

Digital economy as a result of the genesis of the information revolution of society

Nazarov D.M.

Ural State University of Economics
Yekaterinburg, Russia
slup2005@mail.ru

Fitina E.K.

Ural Federal University
Yekaterinburg, Russia
fitina777@mail.ru

Juraeva A.O.

Ural State University of Economics
Yekaterinburg, Russia
juraeva_usue@mail.ru

Abstract — The article presents the author's view on the emergence of the digital economy in the context of the prevailing economic theories, based on an analysis of the processes of information revolutions in society. Informational revolutions are considered as points of bifurcation of social development. The author tried to build the genesis of the development of economic knowledge based on the work of Nobel laureates in the field of economics, which contributed to the emergence of the digital economy.

Keywords — *information economy, digital economy, information, knowledge, Nobel laureates.*

I. INTRODUCTION

The modern era is a logical continuation of the development of the concept of "knowledge economy", which takes the form of a new economic phenomenon - the "digital economy", which is based on the digital transformation of society, achieved through the introduction of digital technologies in all areas of business. In the digital economy, information becomes the key characteristic of the economic structure, as a resource of virtually any economic activity, along with energy, financial, etc., which includes the complete set of information generated in the business processes of business entities and life in general. Considering the specifics of this resource, it should be noted that, firstly, information is practically the only type of "eternal", in the sense of non-exhaustible resource, secondly, it is the essence of the product of intellectual activity of the most qualified and creatively active part of business entities, thirdly, possessing a unique property of accumulation, it contributes to the most rational and efficient use of all other resources, fourthly, the processing

of this resource not only does not reduce it, but also gives rise to new forms of its use and presentation.

Thus, information becomes an integral economic resource that affects the society as a whole in a complex and the activity of any economic agent in particular. At the same time, the theoretical substantiation of the contribution of information as a special type of resource to economics, which constantly generates new theoretical approaches and the change of economic structures requires additional research.

II. THE CONCEPT OF THE THEORY OF CATASTROPHES IN THE STUDY OF THE GENESIS OF INFORMATION REVOLUTIONS

In this article, it is proposed to apply for such research the theory of catastrophes, the key concept of which in the development of systemic methodology became bifurcation points. Applying precisely this theory we will try to synchronize the processes of development of economic thought and information revolutions in order to study more deeply the influence of the phenomenon of information as a resource on economic theory and practice from the point of view of the system and process approaches [[20]].

From the perspective of catastrophe theory, bifurcation points are points at which the system under study becomes unstable and transforms as a result of the slightest fluctuation, acquiring a new structure, or is destroyed altogether, and the bifurcation period is the time any bifurcation points pass. The bifurcation period is divided into two interrelated stages: cumulative (accumulation by the system of "history") and transformational (direct transformation of the system).

Imagine the development of world civilization from the point of view of information revolutions (see Table 1).

TABLE I. INFORMATIONAL REVOLUTIONS IN THE DEVELOPMENT OF WORLD CIVILIZATION

Information revolution	Bifurcation period	
	<i>Cumulative stage</i>	<i>Transformational stage</i>
The first information revolution (the invention of writing) 5-6 thousand years BC	The oral phase of information exchange, a very low degree of accumulation, exchange, intensity of information conversion.	The written stage of information exchange, a very low degree of information dissemination, the search for optimal forms and methods for storing information.
The second information revolution (1300 BC)	The invention of a manuscript book in China, low degree of accumulation, exchange, intensity of conversion and dissemination of information,	A more perfect written stage of information exchange (the emergence of the process of replicating information), the emergence of new forms and methods of storing information, the emergence of a formalized information dissemination technology (artel of scribes), the concept of information value appears, the unit price of information is very high.
The third information revolution (print press, I. Guttenberg, mid XV century)	The invention of Guttenberg's printing press and typesetting between 1450 and 1455 years, the intensity of information exchange, a high speed of information dissemination increase qualitatively and quantitatively	The "book" stage of information exchange, the era of "paper informatics", new technologies for replicating information, increasing the availability of information for the masses, the qualitative development of a system for disseminating information and knowledge (journal systems, periodicals, mail, telephone, telegraph).
Fourth Information Revolution (mid-20th century)	The invention of ECM, the emergence of information technology, a very high speed of distribution and exchange of information	The computer stage of information exchange, the era of "paperless informatics", a sharp change in the technology of replication, storage and exchange of information, the emergence of computer technology and electronic resources.
Fifth information revolution (the beginning of the XXI century)	The invention of computer networks, the emergence of the Internet and global computer networks, hyper-high speed of distribution and exchange of information	The electronic stage of information exchange, the era of the network of "paperless informatics", a sharp change in the technology of replication, storage and exchange of information, the emergence of computer technologies for processing big data, the mobile Internet, intelligent data processing programs and a fundamental increase in the number of types of electronic resources. The emergence of digital resources and technology.

