ATARCA

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D2.1 Report on Crypto-economic Mechanisms for Anti-rival Goods

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Abbreviations

ATARCA	Accounting technologies for anti-rival coordination and allocation
B2B	Business to business
B2C	Business to consumer
CLD	Causal loop diagram
DAO	Decentralized autonomous organization
DLT	Distributed ledger technology
EIP	Ethereum improvement proposal
EU	European Union
ERC	Ethereum request for comment, a token standard (e.g., ERC 1155)
IPR	Intellectual property rights
LIT	Local, independent and traditional
NFT	Non-fungible token
ntNFT	Non-transferable, non-fungible token
P2P	Peer to peer
REC	Real Economy Currency: Barcelona's social, local currency
sNFT*	Shareable non-fungible token
sntNFT*	Shareable, non-transferable, non-fungible token
SD	System dynamics
Web3	Decentralized (i.e., non-centralized) internet, often linked to blockchains

*a new token type, which will be developed in the ATARCA project

1 Introduction

Enabled by digitalization, a characteristic feature of many current economic systems is that they *accrue value as relative resource usage increases.* This added value can often be divided into multiple aspects: increased efficiency in terms of needed raw materials and labor, increased variety of choices, increased enjoyment from shared experiences, decreased inefficiencies due to reduced information asymmetries, and improved production methods enabled by more widely available data and information.

A common characteristic of the mentioned benefits is that they are enabled through *increased sharing:* a primary source of the added value is thus often *increased availability* of information or some other immaterial and intangible goods, such as raw data, software, education, or communication (Kubiszewski et al., 2010; Yoo et al., 2012). In practical terms: the increased costs of sharing are often negligible compared to its benefits.

For example, making music more widely available increases the number of choices for individuals and the potential for shared enjoyment. Correspondingly, sharing information and data in internet-of-things networks enhances efficiency through better coordination (Autio et al., 2018). Sometimes, sharing can create even genuine new value, for example, by allowing previously distinct data sets to be combined and fed to machine learning algorithms, thereby revealing new information about the underlying processes and allowing the processes to be further improved.

In general, mainstream economics labels the mentioned phenomena as *positive externalities*, i.e., aspects of the economy that create positive value but that "by nature" fall outside of the economy or — in other words — that are *external* to the economic system (Teece, 2010). Herein, in the ATARCA project, one of the main goals is to create new incentive mechanisms and new accounting technologies that are capable of capturing and representing *some* of such added value.

In other words, ATARCA aims to create incentive mechanisms that at least partially capture positive externalities arising from sharing resources, especially information and data. Following Weber (2004), we refer to such resources as *anti-rival*, and the incentive

and accounting mechanisms that encourage value creation through anti-rival resource sharing as *anti-rival systems*.

ATARCA's anti-rival system design and analysis work is, at the time of writing this document, being converted into several concrete alternative incentive mechanisms and operationalized in community-driven currency pilot cases: Barcelona Green Shops, Streamr Community, and Food Futures. In these pilot case experiments we quantitatively and qualitatively measure the effects of the new incentive mechanisms and compare the effects to similar systems without such reward structures. This will allow us to further analyze and develop the incentive mechanisms.

From a technical perspective, we focus our efforts on developing a new type of medium of sharing, which is able to capture the positive externalities of anti-rival systems. Our goal is to create new types of crypto-economic tokens: shareable non-fungible tokens. We believe these tokens can not only facilitate anti-rival sharing, but also maintain anti-rival system integrity. Cryptographic tokens allow the creation of very sophisticated economic systems and customize the economic structures to the specific needs of a given community. On the other hand, such sophistication requires careful planning to meet the desired design outcome and avoid system misuse.

Thus, the purpose of this document is to report our current and evolving understanding of the potential of designing anti-rival systems; our focus is particularly in how we can use crypto-economic mechanisms to incentivize the production of anti-rival resources and to facilitate value creation and sharing in anti-rival systems. Ultimately, we aim to reveal potential mechanisms to capture, through cryptographic tokenization, some of the positive externalities of such systems.

This document is organized as follows. First, in section 1, we briefly cover the relevant theoretical and methodological background related to ATARCA and the purpose of this document. Then, in section 2, we introduce ATARCA pilot experiments, and in section 3 we analyze the social dilemmas exhibited by the cases. Section 4 focuses then on the token-based incentive systems designed to mitigate the social dilemmas, and also highlights how the benefits of anti-rivalry can potentially be captured. Chapter 5 takes a sustainability perspective and assesses the proposed designs with a system longevity lens. Finally, chapter 6 discusses our solutions, connects them to theoretical discourse, and concludes.

1.1 Background

1.1.1 The limitations of current economic systems and anti-rival resources

An anti-rival resource (or good) is one that gains value when used, contrary to the typical rival resource, which loses value as it is used (Weber, 2004). As laid out in Table 1, anti-rival goods can be divided into "network goods", whose subtractability is negative, typically due to network effects, but that are excludable, and "symbiotic goods," whose subtractability is negative and that are non-excludable (Nikander et al., 2020). Herein, it must be noted that both subtractability and excludability are scales, not categories. Also, in many cases, the infrastructure on which the resources are handled affects the anti-rival properties of a good: e.g., if a sharing system has a significant transaction cost, a good loses its anti-rival characteristic (Olleros, 2018).

Table 1. The six types of rival, nonrival, and anti-rival goods. (Nikander et al., 2020)

	Subtractability		
Excludability	**Rival**	**Nonrival**	**Anti-rival**
Excludable	Private goods (e.g. coffee)	Club/toll goods (e.g. museum visit)	Network goods (e.g. Fortnite)
Non-excludable	Common-pool goods (e.g. ocean fish)	Public goods (e.g. public beach)	Symbiotic goods (e.g. internet)

Anti-rival goods are not allocated well in traditional markets in which supply and demand depend on the inherent scarcity. Efficient markets are defined under conditions of perfect competition when supply and demand are at equilibrium at a market clearing price. However, for goods that have a very high first fixed cost of production, very low marginal cost, and low secondary fixed costs, existing market mechanisms work poorly (Mueller, 2008). This applies especially to anti-rival goods.

Let us take an example of a digital resource: a piece of information. What is unusual here is that basically any holder of that resource (i.e., the bits representing the goods), may produce additional copies of the good at a very low price, as the cost of setting up the replication machinery (the secondary fixed cost structure) is essentially zero with modern technology (Weber, 2004; Yoo et al., 2012).

Within a private ownership and money-based market for digital goods, if there are no further restrictions, there are two equilibria: either the product is not produced at all due to its high primary fixed cost, or the product is sold at close to its copying cost (Nikander et al., 2020). It further becomes possible to form a closed circle of trusting business partners that each pay an agreed price to cover the initial fixed cost. It remains impossible to agree on a competitive price based solely on supply and demand, other than at the marginal copying cost, due to the shape of the supply curve. Hence, to create a monetary market price that incentivizes data production, either technology (e.g., digital rights management), legislation, or mutually fully trusting circles of trading partners are needed to counter fraud and collusion.

At the same time, from the allocative efficiency point of view, for digital goods their Pareto optimality basically equals universal availability of them, due to their (near) zero copying cost. That is, consumer preferences are best met when all so desiring consumers can access their desired anti-rival goods at will, paying only the near zero copying cost (Weber, 2004). However, without proper incentive structures, the initial production costs of the anti-rival goods will never be covered and therefore the goods will never be produced in the first place.

Thus, considered more abstractly, the primary problem with information and data resources (and other digital goods) is that prevailing market economic systems fail to supply Pareto efficient allocations (Nikander et al., 2020). That is, in general, many such resources are not available as widely as their initial production and copying costs would allow them to be.

Summarized:

- Most anti-rival goods are simply hard to exchange in the strict sense of the word. For example, once information is shared with someone, the recipient cannot simply be told to forget that piece of information. Furthermore, given ubiquitous cloud storage and automatic backup mechanisms, the complete destruction of a digital datum within an organization boundary is a daunting task.
- Because of the poor exchangeability of anti-rival goods, the economic mechanisms structures that organize them are usually based on the idea of forcing exchangeability through creating artificial scarcity, i.e., limiting the availability of the anti-rival goods, for example 1) through legislation or technology, or 2) excessive policing and monitoring to punish bad actors. This implies DRM systems backed up by strict IPR legislation.
- While such an approach may work in some contexts, it leads to reduced efficiency due to some parties not receiving a copy of the product, and to increased enforcement costs and less user-friendly technology.

There indeed exist also some alternative economic structures that do not force exchangeability. As referred to earlier, in small scale communities anti-rival resources can be organized through trust and interpersonal (and interorganizational) relationships (Barbrook, 1998; Ghosh, 1998). Institutions can also set open-access policies, e.g., like in publicly funded research. Moreover, open-source software development has for decades been successful in facilitating anti-rivalry through transparent and merit-based accounting.

However, the mentioned alternative systems are either fairly small-scale (based on interpersonal trust or an agreement of limited set of actors), based on institutional power (public funding), or fit only some specific context (like open-source software). While there have been efforts in externalizing these structures for more large-scale and mainstream use, such efforts are predominantly prone to the so-called tragedy of commons: negative externalities resulting in failures of collective action when all the participating entities use up a common resource for their own gain, and everyone receives diminishing returns from the resource due to its overconsumption (Greco and Floridi, 2004).

Thus, in ATARCA, we design experimental economic systems that 1) have the ability to take into account the specific characteristics of anti-rival resources, 2) incentivize individual and collective action (regarding resource production and sharing), and 3) facilitate positive externalities and mitigate negative ones (in particular, to avoid the tragedy of commons). Moreover, although our experiments are small scale and targeted to specific use cases, we plan for scalability and context-independency.

1.1.2 The limitations of classical mechanism design

The marginalist formalist revolution in the economics science marked a watershed in the derivation and application of the neoclassical technical apparatus within economics. Such revolution also signaled a division in the relationship between economics and the other social sciences (Fine and Milonakis, 2003; 2009; Milonakis and Fine, 2007). In fact, "paradoxically, there were much greater concerns expressed in making the assumptions to allow for the derivation and use of utility and production functions for the narrow application to supply and demand, than there were in extending their application across the social sciences" (Milonakis and Fine, 2009: p. 306). Herewith, classical economics viewed individual self-interest as the primary driver of economic value and was optimistic that market solutions can solve all problems.

Subsequently, with the invention of game theory and the rational choice revolution (Amadae, 2003), economists and other social scientists began to realize that there is a "back hand" to Adam Smith's proverbial invisible hand. This back hand is the problem, discovered by game theory and typified by the Prisoner's Dilemma, that individuals' self-interest may well lead to mutual impoverishment (Amadae, 2016). Throughout the subsequent decades, solving the problem of cooperation, manifested in the Prisoner's Dilemma, became one of the overall goals of institutional designers. Within this world, all value is scarce and necessarily rivalrous. All individuals are motivated by incentives which ultimately have a zero-sum cash value.

Following this recognition that there can be incentive incompatibilities between individuals' self-interest and basic markets and other institutions dedicated to achieving collective actions (Hardin, 1982), institutional designers set about building institutions with appropriate incentive structures to achieve mutually beneficial equilibria (North, 1990). Mechanism design ensued and focused on the challenge that even in markets, individuals have the incentives to be dishonest about the quality of their products, on the one hand, and their willingness to pay for products, on the other hand (Prize Committee, 2007). An overarching challenge is presented by the fact that, to achieve optimal equilibria markets depend on perfect information (or good approximations to this), and yet individual actors have incentives to withhold information.

This challenge of sharing information, provided it is linked to individuals' direct interests, can be overcome if various conditions are met. In ATARCA, we take the approach that, given meeting the conditions of respecting individuals' privacy concerns, data and information are the best examples of an anti-rival good. Thus, while aware of the incentive incompatibility concerns faced by institutional and mechanism designers, we take the approach that transparency and the free sharing of information are net positives that reflect positive externalities. Sharing information, which provides an important basis for informed choice and action, is vital for all of our cases. **Thus, ATARCA's application of anti-rival currencies is both consistent with earlier economic theories and practices, and also reflects a significant leap beyond the endless competition over bounded resources to measuring, recording, and appreciating the positive sum sources of value widely available and integral to societies.**

In summary, while current economic institutions are at best derived from the theoretical worldview of the narrowly self-interested maximization of rivalrous resources traded using zero-sum currencies, there is a wide reservoir of anti-rival value that can be harnessed with the appropriate anti-rival incentives and institutional design. Contemporary dominant competition policies and market regulation are strongly rooted in microeconomic theory and game theory according to which all actors seek increasingly more of inherently scarce resources. This has repeatedly led to poor policy design, but also to numerous and remarkable market and socio-political failures in recent decades.

To solve these issues, we follow Elinor Ostrom's pioneering work which both challenged the routine prisoner's dilemma analysis of economic institutions and led to the vision that many communities will develop the tools to solve collective action problems from within (Ostrom 1990, 2005). In ATARCA, we go beyond Ostrom's work by augmenting her approach with the integration of anti-rivalrous accounting systems and community currencies.

1.1.3 ATARCA's technological approach

From the technological perspective, ATARCA is developing institutions and incentive systems that are based on cryptographic tokens. A *new cryptographic token type is created*, titled *Shareable Non-Fungible Token (sNFT)*, which is a specific variant of the already well known Non-Fungible Token (NFT).

NFTs are unique cryptographical tokens defined by a smart contract existing on a digital ledger (such as blockchain) where each non-fungible token is uniquely identifiable and separable from each other. In practice, this means that they usually would have at least a unique serial number. Typically, NFTs follow similar principles as rival money and resources, i.e., tokens are mintable and exchangeable and once they are exchanged the owner no longer has them. However, whereas currency is fungible and interchangeable from each other, the non-fungible tokens are unique and distinguishable from each other.

Interestingly, the logic of NFTs can be tailored to change their nature away from means of exchange to means of sharing. The aspect of programmability allows the exploration of novel incentivization mechanisms that can be arduous to replicate in an analogue world. For ATARCA and its experiments we leverage this characteristic and implement new kinds of "smart tokens" which follow anti-rival logic and promote anti-rival behavior in our experiments.

Therefore, in ATARCA, we envision implementing new kinds of NFTs that are anti-rival: these shareable NFTs can be "shared" in the same way anti-rival goods can be shared, at an almost zero technical transaction cost. They are used to instantiate quantified anti-rival

value; hence, the tokens work somewhat as money, being a store of value and a unit of account, but instead of being a medium of exchange, they are a medium of sharing. We call this new token type an sNFT, to emphasize on its "shareability" characteristics.

