

Modeling the System of Development of the World Economy in the Conditions of Innovative Globalization Society

Anatoliy Shvidanenko, Henefa Shvidanenko, Oleg Shvidanenko

Abstract: *The article substantiates the priority of intellectualization in the formation of the paradigm of civilizational development of world economies. The object of the study is the processes of development of the world economic system. The subject of the study is a set of theoretical, methodological and practical provisions on the process of intellectualization of the economy, taking into account the information volume of innovative and creative components. The purpose of the article is to substantiate the processes of economic development of the world system, taking into account all changes and realities of modern globalization processes. The article deals with the phase coordinates of the economic system: innovative and creative, which are growing functions. The coefficient of intellectualization of the economy of the country is introduced and innovative thinking is represented by the operator who is applied to the volume of innovative knowledge. The development of an economic system is defined as the solution of the Sturm - Liouville problem, as the Cauchy problem for a system of first order ordinary differential equations. A differential equation is described, which describes the exponential law of self-growth of one's own array of innovative information in the process of innovative thinking.*

It is shown that for the present stage of development of economies of the world system is characterized by the coming of an era of intellectually-innovative paradigm, taking into account the actualization of formation of fundamentally new trends based on the priority of creation and use of intellectual resources acquired in the process of constant cognition.

The graphical interpretation of the process of development of economies in which the array of innovative information is changed only due to innovative thinking is presented. The graph for developing economies in which the array of innovative information is changed only due to innovative thinking is given. It is proved that under the same initial conditions, but with different innovation levels, the economies of developing countries in the phase plane move on divergent trajectories.

It is proved that the modern innovation economy is caused by a hierarchical structure, which is built on the level of innovative development, which is adequate to the size of its own array of innovative information with a creative group at the top.

Keywords: *intellectual capital, intellectual and innovative paradigm, creativity, innovative thinking.*

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I. INTRODUCTION

Today, globalization is the absolute power of the world order over states and societies. Globalization is affecting profound changes in the development of states and societies that are adapting to existence within an interconnected but rather uncertain world. At the beginning of the 21st century, a new paradigm of economic development emerged in the world economic system, which is caused by the diminishing role of material and resource components of social production and the increasing role of the intellectual component. The production, distribution and use of knowledge form the basis of a knowledge-based economy. It is characterized by the growing relationship between capital markets and emerging technologies, and the global nature of the creation and use of knowledge and technology. In new economic conditions, only purposeful formation of innovative potential and its competent use are the basis of economic growth. At the same time, an important task is the formation of the intellectual capital of the state. Intellectual capital is two interdependent components. One of them is a person, his knowledge, education, professionalism (human capital). The second is the result of creative work - an intellectual product (innovation). Intellectual capital is becoming increasingly important in today's world. It should be noted that a necessary condition for innovative development is the constant growth of intellectual potential. The strengthening of the role of intelligence and human capital naturally led to the improvement of the social and humanitarian foundations of the economy [16, 19]. Note that the term "intellectualization" is borrowed from psychology, where it means the use of human intellectual resources, the activation of thinking and all the components of such a complex phenomenon as intelligence, which brings together all the cognitive abilities of the individual. Intellectualization means the acquisition by the economic system of new qualities due to the fact that it is based on intensive use of knowledge and information exchange [12, 20]. At present, there is an increasing intellectualization of world economic development. In this context, Ukraine is implementing international information projects in the fields of science, education, logistics, social mobility, tourism infrastructure and, for example, to improve the quality of information support for international relations and processes.

It should be noted that the civilizational paradigm of social studies takes into account the political, spiritual, cultural, social, religious and other spheres of social life. We emphasize that man is the main subject of civilization as a whole [1, 20]. On the other hand, the civilizational paradigm assumes the unity and integrity of human history. Civilizations, as holistic systems, can be compared with one another, making it possible to make a comparative-historical approach widely used in research. As a result of its application, the history of the economy of a particular region or a particular country is not considered in isolation, but in comparison with other civilizations, which, in turn, gives the opportunity to better understand the historical and economic processes and fix their peculiarities [2, 16].

