Neuroeconomic Modeling of Distributed Barter Systems

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Abstract. The purpose of this work is to analyze the capabilities of automated barter chains based on decentralized technologies - distributed databases and peer-to-peer networks. Blockchain technologies are taken as an example. The authors describe the concept of the so-called game, which is a system-forming platform of automated barter chains for effective interaction between participants in economic processes (players) and aimed at the development and acquisition of wealth of each participant, as well as the disclosure of his creative and personal potential. As a result of the analysis, the function of the equivalent in money-free exchange is determined and it is concluded that it is possible to create a distributed mentoring institute, where every realized talent will take on apprentices and be responsible for their development. This article provides the analysis of questions of generalization of the financial paradigm in the transition to a new socio-economic technological order by changing cultural attitudes to the model of effective, targeted use of resources in the amount necessary for the disclosure of the creative potential of each player and in the amount necessary for his personal sense of happiness and harmony with himself, the surrounding society and nature (symbiotic, ecological, systematic approach). The presented concept is proposed as a basis for ensuring sustainable development of society by redirecting the resource base to the harmonious sustainable development and interaction of man and nature, the formation of an ecocentric social consciousness that determines the ethical attitude of man to The Earth's biosphere, to flora and fauna.

Keywords: Distributed systems · Blockchain · Sustainable development · Neuroeconomic modeling · Economic relations · Barter software

1 Instruction

The development of information systems is largely associated with the use of nature-like technologies and the development of distributed software and hardware solutions. This can be seen in neural network technologies, where instead of a single central processor, a set of elementary calculators — neurons is used. This also applies to the emergence of decentralized algorithms and databases: distributed hash tables (DHTs), interplanetary file system (IPFS), various mechanisms (Filecoin, Bitswap, BigchainDB, Ethereum, Swarm), MaidSafe technology, the purpose of which is to provide

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decentralized communication throughout the world, and others [1–9]. In peer-to-peer (p2p) networks, all networked computers have identical client and server functions [10, 11]. All these systems have increased reliability of transactions, calculations, and other technological processes due to the properties of decentralization and powerful encryption algorithms. This circumstance leads to a rethinking of the economic models established around the world [12-15]. Consider a retrospective review of economic systems and the development of monetary relations based on decentralized networks.

Barter in prehistoric times was considered as a sporadic exchange of products or services. With the growth of labor productivity and the commodity mode of production, there was a need for a universal equivalent, which led to the appearance of money. In a developed capitalist economy, barter occupies a marginal niche, being used, for example, in conditions of lack of liquidity. Money is performed including the role of a value measure and a means of circulation, allowing you to divide in time the moments of alienation by a participant in the turnover of goods a and the acquisition of goods B, C, etc., the total cost of which is equal to the cost of goods A. Early views of economists, philosophers [16] on this issue are associated with the lack of technological prerequisites at that time.

The development of peer-to-peer networks, technologies based on encryption and distributed databases has become the basis of a number of new economic models. It is obvious that the function of money has begun its transformation and this process is difficult to regulate due to technological progress. This is confirmed by the intensive development of various cryptocurrencies.

One of the main technologies is the blockchain, which has proven itself as a tool for economic activity and a tool for distributed information systems (similar to IOTA technology. Technically, it is a distributed crypto database, which is a chain of «blocks» stored simultaneously on multiple computers - a growing list of records that are linked using cryptography. Each such block contains the cryptographic hash of the previous block, a timestamp, and transaction data.

The Open Bazaar project is a blockchain-based trading platform. In general, it is similar to the discussed tools, here it is not barter, but buying and selling for cryptocurrency. There are also known crowdsourcing platforms based on blockchain [9] and “people’s court” systems based on blockchain – crowdjury.org.

A useful feature of this technology is the ability to capture information and thus avoid misinterpretations of agreements (guarantee the reliability of the agreement and the indisputability of transactions). This is an analog of a public digital signature, which cannot be canceled, because it is stored simultaneously on all devices participating in the general economic activity.

This paper presents the concept of a recommendation system for managing barter chains based on decentralized crypto databases and peer-to-peer networks (hereinafter referred to as the game). The concept is based on the following concepts:

* «Desires» (a goal that allows the player to improve the quality of life, designed and published as a message of need);

* «Creation» (creative physical and mental activity of the player that brings him satisfaction and is aimed at improving the game results and benefits the players);

* «Affluence» (having decent housing, freedom and means of movement, a stable balanced diet, physical and mental health).

