Tokenomics for Collaborative Economies in Local Communities: a Model Based on Game Theory

Abstract—**This paper explores the use of tokenization in civic applications of blockchain technology to facilitate resource sharing systems within local communities. It looks at tokenomics, the study of self-sustaining economic systems driven by incentives with the aim of aligning the interests of participants towards a common goal without the involvement of intermediaries. The paper provides a model and analysis of a tokenization system for a collaborative economy aimed at enabling resource sharing and based on nonprofit and mutualistic logics. In particular, we study and evaluate which game theory to use, what kind of incentives to include, and which economic model to refer to.**

Index Terms—**Local community, tokenomics, game theory**

I. Introduction

Distributed ledger technologies (DLTs) have raised new questions about the relationship between the domains of computer science, games, and economics [1] in the study of interactions between participants in a network and the mutual benefits gained from such interactions. Of particular interest is the fact that DLTs have enabled processes of tokenization to emerge. Tokenization can be described as the conversion of value into a digital form or, more precisely, the establishment of a self-regulating (token) economic system governed by rules programmed by the token designer [2]. Tokenomics is a discipline that refers to the study and design of self-sustaining economic systems optimised through token incentives [3]. In this context, the tokens are intended to incentivise a particular behaviour within the network with the aim of aligning the interests of participants towards a common goal without involving intermediaries.

Another topic related to DLTs has emerged recently: the application of blockchain technology for social good. Of particular interest to our research is the category of civic blockchain. By civic blockchain, we mean a particular field of application of this technology, within the broader field of *blockchain for social good*, which is characterised by the co-production of public services to meet societal needs [4], [5]. More specifically, civic applications refer to the design and creation of systems that support processes of civic participation and alternative processes of value circulation within communities and local economies. Core elements of civic applications of blockchain are the co-design and accessibility of this technology at a local community level [6]. This paper aims to show the benefits of leveraging tokenization to digitise valuable assets and of using blockchain technology to facilitate resource sharing systems within local communities. Given the peculiarities of human interactions in these types of collaborative economies, a modified game theory principle has been applied to our model.

A. Motivations

Several civic blockchain applications involve the use of tokens. This can be seen in applications aimed at financial inclusion and social economies, and applications where tokens are oriented towards recognising and rewarding acts of civic participation. Taking a local community as the context of reference, the economic dimension of tokenization can be regarded as a system of exchange and interaction. We decided to adopt the *collaborative economies* model (see Section II) as it best represents the dynamics of resource sharing from the nonprofit and mutualistic perspective that we wish to consider. Indeed, the exchanges envisaged by this model cannot be attributed to market, profit or financial logic. Within this context, a token can be described as a *community token*, indicating a socio-economic unit of value used to facilitate interactions in terms of exchange and distribution of rewards as provided by the incentive system. The design choice to implement one type of community token brings us close to the concept of local currency, and some examples of using blockchain in this way can be found in projects such as Circles [7], Sarafu Network [8] and TrustLine [9] (see Section II). Another fundamental dimension to consider in a tokenization system is that of interactions between network members. Generally, every decision is shaped by strategic considerations. Therefore, when analysing such a system, it is crucial to incorporate the principles of game theory. Specifically, in order to model strategic interactions between members of the community, non-cooperative game theory models are applied. These models are particularly suitable for informal situations like sharing processes, where players are unable to form legally binding agreements. Furthermore, our analysis indicated that we need a model that captures the unique temporal dynamics inherent in sharing schemes. As such, in our context, the non-cooperative games are of the extensive-form type.

The concept of civic blockchain is relatively recent, and there is still no systematisation available of the literature relating to its applications. While use cases show how blockchain technology is also being used in the field of social good to implement community tokens, there are no unambiguous or systematised references related to models for the design and implementation of collaborative-economy-oriented tokenization processes in the context of local communities. Tokenization systems are complex and have several dimensions (economics, incentives, technology, token circulation, strategic behaviour models), therefore making blockchain technology accessible also means making accessible the modelling and design of the system to be implemented. The goal of our research is to provide a model for analysing and designing a tokenization system that supports solidarity-based logics for resource sharing.

B. Our Contribution

As stated in Section I, the research on blockchain-associated tokenomics models presents novel opportunities and challenges for many fields, creating intersections between distributed ledger technologies, economics and social sciences. As such, it becomes imperative to explore the theoretical foundations and practical applications of these models.

The research questions that guide our investigation can be summarised as follows:

a) RQ1: What are the fundamental elements that need to be considered to design a model specifically tailored for a digital collaborative economy? This question is aimed at the identification and construction of a comprehensive theoretical foundation that effectively integrates the principles of tokenomics with the dynamics of sharing resources in a local community. It includes evaluating which game theory to use, what kind of incentives to include, and which economic model to refer to.

b) RQ2: Which parameters exert the most significant influence on the tokenomics of a collaborative economy scheme, and how do they impact its efficiency and stability? This inquiry focuses on identifying key factors that drive the tokenomics model and analysing their role in shaping the overall functionality and success of the sharing system.

