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Identification of types and properties of electronic money in the digital economy on the basis of interdisciplinary integration of knowledge

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Abstract. An attempt is made to identify types and properties of electronic money on the basis of interdisciplinary integration of knowledge. Main levels of interdisciplinary knowledge integration are distinguished: level 1 — individual links between disciplines; level 2 — bi-and versatility polydisciplinary; level 3 — interdisciplinary; level 4 is transdisciplinary, and the most appropriate ones are identified for this study. Definition of electronic money in a broad sense is proposed and brief description of their types is presented: on the basis of maps; on the basis of networks; on the basis of distributed registry of digital transactions. Hypothesis has been put forward about the source of electronic money intrinsic value — i.e. about costs associated with production of energy which is ensuring their existence and functioning. Ideas about the scale of prices, properties of homogeneity, standard nature, and recognition of electronic money are grounded. Demand to continue research related to retrieval and elaboration of indicators of electronic money turnover on the basis of distributed register of digital transactions within the national payment system is indicated.

1. Introduction

It has long been said that money, as an object of research, is attracting attention of not only economists, but also historians, ethnographers, archeologists, jurists, psychologists, technologists, art historians and other representatives of various areas of knowledge. However, their interest in money is limited, as a rule, only to a strictly specific focus of research and almost does not go beyond focused specialization. A certain progress, in terms of interdisciplinary integration of knowledge, is observed every time when a new form of money appears, however, it is limited most often to the level of individual links between disciplines, which is more often has a rather tentative character. The emergence of electronic money, as a new form of universal equivalent, which differs from all previous forms of money by absence of a material carrier, cannot but cause another surge of interest from representatives of different areas of knowledge. Using this, one can try to bring interdisciplinary knowledge about electronic money to a qualitatively new higher level of integration and enrich the modern concepts of money.



The purpose of the study is to identify the main types and properties of electronic money based on interdisciplinary integration of knowledge. To achieve this goal, an attempt is made to solve the following problems:

- determine the nature of the levels of interdisciplinary integration of knowledge and make the most appropriate choice to achieve the goal;
- offer the author's interpretation of electronic money in a broad sense, show the specifics of their types on the basis of the integration of the provisions of the philosophy of material carriers and information theory;
- substantiate inherent properties of electronic money of as a universal equivalent based on integration of technical and humanitarian disciplines knowledge.

Our research will be based on interdisciplinary integration of knowledge of the following subject areas: economic theory [1], money theory [2], carrier theory [3], information theory [4], fractal geometry [5], semiotics [6], cryptography and elliptic curve theory [7]. In this study we will consider electronic money in a broad sense ignoring, to a certain extent, essential characteristics of their individual species, in particular, difference between virtual currency and electronic money (in the narrow sense) discovered by D. A. Kochergin [8].

2. Research methods

The interdisciplinary integration of knowledge is characterized not by a simple addition of the subject competences of individual disciplines but also by emerging of a new, deeper understanding of essence of phenomena and mechanisms of functioning of systems of a very different nature. Knowledge obtained from different disciplines in the process of integration are compared, mutually enriched and developed thus creating a synergistic effect in the process of world cognition. Depending on direction and intensity of interdisciplinary knowledge interaction in the process of scientific knowledge it is necessary to take into account the level of their integration. S. N. Sirenko and A. V. Kolesnikov propose to distinguish the following levels of interdisciplinary knowledge integration: level 1 — individual links between disciplines; level 2 — bi- and polydisciplinary; level 3 — interdisciplinary; level 4 — transdisciplinary [9].

Level 1 — individual links between disciplines: integration of knowledge has a tentative character since it involves the use of general scientific methods of research as tools for solving specific problems and does not involve development and improvement of methods themselves.

Level 2 — bi- and poly-disciplinary: it involves direct transfer of results and research methods from one scientific discipline to another. This transfer is stipulated by retrieval of parallels in the subject domains under study. For example, nonlinear dynamics (synergetics), deterministic chaos, fractals, genetic algorithms, fuzzy sets and other new scientific concepts penetrate into economic theory, promising new discoveries, and at the same time forcing to review earlier obtained knowledge. As a result, new research programs which aim at a more reliable explanation of complex phenomena are emerging. These include, for example, a recently generated discipline called 'econophysics' [10]. Knowledge flows in these areas are moving in parallel and enrich each other by information. Knowledge and methods are supplemented more cumulatively, they are used to solve problems specific for the given scientific field. Such integration does not yet provide a fully holistic vision, which goes beyond the scope of the research field, and enables us to clearly identify what disciplines interact among themselves. Accumulation of results of interdisciplinary research in similar fields of knowledge leads to new poly-disciplinary directions emerging. Comparing results of research within the framework of polydisciplinary approach, it is possible to find new, previously unknown properties of entities under investigation.