2 Materials and Methods

Consider the basic principles of interaction based on automated barter chains. The game is an automated platform for the direct exchange of values, including goods and services with a direct targeting system (P2P-Marketplace). It is a decentralized system of consolidation and mutual assistance; it has a simple interface and is accessible from electronic devices. Allows you to build self-organizing communities aimed at the development, interaction and prosperity of the communities themselves. It has an interface similar to a Bulletin Board with catalogs of products and services published by users, without any restrictions on their personal pages, which are an evolution of the card with information about the user.

The automated search for barter chains is based on an abstract scheme of a network decentralized Game management system - a network graph, each vertex of which-a participant in the game (a living person, a subject) has two lists: a wish list and a list of opportunities (including skills). The general algorithm of the "Game" is that the subjects (hereinafter referred to as players, avatars) agree on barter transactions in the formalism of the Game: the blockchain records the fact of an agreement on a barter transaction and its completion. Trading operations can be delegated to one or more avatars for management. To optimize economic activity and logistics, various optimization algorithms are provided for building rational barter chains in the interests of participants. You can use internal tokens to transfer value or smart contracts [17–19].

The proposed system of smart contracts, organized on the acyclic directed graph principle for Game implementation, is suitable for flexible management of planning, design, progress, time reserves, reporting, private asset management, process support, industrial production, and structuring complex processes in decentralized Autonomous organizations. Targeting in such a system is based primarily on a direct sales model and advertising that is interesting to end users (allowed by them to display).

By joining the Game, a new participant contributes a resource to the game society as a share contribution in accordance with the law on consumer cooperation [20–22]. Resource - a unit or set of intellectual or physical activities. When entering the game, a person notifies the system about what, in what quantity and in what time period he can add to the game fund, for example: products, things [23], services, training, development, any useful and/or demanded actions. In this case, the share payment is entered into his personal account and is his property. The player has the right to dispose the unit fee independently and manage the services of other players, as well as top up the unit fee of the Deposit and confirmation of qualification.

Resources are distributed among players based on the principle of "resources for creative potential" to build this potential into a common collective playing field. The priority is to allocate resources that will directly strengthen the territory of the agreements and the game system as a whole. For this purpose, each user has a personal rating system and a system of social groups, on the basis of which various privacy settings can be applied and certain functions can be enabled. It allows you to adjust flexibly the filtering and security and to provide a comfortable social interaction. Private resources are resources that represent a manifestation of work or creativity. The Union has the

right to transfer part of its experience to a new participant who has joined the Game, subject to the consent of all members of the Union.

Thus, the game implementation technologies are represented as a convergence of historical, cultural and scientific heritage, as well as technologies in the field of telecommunications, marketing, distributed registries, peer-to-peer communication, queuing, machine learning and social engineering.

For the neuroeconomic modeling of the Game, we use a graph-theoretic approach: we associate a participant in economic relations (player) with each vertex of the graph, and the presence of economic interaction with the arcs. The simplest variant of interaction is that two players enter into economic relations, while the first player supplies the resource to the second, and the second, instead of monetary settlement with the first, uses a chain of economic interactions, which is closed to the first player. Thus, the barter chain functions, ensuring that the needs of the first and second players are met.

Obviously, within the formalism of the proposed model, the number of feedbacks in the form of barter chains will determine the level of economic stability of the entire system. In graph theory, such feedbacks are simple cycles.

For further reasoning, we will create a random growing graph and estimate the probability of occurrence of simple cycles in it that simulate economic feedbacks. Consider the algorithm:

1. A set of N nodes (vertices) N = {1,2,3 .... N} is given. Each node is numbered.
2. The initial structure of the graph is set from two connected nodes.
3. Repeat steps 4–7 N times.
4. The structure of the graph is recalculated
5. One of the N nodes is chosen at random and connected to an arbitrary node in the graph
6. The number N of free vertices decreases by one
7. Go to step 3.
8. Stop.

3 Results

For model experiments and estimating the scatter of the statistical values of the parameters of growing graphs, this algorithm was repeated a hundred times. After each run of the algorithm, the parameters were calculated and curves were plotted. These curves were then superimposed on each other to visualize the final results (Fig. 1).

The author's hypothesis is that the presence of multiple feedbacks makes any (including economic) system more stable.

Similar effects with feedback are observed in the neural network structure of the brain of higher animals and humans. In this sense, distributed networking technologies have biological counterparts, proven by natural selection and evolution.