Therefore, our contribution is to propose a model and analysis of a tokenization system for a collaborative economy aimed at enabling resource sharing and based on nonprofit and mutualistic logics. Specifically, the types of exchange considered [10] are:

- access to products or services without the need to own the underlying assets,
- reallocation of goods, and
- exchange of intangible assets.

In a local community, these processes can take the form of: management of shared spaces and commons, redistribution of products from urban gardens, lending systems for everyday objects (libraries of things), and exchange of skills.

While developing the model, we referred to the non-cooperative game theory to avoid the risk of idealising community dynamics and overestimating its uniformity and balance in relationships [11], [12].

Although the non-cooperative game theory is suitable for describing a hypothetical exchange system, it fails to account for some of the relational dynamics that are present in community contexts where the ultimate goal of the system designed is not merely the pursuit of self-interest. In addition, it is important to note that in the context of our community-based sharing system, these decisions are further guided by the principle of trust. This trust-based approach is vital as it underpins the entire exchange mechanism of tokens, ensuring the system operates effectively within a communal, nonprofit environment. For this reason, some modifications to traditional game theory principles have been made. From among the extensive-form games, we specifically focus on *trust games*, which are widely utilised in economics as an experimental, incentivising measure of trust [13]. In the particular case of a sharing system, members act by considering both their own interests and the collective wellbeing of the community. The intent is to explore the potential of translating theoretical constructs into a practical, simulated environment in order to examine and analyse the model's viability and efficacy.

II. Related Work

A. Collaborative Economies

The field of collaborative economies encompasses a wide variety of different economic models and sectors and, for this reason, it is difficult to give an univocal definition [14]. However, some elements can serve to categorise these platforms, such as whether they are for profit or nonprofit, whether the interactions are business to consumer (b2c) or peer to peer (p2p), and whether the services offered can be regarded as professional or nonprofessional [14], [15]. The term collaborative economy is often associated with terms such as sharing economy, gig economy, platform economy, to name a few [16]. Part of this phenomenon has resulted in the commodification of social relations and the proliferation of extractive digital platforms [17]. We intend to distance ourselves from this type of outcome. Instead, for our research, we consider those models of collaborative economies that are oriented towards nonprofit and peer-to-peer transactions. These models can be defined as new socioeconomic models [18]. They allow the redistribution of resources according to the logic of mutuality, which refers to the possibility of having access to resources without implying transfer of ownership [19], [20]. Blockchain technology can play a crucial role in these processes, accelerating the spread of collaborative practices [20]. In addition to offering the ability to implement automated and secure transactions, it has the potential to redefine exchange practices in a decentralised way [21].

B. Incentive Mechanisms and Strategic Behaviour Models

The literature on incentives has a history that pre-dates that of DLTs. There are two disciplines in particular that are interested in studying its effects on human behaviour. Economics is interested in the study of how incentives influence decision-making processes, and psychology is interested in its effects on human behaviour as a whole [22]. Incentives can take a purely materialistic form as an instrumental reward [23], which can foster extrinsic motivation, or they can involve social recognition and a symbolic dimension [23], which can foster intrinsic motivation. Whether the desired motivation is intrinsic or extrinsic, incentives can, depending on the context and the actors' goals, either reinforce or undermine a particular behaviour [24]–[27]. The impact of the incentive system on actors' behaviours depends on the particular model of behaviour considered. In fact, there are models that, unlike game theory, do not focus on self-interest, and they deal best with intrinsic motivations and non-financial incentives. Here are some of these models. The *altruism* model is generally understood as pertaining to behaviour that benefits others at a personal cost to the individual [28]. The *inequity-aversion* model states a preference for fairness and resistance to incidental inequalities [26], [29]. The *team reasoning* model allows people to reason as members of groups (or "teams"), all of whom are justified in performing their component of the combination of actions that best achieves the group's common goal [30]. The *reciprocity* model means that people reward kind actions and punish unkind ones [31]–[33]. The *trust responsiveness* model assumes that people can be motivated by trustworthy actions to behave in trustworthy ways [34], and this is discussed in Section III.

C. Game Theory Applied to Blockchain Systems

Game theory has been and continues to be used to address different kinds of problems concerning blockchain. The main areas of application identified in [35] and [36] are:

- security: selfish mining attacks and denial-of-service (DoS) attacks.
- mining management: individual mining (computational power allocation, fork chain selection and block size setting) and pool mining (pool selection and reward allocation).
- applications on top of the blockchain: cryptocurrency economic trading (for setting transaction transparency and determining the cryptocurrency value), and energy trading.

