes the main managerial contribution, provided public managers can use the results of this research to find ways to deal with corruption and also verify potential positive impacts of blockchain. The use of blockchain

technology can help in the global effort to reduce corruption; Blockchain technology increases security, inviolability, and transparency of transactions and the Blockchain presents the optimal potential to mitigate the non-behavioral and non-structural vulnerabilities to corruption.

A study carried out annually by FEBRABAN, indicates the blockchain with the third most significant investment in technology for the financial system in the country. The survey [64] explains how the great use of technology in the banking sector turns into greater convenience and security for the customer, becoming an essential instrument for discussions in academia, government agencies, media, among others. Among the main limitations of this study is the focus on vulnerabilities to corruption only in Brazil, which, although not impeding the use of results for other countries, limits its interpretation to the socio-cultural and structural specificities of the studied context. Another limitation in the interpretation and use of the results lies in the theoretical nature of the blockchain characteristics. It is important to emphasize that the way of adopting the technology can impact the use and characteristics of the services to be developed through it.

As further research, case studies in governments or public companies in which blockchain was adopted might help to understand the practical contributions of blockchain as a way to reduce vulnerabilities to corruption. A case study could be carried out, mainly involving bidding in the Brazilian public sector, verifying the transparency with the adoption of blockchain in public purchases.

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