Level 3 — an interdisciplinary approach: it is assuming synthesis of various theoretical provisions and methodologies which are being involved to scientific research from different disciplines, cooperation of different scientific fields which are utilizing common conceptual apparatus for investigation of a certain phenomenon. Out of two parallel directions of research a single stream of cognition is formed, which is already inseparable, but we also identify its formation referring to the

sources of its formation. Such integration does not yet have a general scientific status and does not provide an integral holistic view.

Level 4 — trans-disciplinary: it assumes going beyond specific areas or science and is characterized by cognitive schemes transfer from one disciplinary area to another, development and implementation of joint research projects. At this level of integration, when cognition flows are merging into one, it is difficult to single out sources of its formation and result of interaction acquires a general scientific status. With this level of interaction, an integral vision of the object of investigation emerges and a holistic vision of the problem is formed. As a result of work at this level of integration critical thinking, the ability to analyze, compare, generalize, evaluate ideas from different fields and synthesize them are developed. These results are more significant and weighty if compared to those that can be obtained at previous levels of interdisciplinary integration of knowledge.

Proceeding from the existing judgments about the phenomenon of electronic money, it seems expedient to continue research relying at least on the second multidisciplinary level of interdisciplinary integration of knowledge with possible subsequent access to the third interdisciplinary level of integration.

3. Obtained result

Electronic money, in the broadest sense, represents computer carrier-reflected information embodiment of universal equivalent. It can be represented only by secondary abstract information, which is the result of the reflection and encoding of primary specific information about the surrounding world and is used to establish communication links in society [11]. Computer-based carriers of universal equivalent information embodiment are understood as machine-based data carriers which are represented by technical device of any kind (magnetic tape, hard magnetic disk, integrated memory chip, etc.) or a cloud server designed for fixing, storing, accumulating, converting and transmitting of computer information.

Depending on type of computer storage medium and corresponding technology of information transfer, the following types of electronic money can be distinguished: card-based; network-based, and based on distributed register of digital transactions (crypto-currencies).

Card-based e-money provides for microprocessor-based cards (these may also be represented by mobile sim card, flash card, wristwatch, key chain, etc.) which are indicating e-money amount and serve as cash replacement for settlements and payments in trade and service points of retail sales, inter alia, for contactless payments. This type of electronic money is being increasingly promoted by international payment systems in conjunction with major partner banks that have created the appropriate infrastructure.

Network-based e-money is a fully virtual product represented by a program or a network resource and designed for settlements and payments in Internet shops and other companies maintaining business in Internet. Most famous payment systems based on this type of electronic money in Russia are, for example, Yandex Money or Web Money. To use electronic money in such systems it is necessary to have been registered and, in some cases, to install software. Infrastructure of such payment systems is borrowed from the banking sector. To enter or withdraw the amounts it is possible to use either bank and non-bank transfers of cash or cashless money.

Card-based and network-based e-money have the status of a legal means of payment and are created on the basis of applicable national currency emitted by the Central Bank. Other specific characteristics are possessed by another kind of electronic money — crypto currencies (virtual currencies), which appeared on the basis of blockchain technology — a distributed register of digital transactions [12]. Most countries have not determined in their jurisdictions to recognize crypto-currencies as legal payments means, except for Japan where they already consider blockchain as an alternative to existing technologies and amend national legislation authorizing the use of decentralized payment systems [13]. On the whole, this can be explained by novelty of technology and poor knowledge of ways and consequences of its practical application. Process of crypto-currency issuing which is based on complex mathematical problems solution with the use of encryption algorithms and

not connected with monetary authorities' activity is bringing too much uncertainty in the light of further viability of modern mechanisms of monetary regulation. Nevertheless, the practice of applying crypto-currency as a means of payment takes place within virtual communities and network groups solely on the basis of mutual agreement of the parties. Most popular are crypto-currencies such as Bitcoin, Ethereum, Reeples and Litecoin.