Liu et al. [35] also identify which game theoretic approaches are most used to analyse interactions within the blockchain network. They include non-cooperative, extensive-form, Stackelberg and stochastic games.

D. Blockchain for Social Good

Blockchain for social good is a broad field. Here, we focus our attention on applications for social economies and civic participation [6], and we divide these into two categories: tools for community empowerment, and tools for social economies and financial inclusion.

The first category includes tools that allow members of a specific community to create from scratch what they need for a particular purpose, from tokens to a decentralised autonomous organisation (DAO) [37]. In this regard, we shall mention the *community toolkit platforms* of Waves [38], Coinsence [39] and CommonsHood [40], which offer innovative toolsets for the development and operation of Web 3.0 applications. Also of relevance are *platforms for creating community/complementary currencies* like Celo [41].

The second category consists of non-customisable ready-made tools for free use in a community. *Community and complementary currencies* include Sarafu [8], ImpactMarket [42], TrustLines [9], and Circles UBI [7]. In addition to constituting an exchange system, these projects enable the creation of microcredit systems to facilitate financial inclusion. Another set of applications are those that involve *purpose-driven tokens* with the purposes being, for instance, caring for the environment or the common good (Plastic Bank [43], Empower [44]) and recognising civic participation (Colu [45]).

E. Tokenomics Simulations

The literature on tokenomics is extensive and includes various simulators aimed at designing and evaluating the economic systems of different platforms. However, none of the simulators identified in our literature review were suitable for our specific requirements. Letychevskyi [46] proposed a tokenomics constructor aimed at evaluating a token's market fluctuations taking into account different types of agents. Cong et al. [47] provided an asset pricing equilibrium model for tokens for peer-to-peer transactions on digital platforms. Lo and Medda [48] conducted a retrospective analysis of the tokenomics of tokens that are already operational, exploring the relationship between their functions and prices. In addition to academic sources, we also explored models available on the internet like Cenit [49], but they also did not meet our needs. All these models primarily concentrate on token transactions rather than community interactions, they do not apply game theory to analyse the behaviours of actors, and they do not feature the trust responsiveness theory.

III. Description of the Framework

A. Background

1) Local Community: For this work, we propose a formal definition for the term *local community*:

Definition III.1. (Local Community) A *local community* is a finite set $\mathcal{L}_c = \{m_1, \dots, m_N\}$ where N is its size and m_i for $i \in \{1, \dots, N\}$ are its *members*, locally confined in a geographical bounded area of diameter Δ.

Note that members in local communities can be individuals or organisations.

2) Trust Responsiveness Model: Among the strategic behaviour models based on something other than self-interest, we chose to adopt the trust responsiveness model. It is the most suitable because, in the context of a community-based sharing system, decisions are further guided by principles of trust, as stated in Section I-B. The trust responsiveness strategic behaviour model is a specific variant of a trust game and is based on the assumption that trust is a relational and responsive concept. Trust in this sense becomes a determining factor in the decision-making process, as it has the characteristic of eliciting a trust response, and this can determine the strategic choice made by the actor. Pelligra, the author of this principle [34, p. 654] states: *Suppose we have two agents, A and B. According to the "trust responsiveness hypothesis", B's trustworthiness may be induced by A when she manifestly and consciously chooses a trustful course of action. This kind of inducement assumes the existence of a psychological mechanism according to which A's trustful action motivates B to reward such a trustfulness, making* *him behave trustworthily, even though such behaviour implies some material cost.*

The trust responsiveness model is particularly useful for the scenario under consideration because the trust dimension is central to one's decision to take part in a system for exchanging and providing resources for the community. It also differs from other models of strategic behaviour such as the altruism, inequity-aversion and team-thinking models because these do not expect actors' actions to be influenced by a single act of trust. The trust responsiveness model hypothesises that at least one part of trust is developed internally in the relationship through the act of trusting itself [34].

3) Game Theory: We present key definitions of game theory principles that can be found in every book on the topic (e.g. [50] and [51]), to establish the foundational understanding of our study and set the stage for the development of a tokenomics model (explained in Section III-B) tailored to meet the specific demands of nonprofit sharing practices within local communities.

A *game* is a mathematical model of a scenario where multiple decision-makers, or players, all aim to achieve the optimal outcome for themselves. The process implies that every other participant is equally committed to securing their own best possible result in an environment of interactive decision-making.