Even a superficial analysis of table 1 leads us to the conclusion that the sequence of information revolutions has the property of temporal irregularity, and the key characteristic of bifurcation periods is the intensity of information exchange. The connection between the temporal characteristics of the development of civilization and the speed of information exchange is actually causal. Indeed, it is easy to see that with a low speed of information exchange, the successive change of bifurcation periods of information revolutions takes several thousand years (the first and second information revolution), the transition to the third information revolution takes centuries, and to the fourth - decades. This means only one thing: changing the speed of information exchange allowed changing the development time of society by 1 order, that is, increasing the speed of human civilization development 10 times in each bifurcation period. Let's pay attention to the fact that since the beginning of the era of "paper informatics", technological innovations in the field of processing and replication of information have made it possible for the broad masses of consumers to make an information product, since prices have fallen sharply on it. The possibility of multiple replication of information has led to the fact that the process of information exchange has become more efficient, its intensity has increased dramatically, the pace of socio-economic development has increased, which has led to the transformation of socio-economic development - all the institutions of society have changed qualitatively, including not only the economy, but also the systems of science and education. The advent of ECM has led to the emergence of the era of "paperless computer science", which is fundamentally new both in its content and in the consequences it causes in almost all spheres of social activity. Informational or post-industrial society is the product of the fourth information revolution and the subject of study within the transformational

stage of the bifurcation period of the fifth information revolution, which from the point of view of philosophy represents the highest level of development of society, the main and defining value of which is not only material wealth, but also information and electronic resources. The beginning of the XXI century was a turning point, which was the catalyst for the emergence of digital technologies, and with them the *digital society*, by which we understand society, the information exchange in which it has hyper-high intensity and occurs in various digital formats, as well as the overwhelming number of services is provided in electronic (digital) form and, at the same time, a sufficient level of information security of the society is ensured.

III. THE GENESIS OF THE DEVELOPMENT OF ECONOMIC THOUGHT IN THE CONTEXT OF THE DISCOVERIES OF THE NOBEL LAUREATES

The subject of the history of economic thought is the process of studying the emergence, development and change of economic views in a wide scope of views, doctrines, concepts, with the fixation of chronologically appearing sources and their authors in the course of evolution of human society. In economics, there is enough potential to conduct a qualitative analysis of the conceptual provisions of economic theory from different points of view [[31]]. Therefore, in our study, we briefly discuss the stages of economic development, the bifurcation periods of which can also be considered the corresponding periods of information revolutions.

Typical representatives of this direction A. Smith [[25]], D. Ricardo [[24]], J. Mill, L. Valras, they proposed a model of economic behavior based on the assumptions that an economic entity knows for certain what production factors it possesses (awareness of an economic entity in its own affairs [[31]], and

its behavior is the result of a rational choice from the many resources known to it.

The development of views within the framework of economic theory, the emergence of new concepts, directions of scientific thought led to the fact that the model proposed by the classics first underwent significant changes and then completely destroyed.

If we talk in general, the further views of economic scientists were aimed at identifying the essence of information under various conditions that led to the asymmetry of the mechanisms of market equilibrium for various reasons.

Studies by Nobel laureates have convincingly shown that the concepts of classical and neoclassical economic theory in many respects undergo changes over time, changes in the rate of information exchange and the influence of information resources on economic processes.

The first Nobel Prize in Economics in 1969 was awarded to J. Tinbergen and R. Frisch for researching the causes of economic fluctuations in various markets related to the investment crisis, using econometric analysis of data. In the 40s of the last century, for the first time, using the statistical apparatus of multiple regression to analyze accumulated economic data, factors influencing market fluctuations were identified and the first econometric models were obtained that made it possible to convert this data into useful information and knowledge.