Typical NFT standards such as ERC-721[1] and ERC-1155[2] do not define a sharing modality. Instead, the ERC standards define user interfaces for rival use cases such as token minting and token transactions that the NFT contract implementations should fulfil. However, the "standard" contract implementations[3] may extend the functionalities beyond the definition of such interfaces. The tokens developed in the ATARCA experiments are designed to be token standard compatible at the interface level. However, the implementation of token contracts may contain extended functionalities to match the requirements of the experiments such as the requirement of shareability. When considering standard token definitions, shareability of a token could be thought of as re-mintability of an existing token. Contracts define re-mintable non-transferable tokens which retain some reference to previous tokens upon and after re-minting.

Our technological approach is analogous to the manner in which Bitcoin implementation allowed instantiation of the Bitcoin cryptocurrency. However, while Bitcoin created artificial scarcity, the value of our sNFTs will not be based on scarcity but on the underlying human relations, and their relations to the specific value units[4]. Their value reflects the way relationships and contributions are built over time through repeated interactions, by default benefiting all aspects of the community. Herein, sNFTs serve the currency functions of being a metric of value, a medium of sharing, and a store of credit.

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[1] EIP-721: Non-Fungible Token Standard https://eips.ethereum.org/EIPS/eip-721

[2] EIP-1155: Multi Token Standard https://eips.ethereum.org/EIPS/eip-1155

[3] OpenZeppelin The standard for secure blockchain applications https://github.com/OpenZeppelin/openzeppelin-contracts

[4] Value unit is a term from the contemporary network effects literature. Value unit is the economic good which is valuable for someone else.

2 Pilot Experiment Designs

ATARCA's three use cases — Barcelona Green Shops, Streamr Community case, and Food Futures — experiment with novel incentive mechanisms to capture anti-rival value. This chapter introduces the cases by presenting their backgrounds and experiment designs.

2.1 Barcelona Green Shops

The Barcelona Green Shop case is a professional platform that enhances information sharing and interactions of community members that promote sustainable products. This use case is developing anti-rival features within the existing REC platform, a local and digital currency in Barcelona. A shareable, non-transferable, non-fungible token (sntNFT) will be launched, providing feedback to consumers about the impact of their purchases. This feedback is expected to create a new incentive for cooperative behavior.

2.1.1 Background of the experiment

In the last years, the city of Barcelona has seen city districts undergo gentrification, accompanied by the progressive reduction of local, independent, and traditional (LIT) shops and, in some boroughs, even partial commercial desertification (Fresnillo, 2018).

LIT commerce can be broadly conceptualized as a system formed by small commercial businesses with common characteristics (Barcelona City Council, 2017), clearly differentiated from large distribution corporations. LIT shops are generally owned by one person and often employ members of one's own family. The size of these shops is usually tiny, and they sell products like food, fresh groceries, clothes, and cosmetics. These shops often lack strong bargaining positions toward upstream distributors and suppliers and often do not have sophisticated logistical and marketing strategies and capabilities.

Thus, LIT shops have a hard time competing with large competitors. Despite these competitive shortcomings, LIT shops are known to generate a positive impact on consumers and neighborhoods (Hernández, 2016). They can be seen as urban networks whose mere presence and embeddedness in the city produce positive externalities. To adapt to the new competitive challenges and continue to produce positive externalities, LIT shops must improve their business models. Coordination with similar, small shops can enable improvements in dimensions like provisioning, logistics, and marketing.

In the ATARCA project, Novact and Qbit have undertaken a participatory research process to identify the problems of LIT shops in Barcelona. This process consisted of a focus group with LIT shop owners, in which the shop owners stated that they felt alone, and that they lacked coordination mechanisms with other shop owners to defend their interests and improve their businesses. They also stated that one of the identified problems is the lack of a common sectoral or community identity and purpose.

In addition, Novact and Qbit carried out a randomized survey of 411 middle-income consumers from Barcelona. The results showed that a large majority (91%) of the participants stated that they often buy in big supermarkets and less so in local shops. However, 71.5% said they would buy in local shops if they could get more information on their positive impact (Cutillas, 2022).

Also, based on the studies, it is difficult for consumers to perceive the aggregate result of their actions and, therefore, to recognize the positive externalities of their purchases in LIT shops: environmental, health, gentrification, labor rights, human rights, etc. This problem can be conceptualized as a negligibility problem: customers do not contribute because they view their contributions as negligible.

2.1.2 Experiment design

The case experiment focuses on Barcelona's so-called "green shops", for which Rezero has granted such a label, a foundation that promotes low waste consumption in the Barcelona area. Green shops have established a relationship with Rezero, committing to transition to a model of reduced waste based on in-bulk sales and sustainable packaging. The platforms used in the experiment will be orchestrated by a board composed of staff from Rezero, Novact, and Qbit and shop owners.

Our research will test if anti-rival coordination mechanisms (in the form of cryptographically encoded non-fungible tokens for shop owners and their customers) can reduce the negligibility problems identified. Furthermore, we assume that introducing an anti-rival sharable non-transferable non-fungible token will improve the allocative efficiency of non-monetary (time, knowledge, well-being) and monetary resources (income, profits, etc.).

We have designed two interconnected tests, which will take place on two different platforms. The first test will take place on a platform for shop owners, the so-called professional-community platform or B2B platform. The test will explore the differences in behavior when anti-rival coordination mechanisms are introduced. At a pre-defined point during the experiment, a token will be introduced as a reward for contributions to the platform. Identifying differences in behavior after introducing anti-rival compensation tokens will allow us to test whether our hypothesis is correct. The B2B digital platform will be subsidized by Novact (public funds), in the first experiment, and through fees paid by members of the platform in a later stage.

The second test will take place in the REC app, the so-called B2C platform. The REC app is an already established local social currency within Barcelona. Consumers will be able to access the REC app to make purchases in the Green Shops of Barcelona. At a pre-defined moment, anti-rival tokens in the form of sntNFTs will be introduced in the app to reward consumers for shopping in green shops and producing content for the platform. The difference in behavior before and after introducing the tokens will further allow us to test our hypothesis within a different stakeholder group. Similarly to the B2B platform, the B2C digital platform for the customers will be subsidized by Novact in the first experiment, and in the later stage through fees paid by the partners of the cooperative enterprise holding the intellectual property of REC.

The B2B digital platform will be subsidized by Novact (a publicly funded entity), in the first experiment instance, and through fees paid by members of the platform in later stages. Similarly, the B2C digital platform for customers will be subsidized by Novact in the first instance, and through fees paid by partners of the cooperative enterprise holding the intellectual property of REC in a later stage. This cooperative is called Taula de Canvi (Board of exchange) and was constituted in 2019 as the organ that governs and supports the digital currency through its own capital and other funding sources.

2.2 Streamr Community Case

ATARCA consortium member Streamr is developing core technology for decentralized real-time data sharing. Leveraging the core technology, building decentralized platforms and services is a collective effort by the Streamr community. In this use case, Streamr platform will be enhanced with anti-rival tokens, and in particular, with non-transferable, non-fungible tokens. These tokens will be linked to the existing real-time data ecosystem and the Streamr community. The aim of this pilot is to study the impact of such NFTs on community engagement and community contributions towards the development of the Streamr project.

2.2.1 Background of the experiment

The development of decentralized P2P (peer-to-peer) information-sharing platforms and related open-source practices constitute significant research areas within the data economy. Platforms benefiting from community contributions offer a fruitful experimental setting for analyzing behavioral patterns and value flows between community members from an anti-rival perspective. Streamr, a partner of ATARCA itself, is an open-source platform that aims to create a global decentralized network for open but secure data transfer.

The main aim of the Streamr community case is to study and analyze a new incentivization model for reinforcing anti-rival feedbacks in the ecosystem that underlies the Streamr P2P platform. The specific interest is in incentivizing development contributions, by nature either of the non-programming kind (participating in the discourse, sharing knowledge, etc.) or of the programming kind (writing and testing code).

The Streamr community consists of a diverse group of participants and stakeholders, all working toward a collective mission: to successfully build and operate infrastructure for decentralized real-time data transport. Members of the community take on different and sometimes multiple roles in the community. They participate in the system's governance by submitting improvement proposals, voting on improvement proposals, contributing to discussions, and sharing knowledge and ideas.

Interestingly, many community members also actively participate in operating the technical infrastructure of the peer-to-peer network by providing bandwidth and hardware for data transport. Developers of applications that utilize the P2P infrastructure can be also observed to engage actively with other members of the community by sharing knowledge and experience, and thereby contributing to ecosystem development.

In sum, contributors within the community appear to be driven by both intrinsic motivation—belonging to a collective of people bound by a shared mission—and extrinsic motivation, i.e., monetary compensation. On the first point, interviews we have conducted with community members indicate that peer recognition and reputation are typically seen as factors that incentivize contribution.

2.2.2 Experiment design

This experiment introduces a new type of a non-fungible token that community members can receive and share with others who have also participated in the platform's development. The deployment of shareable tokens allows for exploring different dimensions related to sharing, such as the significance and perceived popularity of different contributions within the community.

For context, it may be useful to note that the Streamr community effectively constitutes a decentralized autonomous organization (DAO). Members of the DAO participate in governance and can make different types of contributions towards the development of the Streamr project. In this experiment, non-transferable and non-fungible tokens will be created. The functionality of these NFTs is designed to incentivize DAO members to usefully contribute to community goals.

The anti-rival incentive system will be defined so that there is a reinforcing loop: the more members the community has, the more information the community can generate. It is hypothesized that this increased recognition of those who contribute valuable knowledge and information will lead to a more active and vibrant community. To maximize the value flow in this system, tokenized incentives are intended to capture—at least partially—the positive externalities created in the community. Incentives created in the pilot are non-financial, merit-oriented, and by definition 'eternally ownable' by the recipients. The tokens cannot be traded for monetary gain, though they are shareable with other members of the community in some cases.

Our research hypothesis is that the creation and deployment of new tools for the acknowledgment of community contributions, will positively affect information sharing and knowledge creation in the Streamr community. The intention is that the crypto-economic mechanisms developed in the Streamr use case are applicable and repeatable in other Web3 communities, thereby leading to an industry-wide positive contribution beyond the scope of this pilot.

The experiment focuses primarily on two dyadic interaction relationships: (1) the relation between the ecosystem leaders and contributing community members, and (2) the relation between any two members who share acknowledgment tokens with each other.

In the experiment, due to the nature of the pilot case, the governance mechanisms are mostly centralized. The criteria for assessing and rewarding community contributions are defined by the Streamr team, and each contribution is evaluated against the requirements. Any conflicts arising in the token system will be resolved by the ATARCA researchers.

The experiment will undertake a mixed-methods longitudinal study over six months to study the impact of the introduction of anti-rival incentives, the change in allocative efficiency, and the perceived value of the anti-rival incentives.

2.3 Food Futures

Food Futures is developed within an existing market for cafeteria lunches by freely making available the sustainability impact values of purchase decisions. The Food Futures use case is designed to encourage two forms of anti-rival goods generation: data sharing and positive externalities, inverting the tragedy of the commons. In this use case, anti-rival tokens are allocated as a measure of contributing positive externalities, which otherwise would seem *individually negligible. The shareable, non-transferable, non-fungible token will show the impact of community action and provide a means to contrast it with the daily contributions of non-community members.*

2.3.1 Background of the experiment

Food Futures is developed within the current widely appreciated market failure and tragedy of the commons associated with runaway carbon gas emissions and other environmental forms of degradation caused by production processes underlying agriculture.

One method to solve the global carbon gas resource dilemma has been to introduce systems of carbon credits with market exchanges that attempt to set limits on overall carbon gas emissions in large industries. However, this large-scale method to tackle the problem is targeted at key players who can directly make a difference to overall CO_2 and equivalent gas emissions. In these efforts, consumers' sovereignty and individual choice are left out of the process to achieve efficient markets.

Food Futures employs anti-rival token design to provide consumers with the tools to generate impact by creating virtual communities and providing individuals in these communities with an impact measure to transform otherwise negligible positive externalities into collectively noticeable constructive impact.

2.3.2 Experiment design

Food Futures works within the current markets for purchasing cafeteria lunches and introduces a means to counter the market failures associated with unsustainable agricultural and production processes. Market interactions remain as before, but a means of relaying data and working to achieve greater transparency of information regarding sustainability impact is introduced.

Thus, the one essential feature of the Food Futures pilot use case is to share consumption information freely. This information encompasses the data science of underlying food impact by developing readily accessible data visualization and communications means to enhance the quality of information regarding available food options. Combined with validated information regarding users' meal choices, further information is shared with users regarding their collective impact. Herein, research into service design provides evidence that sharing information with users regarding their collective impact can generate a positive feedback loop that encourages increasingly socially constructive actions.

In detail, the Food Futures experiment is systematically built to achieve the following. First, it is designed to remedy the tragedy of the commons analyzed to be a function of negligibility. The function of negligibility refers to actors' sense that no matter what their actions are, none can make a noticeable impact on the global, or even local, public good of sustainable consumption. Second, navigating between private market solutions and centralized governance structures, Food Futures develops a platform to ameliorate unsustainable environmental impact from actors' everyday meal choices. Participating in the community constructed by this platform is entirely voluntary and also is distinct from either free-market transactions and governmental regulations or provisions. Third, Food Futures represents a mechanism design that navigates the impossibilities of attempting to achieve incentive compatibility and efficient resource allocations in traditional market design structures (Prize Committee, 2007).

Given that the control group, or status quo consumption, is not currently environmentally sustainable and reflects a tragedy of the commons, any tendency toward more sustainable consumption on the part of users signifies greater allocative efficiency made possible by the platform. Thus, by the Food Futures' mechanism design, the increase of impact tokens in users' and donors' possession indicates greater efficiency concerning resource consumption and allocation. The metric of efficiency used in the Food Futures pilot case study is the difference between the control group's average sustainability impact measures (recorded data on non-platform users' consumptive behavior), contrasted against the platform users' consumptive behavior.

3 Social Dilemmas in the Experiments

We will now focus on a micro-level (user-to-user level) analysis of the social dilemmas in the three user cases. Although each case has unique characteristics, on a general level they all aim to transition from the under-provision of public goods and reinforcement of negative externalities into sustainable systems that generate additional value for the ecosystem stakeholders.