Consider a set $\mathcal{M} = \{m_1, \dots, m_N\}$ of players. In our case, these are community members, and $N \geq 2$ represents the size of the community. While members actively interact with each other inside the local community, they are making decisions based on a set of possible strategies. If we denote S_i as the set of strategies for each player i, we can take the Cartesian product of all the members' strategies to obtain $\mathcal{S} = S_1 \times \dots S_N$, the set of all possible strategies. Every strategy S_i takes a member to a defined outcome which, in our case, is the number of tokens that (s)he receives as a reward for his/her action or as an incentive to participate in community activities. We call these outcomes *payoffs*. Let $\mathcal{O}$ be the set of all possible outcomes in the game played. The function that associates a strategy with an outcome is defined as $f : \mathcal{S} \longrightarrow \mathcal{O}$. Now that the game is established, it is essential to assess how each participant decides on their preferred outcome. The function that ranks all the outcomes according to members' preferences is the *utility function* $U : \mathcal{O} \longrightarrow \mathbb{R}$. In particular, given a binary relation $\succeq$ over the set $\mathcal{O}$, then $\forall x, y \in \mathcal{O}$, and $x \succeq y \iff U(x) \geq U(y)$. Here, we use Maschler's notations [51].

Unlike traditional game theory which equates payoffs with utility, our scenario draws a distinction between payoffs and utility functions as a result to the inclusion of human interactions in informal settings beyond mere rational strategies.

We combine classical game theory with Berg's [52] theory on *trust games*, as it holds particular significance for a study on trust-based behaviours in a nonprofit sharing process. Trust games are also analyzed, among others, by D. M. Kreps [53], C. Alós-Ferrer and F. Farolfi, F. [13]. A *trust game* represents a particular form of non-cooperative dynamic game where the elements of trust and corresponding responses play crucial roles. Unlike traditional game theory models, the trust game specifically highlights the distinct responses a participant may offer in reaction to an expression of trust.

Among all the types of representations of games, we consider here the extensive form, in order to best reproduce the dynamic interactions that are typical in a sharing scheme. An extensive form game is defined by a *game tree* where vertices symbolise the game's positions. For details on game trees see [50]. Figure 1 provides an example of a trust game in extensive form. We use here the terminology from [13].

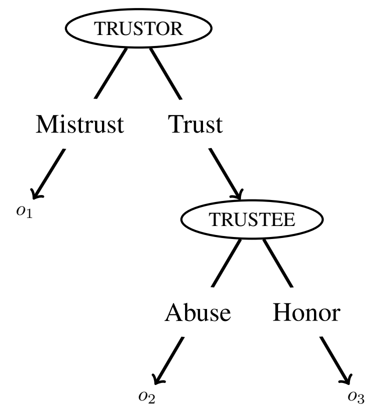

Fig. 1. A trust game between two players ($I = \{\text{Trustor}, \text{Trustee}\}$). Strategies are $\mathcal{S} = (S_{\text{Trustor}}, S_{\text{Trustee}})$, where $S_{\text{Trustor}} =$ (Mistrust, Trust) and $S_{\text{Trustee}} =$ (Abuse, Honor). The set of outcomes is $\mathcal{O} = \{o_1, o_2, o_3\}$. Naturally, any outcome has two realisations, one for each player, of the form $o_i = (o_{i\text{Trustor}}, o_{i\text{Trustee}})$, where $i \in \{1, \dots, 3\}$.

B. Model Description and Parameters

The two major challenges when designing a blockchain-based system for local communities are: 1) identifying a suitable model, accompanied by key parameters, and 2) formulating a well-crafted tokenomics strategy, which is crucial to ensuring the system's ongoing functionality. In this paper, we introduce a comprehensive framework for designing a blockchain-based local community sharing system in which a community value token (CVT) is used as a unit of value for transactions. This is accompanied by a technical analysis of the system performed with Python code available on GitHub[1]. The principal elements and parameters considered in this work are explained here and represented in Figure 2. The decision of which parameters to implement or set depends on the designer's assessment of what is most suitable or necessary, taking into consideration the overall features and requirements of the system.

1) The local community: The local community is considered here as a closed self-sustained system, where members exchange goods or services, provided by themselves or by other members, where members exchange goods or services and perform transactions that serve as the building blocks of

[1]This link is currently omitted to maintain the integrity of the double-blind review process.

a cohesive and collaborative community. Every transaction is an arrow that goes from a member that we call *sharing requester* to another member called *sharing supplier*, given that every action involves resource sharing of some sort. Using the notation of Definition III-A1, the members are represented by the set $\mathcal{M} = \{m_1, \dots m_N\} = \{p_1, \dots, p_K, a_1, \dots, a_H\}$, where $p_1, \dots, p_K$ are individual people represented by singular wallets and $a_1, \dots, a_H$ are local organisations. In particular, K is the number of individual people, H is the number of organisations and $N = K + H$ represents the total scale of the system.