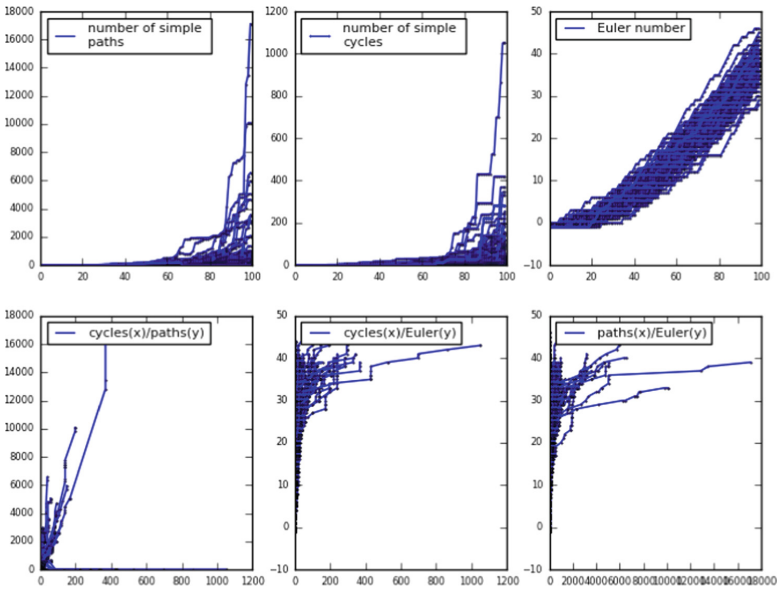

Fig. 1. 100 iterations of graph growth (100 experiments). Top: abscissa - algorithm step, ordinate - parameter value. Bottom: abscissa - the number of simple cycles, ordinate - the number of simple paths (left); the abscissa is the number of simple cycles, the ordinate is Euler's number (middle); the abscissa shows the number of simple paths, and the ordinate shows Euler's number (on the right).

Despite the simplicity of the algorithm, interesting features are observed in the structure of the graph: the probability of a sharp increase in cyclic structures (by 5 and 7 times) is observed in 2% of cases starting from 83 growth steps.

Consider an example of economic efficiency and comparison with the free market model. The disadvantages of the modern economic model are clearly visible in the following typical example. At the beginning of economic activity, one need to take a loan, then spend money on advertising, marketing and searching for counterparties, then return the loan in conditions of inflation and systemic crises.

On the other hand, within the framework of the Game concept, the player forms a desire, and a unique identifier is assigned to the desire. From this moment, the search mechanism aimed at meeting the needs and desires of the maximum number of participants of the barter chain is launched. When the necessary barter chain is found, the cost of the materials and transport delivery (decentralized, national logistics) is formed with fixing all the necessary parameters on the blockchain.

Upon delivery of the product to the customer, the integrity of the packaging and goods is recorded, and compliance with the declared quality and terms of the smart contract is checked, with the possibility of instant confirmation by online observers, if everything went well, the smart contract distributes points and fixes the end of the cycle.

The self-organization of the game allows to optimize not only the economic component, but also the environmental (non-waste) production principles [24–26]. This is a redirection of the resource base to the harmonious more sustainable development of man and nature, the formation of an ecocentric social consciousness, which determines the ethical attitude of man to the Earth's biosphere, flora and fauna [27]. Ecocentric thinking suggests that the biosphere, flora and fauna are not a utilitarian application to humans, but equal to humanity.

4 Discussion

It should be noted that the goal aimed at obtaining wealth (the concept of the game) does not coincide with the goal of making profit (the concept of a common economic model). These are totally different paradigms. Moreover, the proposed model can be used to make a profit, since it is more general.

The question arises: how can the equivalent function be exchanged without money? Tokens (points and their various types - ratings of smart contracts) can have this function, for example, this can be a number of positive reviews. Of course, it is important to use the correct established contract form (smart contract) [28].

The formation of exchange baskets and transaction conditions should be formalized very clearly and in detail in accordance with the legislation of the country (unless otherwise specified in the contract, then it is considered that the goods are considered equivalent - the contract should be drawn up so that it really should not be otherwise). In the Russian Federation, this is Article 568 of the Civil Code - a barter agreement [29].

The relevance and prospects of this topic are due to the growth in the speed of cryptocurrency transactions, which currently reach 50,000 transactions per second (Table 1), as well as a number of publications on this topic [for example, [30–32].

Table 1. Top 5 transaction speed cryptocurrencies in 2021

Cryptocurrency	Transactions/second
Solana (SOL)	50000
Ripple (XPR)	1500
Celo (CELO)	1000
Algorand (ALGO)	1000
Cardano (ADA)	257

5 Conclusions

The article demonstrates the paradox of double negation in the historical development of circulation: direct exchange (barter) - exchange mediated by the universal (monetary) equivalent (commodity - money - commodity formula) - barter in the information society (smart contracts and barter chains without money).

The software platform within the framework of the described concept allows achieving a high level of automation with maximum reliability and guaranteeing the security of transactions.

Software switching and network virtualization technologies with peer-to-peer connections between users, devices and applications allow implementing the proposed decentralized microservice architecture using open source. This will contribute to the sustainable development of society and its harmony with nature.

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