Blockchain-Based Solution for Charitable Supply Chains: Network Proposal Architecture for Portuguese Tax Consignment Program

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Abstract. This paper presents a blockchain-based solution for enhancing transparency, accountability, and efficiency in charitable supply chains, with a focus on the Portuguese Tax Consignment Program, but adaptively to other tax systems. Charitable organizations often face challenges in managing and tracking donations, leading to potential inefficiencies and distrust among stakeholders. Leveraging blockchain technology, this research proposes a network proposal architecture that enables secure and immutable recording of donation transactions, ensures proper allocation of funds, and fosters transparency in the charitable supply chain ecosystem.

Keywords: Blockchain · Charitable Supply Chains · Network Proposal Architecture

1 Introduction

The management of charitable supply chains involves multiple stakeholders, including donors, charitable organizations, and regulatory bodies. Charity initiatives coming from citizens reveal the level of social responsibility of population, therefore such initiatives sometimes require support of State as an intermediary and reliable third-party for safe transactions. However, the lack of transparency and accountability hampers the effectiveness and trustworthiness of these processes. One of the possibilities that State provides for citizens to support socially significant organizations and projects that align with their views and values is called the tax consignment or Personal Income Tax (IRS) consignment. This paper is focused on the example of IRS consignment of Portuguese Republic, which was introduced in 2001 and currently allows taxpayers to contribute to one of more than 4000 eligible nonprofit organizations (NPOs) at no cost [1]. Portuguese IRS consignment is a mechanism that gives taxpayers opportunity to donate 0.5% of

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their tax owned to State to an entity of their choice [2] among the list of registered entities (e.g. NPOs involved in social, cultural, environmental, scientific, health, humanitarian and animal protection), for further convenience referred to as Beneficiary Entity (BE).

However, one of the crucial factors in any charitable initiative is public trust, because often there is only a minimal understanding of how exactly resources are allocated to organizations after citizens make donations [3]. Therefore, public trust building is a central issue that needs to be addressed to stimulate populations' interest in tax consignment programs. Issues, such as the lack of transparency and traceability of transactions might compromise the effectiveness of tax consignment and discourage taxpayers from participating in such initiatives. Questions like "Was the amount I consigned actually delivered to the chosen entity?", "What was the total amount that was assigned to a certain entity?", "How does the chosen entity spend the total consignment amount per year?", "What the NPO entity was able to improve in its sector?" are not easy to be answered, which once again can impact on taxpayers' willingness to participate in IRS consignment programs.

Thus, it is necessary to find solutions that may bring improvement to the tax consignment process and ensure greater security and transparency in transactions. One of the emerging technologies that is being discussed as a promising tool for transparency providing is blockchain technology (BCT). As defined by [4] BCT is a "digital, decentralized and distributed ledger in which transactions are logged and added in chronological order with the goal of creating permanent and tamper-proof records". With this definition, we may understand the potential that this technology holds for the transparency of charitable transactions, providing greater confidence to taxpayers and all stakeholders involved in the process.

This paper introduces the concept of utilizing blockchain technology to address these challenges, specifically in the context of the Portuguese Tax Consignment Program, which allows taxpayers to trace back the allocated percentage of their taxes to eligible NPO.

The purpose of this study is to investigate the ability of BCT to strengthen public trust in NPO-related transactions by providing an extensive level of transparency, traceability and efficiency. Therefore, the goal of this study is to consider the implementation of BCT on the example of Portuguese state tax consignment process through the introduction of comprehensive architecture of potential application.

The remaining of the paper is structured as following: second section contains literature review on the field, third section is describing the tax consignment program and explains the roles of main stakeholders, sections four proposes the architecture of BCT-based solution for the tax consignment program and the conceptual model of it, finally sections five and six discuss the BCT-based solution comparing it with the current process and provide paths for future research.

2 Literature Review

This section is aimed to build an understanding of the operations and the flow of resources in charitable initiatives, as well as the specifics of the BCT and improvements it can bring to charitable programs based on the example of existing applications.

2.1 Nonprofit Organizations' Supply Chains

Supply chain management (SCM) is usually used in a context of business and commercial processes, where the profit is an ultimate goal of stakeholders. However, SCM can also be applied in the context of NPOs, which also require a high level of performance, efficiency of processes and the speed of response. The authors in [5] suggest an adapted definition of such phenomena as the humanitarian supply chain management (HSCM), which characterizes "the systemic, strategic coordination of sourcing, procurement, storage and movement of physical relief goods and donations and the tactics across these functions within a particular humanitarian organization and across other actors within the humanitarian system, for the purposes of alleviating human suffering". Among the five main areas of focus for more efficient HSCM, [6] highlights the need of building trustful relationships across stakeholders and strengthening networks that may potentially extend the human resource pool available.