We see prospects for crypto currency growth in the expansion of practice of nationwide blockchain technology employment in the sphere of property right registration and transfer to material and non-material values. If this scenario is implemented, the crypto currency will become most suitable means of fulfilling functions like (I) unit of account and (II) means of exchange. Currently, interest of banking institutions to blockchain technology and crypto-currencies is increasingly growing. Central banks of a number of countries have shown interest in the prospects of creating national crypto-currencies; largest banks in USA, Western Europe and Asia are interested in possibilities of blockchain technology use for interbank settlements both at national and interstate levels. In our opinion, if crypto currencies created on the initiative of the banks take their place in the system of interbank settlements at the regional and international levels, in the future they will be able to replicate the fate of the European account unit of the ECU, which has been transformed into a single Euro currency in the course of time. The idea of using crypto currency in international settlements is also attractive in that it removes dependence on the national economic and political interests of countries whose currencies perform the function of world money.

With all the wealth and variety of attempts to reveal the essence and features of electronic money, the problem of determining the scale of prices and the value content of an electronic monetary unit is lost sight of. By analogy with full-value money whose price scale was determined by the weight content of precious metal in a monetary unit, the scale of prices of an electronic monetary unit should be determined by the volume and value of the information that represents it. It is generally known that the minimum unit of measurement reflected in electronic media is calculated in bits. The word 'bit' of English origin when translated into Russian means 'binary digit'. If we look at this value from a different angle we can say that it is a memory cell in electronic computers, which is stored in two digits: 0 and 1 [14].

In our opinion, in attempts to retrieve the source of intrinsic value of secondary abstract information (embodying electronic money) it is required, first of all, to take into account energy costs associated with functioning of technical devices which are ensuring mere existence of electronic money — beginning from emission up to storage and transfer in the course of settlements and payments. Electric power ensures electronic money functioning in the same way like metal and paper provide functioning of metal and paper money. Here, it makes sense to draw analogies with how the source of monetary unit value and purchasing power was changing in the course of evolution of money forms and types. In the era of precious metal bars and coins circulation, the value of monetary unit was determined by legally established amount of metal which one monetary unit shall contain and which determined its purchasing power. With transition from metal to paper money, the value of monetary unit ceased to depend on the value of material spent for banknotes fabrication. The power of law gave it the status of payment means and purchasing power began to depend on market situation.

The process of precious metal money displacement by paper money as well as the process of paper money replacement by electronic money is explained by the law of Gresham, which is usually formulated as 'bad money drives out the good', however, to be more precise, it says 'cheap money will drive out expensive money'. The reason that cheaper money always prevails is that the choice of using these or alternative money is mainly for those who pay them in exchange, and not for those who receive it. If someone has a choice to pay their debts by this or alternative money, the motives of thrift will make him choose the cheaper. If initiative or choice was, predominantly, a prerogative of the receiver (not of the payer) the opposite case would be justified. Then the more expensive, or 'good', money would drive out cheaper or 'bad' money.

The designation of electronic money by a certain set of signs (numbers or letters) operated by technical devices, provides, among other things, presence of such an important property for the

universal equivalent as the homogeneity that underlies standardization, recognition and universality of any means of payment. Thus, formerly, homogeneity of chemical composition of gold, due to its stability from the effects of other substances and in combination with its other properties, led to the recognition of this noble metal for the status of a universal equivalent. Homogeneity of gold ensures its uniformity throughout its volume, as a result of which equal in weight quantities of gold always have exactly the same value. At a later stage standardization and universalization of payment means were provided (I) by ingot stamping requirement aiming to certify metal purity and weight, (II) introduction of monetary statute legally defining nature of coinage, sample of currency metal, weight, type, legend of coins being issued, remedium allowance, coin withdrawal rules; (III) centralization and monopolization of bank and treasury notes issuing on the part of state. Taking into consideration the decentralized nature of electronic money emission, their uniformity as a means of payment must satisfy the requirements of unique information-identification algorithm for transactions processing.

To what extent it is fair to assert that inherent property of electronic money is homogeneous, we will try to justify it with the help of semiotics — the science of signs and sign systems, which studies human communication with the help of natural or artificial language, as well as social and information processes, animal communication, all kinds of art, functioning and development of culture.