In the model, organisations are expected to lend but not borrow items or services. They have multiple financial roles. They can mint new CVTs to inject into the economy or burn existing CVTs to contract the monetary supply, thereby managing the community's liquidity and value stability. Otherwise, they can decide not to manage tokens and simply use the tokens in circulation in that moment. Additionally, they can hold a reserve of CVTs garnered through crowdfunding efforts, which can be used to finance community projects or to incentivise participation by distributing token rewards to community members.

2) Behavioural Distribution of the Population: In our model, interactions between participants are governed by modified game theory rules, as explained in Section III-A3. The modifications are related principally to the addition of other behaviours beyond those that are purely rational in order to better represent real-life community dynamics where people are more likely to reciprocate trust. These principles come under the concept of trust responsiveness explained in Section III-A2: people tend to respond positively to people that place their trust in them. For these reasons, participants need to be categorised into behavioural groups. Following the work of J. Poncela-Casasnovas et al. [54] we introduce the following behaviours that are intended to reflect a realistic classification of people: virtuous, rational, malicious, and random. Virtuous individuals prioritise others' welfare in their actions. Rational individuals follow classic game theory behaviour, seeking the most advantageous outcomes for themselves. Malicious individuals aim to disrupt the system, regardless of personal benefit. Random individuals act unpredictably, often changing their stance. In particular, the different outcomes of the different behaviours are reproduced in the different utility functions assigned to the trust game. Using the notation of Section III-A3, $U(o_{1\text{Trustor}}, o_{2\text{Trustor}}, o_{3\text{Trustor}})$ and $U(o_{1\text{Trustee}}, o_{2\text{Trustee}}, o_{3\text{Trustee}})$ vary according to the behaviour and corresponding payoff assigned to each player.

3) Probabilistic Parameters: In our endeavour to accurately replicate the dynamics of a local community within our simulation, we have grounded our model on several probabilistic hypotheses that are essential for introducing variability and realism into the simulated environment, given that real data is not yet available at this stage of the study. The hypotheses are based on the following assumptions. We assume a certain probability that a member will find an available object or service that suits their needs. The time period for which an item is borrowed or service employed is determined based on probabilistic factors. Community members are randomly chosen to interact with each other. A member's choice of a specific object or service is treated as random selection. The distribution of different behaviours (virtuous, malicious, rational, and random) within the community is based on probabilistic factors and ensure a diverse and dynamic population mix.

4) Type of Sharing Processes: Sharing can occur in two ways: simple borrowing or renting. In the simple borrowing scenario, users reserve and utilise objects or services without the need to lock tokens as collateral or make any pre-payment. This type of interaction is depicted in Figure 2 as a simple arrow. Renting takes place when an object is borrowed and, for the duration of the borrowing period, a specified amount of tokens is locked (in the "CVT locked for rental" cylinder in Figure 2), to ensure a level of security for the renter. The tokens are then transferred to the lender as a rental fee.

5) Incentive system: The system is built on incentive mechanisms. These incentives are distributed via token exchanges serving as either rewards for positive behaviour or a representation of value. All transactions in this system are conducted using the same CVT type and, for this reason, the local community setting is regarded as a closed system. Additionally, the overall flow of tokens is critical to understanding the health of the local community system. By monitoring token circulation, we can gain insights into the effectiveness of the incentive schemes and the engagement level of community members, which are key indicators of the system's vitality and sustainability.

C. Outputs

This subsection presents the outputs of our simulation. Each output directly addresses a specific question related to the design and sustainability of the tokenomics system. The simulation aims to answer critical questions that are fundamental to assessing the viability and effectiveness of the tokenomics model. By analysing these key aspects, it is possible to make informed decisions on how to refine and optimise the tokenomics model. We focus on three primary types of outputs: token distribution according to individual members' behaviours, the number of exchanged tokens per unit of time and the number of tokens owned by the organizations for every loan.

1) Token Distribution Analysis: The token distribution output provides insights into how tokens are allocated among community members based on their behaviours and contributions. This aspect of the simulation helps us to understand whether the incentive mechanisms are designed appropriately to encourage the desired behaviours in the community.