On the example of charity shops, [7] formulated the most common barriers that prevent populations' to be more involved in charitable initiatives, among which such issues as (1) the lack of information on how charity shops make use of donations; (2) the lack of familiarity and knowledge about the donation process; (3) the lack of awareness of the impact that donations make and other constraints can be highlighted.

When compared to commercial supply chain sector, HSCM is still an underdeveloped area, which requires more attention from scholars [8]. In order to facilitate the improvement of charity SCs and highlight the sustainability component of such, [9] suggest scholars to focus on the area of emerging technologies adoption and explore the potential that novel solutions hold for the elimination of information asymmetry and acceleration of the information flow across players. Like this, decentralized structure of the network would potentially add value to users that want to participate in charitable activities and ensure the receival of their donations in the selected organization. Thus, the next subsection is going to reveal the technological features of BCT to uncover the potential that it holds for the transparency of transactions in charitable area.

2.2 Technological Specifics of Blockchain Technology

Blockchain technology is a part of DLT (Distributed Ledger Technologies), which means that by default multiple copies of the ledger are held by different parties and are accessible in real-time, where data is added through consensus mechanism eliminating the need for a third party [10] and each transaction is represented by a data block with information, guaranteeing the security and integrity of the data (hash) [11, 12].

Like this, the main characteristics of BCT are decentralization, resistance to failures and cyberattacks, transparency and immutability of the recorded data, which enables the efficiency and trust in data for all ledger participants [10, 13]. Being immune to alteration, tampering or fraud entry [14], BCT-based networks allow verification of past entries at any time [15]. Although transparency is one of the main features of the technology, this does not mean that all data recorded on the network is necessarily visible to all participants. If required, it is possible to define different levels of access and permissions on the network, allowing only certain group of participants to have access to specific information, keeping the remaining information confidential. This is possible through

encryption and authentication techniques, which ensure that only authorized users have access to confidential data [16], thus BCT-based solutions ensure both transparency and confidentiality, depending on the needs of each use case.

BCT-based solutions can be divided into three main types: public, private and hybrid/consortium networks. Public networks were first introduced for the use of Bitcoin cryptocurrency trade, these are open and fully decentralized networks that allow anyone to participate and make transactions without the need for prior permission [17]. Private networks are more compatible with business applications and are controlled by a single entity or group of entities and require permission to access. Hybrid or consortium networks combine elements of both public and private architectures, allowing some parts of the network to be public while others remain private, it usually involves multiple organizations working together in a controlled and secure environment.

2.3 Existing Use Cases of Blockchain Technology in NPO Area

Blockchain technology is discussed to be applicable in a broad spectrum of different sectors and industries such as finance, healthcare, supply chains, governance, food and agriculture etc.

The use of blockchain solutions to fund NPOs is being actively implemented as it allows reduction of costs associated with third-parties services, protection of donating individual's data and information, and increased efficiency in recipient organizations [18]. There are several existing use cases of BCT applications for management and tracking of donations, such as:

- **BitGive Foundation** - an NPO that is dedicated to BCT application for transparency of donations of social and environmental causes. Through the GiveTrack platform, donors can track the path of their money and see how it is being used by the recipient organization [19].
- **Giveth** - an organization that promotes a reward culture and is aimed to empower people that are willing to make donations. Giveth uses Web3 to disrupt and transform the way public goods are funded, helping NPOs to evolve and reach a new level of transparency [20].
- **Goteo** - BCT-based crowdfunding platform that is built upon a "win-win" model, where donors are rewarded with non-monetary rewards, such as exclusive access to events or products. The platform aims to fund projects that may bring positive social, cultural or environmental impact. It was one of the first BCT-based crowdfunding projects in Europe and since then has been a leader in social and financial innovation [21].
- **Blockchain Charity Foundation (BCF)** - is an initiative led by cryptocurrency organization Binance, it applies BCT to help address global charity and philanthropy problems. BCF aims to provide a secure and transparent platform for charitable donations around the world, applying BCT for donations tracking to ensure they reach the right charitable organizations. BCF's platform allows donors to see where their donations were used, as well as the results achieved by the charities they support [22].