Our approach to micro-level analysis is based on Ostrom's principles (1990, 2005) of institutional design in a commons context. We take a game theory perspective and model the cases' core interactions as a two-person, two-action (2x2) game, which two players interacting with two choices: collaborate or defect. In identifying the core interactions, we follow Choudary's (2015) approach to platform design and try to recognize one or more core interactions central to the ecosystem.

In practice, we address each case experiment by 1) describing the core interactions of interest, 2) modelling the interactions as a 2x2 game (here, instead of formal notation, we aim for insight and discussion of benefits, sacrifices, and externalities involved in the interaction), and 3) highlighting the relevant social dilemmas.

3.1 Barcelona Green Shops

3.1.1 Core interaction 1: Shop owners' business information sharing

The first core interaction (CI) of the Barcelona case, "shop owners' business information sharing," occurs through the shop owners' professional community platform (also referred to as a B2B platform). Here, as informed by the research carried out in the participatory process (as described in Section 2), and further abstracted in this analysis, stakeholders Shop owner one and Shop owner two **either share (modeled as cooperation) or do not share information (modeled as defection)** on their business activities. Sharing has the potential to improve both parties' business outcomes (individual benefits), as well as to support their business communities and city neighborhoods (positive externalities).

In more detail, in the case of **both stakeholders collaborating (both share information)**, both parties get *business information* from each other and gain *business relationships*. In return, both parties have to give up *information asymmetry and exclusivity* –based business advantages. In a repeated scenario, the parties *get affiliation to a thriving business network*. From the **externality** perspective, this scenario *increases (positive) the vitality of the city neighborhoods* and *increases (positive) the value of the business community the stakeholders are involved in.* Table 2 summarizes.

Table 2. Benefits and sacrifices when both shop owners collaborate in Barcelona CI1.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Shop owner 1 (collaborates)	+ business information and relationship	+ affiliation to thriving business network + *increased value of the business community (externality)* + *increased vitality of the city neighborhoods (externality)*	- information asymmetry and exclusivity	
Shop owner 2 (collaborates)	+ business information and relationship	+ affiliation to thriving business network + *increased value of the business community (externality)* + *increased vitality of the city neighborhoods (externality)*	- information asymmetry and exclusivity	

In an outcome of **only one stakeholder collaborating (sharing information)**, and the other one defecting (not sharing), the defector will *get business information* from the other party, while the collaborator gains *no benefits*. The defector sacrifices *the trust of collaborator*, while the collaborator sacrifices *information asymmetry and exclusivity –based business advantages.* In a repeated setting, defector *loses reputation* in one's business community. From the **externality** perspective, both parties *suffer (negative)* from *weakened city neighborhoods and business community*. Summary of the outcome is presented in Table 3.

> *Note: the scenario is symmetrical: the outcome is the same, although inverted, if shop owner 2 defects and shop owner 1 collaborates.*

Table 3. Benefits and sacrifices when only one shop owner collaborates in Barcelona CI1.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Shop owner 1 (defects)	+ business information		- loss of trust of other stakeholder	- reputation in the business community *- weakened city neighborhoods (externality)* *- weakened business community (externality)*
Shop owner 2 (collaborates)			- information asymmetry and exclusivity	*- weakened city neighborhoods (externality)* *- weakened business community (externality)*

In an outcome of **both parties defecting (no one shares information)**, they both gain *nothing* immediately or in a repeated setting. Both sacrifice trust of each other, and the reputation in the business community. Also, from the **externality** perspective, the city *neighborhood and business community weaken (negative)*. Table 4 illustrates.

Table 4. Benefits and sacrifices when both shop owners defect in Barcelona CI1.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Shop owner 1 (defects)			- loss of trust of other stakeholder	- reputation in the business community - *weakened city neighborhoods (externality)* - *weakened business community (externality)*
Shop owner 2 (defects)			- loss of trust of other stakeholder	- reputation in the business community - *weakened city neighborhoods (externality)* - *weakened business community (externality)*

To summarize, from the incentive perspective, core interaction one creates a *social dilemma: while pareto optimality is that both collaborate, without taking externalities into account and without strong institution the parties resort to both defecting due to risk aversion*. Also, in a larger business community (with more anonymity) a *defect-collaboration strategy (gambler) is possible*.

3.1.2 Core interaction 2: Consuming in green shops

The second core interaction, "consuming in green shops", is carried out through the REC app, as described in section two of this document. Here, representative stakeholder Customer one interacts with a Customer N-1 (representing all the other customers). Customer one decides whether to **consume environmentally responsible and more expensive goods (modeled as cooperation)**, or to **consume cheap and less responsible products (modeled as defection)**. As this is a 1 vs. N-1 setting, the analysis focuses primarily on the payoffs of Customer one.

If Customer one and everyone else **collaborate**, customer one receives *high quality goods and services and new relationships* but must bear the *higher prices* and sometimes *less practical purchases*. When this setting is repeated there will be positive **externalities**: *vitality of the city neighborhood improves, green shop network thrives, and sustainability is promoted*. Also, the *prices of sustainable products will be lower.* Table 5 summarizes.

Table 5. Benefits and sacrifices when everyone collaborates in Barcelona CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Customer 1 (collaborates and others also collaborate)	+ high quality goods and services + relationships	+ *vitality of the city neighborhood improves (externality)* + *green shop network thrives (externality)* + *sustainability is promoted (externality)* + *lower prices for sustainable goods (externality)*	- slightly higher price - less practical purchases	

If **Customer one defects but others continue collaborating (free-ride scenario)**, Customer one receives the *price and practicality benefits of cheap goods* but sacrifices individually with regards to the *quality of the goods*. In terms of **externalities**, *vitality of the city neighborhood still improves, green shop network thrives, and sustainability is promoted*, as one customer’s defecting has only minimal negative impact. Table 6 summarizes.

Table 6. Benefits and sacrifices when Customer one defects but others collaborate in Barcelona CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Customer 1 (defects, while others collaborate)	+ cheap goods and services + practicality	+ *vitality of the city neighborhood improves (externality)* + *green shop network thrives (externality)* + *sustainability is promoted (externality)*	- worse quality of the goods and services	

If **Customer one collaborates, but no one else does**, Customer one receives *high quality goods and services*, but sacrifices individually from *very high cost*. In terms of **externalities**, city neighborhood and environment quality are worsened, and the local shop network is lost in a repeated setting (which makes the whole scenario obsolete). Table 7 illustrates.

Table 7. Benefits and sacrifices when Customer one collaborates but others do not in Barcelona CI2

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Customer 1 (collaborates, while others do not)	+ high quality goods and services		- very high cost	- *worsening city neighborhoods (externality)* - *worsening of the environment (externality)* - *loss of the local shop network (externality)*

If **everyone defects**, everyone receives the *price and practicality benefits of cheap goods*, but all sacrifice in *quality of the goods*. **Externalities** are similar to the previous scenario: city neighborhood and environment quality are worsened, and the local shop network is lost. Table 8 summarizes.

Table 8. Benefits and sacrifices when everyone defects in Barcelona CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Customer 1 (defects, and others also defect)	+ cheap goods and services + practicality		- worse quality of the goods and services	- *worsening city neighborhoods (externality)* - *loss of the local shop network (externality)* - *worsening of the environment (externality)*

Thus, in core interaction two, Customer one obtains a better payoff by defecting if other customers collaborate: one can benefit from the positive externalities of others' responsible collective behavior. If other customers start defecting, Customer one will still obtain the same individual result. *Thus, prior to introducing any institution, stakeholder one's best strategy is always to defect*.

3.2 Streamr community

3.2.1 Core interaction 1: Screening a contribution

The first core interaction happens when a Contributor (a member of the community) makes a contribution and a Community leader evaluates it (in practice, the evaluation is done by qualified person(s) in the Streamr team). The aim of this interaction is to assess the quality of community contributions, to encourage high-quality contributions, and to avoid low-quality contributions gaining undeserved recognition or following in the community.

Screening a contribution can be viewed of as a game with two players: To **collaborate, the Contributor makes a valid contribution** (a contribution that is legitimate, has no malicious hidden agenda, is valuable for the project, and is the original work of the contributor). To **defect**, the **Contributor makes an invalid contribution** (one that does not meet the above criteria). In turn, the **Community leader collaborates by making a fair and honest evaluation** of the effort. To **defect, one** makes a dishonest or **unjust evaluation**.

> *Note: To focus the experiment, in this pilot case, Streamr acts as a centralized decision maker in reviewing the contributions. In later experiments, Streamr role will be decentralized.*

When **both players collaborate**, the Contributor makes a valid contribution, and the Community leader truthfully evaluates the impact and value of the contribution. The Contributor gains *assurance and information* about what the Community leaders (i.e., the Streamr team) find valuable. The community leaders gain *valuable content that helps develop the project technology*. Over time, collaborating interactions reinforce the Contributor's *reputation as a valuable member of the community*, and provide the Community leader with *valuable contributions to the platform in line with the vision*.

The sacrifice by both parties for participating in collaborative (or honest) interaction is straightforward: *some amount of effort is needed to create and evaluate the contribution*. In addition, the Contributor has to bear the *cost of uncertain payoffs in making contributions without direct compensation*. **Externalities of the interaction** are linked to the Community leader's chance of *gaining curated content for their ecosystem (positive)* with the *risk of demotivating the providers of radically novel contributions (negative)*. The interaction is summarized in Table 9.

Table 9. Benefits and sacrifices when both players collaborate in Streamr CI1.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Contributor (collaborates)	+ affirmation by approval of a contribution + Information about what leaders find valuable	+ increased reputation in community	- effort required for the contribution	- uncertain (or indirect) payoff for the contributions
Community leader (collaborates)	+ a valuable contribution to the project	+ contributions more aligned with project vision + *curated content for the community (externality)*	- effort required to evaluate the contribution	- *demotivation the providers of non-aligned (radically novel) or invalid contributions (externality)*

If the **Contributor collaborates** by providing valuable content for the community but the **Community leader defects** by failing to fairly acknowledge the contribution, the Contributor spends *the effort without the deserved merit or reputation effect*. The imbalance will be demotivating and, eventually, will lead to *decreasing or worthless inputs from the community*. The immediate sacrifice by the Community leader for defection may be small in the near term. However, defection will lead to negative **externalities** through *lost reputation and diminished trust within the community*. For a summary, see Table 10.

Table 10. Benefits and sacrifices when the Contributor collaborates but the Community leader defects in in Streamr CI1.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Contributor (collaborates)			- effort required for the contribution - no merit or recognition for the contribution	- lost motivation to contribute - *losing trust to the evaluator(s) and the system (externality)*
Community leader (defects)	+ a valuable contribution to the project	+ valuable contributions gained with minimal effort	- effort (even if minimal) required to evaluate the contribution	- loss of reputation as a community leader

If the **Contributor defects** by providing useless or malicious content but the Community **leader collaborates** by evaluating the contribution fairly, the Contributor *does not receive any credit and the overall quality of the project remains uncompromised*. The Contributor *spends less effort while still sacrificing some spent resources***.** In a repeated setting, *one also loses reputation*. The Community leader gains due to *continued quality assurance of the project* but sacrifices *resources on the evaluation of contributions*. There is positive **externality:** the project quality increases over time. See Table 11.

Table 11. Benefits and sacrifices when the Contributor defects but the Community leader collaborates in Streamr CI1.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Contributor (defects)	+ some effort required for the contribution		- (some) resources spent	- loss of reputation as a potential contributor
Community leader (collaborates)	+ protecting the system and sustaining the level of acknowledged contributions	+ increased reputation as a fair evaluator in the community + *better quality of contributions (externality)*	- effort required to evaluate the contribution	

If both **parties decide to defect**, the Contributor submits a contribution or poor quality, and the Community leader dishonestly accepts and rewards the contributor. Both parties gain short-term benefit: The Contributor *is unfairly recognized*, and the Community leader *presents a seemingly active community*. Both parties also *save on time and effort*. However, both parties sacrifice a *moral loss*. In a repeated setting the parties *risk getting caught and losing reputation*. The negative **externalities** include *the loss of reputation of the entire community and the loss of quality in project technology*. See Table 12 for a summary.

Table 12. Benefits and sacrifices when both players defect in Streamr CI1.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Contributor (defects)	+ recognition for invalid contribution		- (some) resources spent - moral loss	- risk of getting caught *- decreased value of recognition(s) (externality)*
Community leader (defects)	+ seen as a leader of an active and contributing community		- effort (even if minimal) required to evaluate the contribution - moral loss *- decreasing quality of content and evaluation (externality)*	- risk of getting caught *- decreased value of community and technology (externality)*

To summarize the dilemma, *the Contributor is tempted to gain more recognition with less effort, whereas the Community leader hopes to increase the volume and quality of community contributions*. By screening the contributions, the Community leaders can protect the community from low-quality work and motivate the providers of high-quality efforts by fairly acknowledging the value of their work.

However, the Community leaders cannot truly know the future value of any specific contribution. There is an information asymmetry as the leaders don’t know the true preferences of the Community members; the screening process rather represents the vision of the Community leaders. It is therefore not a given that the screening process leads to an outcome in line with the community values. In other words, there is a risk that screening *leads to a rejection of contributions which are not consistent with personal views of the community leaders.*

3.2.2 Core interaction 2: Sharing recognition with a co-contributor

The second core interaction involves the contributors' evaluation and recognition of the work done by other contributors. The purpose of this interaction is to encourage a fair attribution of contributions and make visible the true development process behind a contribution, especially in the case of collaborative effort. Hence, the interaction takes place between the *Primary contributor (or just "Contributor")* and *Secondary contributor (or "Co-contributor")*. The Primary contributor is someone who has made an original contribution with the help of others contribution. The Secondary contributor has helped in the making of the original contribution and wishes to be recognized for their effort. The interaction addresses the question of fairly acknowledging the participation of other community members.

If **both stakeholders collaborate**, the Primary contributor conducts a truthful evaluation of a secondary contribution conducted by another community member. In turn, the Secondary contributor provided *a* valid contribution in support the Primary contributor's work. The Primary contributor gains by *being seen among peers as someone who fosters cooperative collaboration and*. In a repeated game, the *growing reputation further improves their future collaboration opportunities in the community*. The Primary contributor bears *the effort of truthfully evaluating the co-contributor's work and sharing the merit*. In a repeated scenario, the Primary contributor sacrifices *due to more fragmented history of contributions*. The Secondary contributor, in turn, gains *recognition for one's contribution*, and in a repeated setting, gains *increasing reputation in the community*. There is, of course, *a cost in terms of time and effort* for taking part in the contribution. In terms of **externalities**, this interaction scenario increases the *community's reputation for acknowledging contributions*, and therefore increases the *overall willingness to contribute to future projects*. Table 13 summarizes the interaction.