2) Tokens Exchange Viability: The volume of token exchanges are critical indicators of the system's dynamism and sustainability. This output assesses the level of economic activity within the community token system. A monotonic increase in token exchanges suggests an active and engaging

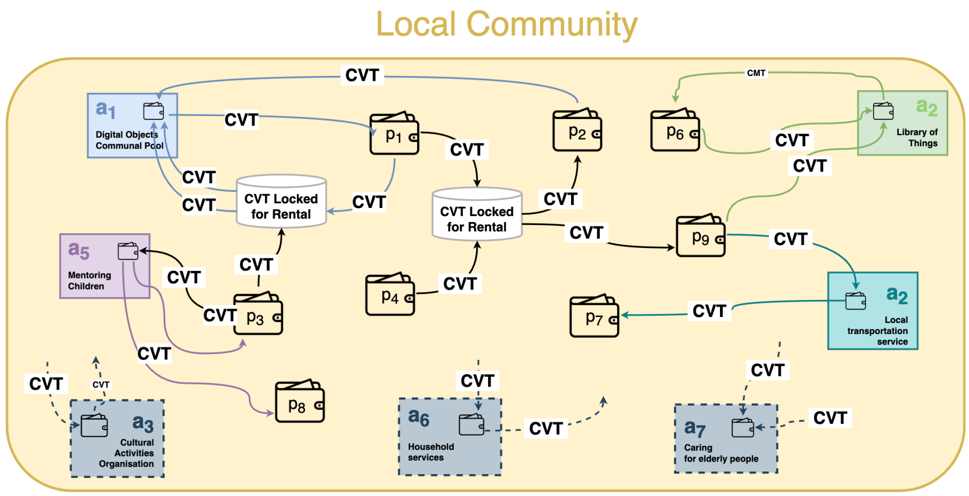

Fig. 2. Representation of the local community's closed system in which members (represented by the wallets m_i) interact with organisations and with each other through CVT token exchange

ecosystem, whereas low activity levels represented by flat lines may indicate issues in the system's design or token utility.

3) Number of Tokens Owned by the Organisations: In order to monitor the roles of the different organisations in the simulation, it is convenient to track the number of shared resource exchanges as well as trends in the number of tokens owned by the organisations.

IV. Testing and Evaluation

In order to rigorously test and evaluate the proposed framework, and to understand the impact of varying the parameters, we executed a series of simulations. These tests are intended to indicate to the designer potential areas for optimisation and innovation. For every test, a period of 100 days was considered for the simulation. Two tests stood out as most relevant.

The first test presented a realistic scenario, modelling interactions between community members within the confines of a singular association. This test was intended to offer insights into the practical applicability of our framework. Following this, we conducted two highly specific tests, each designed to scrutinise specific parameters that are critical to understanding the sharing mechanisms in a local community context. The focus here was on the size of the community, which could be very small or very large, and the number of members together with the number and size of the organisations.

A. First Test: a Realistic Scenario

This test was intended to examine the dynamics of a community rental system under the following realistic assumptions. The number of individual community members is 150. The selected distribution of population behaviours is: malicious: 5%, virtuous: 70%, rational: 20%, random: 5%. In fact, a significant majority of the community members are considered virtuous, which aligns with the hypothesis that individuals participating in a local community sharing initiative are generally well-disposed towards communal activities and fellow members. Moreover, an appreciable portion of the population behaves rationally, making decisions based on logical and self-benefitting reasons. The 5% of random people adds an element of unpredictability to the simulation, as this is present in all groups of people.

In order to facilitate the simulation and its analysis, only one association is included in the community. The association is in charge of sharing activities and is able to mint tokens as needed to distribute rewards to other members, thereby ensuring a fluid and responsive token economy.

The tokens rewards are $p_B = (0, 0, 2)$ and $p_L = (0, 0, 1)$ in order to incentivise borrowing. Moreover, every time a person showcases an item, $1CVT$ is earned, and every time a person wants to enter the system, (s)he earns $10CVTs$.

With these set parameters, virtuous people earn more tokens. Random behaviour slightly affects the overall system as random people can unexpectedly act as virtuous people. Rational people do not earn anything as borrowers or lenders, as the payoffs suggest they would not participate in the sharing process. The majority of tokens are earned by virtuous lenders. Malicious lenders own tokens only when they showcase their objects. This is shown in Figure 3.

In Figure IV-A the trend in the number of tokens exchanged each day within this realistic scenario is shown. The graph shows the dynamic vitality of the system. The frequency of exchanges exhibits a consistent, almost monotonic increase, reflecting a steadily growing level of activity.

B. Second test: Varying the Population Size

This test was aimed at examining the scalability of our simulation framework by varying the size of the population. Understanding how the simulation reacts to different population sizes is crucial for assessing its applicability to diverse real-world scenarios. The distribution of behaviours here is intended to be as realistic as possible with the following probabilities: malicious: 5%, virtuous: 70%, random: 5%,