One of the representatives of this field of interdisciplinary research, A. N. Barulin, is proposing the following interpretation of the sign: under the sign of S we will routinely understand the structure consisting in the simplest case of (I) a certain sensible object X (= signifying the sign S), which some person Ant (= address of the sign of S) in a particular the context (III) uses Σ as model (II), not necessarily the sensible Y (= signifying S) in order for the person At (= to the addressee of the sign S) due to the ability to establish between X and Y the necessary ratio ω (= code or code relationship between the signifier and the recognized of sign S) recognized the object Y on the object X and reacted to it in accordance with the rules of semiotic behavior of $Ant'y$ and $At'y$. This definition is somewhat difficult to understand, but it accurately reflects the functional purpose of the signs that symbolize electronic money in the information space.

V. V. Tarasenko is construing advantage (in homogeneity) of artificially over naturally created signs as follows:

‘In nature there are no two identical leaves. A person will never make two identical signatures. But we are able — through our ability to perceive a sign — to perceive two different leaves and two different signatures as identical. From this point of view, we, cognitive systems, are interfaced with reality. We begin to adjust our behavior to the situation based on similarity found between our cognitive abilities and difference in signs.

Therefore, the sign is understood as body capability to perceive i.e. to recognize the perception among a variety of sensations, as well as to demonstrate the behavior associated with this perception.

The computer is capable of something that nature is not capable of in principle — to produce two or more absolutely identical artefacts. Artificiality gives birth to objects which are identical to each other — without a ‘bitch and hitch’, without rough edges. Nature always leaves and shapes the difference, gives a crack, reveals the possibility of something unforeseen, different from our ideal.

In artificial systems, there are failures — nonconformity of changes with specified parameters and programs, that is, what Kant called a conceivable cause of the action. Therefore, artificiality is determined at the time of this type of malfunction, dysfunction, fissure, inconsistency of the result with goal-setting. And nature has no failures. In this sense, nature does not make jumps’ [15].

Just as the use of material carriers of the universal equivalent requires ensuring protection of such forms of money from counterfeits, the use of electronic money requires high degree of information security of its creation, storage and transfer processes. Currently, most promising, from efficiency and security viewpoint, is cryptographic elliptic curves theory — based approach. For a long time, the theory of elliptic curves was a field of pure mathematics until in the 1980s its practical applications to the construction of algorithms for the factorization of large numbers were found. Thanks to this, the theory of elliptical curves has found application both in classical cryptography for the generation of pseudo-random sequences, and in the construction of public key cryptosystems, in the development of

key distribution protocols and digital signature protocols. Interest in elliptical curves in cryptography is caused by the fact that they provide the same cryptographic properties as numerical or polynomial cryptosystems, but with a much smaller key size.

4. Summary

1. Electronic money, in a broad sense, is reflected in computer media information embodiment of the universal equivalent. Depending on the type of computer media and the corresponding technology of information transfer, the following types of electronic money can be distinguished: card-based; network-based; based on distributed register of digital transactions (cryptocurrency).

2. Appearance and spread of certain types of electronic money clearly illustrates evolvement of electronic money as a new form of universal equivalent. In particular, card-based electronic money is the closest in nature to conventional cashless form of money with the only difference that physical banknotes are replaced by electronic ones. Crypto currency is distinguished by qualitatively different characteristics starting from emission mechanism and ending with the way of carrying out transactions allowing them to be attributed to an absolutely new form of the universal equivalent. Network-based e-money with mechanism of emission basically does not differ from card-based e-money and by the way of realization of transactions are closer to electronic money based on distributed register of digital transactions.

3. Use of any kind of electronic money does not imply any costs other than electricity that have a certain value. At the same time, cost of electricity for using electronic money is just as negligible compared to the cost of paper for using paper money, as in the past, they were negligible compared to the costs of precious metals for using metal money. In favor of this version I would also like to mention that highest activity of Bitcoin crypto currency miners was recorded in the countries of South-East Asia and some provinces of China with cheapest electric power if compared with the rest of the world provided the maximum profit from the subsequent sale of the extracted crypto currency at the market price.

4. Designation of electronic money by a certain set of signs (usually in the form of two digits: 0 and 1), which operate technical devices, ensures important property of the universal equivalent like homogeneity which is the basis for standardization, recognition and universality of any means of payment.

5. Directions for further research

We associate the directions for further research with retrieval and development of indicators of electronic money turnover on the basis of distributed register of digital transactions within country national payment system. Currently used indicators of composition and structure of money supply for various reasons are not yet adapted for the accounting and measurement of electronic currency created outside the banking system.

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