Thus, for the modern stage of development of the economies of the world system is characterized by the coming of an era of intellectually-innovative paradigm, taking into account the actualization of formation of fundamentally new trends based on the priority of creation and use of intellectual resources acquired in the process of constant cognition. It should be noted that knowledge is an intellectual substance that leads to the creation of a powerful intellectual apparatus for the introduction of a wide range of destructive technologies and the transformation of all processes of production and consumption that change the trajectory of social development [3, 15].

Most researchers agree that knowledge plays a leading role in the development of world economies, as a key component of all changes taking place in a globalizing society. In this connection, it is extremely important to mathematically justify the level of development of the economies of the world system with their innovative intellectual level, with an adequate amount of their own array of information that represents them.

The scientific basis for determining the trends and concepts of civilized development of the world system are the scientific views of M. Weber, F. Brodel, A. Toynbee, S. Huntington, L. Morgan and others. [4, 19]

M. Drucker emphasizes that the future society is a knowledge society, which is the basis of a market-based innovative entrepreneurial economy [5, 17]. F. Hayek and M. Friedman develop the theory of "intellectual technology" and emphasize that the development of information economy can be undermined by attempts

Planning in Toffler's theory of "third wave" and "power shift", A. Toffler writes about the formation of a global world market based on innovation [6].

The future intellectualization of the country's economy in the context of globalization can be traced by analyzing the works that characterize the transformation of the socio-economic structure of society at the end of the 20th century. In these developments, the main focus is on innovative development as the basis for the transformation of modern society. Galbraith in earlier writings warned of the increasing influence of large corporations on economics and politics and called for antitrust regulation [7,19]. On the future intellectualization of the economy of the country in the context of globalization with a focus on innovative development is investigated by D. Bell, W. Rostow, etc. [8, 18].

We emphasize that the intellectual economy of a country is related to the following concepts [9, 10,11]:

- innovative potential (set of scientific and technological, financial and economic, set of scientific and technological, financial and economic, production, social and cultural and educational opportunities of the country, which are necessary for innovative development of economy). Ingredients: production and scientific-technical base of production, information technologies, external information networks and market activity;
- human potential (the set of knowledge, skills and labor of man);
- human intellectual potential and its capacity for specification;
- intellectual capital (knowledge that is converted into value);
- innovative production (intellectual, creative use of information).

Thus, the problems of construction and development of economies of the world system under the condition of intellectualization of innovative development of globalization society are devoted to a number of models, concepts and theories, namely: communication, civilization, integrated, model of global development, global economic, structuring theories, theories of economic development, evolutionary theory economic changes [12,13,14]. However, these models are mostly partial and do not reflect the essence of modern globalization processes. In addition, the conceptual issues surrounding the processes of intellectualization as a trigger for the development of world economies are fragmented and, a priori, need further investigation.

II. METHODOLOGY

The development of an economic system is defined as the solution of the Sturm - Liouville problem, as the Cauchy problem for a system of first order ordinary differential equations [9]. The phase coordinates of the economic system are considered: innovative and creative, which are growing functions. The coefficient of intellectualization of the economy of the country is introduced and innovative thinking is represented by the operator who is applied to the volume of innovative knowledge. The differential equation is described, which describes the law of self-growth of one's own array of innovative information in the process of innovative thinking.

III. RESULTS

Any economic system, in particular, and socio-economic is capable of being described with the required precision of any number of constants and variables of whatever size, but finite. Variables are called phase coordinates, and a system change can be interpreted as moving a point in a multidimensional phase space. Its measurement is equal to the number of professional coordinates, and their choice is determined by the purpose of the study.

If S is the number of economic systems, then the development of each is determined by the solution of the Sturm - Liouville problem for the system of s ordinary first order differential equations [9]:

$$\frac{dX_s}{dt} = F_s(X_s) + f_s(t), \quad S \in [1, S], \quad (1)$$

where $X_s = (x_{s_1}, x_{s_2}, x_{s_3}, \dots, x_{s_n}, a_{s_1}, a_{s_2}, a_{s_3}, \dots, a_{s_m})$ is the vector function of the state of the economic system;

$x_{s_i}, i = \overline{1, n}$ - phase coordinates;

$a_{s_k}, k = \overline{1, m}$ - numerical parameters;

$f_s(t)$ is a time-dependent function.