Table 13. Benefits and sacrifices when both players collaborate in Streamr CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Primary contributor (collaborates)	+ valid co-contribution + signal cooperative collaboration among peers	+ increased reputation for being a fair attributor + more collaboration opportunities in future *+ grows community's reputation for fairly acknowledging contributions (externality)*	- effort spent in the evaluation - having to share the merit	- fragmenting the recognition for past contributions - uncertain (or no direct) payoff for the contribution
Secondary contributor (collaborates)	+ recognition for the contribution	+ increased reputation in community *+ increased willingness and trust to contribute to future projects (externality)*	- effort spent in the contribution	- uncertain (or no direct) payoff for the contribution

If the **Secondary contributor collaborates by making a valid contribution** but the Primary contributor defects by not evaluating it truthfully, the Primary contributor gains *unearned merit in the community*. However, one sacrifices a *moral loss*, and, in a repeated setting, *risks trust and future collaboration options within one's peers*. The Secondary contributor gains only *experience* while *sacrificing due to the effort spent in making the contribution*. In a repeated game, the Secondary contributor gains *information on with whom to cooperate* but sacrifices *motivation*. The outcome produces the negative **externality** of *lowered community value and activity*. See Table 14 for a summary.

Table 14. Benefits and sacrifices when the Primary contributor defects and the Secondary contributor collaborates in Streamr CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Primary contributor (defects)	+ taking credit for others' work + signal own contribution disproportionately		- moral loss	- risks losing trust - less future collaboration possibilities *- lowered community value and activity (externality)*
Secondary contributor (collaborates)	+ experience	+ knows whom not to trust in the future	- effort spent in the contribution	- demotivated mental model *- lowered community value and activity (externality)*

Alternatively, if the **Secondary contributor defects** by making an invalid contribution but the **Primary contributor collaborates** by evaluating it fairly (and therefore declines the proposed contribution), both parties *gain nothing but sacrifice time and resources*. In a repeated setting, the Primary contributor is likely to *receive better quality inputs from the collaborators* (by not giving credit where it is not due). Over time, the Secondary contributor will experience *a loss of reputation*, assuming the quality of inputs remain low. As to the **externalities**, the *quality of the contributor base and contributions is likely to improve*. Table 15 summarizes the interaction.

Table 15. Benefits and sacrifices when the Primary contributor collaborates and the Secondary contributor defects in Streamr CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Primary contributor (collaborates)		+ better content through fair evaluation + avoids devaluating own efforts for contributions + *quality of contributions and contributors improve (externality)*	- effort spent in the evaluation	
Secondary contributor (defects)		+ *quality of contributions and contributors improve (externality)*	- (some) effort spent in the contribution	- loss of reputation

There is also the case where both **parties defect**: the Primary contributor provides an untruthful evaluation of an invalid contribution. In practice, this can translate to either crediting poor work or acknowledging the wrong people. The Secondary contributor either *receives recognition for an invalid or a non-existent contribution* or, in a repeated setting, has a *chance to distribute defective or malicious contributions without being directly associated with harmful content*. In turn, the Primary contributor simply gains *the credit for others' work* (if not sharing the credit) or shares the credit dishonestly. One may be motivated by *reasons external to the system*: e.g., personal relations or monetary agreements.

Both parties sacrifice *moral loss*, and in a repeated setting, due to the transparent nature of open-source communities, *risk a loss of reputation if another member looks at their work in detail*. Moreover, by failing to honestly acknowledge secondary contributions, the Primary contributor *risks their personal reputation by claiming to be responsible for bad work*. Looking at the **externalities**, the *value of the open-source community decreases as the merits of the contributions become unclear or invalid*. See Table 16 for a summary.

Table 16. Benefits and sacrifices when both players defect in Streamr CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Primary contributor (defects)	+ taking credit for the work of other(s) + benefits for defection outside the system		- moral loss	- loss of reputation if caught - taking the blame for invalid contributions *- merits of contributions become unclear or invalid (externality)*
Secondary contributor (defects)	+ recognition for invalid contribution	+ can distribute defective or malicious contributions	- moral loss	- loss of reputation if caught *- lowered community value (externality)*

In summary, this core interaction highlights a tragedy of commons: *both parties defecting is the most attractive strategy in the short term even if, in the long term, everyone would be better off by collaborating*.

3.2.3 Core interaction 3: Capturing the community opinion

The purpose of the third core interaction is to facilitate a continuous process of rating community contributions with the aim of identifying valuable content. A community member can **decide to openly endorse a contribution (i.e., to cooperate)** or **silently endorse a contribution (i.e., to defect)**.

Open endorsements are favorable for the community, as they can help make it transparent how the endorsements of certain individuals can shape the general opinion or emerging preferences within the community. In contrast, by making a silent endorsement, a community member will not make a public commitment to a certain opinion. As the interaction takes place between different and arbitrary members of the community, the players are modelled as Member 1 and Member N-1.

Note: In this analysis, some potentially limiting assumptions are made for simplicity. We assume that the community members always put effort toward evaluating the contributions, and only endorse ones they personally consider valuable (we exclude untruthful evaluations). We also assume that open endorsements are given only after careful evaluation, while silent endorsements can be given with less careful evaluation.

If Member 1 and all other members **collaborate**, contributions are endorsed openly. As an immediate benefit, Member 1 *gets their voice heard* with the cost of the effort in the evaluation and endorsement of a contribution. Since the endorsement is open, Member 1 publicly commits to supporting a specific contribution. In a repeated setting, open endorsements are beneficial by revealing the community's preferences, making it easy for Member 1 to *choose the focus on future contributions*. There is a cost to Member 1 in *risk of being socially sanctioned for endorsing a specific opinion* and *limiting the possibility to change opinion later* due, given the earlier public commitment in support of a specific contribution. There will be positive **externalities** through *better coordination of content production within the community*, and negative externalities through *risk averse behavior*, should Member 1 become less active due to potential social sanctions. Table 17 summarizes the interaction.

Table 17. Benefits and sacrifices when everyone collaborates in Streamr CI3.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Member 1 (collaborates, and others also collaborate)	+ get one's voice heard	+ better ability to focus contribution efforts + *better community coordination of content production (externality)*	- effort spent on the evaluation and endorsement - a public commitment to a specific option with your identity	- risk of being socially sanctioned for endorsing a specific opinion - less flexibility of changing opinion later - *risk averse behavior (externality)*

It is also possible that **Member 1 defects, but others collaborate**. This is a situation where Member 1 is the only one endorsing silently, and all other members openly endorse contributions. Member 1 benefits from *getting to vote without making a public commitment*. There is, nevertheless, a cost for the *effort spent in the endorsement*. In a repeated setting, silent endorsements give Member 1 *the flexibility to signal a public image that differs from actual votes* and even the *possibility of tampering the results through multiple voting*. This creates considerable negative **externalities** with the risk of having a *single malicious actor tampering the voting* and causing *distorted voting results*, if it is not prevented by the system. Table 18 illustrates the interaction.

Table 18. Benefits and sacrifices when Member 1 defects but others collaborate in Streamr CI3.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Member 1 (defects, but others collaborate)	+ gets to vote without public commitment to any opinion	+ possibility to signal preferred public "image", not real opinions + possibility to tamper the voting to suit individual preferences (multiple voting)	-effort spent on the evaluation and endorsement	- opinion might have less power as it has not been publicly endorsed *- risk of a (single) malicious actor tampering the voting (externality)* *- distorted voting results (externality)*

If **Member 1 collaborates but no one else does**, Member 1 is the only one endorsing openly. One gets *to be heard* at the cost of the effort spent on the *evaluation and endorsement*, while also *making a publicly commitment to a specific opinion*. In a repeated scenario, Member 1 can enjoy reputational benefits *by being the only one who has openly endorsed contributions*. There will be a sacrifice of *not knowing what other community members truly think or what leads to the popularity of different contributions*. In addition, there is a cost of *being socially sanctioned for endorsing a specific opinion* and thereby *limiting the flexibility to change opinion later*. See Table 19 for a summary.

Table 19. Benefits and sacrifices when Member 1 collaborates but others do not in Streamr CI3.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Member 1 (collaborates but others do not)	+ get one's voice heard	+ increased reputation in community by being "only" one openly endorsing contributions	- effort spent on the evaluation and endorsement - publicly commit with one's identity to specific opinion	- frustration caused by not knowing what others think or how decisions are made - risk of getting socially sanctioned for endorsing a specific opinion - less flexibility of changing opinion later

If **everyone defects**, all the community members will only endorse contributions silently. This allows Member 1 to *get to know the public opinion* and *vote without making any public commitment*. However, Member 1 will bear the *effort of endorsing* and *not knowing who has really voted*. In a repeated game, Member 1 has the *flexibility to change opinion or endorse different contributions* later but *cannot be certain if their actions have made any difference* to the result. Moreover, the silent voting can be prone to negative **externalities** *by distorting voting results*. See Table 20 for a summary.

Table 20. Benefits and sacrifices when everyone defects in Streamr CI3.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Member 1 (defects, and also others defect)	+ get to know the public opinion + gets to vote without public commitment to any opinion	+ possibility to change to endorsing (or voting for) different opinion later	- effort spent on the evaluation and endorsement - not knowing who has voted or not	- unclear if actions made any difference *- distorted voting results (externality)*

To summarize, the situation where everyone else endorses their views openly (collaborate), but one member can endorse silently (defect) would the most favorable for Member 1 (the *community member making the silent endorsement).* The defecting community member enjoys all the benefits the community can provide by free-riding, i.e., without making any public commitment. In the long run, this can end up creating a situation akin to the tragedy of commons. Moreover, if the single individual is malicious and wishes to tamper the results, there is an opportunity of casting multiple endorsements through fake accounts.

If all community members always openly endorse their views, the coordination of collaborative efforts can be improved. This would happen at the expense of everyone committing personally to their opinions and accepting the consequences. Hence, open endorsement will likely enable better coordination of effort and more efficient allocation of resources within the community. This would happen at the likely expense of favoring contributions linked to or supported by the most influential members of the community.

In this setting, the benefits of better coordination and a deeper understanding of how preferences are formed is practical due to a traceable log of open endorsements. However, carefully drafted and effective policies are required to prevent any misuse of the accrued data. If such risks can be managed at the system level, the open endorsement of community members' preferences can help to visualize not only the aggregate public opinion but also help understand the views of the community leaders or other prominent members of the community help to shape that public opinion. The endorsement process can also be studied to help spotting potential instances of disagreement about the future direction of the community, and thereby help resolve differences in an amicable and efficient manner.

3.3 Food Futures

3.3.1 Core interaction 1: Purchase of a meal

Food Futures has two core interactions with the app and its token allocation function. The first interaction is the validation of a meal purchase. Through this interaction, it is revealed whether the actor chose to eat a green, yellow, or red meal, labelled according to its carbon footprint. This is to solve the incentive incompatibility problem according to which actors may eat a red-coded meal, and yet intentionally or subconsciously report having selected a green-coded meal.

Although in the pilot experiment this validation process remains informal and relies on peer review, as the app is developed in the next phases of experimentation this validation process will be formalized and automated. *Due to the temporary implementation of this core interaction (it will be different in the live platform), this core interaction is not assessed here using game theory)*.

3.3.2 Core interaction 2: Selecting a meal

The second core interaction is the meal selection itself, which provides the direct causal link between micro-actions and macro (and global) outcomes, in this case an over-concentration of carbon gases in earth's upper atmosphere.

To model this interaction, we make some simplifying assumptions: 1) we assume that the nutritional content of all meals, as well as their prices, are indistinguishable and equivalent (this is true for price but is simplified with respect to nutrition); 2) we also assume an average user who has habits between the two extremes of being a pure vegan or pure carnivorous eater. The latter assumption enables us to postulate that there is a negligible difference on average between the overall experiential quality of the meals offered by the vendor: all satisfy basic nutritional requirements and are of equal cost.

Food Futures analysis has been conducted from a public goods game perspective. However, to allow comparison with the other cases, we present the modeling in a form of a 2-player version of the public goods game. Stakeholders choose whether to **cooperate with carbon gas reduction by selecting a green meal (collaboration) or to eat a high-carbon footprint meal (defect)**.

> *NOTE: Although the Food Futures case user interface differentiates between green, yellow, and red meals, in the modeling we only represent green and red meals. This is a temporary simplification corrected with an algorithm for minting anti-rival tokens.*

If both stakeholders **collaborate**, both gain *satisfaction for a mutually sustainable meal choice*. In terms of **externalities**, all players are better off if their virtual community does their share of greening the global atmospheric commons. Table 21 illustrates.

> *Note: for simplification, in our initial pilot experiment, we assume an average user (neither a strict vegan nor a strict meat eater).*

Table 21. Benefits and sacrifices when both stakeholders collaborate in Food Futures CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Stakeholder 1 (collaborates)	+ satisfaction for mutually sustainable choice	+ *better environmental sustainability (externality)*		
Stakeholder 2 (collaborates)	+ satisfaction for mutually sustainable choice	+ *better environmental sustainability (externality)*		

If one does not have a strict preference to eat green, and if the red-indexed meal conveys negligibly more satisfaction, without the assurance of others' cooperation, the other player may go alone: In this case, **one stakeholder collaborates and the other defects**. If it is a two-person community, and if these two individuals could view each other's dining choices, then this rationale could apply to making a small sacrifice of *eating a vegetable-based meal, then watching one's dining companion or neighbor eating a meat-based meal and feeling regret for having made this singular choice*. Table 22 summarizes.

Table 22. Benefits and sacrifices when only one stakeholder collaborates in Food Futures CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Stakeholder 1 (collaborates)		*+ better environmental sustainability (externality)*	- regret for singular choice	
Stakeholder 2 (defects)		*+ better environmental sustainability (externality)*		

If **both simultaneously defect**, neither *has regrets, and no contributions to greening the commons is made*, as shown in Table 23.

Table 23. Benefits and sacrifices when both stakeholders defect in Food Futures CI2.