Existing use cases once again prove that donation-related BCT projects are aimed at the improvement of transparency, traceability and efficiency of the donation process and transactions processing, guaranteeing that donations and contributions will get into the right organization safely and reliably.

3 Tax Consignment Process: From Taxpayers to Beneficiary Entities

This section aims to clarify the steps of the current process of tax consignment to BEs in Portugal, identifying challenges and constraints that needs to be addressed in future. Status quo is crucial to be understood and analyzed, as the limitations of the current process will identify where and how BCT may bring improvements.

3.1 Current Process

Tax consignment program in Portugal started in 2001, pursuing the aim of encouraging civil society participation in financing causes of public, cultural, environmental, and social interest, and thus contribute to the development of these areas for the good of country. Initially, the consignment was aimed exclusively towards religious institutions, private social solidarity institutions and public utility donations, but it has later been extended to other NPOs, including, but not limited to animal welfare, sustainability and environmental organizations etc.

Currently, in terms of tax consignment in Portugal, there are two main ways to consign part of the tax to a BE: through IRS consignment or through VAT consignment. As mentioned earlier, the IRS consignment allows taxpayers to donate 0.5% of the value of the tax they have already paid, or will pay, whereas, VAT consignment amount is deducted directly from the amount that the consumer would receive in terms of tax benefit. Both forms of tax consignment are completely voluntary. If the taxpayer does not indicate any NPO entity, or if the entity indicated does not meet the legal requirements, the value of the tax consignment goes to the State. Currently, there are 4,752 BEs registered on the Tax and Customs Authority (AT) website, which are authorized to receive the tax consignment in Portugal [23].

To be able to donate taxpayers need to indicate the entity they wish to donate to, access the AT website and indicate the Tax Identification Number (NIF) of the entity they wish to support, along with the option to consign IRS, VAT or both. After filing the IRS return, the tax consignment process is managed by the AT, which is responsible for receiving the consignations and performing transference to BEs through banking institutions.

The clearance of the consigned amounts is supervised by the AT's own internal inspection entities and external entities, such as the Court of Auditors (CA). These would be the entities responsible for the verification of the correct transfer amounts to BEs and controlling the process as a whole. AT does not publicly share such type of information, therefore according to newspapers [24], between 2014 and 2022, around 187 million euros were consigned to BEs through tax consignment program in Portugal. This once again proves that tax consignment program is an important source of funding

for BEs in Portugal and that taxpayers' participation is increasing to support causes of public, cultural, environmental and social interest. However, the transparency and effectiveness of the tax consignment process is still an open issue, thus to involve and attract more citizens to participate in the program, there is a need for the assurance that the amounts consigned by taxpayers are properly delivered to the BEs of their choice, and are effectively contributed to further development and prosperity of the chosen sector.

3.2 Challenges and Potential Problems Identified

Although tax consignment is an important source of funding for Portuguese BEs, there are still some open issues and challenges that may compromise the effectiveness of the initiative, therefore discouraging taxpayers from participating in the process:

- **Bureaucracy** - The process of registering to become an accredited BE and obtaining authorization to receive the tax consignment can be bureaucratic and time-consuming for smaller NPOs;
- **Lack of awareness about the program** - The tax consignment process is only disclosed at the time of IRS submission, thus those individuals that were not aware about the possibility to consign or did not educate themselves about available options to donate might ignore the participation at all;
- **Complexity of choosing the right BE to donate** - Although there are more than 4,700 entities registered on the AT website, taxpayers often do not know how to find entities that are aligned with their visions and values;
- **Lack of transparency and traceability** - The current tax consignment process does not offer much transparency to taxpayers about the final destination of the consigned funds;
- **Difficulty in budget forecasting** - Entities that benefit from the tax consignment receive the consigned values referring to the previous year, thus makes budget forecasting difficult for those BEs which depend heavily on tax consignment funds.

As can be seen from the above-mentioned issues, it is necessary to build solutions that improve the process of tax consignment for both taxpayers and BEs, ensuring greater transparency, efficiency and traceability in transactions, where BCT emerges as a promising alternative to address these challenges and improve the process of tax consignment program.

4 Conceptual Design of Blockchain-Based Solution

The data flow diagram below (Fig. 1) represents a process that starts with the taxpayer's tax return, which is stored in the AT database. The AT then uses this database to create a smart contract that defines the transfer rules from the taxpayer to the BE. Before transferring the amount to the BCT-based ledger, the smart contract verifies the records and initiates steps that are predefined through the smart contract transaction automation. When funds are transferred by the AT in a token form to the BCT ledger, the smart contract is completed by automatically transferring the funds from taxpayer's wallet to the BE(s) of the choice, according to the rules predefined previously.