If the system S_1 is an element of system S , then the trajectory of the system S_1 is determined by the solution of the equations:

$$\begin{cases} \frac{dx}{dt} = F(x) + \Phi(y), \\ \frac{dy}{dt} = S(y) + \Phi(x). \end{cases} \quad (2)$$

It is a task of self-regulation or self-organization of a complex economic system, which consists of two subsystems $F(y)$ and $F(x)$. It can be assumed that their mutual influence will depend on the importance of their respective influences.

Note that the multidimensionality of the phase space and the complexity of the connections make it impossible to use a rigorous mathematical model in this form (2). In this regard, it is advisable to limit ourselves to modeling the process of changing some characteristics of the economic system. Note that one of the most important features of a system is the structure of an array of innovative and intelligent information.

The phase coordinates of the economic system necessarily include intellectual property, which is a statutory right to the technical basis of innovation performance. Intellectual property of the country's economy can be represented by two components: innovative $y(t)$ and creative $x(t)$, which will be considered as increasing functions: $y > 0, x > 0$. We emphasize that creativity is the process of generating new ideas, and innovation is their practical implementation.

Creativity is a complex process that cannot be categorized into one system of concepts, it can be developed or supported by appropriate institutional tools. Creativity may actually form an idea that pops up in our minds as an outburst of inspiration, but it will remain useless until it is realized. Under these conditions, there is a possibility of an innovative product. Creativity is the ability to create and find new original ideas that deviate from accepted thinking patterns, to successfully solve tasks in a non-standard way, as well as the ability to solve problems that arise within static systems. It's a vision of problems from a different angle and solving them in a unique way. Creative thinking is a revolutionary and creative thinking that is constructive. Creative thinking is of value in all the dynamic areas of life where competition is developed. That is the value of creativity for society.

The relation $y/x = k$ will be called the coefficient of intellectualization of the economy of the country. In general, if we define intellectualization as the process of processing an

array of innovative knowledge, the result of which is new knowledge, then we can assume that innovative thinking is an operator of the form $M = x + y$, which can be applied to the volume of innovative knowledge Q and which, over time Δt , is growing. We have:

$$dQ_m = Q_m' dt \rightarrow Q_m' = MQ_m, \quad (3)$$

where Q_m - the amount of innovative knowledge gained only through innovative thinking,

ΔQ_m - the increase in the volume of innovative knowledge.

Then the solution of differential equation (3) will be in the form of an exponential law of self-growth of its own array of innovative information in the process of innovative thinking:

$$Q_m = Q(0)e^{\int M dt} = Q(0)e^{\int (x+y) dt} = Q(0)e^{\int x dt} e^{\int y dt} = Q_x Q_y. \quad (4)$$

If $x = const, y = const, Q(0) = Q_0^2$ so, own array of innovative information will be:

$$Q_m = Q_0 e^{xt} Q_0 e^{yt} = Q_x Q_y. \quad (5)$$

or

$$Q_m = (x+y)Q_0^2 e^{(x+y)t} > 0 \quad (6)$$

The parametric equations of motion in the phase plane (Q_x, Q_y) will be:

$$Q_x = Q_0 e^{xt}, \quad Q_y = Q_0 e^{yt}. \quad (7)$$

Write the parametric equations (6) in canonical form:

$$Q_y = Q_0^{k-1} Q_x^k. \quad (8)$$

Let's put:

$$Q_0 = 1, \quad x = 1. \quad (9)$$

Then

$$Q_y = Q_x^k. \quad (10)$$

The structured array of innovative information β and its change over time depending on the coefficient $k = (y/x)$ is described as follows:

$$\begin{aligned} \beta &= \frac{Q_y}{Q_x} = e^{(k-1)t}, \\ \beta' &= (k-1)e^{(k-1)t} \end{aligned} \quad (11)$$

Graphs of the structured array of innovative information $\beta = \beta((k-1), t)$ are presented in Fig. 1.