In the mid-1950s, the theory of general equilibrium was seriously transformed. K. Arrow from the position of generalized topology proved the existence of competitive equilibrium in the abstract multi-market model of the economy, and also showed that such an equilibrium can be Pareto-effective in terms of using market mechanisms. The model provided the most important information for the implementation of rational behavior in the national economies of the countries: States should not intervene in the functioning of the market mechanism directly through the control of market prices; they can do this, if necessary, indirectly, using the tax system and transfers.

In 1993, scientists D. North and R. Vogel received the Nobel Prize for two interrelated discoveries: the first for rethinking the concept of institutions in economic history (singled out formal and informal institutions, 1968-1970), the second for a radical update of data processing methods of historical and economic research based on the latest methods of data analysis. North criticizes the neoclassical theory for its inability to interpret differences in the economic growth of different national economies, since neoclassical features especially use market mechanisms at different periods of time, as well as the development of technologies, including informational and institutional development of society (rules of the game between economic agents). In his theory, Douglas North retains the initial position of the neoclassical theory of limited resources, competition, analytical tools of microeconomic theory, but radically changes the premise of rationalism, linking it with the time factor. The main merit of R. Fogel [[3]], who is considered to be one of the founders of "cliometry", is a fundamental renewal of research methods and the assessment of facts of economic history based on the methods of mathematical economics and economic analysis. As a result of the analysis, for the first time, he drew attention

to the fact that small innovations in industry contribute more to its evolution than large technological discoveries. Thus, it was found that a retrospective analysis of economic data can provide new useful information that can improve, in terms of rationality, the behavior of various market agents and the state, as well as economic and institutional changes at various levels.

Analyzing the behavior of market agents in the economy, John Nash (Nobel Prize winner in 1994) noted that in the face of fierce competition, the results of economic activity lead to the same result there is always a winner and a loser. One of the most important principles for the implementation of such behavior can be safely called A. Smith's rule "the invisible hand of the market, which is responsible for coordinating economic mechanisms. The meaning of this rule is that if each agent strives for his own self-interest (profit), the "invisible hand" of Providence will lead to general welfare — a fairly stable and rational behavior in different markets. Until the middle of the 20th century, this rule of rational behavior of economic agents was considered as a kind of axiom of economics and almost never was questioned. J. Nash developed game-theoretic methods of analysis and showed that A. Smith's classical approach to economic development in a competitive environment, in which "every man for himself" is not optimal. More effective market strategies are situations in which market agents striving for optimal behavior take into account the rational behavior of their competitors (they also strive for optimal action).

That is, J. Nash was able to determine which strategy to use a reasonable market agent in conflict with a reasonable competitor (or competitors) in order to ensure, on average, the maximum possible gain for himself by simulating a situation in which both parties use ideal competitive strategies, which leads to the creation of a stable equilibrium. This balance was called the Nash equilibrium (NE): It is beneficial for players (agents) to maintain this balance, since any change will only worsen their position in the market. John Nash, in fact, made a revolution in the perception of the relations of participants in economic activities and proposed strategies for resolving conflict situations in a competitive market through cooperation. The market received new information and knowledge to resolve conflicts and search for other compromise solutions, which allowed competitors to look for potential partners, increasing the welfare of each of the participants in the partnership agreement.

In 2001, the prize was awarded for research that can be called the "information economy" (George Akerlof, Michael Spence, Joseph Eugene Stiglitz). J. Akerlof drew attention to the fact that market information may be "private" or "hidden", which may give rise to its uneven distribution among two types of economic agents: Sellers and buyers, ultimately, will provoke a situation of "reverse selection" on the market - when a high-quality product remains in the hands of the seller, and to a large extent there is only a low-quality product. K. Arrow attributes the uneven distribution of information about the quality of goods among economic agents selling goods to the moral aspect: one seller, using the ignorance of the buyer to reduce the quality of goods, that is, reduce their costs, and the other, offering quality goods, spending on informing customers about it, increases its costs and, in fact, the price, thus becoming uncompetitive.