	Immediate benefit	Repeated benefits	**Immediate sacrifice**	Repeated sacrifices
Stakeholder 1 (defects)				*- worse environmental sustainability (externality)*
Stakeholder 2 (defects)				*- worse environmental sustainability (externality)*

To summarize, while pareto optimality is that both collaborate, without taking externalities into account, the parties resort to both defecting due to *contribution negligibility problem*. As the case manifests, individuals can experience that their individual choices cannot make any significant causal impact of large-scale environmental concerns. To address this, an institution is needed to directly counter individuals' experience of the insignificance, and hence negligibility of their actions.

4 Capturing Anti-rival Value

The token systems and the logics of anti-rival value capture in ATARCA's three use cases are described in this chapter. First, the individual tokens and their interconnections are elaborated. We describe the token types, and how tokens connect to the social dilemmas presented in chapter three.

Then, the dynamics of the token systems are illustrated, and the ways anti-rival value is created and shared are highlighted. Here, we use systems dynamics modelling, as our mechanisms include non-allocative aspects and feedbacks (i.e., mechanisms that are not strictly bounded or linear), classical mechanism design might not work. In general, a system with feedbacks easily begins to behave chaotically, where even small changes in the starting values will lead to highly different outcomes. As there is no easily identifiable local optima, we are compelled to use modelling methods that have been developed to model complex and adaptive systems (CAS). System Dynamics (SD) is such a method.

SD is a field of mathematical modelling, geared towards continuously evolving quantities rather than individual transactions, as game theory and mechanism design are. System dynamics is a methodology that uses feedback loops, accumulations, and time delays to understand the behavior of CAS over time (Sterman, 2000; Forrester, 1971). One of the primary strengths of SD is that it allows for the inclusion of both social and technical elements in the same simulation model (Forrester, 1993; Garcia and Sterman, 2019; Senge, 1997). This allows the modelling and simulation of complex adaptive socio-technical systems, such as business models, platforms, and currencies (Nikander and Elo, 2019).

4.1 Barcelona Green Shops

4.1.1 Token system

The token mechanism designed for the Barcelona case provides incentives for shop owners and customers. To facilitate shop owners' contributions to the B2B network, shop owners will earn sntNFT tokens (shareable, non-transferable, non-fungible) from platform contributions (e.g., mentoring and joint purchases), referred to as **acknowledgment tokens**. At the system level, the contribution of a shop in the B2B network strengthens the network by creating economies of scale, positive network externalities, and brand recognition. The contribution also directly benefits the shop: the tokens gained can be used for targeted marketing through the REC app's marketplace functionalities. Each community member can see (and optionally share) these tokens with other community members. As the tokens live on a decentralized ledger, the tokens' existence is not tied to the B2B or B2C platforms. Instead, the holders will also be able to prove ownership of these tokens outside of the platform (e.g., as a proof of participation in the community and related skills acquired through participation).

In the B2C platform (including REC), the customers will earn sntNFTs for shopping in Green Shops and contributing to the platform (e.g., reviews of products, purchases); these are referred to as **impact tokens**. The sntNFTs will display the impact of Green Shops purchases (e.g., saved CO2, saved waste), bringing awareness of the potential impact to the larger audience. The token balances can be viewed in the customers' REC app accounts. The users can apply the tokens directly to the in-app environment and decide to share them with other users. When a user shares a token with someone, ownership of the root token is maintained, and the receiving side gets a cloned token that references the root token. Both parties can view the tokens (root and shared one) in their wallets. Shareable tokens may change their behavior or properties based on how often they are shared and how much impact has been generated by the chain of users who have shared the clones. Thus, by showing the trajectory of the tokens, the platform will show the accumulated impact of a group of users. The participants may be given rewards when they reach certain milestones. Table 24 summarizes the anti-rival token logic of the Barcelona Green Shops case.

Table 24. Anti-rival token logic of the Barcelona Green Shops case

	Acknowledgement tokens (B2B platform)	Impact tokens (B2C platform)
Token type	sntNFT	sntNFT
What is being tokenized?	B2B Platform contributions	Impact creation by changing consumption preferences (B2C)
How is the token created?	Minted after a contribution is made	Minted after a contribution to the platform is made or a purchase is completed in a Green Shop. Tokens can also be shared with others in the community.
What type of sharing is possible?	Permissioned sharing	Permissioned sharing
Which value flows are affected by token sharing?	Acknowledging and rewarding collaboration and contributions to collaboration	Impact recognition
How is the token sharing initiated?	Shop owner executes contribution action in the B2B platform. Other shop owners can share the NFTs to show their recognition.	Customer provides specified content to the platform. Customer makes a purchase in the platform. sntNFTs can be shared with other users, after contribution, to improve their parameters inside incentivization environment
Who or what is the token attached to?	Shop owner	REC app user
Why is the token valuable?	Provides a way to recognize the contributions, engagement, and knowledge of the shop owner; recognizable reputation between platforms	Motivates the consumers to create positive impact on environment

4.1.2 Capturing anti-rival value

Barcelona Green Shops tokenizes the positive externality of a more vital, sustainable shop community to two contribution tokens: one for businesses and the other for customers. Also, the gained tokens can be further shared if one actor wants to acknowledge others; this decentralizes the token allocation. Herein, we assume that although one actor's effect on the community is often perceived as negligible, collating the contributions of the whole community together and concretizing it as a set of validated acknowledgement tokens increases the positive externalities. We assume that by imposing our token system, the result is that:

1. The community members participation increases (with selected actions – vs the case without tokens)
2. Possibility of decentralized acknowledgement sharing improves the quality and quantity of selected contributions (vs without sharing functionality)

The system dynamics causal loop diagram in Figure 1 illustrates our reasoning. Loop **R1 shows how overcoming negligibility** is reinforced inside the Barcelona Green Shops customers community. When the *number of customers* increases, it increases the *behavior data* in proportion, which leads to *minting (and sharing) of more* ***impact tokens***. Customer *community achievement awareness* then increases, which in turn leads to attracting more *customer community members*, leading back to *number of customers*, and closing the feedback loop. The model is driven by the causality marked with the blue arrow—*community ethos*—which refers to the whole community's (customers and businesses) purpose.

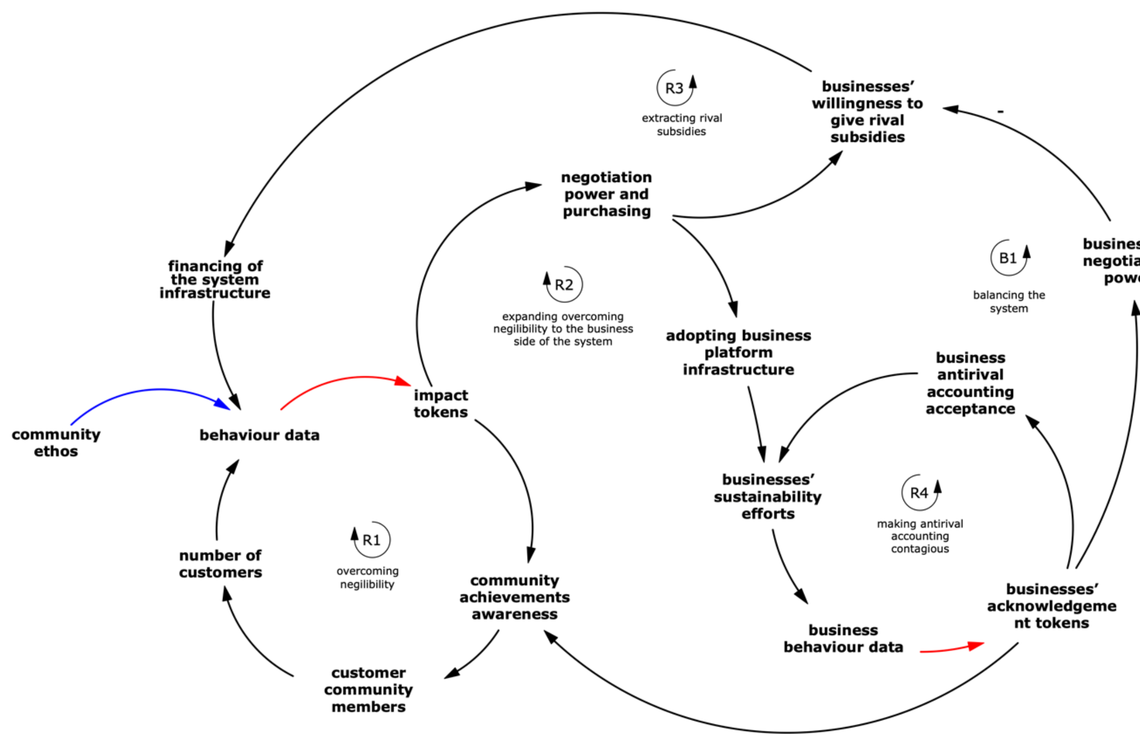

Figure 1. Systems dynamic model of anti-rival value capture in Barcelona Green Shops case.

In feedback loop **R2 (expanding overcoming negligibility to the business side of the system)**, the customer community uses its increased *negotiation power and purchasing* to encourage businesses to change their mindset toward enhancing positive externalities and to move from a rival mindset to an anti-rival mindset. This causes an increase in *adopting business platform infrastructure* and *businesses' sustainability efforts*, leading to related *business behavior data*. This, in turn, gives rise to minting (and sharing) more ***businesses' acknowledgement tokens***, which connects to the previous causality by enhancing the *customer community achievements awareness*, which via **R1** closes the feedback.

In **R4 (making anti-rival accounting contagious)**, the increase of ***businesses' acknowledgement tokens*** leads to greater *business anti-rival accounting acceptance* (how relevant the acknowledgement tokens are for the business), leading to the further growth of *businesses' sustainability efforts*, and thus to an increase of *business behavior data.* This leads to more ***businesses' acknowledgement tokens,*** the final causality closing the reinforcing loop **R4**.

Looking back to the customer community, in **R3 (extracting rival subsidies)** the customers' increased *purchasing* increases the *businesses' willingness to give rival subsidies* to the customer community (rival benefits that the customer can claim). The increased subsidies lead to greater *financing of the system infrastructure*. The resulting increase of *behavior data* and ***impact tokens*** leads to more *negotiation power and purchasing*. This closes the feedback of **R3**. On the other hand, in loop **B1 (balancing the system)** the accumulation of *businesses' acknowledgement tokens* results in an increase of *businesses' negotiation power,* based on the accumulated anti-rival value, which in time reduces the *businesses' willingness to give subsidy to the customer community.* This connects the **B1** loop to the **R3** loop, which via, **R2** loop, closes the **B1**.

To summarize, **R1** describes the **customer side network effect**; **R4** the **business side network effect**; and **R2** and **R3** the **cross-side network effects**. The system exhibits a mixed rival/anti-rival dynamic as the motivation for creating the tokenized causalities is to utilize the rival value connection between the parties. This will promote the contagion of anti-rival accounting and tokens and drive positive network effects. Contagion refers to the spread of anti-rival accounting to others outside of the community, which is one of the goals of this project. Further, the contagion is controlled by the **goal seeking loop B1**, which is decided on and controlled by the system orchestrators. The extracted subsidies need to be carefully balanced with the anti-rival investments to achieve contagion and to make it sustainable.

In parallel, all parties of the system should constantly be involved in the discussions on the ethos of the community. Should this not happen, there is a risk that the system will divert to leveraging only the immediate economic benefits. If this were to happen, the increasing anti-rival value on the business side could be wasted, as the system would reduce into a mere vehicle of subsidy, instead of striving for more vital local communities.

4.2 Streamr Community

4.2.1 Token system

The Streamr community case incentivizes three different types of core interaction using three different tokens: *contribution tokens*, co-*contribution tokens*, and *endorsement tokens*. As described in Table 25 below, this experiment includes two distinct token types. **Contribution** and **co-contribution tokens** are shareable, non-transferable, non-fungible tokens (sntNFT). **Endorsement tokens** are shareable, non-transferable, non-fungible tokens (sntNFT), although they are narrowly shareable only to oneself.

Contribution tokens are granted to community members by the Streamr team. These tokens attempt to capture and make transparent the effort done by the token recipients. They serve as a record of merit and as a trusted proof that the Streamr project has evaluated and recognized the value of a contribution. The nature of each particular contribution is encoded in the metadata of the token.

The incentive system aims to encourage community members to share the recognition for a contribution with others. This is done through **co-contribution tokens**. These are permissioned sharing tokens, and they allow the original token holder to acknowledge other community members' participation in the contribution. Co-contribution tokens can be used to distribute merit to those who helped make the contribution. The metadata of the token encodes the identity of the co-contributors, and a permanent record is made in the blockchain of the collective effort underlying each contribution. This mechanism helps make the otherwise hidden network of contributors visible.

Community members are also encouraged to endorse other members' contributions through **endorsement tokens**. Granting an endorsement token signifies that a community member approves of or applauds a specific contribution by another community member. In contrast to contribution and co-contribution tokens, endorsement tokens can be openly shared. Open sharing of tokens allows anyone accessing the blockchain to include the token into their wallet.

Effectively, a widely endorsed contribution will be seen as something of significant value to the community.

There are different management and governance mechanisms underlying these tokens. In general, only the owners of the relevant token contracts—selected members of the Streamr team and the research personnel—are allowed to mint and transfer new contribution tokens. Once tokens are minted and transferred to their recipients, however, the contribution tokens and co-contribution tokens can be shared and transferred to new owners. Anyone can mint an endorsement token to themselves as long as the corresponding contribution token continues to exist. Endorsement tokens are always linked to a contribution token, thereby maintaining the connection to the original contribution and keeping a record of a growing network of endorsements.

Neither contribution tokens nor endorsement tokens hold any direct monetary value. The transferability of these tokens has been disabled by choice in the design of the incentive mechanism (hence the notion of non-transferability). This prevents a monetary exchange of these tokens and speculation towards a financial reward.

Nevertheless, contribution and endorsement tokens are expected to hold indirect value and capture at least some of the positive externalities arising in the community. Tokens are expected to derive value from the functionality of the Streamr project and from the interaction and information sharing within the community.

Further indirect value can be achieved if these kinds of tokens are later used in other domains outside the Streamr ecosystem. Possible use cases include the acknowledgment of open-source community contributions or the creation of meritocratic governance mechanisms in other decentralized open-source projects.

Table 25. Anti-rival token logic of the Streamr Community case.