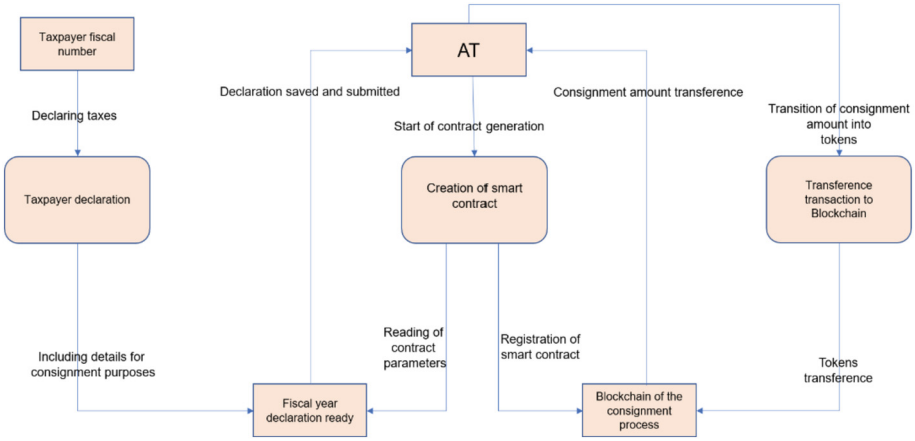

Fig. 1. Proposed data flow on a Blockchain network for tax consignment

The proposed BCT-based system guarantees the transparency of transfers of the taxpayers' consignments to the BEs, generating greater trust of taxpayers in the system itself and creating accountability in the further use of the donated funds. In terms of its architecture, the proposed BCT-based solution is conceptualized to be hybrid in order to ensure taxpayers' interests are safeguarded, at the same time providing the maximum possible transparency through open access to information. The anonymity of the taxpayer is a crucial point that needs to be considered, thus only the individual taxpayer, the AT and the CA can gain the visibility to such confidential data.

Considering the linear growth of the number of records and entries on the BCT ledger, the consensus mechanism of choice for this case is the Proof of Authority (PoA). This consensus mechanism considers that validators are trusted authorities, also called as deciding agents, thus their 'identities' are known to other players, which creates a "decentralized delegated centralization" environment [25]. For the State program, such as tax consignment, PoA is a consensus of fit, because here the knowledge about the trusted entity that is managing the funds allocation to BEs brings more security and confidence to all stakeholders involved, especially to citizens.

The role of validator nodes in the network are taken by State entities and other strategic partners in the blockchain ecosystem. These validators make their identity public, as their reputation and integrity of the process are critical to trust in the designed network. Through their active participation in the validation of transactions, validators help ensure the security and stability of the network, which is essential for its long-term growth and development. Such network architecture promotes and reinforces the legal mechanisms that support the original idea of tax consignment, which is the encouragement of civil society participation in socially significant projects.

4.1 Tax Consignment Process in the Blockchain Network

In order to achieve the objectives of creating a decentralized system, where all stakeholders have the possibility to contribute to the improvement of the solution it was chosen

to apply the concept of Decentralized Autonomous Organization (DAO). DAO can be characterized as a network, where it is guaranteed that all active parties of the process have influence on the designation and success of the blockchain system. Since this paper suggests the architecture of a solution for a State program, any decision to change the rules of the proposed network must be framed in accordance with the Portuguese legal context.

The process starts with the taxpayer filing the tax return, and upon the finalization of the tax return process the taxpayer has the possibility to choose an BE to which he/she wants to consign part of the income tax. Once the tax declaration is completed and validated by the AT, a smart contract is created and the following steps are further taking place on a BCT-powered network:

1. The smart contract is created and registered on the network;
2. The donated amount is made available in a token form and is transferred to the taxpayer's address;
3. Further, this donated amount will be automatically transferred from the taxpayer's address to the selected BE's address, thus allowing to keep track of the funds transference;
4. When the funds are received by the BE, it is free to decide when to withdraw them, removing them from the tokenized network and converting them into monetary values.

To initiate the entrance to the blockchain network, it is necessary that the taxpayer consigns part of the tax to be donated to a BE, and that this declaration is further validated by the AT. If so, the AT creates a smart contract that will be placed on the BCT network and will allow the taxpayer to visualize the track of dedicated donations until they get to the chosen BE.