Thus, the principle of uneven distribution of information contributed to the emergence of the idea of limited rationality in the behavior of market participants.

In 2002, the Nobel Prize was awarded to Daniel Kahneman and Vernon Lomax Smith for research in the field of decision-making and the mechanisms of alternative markets. Their proposed decision-making models under uncertainty described people's behavior when choosing alternatives based on the "value" criterion that a person determines in a subjective way using certain heuristics.

Thus, economic theory has been enriched with new knowledge: in order to optimize the behavior of the market agent, it is necessary to take into account his "human size", that is, decisions made in real life and management practice are optimal not in terms of known probabilities of known gains and losses (model evaluation of alternatives), but from the point of view of subjective assessments of the value of decision making (choice of alternative) by a specific person, this fact must be taken into account when describing the behavior of market agents.

Israel Robert John Aumann, Thomas Crombie Schelling in 2005 received a Nobel Prize for deepening our understanding of the essence of the conflict and cooperation by analyzing game theory. They gave an extended interpretation of the problem of conflict and cooperation within the framework of game theory and analyzed the strategies of the "coordination games" strategy. This led to the introduction of the concept of "focal points" into scientific use. Focal points describe the equilibrium game (conflict) state due to the fact that players choose the same option from a variety of options, guided by the same rules and rules of the game.

The focal point effect has enriched economic theory with new information that the most likely equilibrium states in a conflict situation do not always coincide with the results of calculations in the framework of the classical game theory and the more effective the institutions adopted in society are, the effect of focal points works more reliably, which means that stable equilibria can be predicted almost reliably.

The following Nobel Prizes can be combined under one name: "Design of economic mechanisms" (Leonid Gurvich, Eric Maskin, Roger Bruce Myerson, Paul Krugman, Elinor Ostrom, Oliver Williamson, Peter Diamond, Dale Mortensen, Christopher Pissarides). These works by Nobel laureates significantly complement classical and neoclassical economic theory, filling already existing and proven provisions with new content, in particular, describing from different positions the issues of ensuring the optimal behavior of economic agents. Models implemented within the framework of theoretical and methodological studies of economic mechanisms of different nature ("design of mechanisms"), confirmed the earlier studies and allowed us to better explain the problems and paradoxes arising in practical activities, they are essentially a set of rules that allow to set the trajectories of market agents.

Synchronization of the development of economic theory, based on the analysis of information about the discoveries of the Nobel laureates and information revolutions is presented in Table 2.

Thus, as a result of the analysis of the most significant works of leading economists of the 20th century, it can be stated with confidence that the prerequisites for the emergence

of the digital economy were the so-called stage of social development - the information economy.

In a broad sense, the information economy is viewed in the context of the evolution of social and economic relations, as their new level, ensuring the growth of the quality of life of society and the intensity of development of business processes, with the predominant role of intellectual and creative labor and information products.

In a narrow sense, information economy is a special branch of economic theory based on the paradigms of the information society, which studies the role and impact of information as one of the production factors, as well as information and communication technologies and products for the development and adoption of economic and management decisions in the new economic conditions.

Such key notions as information and knowledge have played a significant role in the development of the information economy. There are many scientific approaches that detail two very capacious concepts of "information" and "knowledge", which in modern conditions are almost never used separately.

Digital economy - a system of economic, social and cultural relations based on the use of digital information and communication technologies [[23]]. Digital economy is an economic activity, the key factor in which production is in digital form, and contributes to the formation of the information space, taking into account the needs of citizens and society in obtaining high-quality and reliable information, the development of the information infrastructure of the Russian Federation, the creation and use of Russian information and telecommunication technologies, as well as the formation of a new technological basis for the social and economic sphere [[23]]. Derivatives from the digital economy can rightly be considered: a collaborative (shared, joint) economy, a unit economy that emerged against the background of the development of cloud services and services, as well as cohort data analysis. A collaborative economy is a collection of business models in which market agents (people, organizations, communities,) are able to collectively use any goods and services through barter, rent, lending, donation, resale exchange, and replacement [0]. That is, these models are based on the paradigm of temporary (joint), rather than permanent (sole) possession of a thing in the broad sense of the word. Unit economics is a method of economic modeling used to determine the profitability of a business model by assessing the profitability of a product or a single customer. As a rule, it is used to assess the profitability of a startup business idea. A business can be successful only if a single unit of a product or service is profitable. [[20]]. In the framework of unit-economy, cohort data analysis is used as a basic tool. A cohort analysis is the selection of a specific group of users (cohorts) and the analysis of its behavior over time. Users in the cohort are united by performing an action on a certain period of time.