	Contribution tokens (Primary tokens)	Co-contribution tokens (Permissioned shared tokens)	Endorsement tokens
Token type	sntNFT	sntNFT	sntNFT
What is being tokenized?	Recognition of an original contribution	Sharing the recognition for a contribution with others	Endorsement of a contribution
How is the token created?	Minted after a contribution is made and assessed	A contribution token shared with others in the community	Freely by any member of the community
What type of sharing is possible?	Permissioned sharing	Permissioned sharing	Open sharing
Which value flows are affected by token sharing?	Acknowledging and rewarding valid contributions, maintaining and growing reputation	Peer recognition of valid contribution, maintaining and growing reputations	Expressing community opinion on contributions, maintaining and growing reputation
How is the token sharing initiated?	Streamr team grants contribution tokens on the pilot platform after an assessment and approval	Community members who have received contribution tokens can further share their tokens on the pilot platform	Streamr community members can endorse a contribution once a contribution token is available on the platform. Endorsement tokens can only be 'shared' to one-self.
Who or what is the token attached to?	A community member, contribution	A sharing community member, co-contribution community member and a contribution token	A community member, a contribution token, or a co-contribution token
Why is the token valuable?	Provides a way to recognize contributions by the community; allows for maintenance of reputation; motivates community members to create new content and share information	Connects community members to the original contribution; reveals and quantifies emerging network effects	Facilitates the coordination of community contributions; allows for consensus formation on contribution quality; allows for a new way of community participation

4.2.2 Capturing anti-rival value

The Streamr case strives for a higher quality and quantity of community contributions and a more engaged community. We aim to capture anti-rival value by a system of three tokens: two contribution tokens and the third token for the endorsement of contributions.

The contribution tokens issued by the Streamr team can be shared by the original token holder to create co-contribution tokens. The hypothesis is that acknowledging contributions increases community engagement by raising the visibility of both the contributions and the contributors. Additional engagement is expected to lead to positive externalities in the resulting new endogenous system.

The use of endorsement tokens is also expected to lead to additional community engagement. The token lowers the bar for participation and provides data about the relative value of contributions as seen by an average community member. Moreover, the open endorsement (i.e., making a public commitment in support of a contribution) provides interesting data about the relative importance of contributions and about the role of the community members making the endorsement. These are possible outcomes in the resulting system:

1. Increasing participation by community members.
2. A better understanding of the relative value of different contributions.
3. A more timely and accurate acknowledgment of effort by community members.

The system dynamics causal loop diagram in Figure 2 illustrates how these outcomes may arise. The **main value creation** happens in a **goal seeking causal feedback loop (B1)**. Here, the *work ethos (shared purpose of the contributors)* and *additional work on existing contributions* together help generate additional *contribution candidates (i.e., contributions not yet validated by the community)*. Additional contributions, combined with *professional evaluation work (moderation conducted by Streamr team*), result in a *higher volume of* ***contribution tokens and co-contribution tokens***. The new and existing **contribution tokens and co-contribution tokens** in the system, together with *participatory work (effort by the community members),* lead to *open endorsement of other community members' work, i.e.,* **endorsement tokens**. When making an open endorsement, a community member reveals their identity as well as their opinion about the relevance of other people's contributions. The end result is a continuously updating ranking of community contributions. The additional information in such a ranking helps coordinate and direct the community efforts, closing loop **B1**.

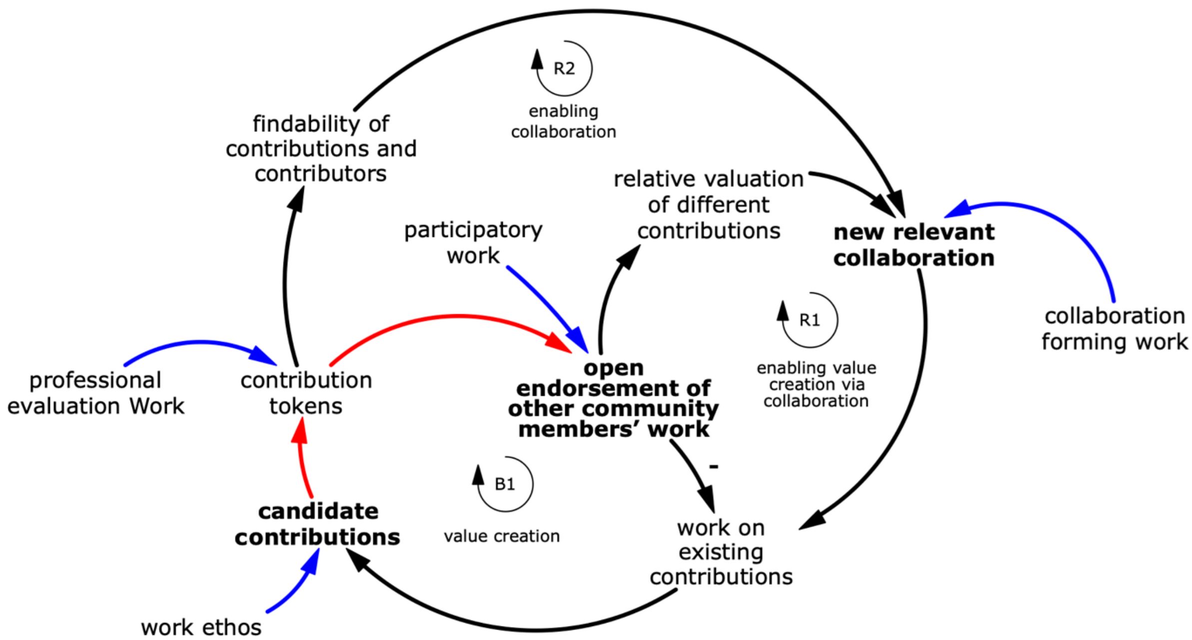

Figure 2. Systems dynamic model of anti-rival value capture in Streamr Community case.

Loop B1 is embedded in a reinforcing causal feedback loop R1 **(enabling value creation via collaboration)**. Open endorsements help refine the current estimate of the *relative valuation of different contributions* and also serve to highlight the current focus of the community. The faster the *new relevant collaborations* node grows, the more effort is devoted to *work on existing contributions.* This closes the exponentially growing **R1** feedback loop. On the other hand, in loop **R2** (**enabling collaboration**), *newly minted* ***contribution tokens*** encourage new collaboration efforts through better *findability of contributions and contributors*. This loop embeds both **R1** and **B1**. *Collaboration forming work* represents the effort of the community members in forming new collaboration groups or teams. Where that happens, additional community contributions are expected. That part of the system is, however, modelled exogenously to this version of the model.

We should also note that the inherent embeddedness of blockchain technology in the Streamr platform leads to improved *findability of contributions and contributors,* due to the **DLT transparency effect** and **DLT integrity** effect. The DLT transparency effect refers to the main effect of running a digital community on top of the open blockchain platform: Anyone either within or external to the community can see the actions of participants and the results of those actions. This feature of the blockchain technology makes contributions easily discoverable. Moreover, due to the DLT integrity effect, the contribution bookkeeping is robust due to (practical) immutability and unforgeability. These features of the technology further enhance contribution discoverability, therefore encouraging community members to avoid malicious contributions.

4.3 Food Futures

4.3.1 Token system

Two types of tokens are issued by ATARCA's Food Futures: a **history token**, which is issued every time a user validates a meal purchase on the app, and an **impact token** allocated based on the positive externalities associated with sustainable meal purchases.

Customer gains a non-fungible **history token** when a contribution action (meal selection) is executed in the Food Futures platform. All such acts "earn" equal contribution recognition. The token signals contribution and engagement of the customer. The **impact tokens** are designed to encourage, acknowledge, and reward positive externalities in the form of positive environmental impact. Given the assumption that history tokens accurately reflect meals purchased, the primary mechanism design of Food Futures is issuing anti-rival impact tokens to provide a metric for measuring the positive externalities correlated with sustainable meal choices. Once meal choices are validated, the mechanism relies on a transparent algorithm.

A common challenge for mechanism design is that there can be an incentive incompatibility between an agent's type—here, agents' meal choices—and how they may prefer to signal their type. In Food Futures, for example, those who intrinsically prefer meals with lower environmental impact will truthfully report their type, while those who intrinsically prefer higher environmental impact meals may be tempted to eat red meat while signaling a vegetarian diet. This is potentially a significant challenge that must be addressed in subsequent iterations of the Food Futures pilot use case: the validation process should be automated at the point of purchase so that the data stored in the platform and used to allocate cryptocurrencies will be verified as trustworthy. Table 26 summarizes the anti-rival token logic of the Food Futures case.

Table 26. Anti-rival token logic of the Food Futures case.

	History tokens	Impact tokens
Token type	NFT	sntNFT
What is being tokenized?	Use of Food Futures app when making meal selection	Impact creation through positive-sum sustainable consumption acts
How is the token created?	Minted when a contribution action is executed in the platform	Minted once meal choice is validated
Which value flows are affected by token sharing?	Collaborative contribution of data sharing	Impact measurement and recognition
How is the token sharing initiated?	Customer executes contribution action in the Food Futures platform; all such acts "earn" equal contribution recognition	Customer uses platform and makes sustainable meal choices.
Who or what is the token attached to?	Customer	Customer
Why is the token valuable?	Signals contribution and engagement of the customer.	Token measures tangible impact; remains as an indelible mark of impact

4.3.2 Capturing anti-rival value

Food Futures tokenizes individuals' positive externalities of increased food sustainability into Impact tokens. We assume that although one person's effect to the environment is negligible, aggregating the contributions of the whole community together and concretizing it as a set of validated impact tokens increases the positive externalities by:

1. Increasing the community members' participation and providing them with the necessary data to make more sustainable meal choices aligned with their values
2. Partnering with the organizations connected to the community to change their operations to be more sustainable

The Food Futures system dynamics model is presented in Figure 3. Loop **R1 (overcoming negligibility)** is similar to the **R1** in the Barcelona Green Shops pilot case, with the exception of the rival *financing of the system infrastructure,* being exogenous. In Loop **R2 (compelling vendors to adopt)**, rival *negotiation power and purchasing* of the customer community grows in relation to the number of ***impact tokens***. This leads to food vendors increasingly *adopting business platform infrastructure*, which grows vendors' *sustainability efforts*. Such an increase accumulates vendor *behavior data*, leading to the growth of customer *community achievements awareness*, also closing loop *R2* by joining it with *R1*.

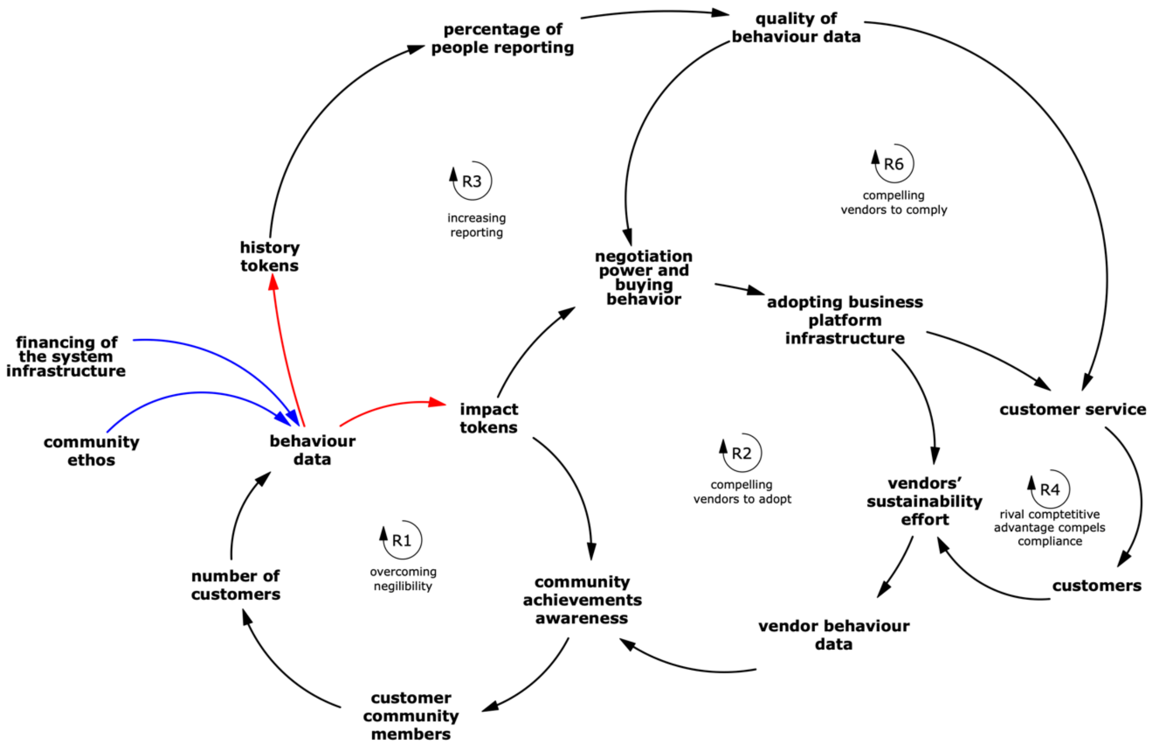

Figure 3. System Dynamics model of Food Futures.

In loop **R4 (rival competitive advantage compels vendor compliance)**, through the increase of *adopting business platform infrastructure*, the vendor gets access to the customer consumption data, which helps the vendor perform better *customer service*. This leads to the attraction of more *customers*, further increasing *vendors' sustainability efforts* and merging **R4** with loop **R2**.

Moreover, in loop **R3 (increasing reporting)**, in line with the growth of *customer behavior data*, the number of ***history tokens*** *also increases*. **History tokens** incentivize all eaters to *report* their actions – also *"defectors"* – which increases the *percentage of people reporting*, which leads to increased *quality of behavior data*. This quality increase will lead to better *customer service*, joining the loop with **R4**. Moreover, the quality of *behavior data* also increases *negotiation power* and *purchasing* focusing on the community.

Finally, causalities marked blue originate from exogenous variables – *community* *ethos* and *financing of the system infrastructure*. Such connections mediate the behavior of the model. The red arrows, in turn, represent the tokenization of the externalities.

5 Assessing the Sustainability of the Cases

To assess the long-term viability of the experiment designs, and their incentive systems, we use an adapted version of "The Sustainability of Polycentric Information Commons" framework by Mindel, Mathiassen, and Rai (2018). The framework addresses the prevalent dilemma of eventually declining user engagement and overall activity in most open source, digital commons, and P2P systems–like our case experiments. The framework highlights how certain design principles can mitigate the mentioned sustainability challenges (i.e., the resilience and longevity challenges of the system).