4.2 Smart Contract

The nature of a smart contract is an automated and digitalized version of a contract in the physical world, where an agreement between several parties exists and where several conditions need to be met in order to confirm and trigger the execution of a smart contract. The major difference between a classic physical business contract and a smart contract is that the smart contract is purely digital and automates the execution of the rules and conditions pre-defined in the contract [26], which is designed to be autonomous, immutable and secure without the need to rely on third-parties and intermediaries [27].

In the proposed architecture, smart contract is applied to automatically execute and deposit the donated amounts consigned by each taxpayer, they further validate that the BE meet the necessary legal requirements to receive the designated funds, and finally safely and transparently transfer the funds to the BEs' portfolios. Since such process can be carried out without the need for human intervention, it is expected to be more efficient, secure and unbiased. Any changes to the rules and pre-defined conditions of this contract must be first communicated and agreed upon the defined governance parameters.

After submission of each taxpayer declaration, its verification and subsequent validation by the AT, a smart contract is created and stored in the BCT network. Once the AT is able to generate tokens in exchange for monetary funds that are placed in reserve, smart contract will deposit tokens at the taxpayer's address. After confirming

the deposit, smart contract will transfer the tokens from taxpayer's wallet to the chosen BE. The whole process is automated based on the rules contained in the smart contract coding and registered in the blockchain by the AT. The sequence diagram below (Fig. 2) demonstrates the execution of the smart contract as per described process.

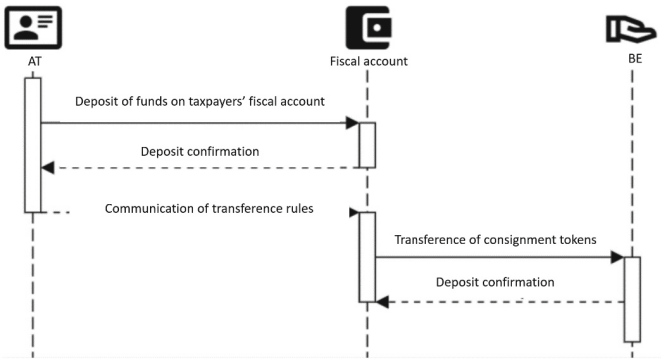

Fig. 2. Smart contract execution process

4.3 Tokenization of Assets on Blockchain

This network is based upon the transference of an asset that translates into the amount of tax consignment assigned to a BE by the taxpayer and further facilitated by the AT. The design of this system, is supported by the State, therefore it guarantees the conversion of the dedicated amount of money into a token and vice versa.

The proposed design of the system guarantees stabilized value of the token within the network, since there is no mechanism for either reducing or increasing them. State entity will be the actor that is responsible for the reserve of monetary values that are corresponding to the number of tokens within the network.

The decision to create an asset that transits the network was made in order to be able to leverage the creation of an ecosystem that increases the use cases within the same environment and generates synergies that can leverage the positive contribution to the fulfillment of the mandate of the BEs that are one of the key parts of the ecosystem. Under this proposal, the token is suggested to be named "Solidarity Currency" to signify the values and goals of the described solution.

4.4 Incentive Mechanisms for Blockchain-based Network Participation

Due to its hybrid typology, any entity or individual that is granted access by the State, can participate in the maintenance of this network and contribute to its success. Although the State is the guarantor of the proper functioning of this network, it is important that the network stays open and transparent to remaining actors of the process.

There may be several incentive mechanisms for participants of the platform (specially taxpayers and BEs):

- **Reputational** – for taxpayers it creates the way to increase positive experience with the tax consignment process by contributing in a novel and more involving architecture of the network;
- **Access to data in a direct way** – for State entities the novel decentralized way of accessing the data and information in the real time will likely increase the efficiency of the process;
- **Ability to trace back or forward** - for both taxpayers and BEs the transparency provided through BCT allows the traceability of all transactions, where BEs will be guaranteed to receive the exact amount of donations, and taxpayers will be able to verify such allocation of donations.

Depending on the strategic path given to this application and the spread of its adoption, other forms of incentives can be created to move more towards a decentralized network.

4.5 Availability of Transparent Data and the Importance of the User-Friendly Interface

One of the key features of BCT is its decentralized nature and the ability for any participant in the network to read all of the transactions that are in the ledger. However, it is important to keep in mind that even though BCT creates a greater level of transparency, its novelty and complexity can make it difficult for the general public to interpret the data.