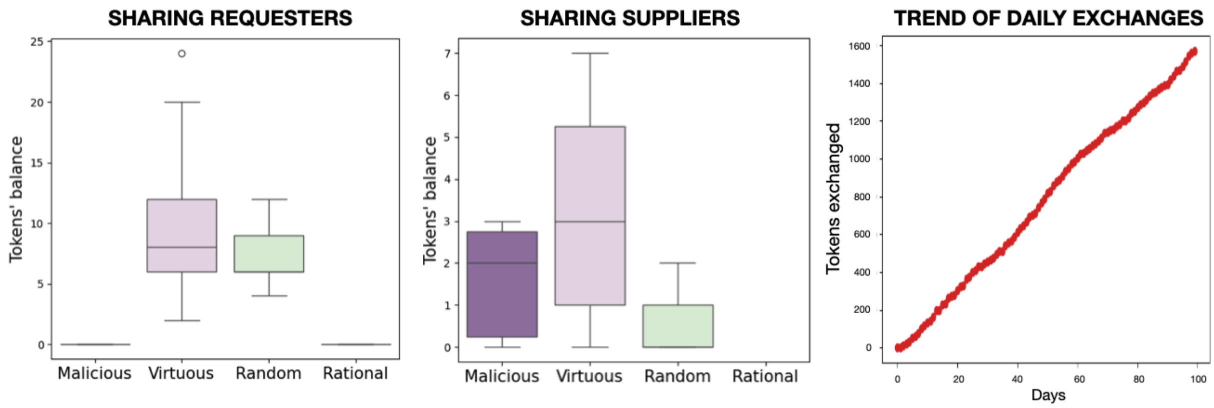

Fig. 3. The representation of token balance in the realistic scenario. Note that for the sake of better visualisation, outliers are not shown in boxplots.

rational: 20%. Two population sizes are considered. In the first case, there are 10 individual members that act in the community, whereas in the second case, there are 1,000 such members, reflecting a more advanced stage in the sharing system.

Boxplot analysis of token distribution showed some differences across behavioural groups with the change in the number of members. The two boxplots on the left in Figure IV-B illustrate the scenario with 10 members. The limited number of participants results in distributions predominantly influenced by virtuous behaviours, given the presence of either 0 or 1 malicious or random members (5% of the total population). Conversely, the other boxplots on the right depict the case with 1,000 members, showing a notable shift where malicious and random behaviours become more influential and significantly impact token allocation. Comparative analysis of token exchange dynamics in systems with varying numbers of members point to a change in sharing processes when there is a change in the number of members. The graph for the 10-member scenario (Figure IV-B) reveals a graduated scale indicating intermittent token exchanges. It reflects that there are days where the limited number of members do not find items to borrow. In contrast, the graph for the 1,000-member system (Figure IV-B) shows a smoother curve indicative of consistent token exchanges. Due to the larger pool of participants, there is a higher likelihood of members always finding something to borrow.

This study considers three distinct local organisations: a library, a study-help organisation for children, and a transportation service akin to Uber. Each offers a comparable number of services. In the scenario with 10 members, borrowings are sporadic, with a limited number of transactions taking place. Conversely, with 1,000 members, the borrowing frequency increases significantly, leading to a convergence in borrowing patterns across all organisations, as evidenced by the curves merging in the graph.

V. Results and Discussion

The proposed model shows how it is possible to design and analyse a tokenized collaborative economy system on a local scale. The simulator we used makes it possible to vary the parameters according to the characteristics of the application's context and thus design the tokenomics of a sustainable system in terms of exchanges and interactions. The first test shows how in a plausible context[2] the design of tokenomics enables us to arrive at a sustainable system in terms of consistent exchange frequency and increase in the viability of the activities considered. It shows the effectiveness of considering strategic choices and material payoffs, and considering the intrinsic motivation of actors and the relational aspect of trust in interactions. The second test shows how varying the parameters can affect the system. In the case of a very small community of 10 members, the distribution of tokens seems to be more influenced by the intrinsic motivation of the participants, leading actors with virtuous behaviours to benefit more from exchanges. However, in this situation, the viability of the system in terms of exchanges is suboptimal because, in the long run, there does not seem to be a match between supply and demand (See Fig. IV-B and IV-B). This scenario changes with a very large context of 1,000 participants. Here, the increased supply of resources leads to a situation of great activity and growth in the system. The increase in the number of participants leads at the same time to an increase in payoffs even for actors who are rational or malicious, indicating that non-material incentives have less influence.

Our simulation, while informative, is not without its limitations. Certain parameters were estimated in the absence of comprehensive real datasets. Furthermore, given the extensive range of adjustable parameters in our model, the resulting

[2] A trial of this model is currently underway in a local community located in the neighborhood of a city. It is a sustainable object lending system (Library of Things) in which transactions involving the exchange of tokens are handled through a blockchain-based wallet app. Each object is represented by a non-fungible token (NFT). For each action, the platform generates community tokens that can be used to borrow objects. Being decentralised, each exchange involves direct contact between two participants.