Our adapted version of the framework focuses on identifying the 1) sustainability drivers, 2) collective-action threat mitigation measures, and 3) polycentric governance enablers. The complete framework is illustrated below in Figure 4, and the application of the framework to ATARCA cases is presented in following subsections.

Sustainability drivers

- Provision: How to ensure that providers continuously contribute to the system
- Appropriation: How to ensure that appropriators continuously consume the system's output
- Revitalization: How to make sure there is a constant stream of new contributors (to offset the disengaging ones)
- Equitability: How to distribute provision activities across a base of providers

Collective-action threat mitigation

1. Free-riding: How to reduce appropriators' free resource usage
2. Congestion: How to avoid appropriators clogging the system
3. Pollution: How to avoid contribution misalignment with the system's purpose
4. Violation: How to avoid the situations in which the stakeholders purposefully break internal and external morals, rules, and laws
5. Rebellion: How to avoid stakeholder disengagement due to dissatisfaction with producer actions
6. Negligibility: How to avoid stakeholders' disengagement due to the feeling that their impact is negligible

Polycentric governance drivers

- Boundary regulation: How do the rules and infrastructure features afford contributions and appropriation consistent with the system's purpose
- Incremental adaptation: How are the changes in the infrastructure and rules gradually introduced, and providers and appropriators are actively involved in shaping them
- Shared accountability: How do the rules and features afford peer-monitoring and gradual sanctioning to support appropriate behavior and dispute resolution in the system
- Provider recognition: How do peers, appropriators and producers acknowledge the providers

Figure 4. Sustainability driver framework (adapted from Mindel et al., 2018)

5.1. Barcelona Green Shops

5.1.1 Sustainability drivers

Provision. The system has three kinds of providers: first, promoters Rezero and Novact; second, shop owners of the Green Shops network; and third, customers of the Green Shops. To ensure that providers continuously contribute to the system, different types of incentives are required. First, promoters are incentivized by having “skin in the game”; Rezero and Novact’s missions of promoting environmental sustainability and social justice are in line with the objectives of the Green Shops network. In addition, the future sustainability of Rezero and Novact as organizations is partially dependent on the successful development of the Green Shops’ ecosystem in Barcelona. Shop owners, in turn, may contribute to the network for financial gain, but also for non-monetary and intangible benefits related to the relational needs of shop owners and the positive indirect effects that local green shops may have on their neighborhood and city life. Finally, customers of Green Shops are incentivized also for non-monetary and intangible benefits related to environmental sustainability issues. Thus, when considering provisioning as a sustainability driver, Barcelona Green Shops’ token system incentivizes the sharing of information among shop owners, and acknowledgment of leadership in collaboration. Tokens are also used to signal environmental sustainability of shops’ goods and services, and customers’ purchases.

Appropriation. Several elements within the platform are designed to ensure that appropriators use the platforms and contribute to them by consuming their resources and offering feedback. First, the platform for shop owners offers information and focus on issues of common interest and providers channels for collaboration. Here, tokens function as an indicator for engagement and contribution in the community. Second, the platform for customers offers information on sustainability of shops and their products and services. Here, tokens function as an indicator of the environmental sustainability of purchases in the green shops.

Revitalization. Regarding system revitalization, there should be a constant flow of contributions that generates attention and common interest. To facilitate this, Rezero and Novact will generate content weekly that will be shared through a news bulletin. In the second phase of the project, when attention and interest already exist from shop owners, recognition for providing new contributions will become more relevant and must be therefore translated into higher token value. The contributions will be visible and transparent to others with reputation mechanisms such as badges and medals. Also, external reward structures could be built on top of the tokenized rewards in the future. For example, governance mechanisms based on tokens can be created to manage the network, putting further decision-making power into the hands of community members.

Equitability. Ensuring an equitable provision across providers is achieved through a process of engagement and education of shop owners and through progressive delegation of governance roles from system architects and first adopters to other shop owners. This progressive decentralization must occur also through the implementation of the tokens for shop owners, which must incentivize initiation of sharing actions and collaboration projects.

5.1.2 Collective-action threat mitigation

Free-riding. In the shop owners' professional-community platform, free-riding refers to not sharing information while enjoying the platform benefits. However, the benefits of one individual sharing information largely offset the costs of one individual not sharing it. Therefore, the ecosystem focuses on rewarding positive externalities in the form of contributions and does not use punishments to deter non-contributions.

Similarly, in the case of the customers' platform, a person willing to free-ride on the community by buying unsustainable products and services would not use the app to do so, but would just buy in other shops without paying attention to our app.

Congestion. It is very unlikely that appropriations may clog the system, since the community of shop owners is a private community that one can only access after having obtained the "green shop" certificate granted by Rezero. However, when the community grows, robust filtering mechanisms are needed so that congestion will not hinder the community. In the case of the customers' platform, it is also unlikely that customers will clog the system, since their contributions are limited to searches and reviews of products and shops. This system will function in the already existing REC app, which has already been tested repeatedly for the last 3 years and has functioned successfully at levels of activity superior to the ones expected in this experiment.

Pollution. Information sharing in the professional-community platform is vulnerable to pollution the form of communications that are not related to business issues. For this reason, the platform will combine a system of moderation by the promoters of the project (Rezero, Novact and first adopters) and a system of rewards that will only translate contributions into token value when these are endorsed and shared by other participants of the platform, signaling that they are not pollution.

Violation. As has been mentioned before, the shop owners professional-community platform is formed by members accepted as “green shops” by Rezero. Such close social ties of the community can reduce the risk of violations or other misbehavior. Nonetheless, the moderators of the platform will report any observed illegal or unlawful behaviors to the system providers and, if needed, authorities. In the case of the customers’ platform, content provided by customers will be moderated. Further, we believe that the profile of the customers of green shops and users of REC make it unlikely that violations will occur on a regular basis. To maintain focus, the violations are processed centrally in the current experiment; this is an area of concern for the next versions of the pilot development.

Rebellion. To avoid stakeholder disengagement and rebellion due to dissatisfaction with producer actions, the systems’ governance is designed to be accountable to the community. The governance is representative; as the network develops and strengthens, an increasing governing weight will be given to the shop owners, less weight for the customers, and a decreasing weight for Rezero and Novact. Community opinion can be estimated, quantified, and understood via interactions inside the community, and open and closed sharing of the tokens. The current pilot is centrally governed, but in the future, additional governance power could be granted based on accumulated contributions or other reputations.

Negligibility. News bulletins shared with the rest of the network by promoters and first adopters will convey realistic optimism, especially in the initial period of the experiment. Promoters will mentor first adopters and explain how the platform works and express the importance of their contributions in jump-starting the platform. Also, the token system will reduce negligibility by offering recognition and publicity for contributing shop owners within the customers' networks.

5.1.3 Polycentric governance drivers

Boundary regulation. In the Barcelona Green Shops case, the community of green shops has concrete off-line and institutionally established boundaries, mostly determined by Rezero requirements to obtain the green shops label. The token will originate only within the community, although it will be shareable outside it.

Incremental adoption. The system will be implemented and scaled in phases, starting with the pilot experiment. The system will be continuously evaluated for strengths and weaknesses, and new features will be introduced based on identified needs and opportunities. The representative governance of the system ensures that the changes will reflect the desires of the contributors, users, and the target community. The system and the new features will be promoted through on- and off-line marketing actions among stakeholders in Barcelona and the surrounding region.

Shared accountability. Appropriate, rule-following behavior is encouraged and incentivized by the promoters. This pilot does not include a digital mechanism for dispute resolution. When conflicts arise, they will be moderated by the promoters and dealt with outside the digital platform, preferably with a consensual and non-coercive approach. In the future, there should be a mechanism to report that a particular contribution is outside the purview of the community. While decision making in the Barcelona Green Shop's experiment is currently centralized, future iterations should include public curation, e.g., a way to mark tokens "permanently valid", i.e., unable to be revoked or adjusted.

Provider recognition. Provider recognition defines the core interactions of the Barcelona Green Shops case: sharing other people's contributions. Providers will also be recognized on the platform, for example through top-10 lists, associated badges and counters.

5.2 Streamr Community

5.2.1 Sustainability drivers

Provision. The ecosystem includes two kinds of contribution providers: (1) Streamr employees and contractors on the Streamr team and (2) community members. To ensure providers actually contribute to the ecosystem, different types of incentives are required. Direct employees and contractors are already compensated for their work in monetary terms. Community members may be internally incentivized to contribute to the system due to personal investment, as they may be owners of DATA tokens (fungible Streamr utility tokens with a monetary value; rival goods developed outside ATARCA), or they may contribute to the project for non-monetary and intangible benefits. It is this latter group of community providers who are expected to make use of non-transferable, non-fungible tokens (shareable or not) deployed to the community members in the pilot experiment. As described above, the contribution and endorsement tokens are expected to have a significant role in incentivizing community participation and the acknowledgment of effort.

Appropriation. The aim is to ensure that the appropriators adequately consume the system's resources. Towards that purpose, new content available for consumption can be highlighted and the visibility of popular content raised. Tokens function as an indicator of different contributions' popularity in the community and serve as an indicator for recognized discoveries of the community.

Revitalization. A stream of new contributors is useful in offsetting any disengaged community members. To facilitate the revitalization of the community, recognition of contributions and integration into the community should be a positive experience. The benefits of being recognized may be immediate or delayed. The new tokens have multiple roles here. They are visible and transparent to others and thereby help create reputation mechanisms, such as top-10 lists. To mitigate a lack of revitalization, external reward structures can be built on top of the tokenized rewards in subsequent versions of the pilot platform. For example, novel governance mechanisms for peer-recognizing reputation can be designed once sufficient trust has been established within the community. Such a governance method can be thought of as a kind of "jury duty", where community members provide and receive judgement for their contributions in a decentralized evaluation process.

Equitability. To be sustainable, the ecosystem needs to be and to be seen as equitable, and provision activities need to be distributed across a wide cross-section of providers. In this experiment, each community member has an equal right to make contributions or endorse contributions made by others. To the extent that some contributors or contributions end up being more highly valued or endorsed than others, any differences either emerge endogenously from the community or are based on well-defined criteria in the assessment on contributions.

5.2.2 Collective-action threat mitigation

Free-riding. In the Streamr community case, free-riding is not considered a problem; rather, it is encouraged. The more appropriators there are, the more valuable the community becomes. If the incentives are compelling enough so that the number of appropriates increases, it is expected that some of them will turn into providers and thereby contribute to the success of the community. In order to facilitate that happening, there is a low barrier of entry. The incentive structure rewards participation and is designed to increase the likelihood of changing stakeholders' behavior from appropriation of contributions to actually making contributions.

Congestion. If bots (specialized and automated computer programs) are attracted to appropriations, the system may become congestion. Bots can clog the system by flooding it with noise, e.g., by mindlessly and repeatedly sharing contributions or creating an excess of invalid contributions. To mitigate this threat, tokens shall have a small sharing cost to discourage abuse of the system. In future versions of the pilot, robust filtering mechanisms may be needed if the small cost of sharing is not sufficient to prevent congestion.

Pollution. The two sharing modalities, permissioned and open sharing, are vulnerable to pollution. Pollution may manifest itself by e.g., community members mindlessly engaging in open sharing. Permissioned sharing may be affected by external incentives from outside the system. Even the original contribution tokens are vulnerable if members of the Streamr team misbehave. It is also likely that the ecosystem and the community goals evolve over time, and tokens designed and deployed today may not be fit for purpose at a later point in time. To mitigate the pollution threat and to allow for evolution, a constitutional charter and a more sophisticated governance mechanism may be needed in the next versions of the pilot platform.

Violation. We see very little risk of national laws or regulations being broken in the pilot experiment. There is, however, a moral imperative to follow the community ideals and founding principles. While members of the Streamr team will assess the contributions and grant tokens, there is no well-defined mechanism to hold team members accountable for their actions in that role. Procedures may be required to catch instances of misconduct and revert actions that violate the system's purpose or founding principles, possibly revoking tokens deemed to have been erroneously minted. In the pilot experiment, monitoring of the assessment will be done centrally. In the future, governance mechanisms allowing for proper monitoring of the minting process may be required. Decentralizing the assessment of the contributions to qualified community members is also a possibility.

Rebellion. To avoid stakeholder disengagement and rebellion due to dissatisfaction with producer actions, feedback and criticism should be allowed, and the system should be accountable to the community. Community opinion can be canvassed and quantified through sharing of the tokens, and it can be expressed in discourse and debate in the existing Streamr community forums. While the current pilot is centrally governed, additional governance powers may need to be later granted based on accumulated contributions or other metrics of the community members' reputation.

Negligibility. Making the power of the network effect of the shareable tokens visible can help engage the community. Permissioned acknowledgment tokens and open sharing are mechanisms to guard against negligibility: they make contributions visible and transparent.

5.2.3 Polycentric governance drivers

Boundary regulation. Integration of polycentric governance into Streamr system design determines how easy it is to fend off collective action threats and make the system sustainable over the long term. It's an unanswered question of who can prevent illegal content from entering a decentralized system and how to balance boundary regulation with freedom of opinion. In the experiment, the boundary regulation is less of a token issue and more of a case of governance of the peer-to-peer network by the project members and the community.

Incremental adoption. Incremental adoption is achieved by starting with the pilot experiment, evaluating the weaknesses and strengths of the system as the pilot matures. The intention is to continuously adopt new features within the system as issues arise and solutions are found.

Shared accountability. While appropriate, rule-following behavior is encouraged and incentivized, the pilot lacks a dispute resolution mechanism. Should a token prove to have been erroneously granted, there should be a way to correct the situation, by e.g., revoking a particular token after a community vote. Later versions of the pilot platform may consider a public curation period before a token is considered "permanently valid", or without the possibility of revocation. Some tokens may become obsolete over time and may need to be replaced by new tokens.

Provider recognition. Provider recognition is at the core of the Streamr case, where sharing other people's contributions is acknowledged and incentivized. Aside from granting and sharing tokens, the later versions may also consider other means of provider recognition based on the information available in different tokens and their provenance. These methods may include, for instance, a recognition of content providers on community platforms and social media channels with unique visuals such as badges and tags. Another idea would be to make content more visible and easier to discover using different types of visualizations.