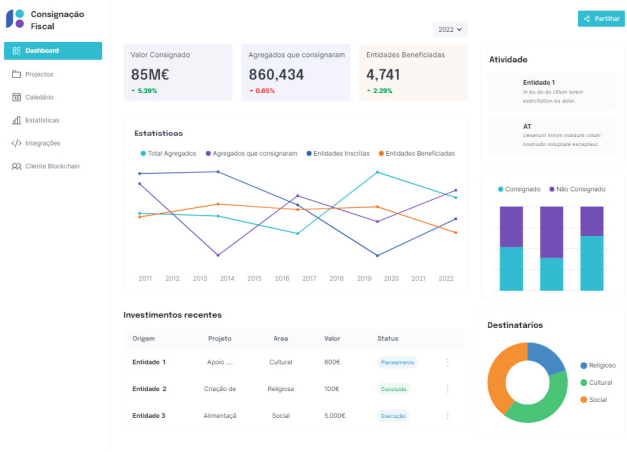

Fig. 3. User-friendly interface proposal for the tax consignment tracking

In this sense, it is essential that the competent entities disseminate the tax consignment data with interfaces and tools that allow presenting the data in a clear, intuitive and accessible way, such as graphs, tables, maps and other visual resources that facilitate the understanding of the data. In addition, it is important that information about the meaning

and importance of the donated data will be accessible and available to taxpayers, so that they will visualize the relevance of tax consignment and the impact of their choice on societal benefits. Exemplary proposal of an interface can be seen in Fig. 3.

5 Discussion

The current process of tax consignment is characterized by being highly dependent on the AT, since it is the entity that manages the process from the submission of the taxpayer's taxes until the transfer of the consigned amount to the BEs that benefit from this system. During this whole process, both of the parties (taxpayers and BEs) do not have any information about amounts that were funded, how much BEs will receive, or even when they will receive it [1]. This lack of transparency, associated with the long periods of time between the submission and dedication of the taxes to the BEs by taxpayers, until the final transference and receival of funds by BEs, damages the reputation and credibility of the AT and public institutions in general, and creates difficulties for the BEs that rely on such funds and are not able to allocate capital or plan actions in a concrete way. On the taxpayers' side, there is currently no way to directly validate that the amount that was consigned by them, if it actually reached the chosen NPO.

The proposed BCT-based network brings solutions to all of the abovementioned challenges, as it creates traceability of the transactions and therefore provides more trust towards the tax consignment process. This type of proposed solution is able to generate an active development of the BCT-based network, as all stakeholders will have their own motivations in moving towards a more transparent network. The main challenges of the implementation of such solution are twofold: (1) currently there is still a lack of clear and specific legal regulations regarding BCT-based networks, especially applied to State programs; (2) the lack of awareness and knowledge of the BCT itself might create hesitancy in cooperation between various entities, which may further translate into higher costs and greater complexity.

6 Conclusions and Future Research

The use of BCT for tax consignment process has several advantages over the current situation, such as transparency and security of donated funds, build of trust towards the program, elimination of intermediaries, and guaranteed accountability. With the implementation of the proposed solution, taxpayers will be able to verify that their dedicated part of tax is safely designated to chosen BE, thus increasing confidence in the donation and encouraging participation in solidarity actions and socially significant projects.

This paper focused on a simplified concept of tokenization and the value transfer between the taxpayer and BE through a State entity. Other ideas for tax consignment that might be explore in future would also add value to the solution proposed in this paper. The most interesting directions for future:

– Allowing the transfer of tokens between BEs will allow an increased cooperation between NPOs;

- Allowing the purchase of tokens for direct donations to BEs will extend the scope of donation to anyone who wishes to donate funds, without limiting it to taxpayers only;
- Development of the solution to allow BEs to register projects they want to develop and to give the taxpayer/donor the ability to clearly see and track where their funds have gone within the network. Such functionality could additionally allow the registration of invoices or cost statements to ensure the trustworthiness of the projects within the network;
- Involvement of the CAs as external auditors of the process, in order to use the BCT-based network as a tool for its supervisory function. The use of smart contracts will also help validate that the BEs have met the legal and statutory requirements, i.e. were in a position to be granted to receive the tax consignment;
- Future extension of the platform to other NPOs that are not accredited as BEs for tax consignment.

We hope that this paper will serve as a comprehensive basis for the BCT-based solution for charitable supply chains, which opens new frontiers for the applications of State programs and involvement of citizens in socially significant activities.

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