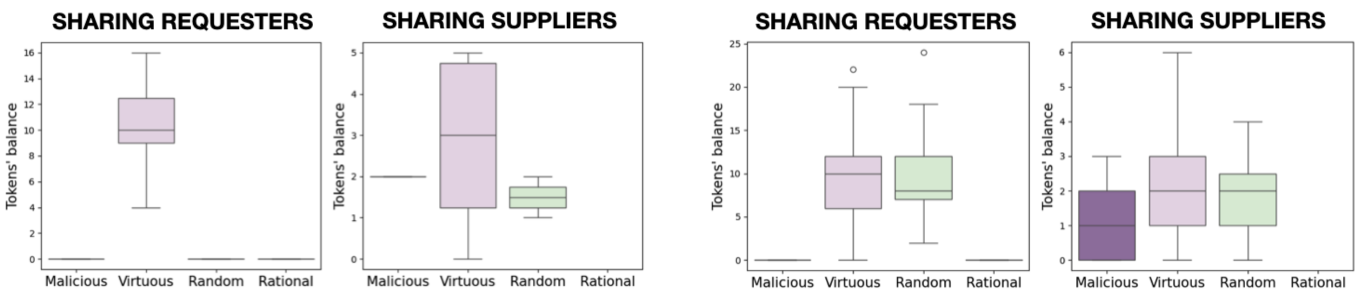

Fig. 4. Comparative boxplot analysis showing token distribution across different behavioural groups depending on the number of members. The two boxplots on the left illustrate the scenario involving 10 members and the others on the right depict the scenario involving 1,000 members.

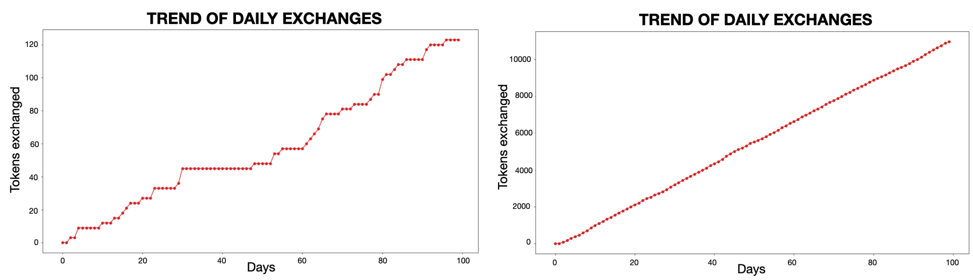

Fig. 5. Differences between the intermittent token exchanges when there are few members in the community (left) and the more smooth pattern of exchange when more members are present (right)

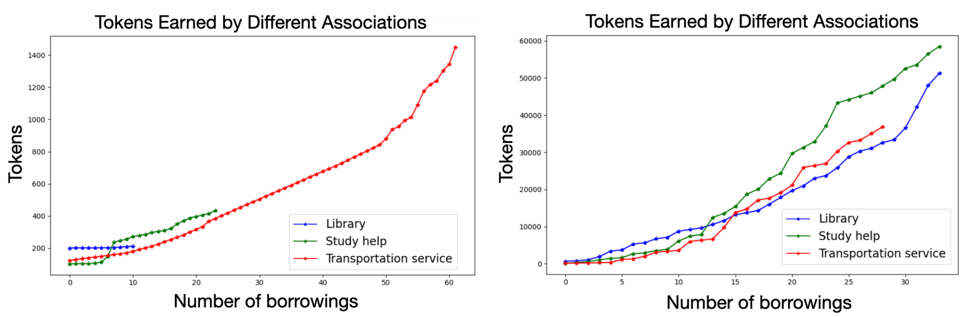

Fig. 6. Test analysis of borrowing patterns and tokens earned by the organisations demonstrate the impact of the number of members on borrowing activities and the resulting tokens earned by these organisations.

visualisation provides only a partial representation of the system's dynamics.

VI. Conclusions and Future Work

This paper introduced a framework for designing and evaluating a nonprofit sharing system within a local community, focusing specifically on its tokenomics. The model incorporated interactions between different types of actors in terms of strategic behaviours and roles. Non-cooperative game theory was used to design interactions where different utility functions were integrated to ensure that payoffs are based on the strategic behaviour model of trust responsiveness. Exchanges within the system-defined collaborative economy were regulated by the use of a community token. Through simulation, it was possible to test the tokenomics and evaluate the system in different scenarios, showing how the dynamics of reciprocity makes a blockchain-based system sustainable in a local community context and suitable for civic application. This is an initial attempt to provide a tool that aims to make blockchain technology accessible to support solidarity-based logics for resource sharing. Proposing this technology in local community contexts often involves, at least in the initial phase, the mediation of experts with sectoral technical knowledge. Our goal is to develop increasingly accessible tools for empowerment and financial inclusion in local communities.

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