The basis of all the above varieties of the digital economy is the possibility of almost instantaneous processing of information, the emergence of global network technology, the design and widespread use of databases and knowledge that facilitate the rapid adoption of optimal decisions in the course of any economic activity.

TABLE II. SYNCHRONIZATION OF THE DEVELOPMENT OF ECONOMIC THEORY AND INFORMATION REVOLUTIONS.

Years	T (1776-1870)	T (1871-1935)	T(1936-1970)	T(1971-2000)	T(2000-2017)	T(2017- present time)
The name of the prevailing economic theory	Classical Economic Theory (A. Smith, J. S. Mill, K. Marx)	Marginalism and neoclassical theory (U. Jevons, L. Walras, K. Menger)	Keynesianism, early game theory, programming (J. Von Neumann, O. Morgenstern, L. Kantorovich)	The theory of expected utility and software-game approach, (J. Nash, R. Zelten, R. Lucas, T. Sargent)	Information and communication economy (J. Akerlof, M. Spence, J. Yu. Stiglitz, I. R.J. Aumann, T. K. Schelling)	Digital Economy (L. Gurvich, E. Maskin, R. B. Myerson, P. Krugman, E. Ostrom, O. Williamson, P. Diamond, D. Mortensen, K. Pissarides)
Mathematical apparatus	Elementary Mathematics	Mathematical analysis	Probability theory and mathematical statistics, mathematical programming	The theory of games in economics, the theory of fuzzy sets, the theory of information	Game Theory in Economics, Fuzzy Set Theory, Information Theory, Data Mining Technologies	Game Theory, Big Data Analysis, Data Mining
Information Revolutions	Third Information Revolution (200 years): Guttenberg's invention of the printing press and typesetting between 1450 and 1455; cumulative stage: possibility of multiple replication of information (paper informatics); transformational stage: systemic changes in society.		Fourth Information Revolution (60 years): computer invention cumulative stage: development of computer technology, technological innovation (paperless informatics) transformational stage: systemic changes in society and conceptual changes in the paradigms of the economy, information is a material good.		Fifth information revolution (17 years): cloud technologies cumulative stage: development of computer technologies and their use in all areas of activity, high-tech innovations (paperless informatics) transformational stage: qualitatively new level of economic relations, digital transformation, data mining	

The essence of the digital economy is to implement a new type of economic relations within the framework of the modern information society, in which the data-information-knowledge triad is the main link between production and consumption, between the stages of material and non-material production. At the same time, digital economy is a dynamic system of a new type, which should efficiently distribute digital resources - data, means, values, reserves, opportunities, sources of processing, storage, distribution and consumption of information in order to create new knowledge.

IV.CONCLUSIONS

One can reasonably say that a qualitatively new stage in the development of civilization is occurring, characterized by a new type of economy - the digital economy, the essence of which is the development and large-scale use of data, information, digital resources and its highest form - scientific knowledge in almost all areas of social activity of society. Note that the main tools in the digital economy are digital resources that combine data, information, knowledge and intellectual technologies, which generate new factors that do not have a real market value. But despite this, the impact of such factors on the economic activity of an economic entity may provoke the appearance of bifurcation points on the trajectory of its development, the passage through which can lead to unpredictable consequences. Therefore, one of the trends in the development of the digital economy is the design and introduction into practice of the activities of business entities of tools for translating these factors into specific assets of an enterprise.

Conceptual innovations in the development of modern society are due to the unprecedented scale of modernization of

the traditional and even information economy, aimed at the development of the information society and changing the focus of all business processes on the intellectual level against the background of globalization processes. This allows us to formulate a hypothesis about changing the “world economic architecture”, where the basis is not a material resource in its traditional sense, but digital resources and factors, which include information, knowledge and intellectual technologies.

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