5.3. Food Futures

5.3.1 Sustainability drivers

Provision. The system has three kinds of providers: customers, vendors, and, potentially in the future, sponsors who donate surplus goods. Customers are attracted to the ecosystem because it provides data about the sustainability values of meal choices. This feature alone is likely sufficient to attract users to the app. Vendors are attracted to the ecosystem because it aligns with their sustainability goals and is helpful in the achievement of those goals. Furthermore, vendors learn about their customers' sustainability values and then can work collaboratively with this information to design menus catering to customers' interests. The third type of provider would be sponsors who could potentially receive, e.g., tax credits for their support of this sustainability ecosystem. They would receive token units as an indication of their levels of support for various types of sustainability impact, including the reduction of carbon gas emission.

Appropriation. Data drives the Food Futures app and renders the emergent ecosystem attractive to users who appropriate this information to make more informed, and hence more empowered choices. Information flows on a two-way street, with vendors conveying sustainability information via the platform to customers, and customers communicating their sustainability interests via the app to vendors. This data circulation is further enhanced by providing data about the collective impact of customers' meal purchases from the perspective of the purchase's sustainability.

Revitalization. The Food Futures first use case is with university students, a population that is automatically regenerated on an annual basis. This age group is inherently dynamic and looking for ways to revolutionize and transform older traditions and practices. In this case, younger adults are particularly concerned about the future of ecological sustainability, and this ecosystem empowers this virtual community to achieve demonstrative positive collective impact. As students can select to remain in the ecosystem after graduation, they can become legacy users, while new users constantly come from incoming student cohorts. Additionally, the Food Futures ecosystem is structured to invite lifelong learning, and thus to also be attractive and available to individuals of all ages. This, then, provides a second means to revitalize the membership in the ecosystem.

Equitability. Equitability entails equal access to all potential users, and equal treatment and allocation of resources to all ecosystem members. Access will be available to all interested stakeholders who can visit vendor locations once the pilot experiment turns into an active use case. All who visit participating vendors will be able to receive tokens acknowledging app use with meal purchases. In addition, every user has equal access to the data sharing functions of the Food Futures app. Furthermore, receiving Impact tokens for sustainable meal choices is simply a function of making appropriate choices. The only case in which equitability may be compromised is if individuals with dietary restrictions or allergies are prohibited from making sustainable meal choices as a function of lack of available, appropriate meal options. However, it is a strength of the Food Futures app that this inequitable access to sustainable meal choices will likely encourage vendors to directly address this inequitable access—the app only demonstrates this lack of equal availability of sustainable meal options, it does not cause it to occur. Therefore, the app will be an important tool to providing a remedy for this potential pre-existing limitation.

5.3.2 Collective-action threat mitigation

Free-riding. With respect to the Food Futures ecosystem, free-riding as a consequence of the app is not possible. The ecosystem is designed to reward positive externalities in the form of sustainable food choices. At the moment, individuals throughout advanced consumer societies make choices about what they eat as a matter of personal preference. Some may conclude that more carnivorous diets signify that those individuals "free ride" on individuals who have vegan diets and live within sustainability boundaries for meal consumption. However, the Food Futures ecosystem makes no such assumptions or classifications of individuals' action. With respect to analyzing the tragedy of the commons characterizing run away carbon gas emission, the micro-analysis provided in section 3 modeled this problem as a "Stag Hunt game" with a large-scale negligibility problem that no single individual's meal choices can make an appreciable causal impact on climate. Hence, there is no way for individuals to free ride on others' efforts or contributions as a matter of using the Food Future's app. Rather the reverse, those individuals who eat low impact diets are rewarded for their sustainable choices.

Congestion. In its early phases, even after the initial pilot experiment is run, it is doubtful that there would be too much traffic for the ecosystem. If, however, the user community grew to the point that congestion could be a problem, the first solution would be to integrate meal purchase validation with an existing payment system to reduce and eliminate any challenges caused by congestion. As individuals typically only have one lunch, the total number of possible transactions that could be held within an existing ecosystem can be accurately anticipated and hence properly prepared for.

Pollution. In the pilot use experiment, pollution presents a greater potential challenge than after the use case is successfully developed. In the test environment, validation of meal purchases is informal and checked by a low-key peer-review process. This peer review process could introduce pollution in the form of inadequate data, which would prove toxic to the system if it surpassed a normal error rate or noise associated with the information in this system. This problem will need to be changed to an automated validation system in the next iteration of the pilot experiment, and if not completed fully by then, certainly by the time of being an actual use case.

Violation. The most likely source of violation of the Food Futures virtual community is linked to the political polarization of sustainability, or "green," concerns. Students have reported that diets are a matter of personal identity and political identity. At the same time, universities and large organizations have stated their commitment to planetary sustainability goals, such as the UN key performance indicators for sustainability. However, it is possible that individuals who feel threatened by the goal of achieving sustainability in carbon gas emissions may attempt to launch an attack on the platform. If sufficient numbers of individuals used the app but made consistently and deliberately unsustainable food choices, this could have the opposite impact of that the app is designed to augment. Given that this situation already exists without the app, it represents a larger challenge that the app can be part of the puzzle of solving.

Rebellion. Rebellion within the context of Food Futures would be a lack of interest in the app. As currently there is no sufficient means to reduce greenhouse gas emissions (and other unsustainable consumer food purchases), rebellion returns us to the now existing status quo. Given the focus group study of students exposed to the Food Futures app, it seems that there are sufficient numbers of the incoming student population who are oriented to developing sustainable lifestyle practices, and we do not anticipate rebellion being a challenge.

Negligibility. The Food Futures app is designed specifically to tackle the problem of negligibility which underlies the tragedy of the commons with respect to large-scale, and in this case planetary, collective action problems. Many individuals do feel and experience that their individual choices cannot make any significant causal impact of large-scale environmental concerns. To address this, Food Futures renders it possible to create a virtual community of users. These users do not need to intentionally work together to achieve collective outcomes. However, the sNFT token metric, recording, and appreciation system directly counter individuals' experience of the insignificance, and hence negligibility of their actions.

5.3.3 Polycentric governance drivers

Boundary regulation. Food Futures builds on Ostrom's conceptualization and institutionalization of polycentric governance (1990, 2005). Establishing boundaries around communities is essential for an appropriate recognition and incentive structure that notices who is contributing and can attribute accurate measures of impact to those contributors. Food Futures moves beyond Ostrom's work by introducing anti-rival incentive structures. Here competition can be positive sum, and not zero sum (as is standard in rivalrous reward systems, such as those driven by standard monetary currencies). All members of the Food Futures ecosystem have the capability to receive Impact tokens for sustainable meal choices. In this case, as the current boundary around consumers does not exist, Food Futures offers an opt-in boundary with an endogenous reward system that does not sanction or shame "bad," or unsustainable actions. The boundary is self-regulating.

Incremental adoption. The Food Futures platform and the virtual communities it enables to emerge is designed to function incrementally, with each new generation of users who is introduced to the app and begins to use it. Next steps are to retain existing users, as well as to expand the number of vendors who support the app. These incremental steps can be taken with respect to one vendor at a time, or alternatively the app could also be associated with university curricula, and hence be introduced to new locations in the form of campuses, cities, and countries.

Provider recognition. The Food Futures app is designed to bestow provider recognition to customers, vendors, and potential sponsors. Recognition comes in the form of receiving History tokens (for validating meal purchases using the app), and Impact tokens (for making individually and collectively sustainable meal selections. Additionally, if vendors choose to sponsor these decisions with donated surplus goods, such as leftover food, then the Impact tokens are shared to indicate this sponsorship, while customers always retain the proof of their contribution of positive externalities. Similarly other donors of surplus goods will also receive shared Impact tokens and can display these accounts on their webpages. Over time, this method of recognition, rendered transparent within blockchain's distributed ledger means of accounting, may be afforded, e.g., tax credit status in parallel with other types of subsidies offered for sustainable actions.

6 Concluding Discussion

This chapter summarizes the contributions of ATARCA within the context of mainstream economic theory and practice. All ATARCA pilot use cases share the basic design feature of capturing the otherwise elusive value of anti-rivalrous positive externalities. The distributed ledger accounting technology made possible by blockchain, supporting community-based currencies of sharing, provide the means to generate and proliferate such anti-rival values.

The pilot use cases depart from mainstream economics which is limited by an orthodox position on rationality that is myopically self-interested and perpetually seeks more scarce resources. Although embryonic, the use cases provide an experimental basis to test innovative institutions that offer the possibility of achieving enhanced allocative efficiency of anti-rival goods.

Thus, we contribute to the theory and institutionalization of new means of solving existing market failures by implementing platforms and establishing ecosystems in virtual communities which share value through the contribution of positive externalities and encourage such contribution through the attribution of shareable nonfungible tokens.

6.1. Our approach in abstracted form

As laid out in the introduction of this report, market failures are often characterized by the inability of exchange relationships to capture all the values and costs generated by transactions, specifically those accrued to external parties. In the case of digital goods markets, given the positive benefits, and low costs, of widespread sharing beyond a limited set of transactions priced to cover the costs of production, markets are not designed appropriately to generate all of the positive benefits that would be facilitated by wide-spread sharing. The implication is that digital goods sales are tightly controlled by access rights, blocking many who could otherwise benefit with virtually zero copying costs. If on the other hand data is provided for free, generators of these information sources will not have adequate incentives to provide the good. A similar problem arises in the case of tragedy of the commons wherein transactions do not contain the price of negative externalities that, as in the case of carbon emissions, eventually serve to undermine the common viability of all actors.

ATARCA's pioneering development of anti-rival tokens and distributed ledger accounting system is designed to measure, record, and appreciate the value of positive externalities. These positive externalities can be in the form of generating and sharing data, or alternatively in the form of public goods contributions which all community members can share the benefits of. All ATARCA use cases have conducted a micro-level and macro-level analysis of their individual actions and overarching patterns that exist before and after the institutionalization of the anti-rival token systems. In all ATARCA cases, positive externalities are under-provided within the current economic system institutionalized with rival currencies. In the cases of digital and public goods contributions, few adequate incentive structures currently exist to achieve allocative efficiency in encouraging and measuring the potential sharing of positive sum actions.

Looking to ATARCA cases in more detail, in the Barcelona Green Shops, consumers do not have enough information about the positive benefits of local shops, and shop owners do not have a platform or incentive structure to contribute to positive-sum professional-community discussions. In the Streamr community, in turn, there is no rival-incentive structure to compensate or reward users for their contributions, although users have much content they could share. Correspondingly, regarding the clientele relevant for Food Futures, neither those who would be predisposed to eating sustainably nor those who might make that choice regularly if they were certain their contributions could make a difference, currently have any means of perceiving of, or being acknowledged for, their potential impact. Thus, in all cases, shareable goods in the form of externalities falling outside of standard market transactions remain unproduced because there is a lack of either an accounting system or reward structure to support the generation of these values.

ATARCA's sNFT token systems assist in all of these cases to promote the allocative efficiency of anti-rival goods that either solve digital goods sharing limitations, or ameliorate public goods failures, or possibly contribute to both. Sharing information is key to all cases, and widespread access to information is a positive externality that ATARCA's sNFTs are tailor-made to proliferate. Through various types of acknowledgement tokens, which are inherently unlimited in parallel to the information sharing they reflect, contributors of information are immediately acknowledged and gain community recognition for their efforts. With respect to public goods failures, which is a standard problem throughout micro-economics, individuals may fail to contribute because there is no direct acknowledgement of each individual's actions, or even because one individual's actions can make no appreciable difference to large-scale collective outcomes. Herein, ATARCA's pilot use case platforms enable the creation of virtual communities which can share information freely, and can measure, track, and reward every individual's contributions.

ATARCA's tokenized sharing systems apply to a variety of contexts. The value of the token system, which goes beyond simply counting downloads or likes, lies in the economic role of anti-rival goods: These goods, and achieving their allocative efficiency, exist in parallel to the exchange of rival goods. However, they will tend to be under-provisioned in a rivalrous economic system because that system only *exchanges* value but does not *proliferate* value with positive sum benefit. In more detail, in the Food Futures case, for example, planetary eco-sustainability is a collective benefit which future generations are wholly dependent on. Yet our contemporary rivalrous system has not yet identified a market-driven mechanism to ensure that human civilization lives within its physical constraints. The Food Future's token system serves as a positive sum micro-credit system for measuring and acknowledging individuals' contributions. This may be thought of as a micro-financial system for rewarding micro-sustainability actions. Given the impact communities of individuals acting together can have, non-negligible positive sum impact can be documented and rewarded. Eventually such actions could be rewarded by access to donated surplus goods, or even with sufficient reason, by institutions surrounding and connected to the community running the token system.

6.2. Our contribution: new ideas to institutional design

The proliferation of neoclassical economics into other social sciences has had the effect of dividing the social sciences in relation to neoclassical economics into three broad areas around the rational vs. nonrational divide: 1) pure models depending upon optimizing agents only; 2) mixed models somewhat inconsistently combining rational with non-rational motives, behavior, culture, or whatever; and 3) the rest seeking to escape the rational vs. non-rational dualism as the basis for social theory.

ATARCA acknowledges this artificial division, which considers heterodox forms of rationality and instinctive-emotional realities as non-rational and non-logical. Yet, anti-rival goods are a creature of this supposedly non-rational and non-logical realm, as these goods are shared and exchanged very often for non-economic or at least non-monetary motives. Thus, explaining such behaviors with a technical apparatus that does not acknowledge such behaviors as part of the scientific reality presents important methodological limitations.

To overcome such limitations, we have attempted to design methodological and theoretical approaches that combine pure rational choice modelling, mixed-modelling and heterodox social theory. More concretely, this has been done by implementing micro-level modelling, by applying game theory; macro-level modelling by applying system dynamics analysis; and complementing those to analyze the nature of anti-rival goods and behaviors around them using with a diversity of heterodox scientific approaches coming from critical political economy, social anthropology and psychology from the psychoanalytic tradition. The same approaches have also been applied to analyze the social and economic realities of the different pilot cases.

Such a combination of scientific and methodological approaches has been done in a dialectical, organic and eclectic manner, without hierarchizing between the different approaches. This approach should result in the design of institutions and incentives that internalize the historical and social realities that are now left outside the neoclassical institutional design. Thus, the methodological realm of ATARCA—may it be labeled "*anti-rival institutional design*"—has the potential to shed light into the schizoid nature of rationalistic neoclassical economics and generate insights for a new integrative socioeconomic institutionalism. Such an approach could align traditional (rival) economic systems with anti-rival systems and address the tensions between them.

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