Figure 1 depicts a graph for emerging economies in which the array of innovative information changes only through innovative thinking.



Under the same initial conditions, but with different innovation levels, the economies of developing countries in this phase plane move along divergent trajectories.

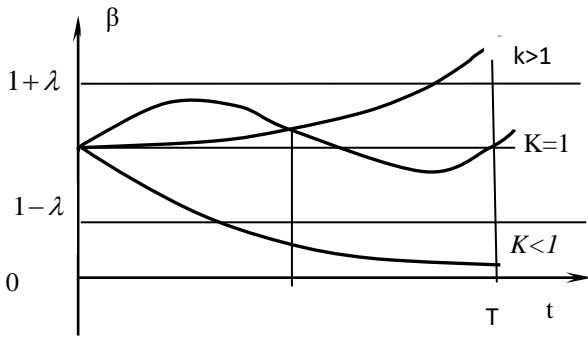


Figure 1. Schedule of change of structured array of innovative information

Source: author's calculations based on [9, 12,19]

There is a certain area of security or resilience $1-\lambda < \beta < 1+\lambda$ in which short-term changes in innovative economic development are possible. Thus, the strategic innovative development of the economy is to increase its volume of innovative information and harmonize innovative thinking, which can be written in a symbolic form as follows:

$$Q'_y > 0, k \rightarrow 1. \tag{12}$$

It should be noted that external innovation information is the process of development of international information links, development of the world information infrastructure. The information sphere is much globalized and contributes to further globalization of the sphere of knowledge, encompassing science, education, innovation, data [17].

Therefore, under the influence of the knowledge economy, new directions of the Internet development (web services, networks), information resources of the world scale, types of information and scientific services with global access are emerging. Today, we can argue about the emergence of a global knowledge economy, which begins to combine intellectual resources and knowledge markets of different countries [11]. Given the existence of an external source of innovative information G ($M_g > M_q$), its own array is determined by equation (3).

Then the array of a given economy of the country will be formed both at the expense of innovative thinking and at the expense of an external source of innovative information, and will be determined by the system of equations (13):

$$\begin{cases} G' = M_g G, \\ Q' = (a - M_q)Q = a(t)G. \end{cases} \tag{13}$$

where the function $a = a(t)$ is characterized by the amount of absorption of external innovation information.

Thus, if

$$M_g = x_g + y_g, M_q = x_q + y_q, \tag{14}$$

then system (13) is the projection of system (2) onto the phase plane (Q, t) .

As an external source of innovative information it is possible to accept set of developed economies. Let's make some assumptions:

1. The initial conditions of the economies of the world are the same:

$$G_0 = Q_0 = 1 \tag{15}$$

2. The level of development of innovative thinking of the economies of the world is the same and stable, they differ only in the level of innovative thinking, which does not change over time, which can be represented as the following conditions:

$$y_g = const, y_q = const, y_g > y_q, k_g = \frac{y_g}{x_g} = 1, \tag{16}$$

$$y_g = x_g = x_q = 1, k_g = \frac{y_q}{x_q} = \frac{y_q}{x_g}$$

$$M_g = 2, M_q = k_q + 1.$$

3. Characteristics of absorption of external innovative information

If one considers the difference of own arrays $(G-Q) > 0$ as analog of the rate of innovative information supply, and the absorption of innovative information is the analogue of interest, then one can assume the dependence $a(t) = F(G-Q)$ (Fig. 2).

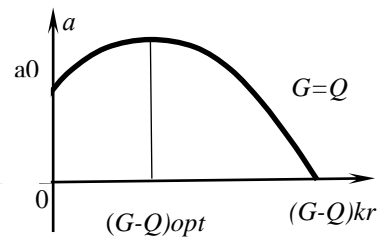


Figure 2. Function of assimilation of external innovative information

Source: author's calculations based on [9, 14,20]

With this assumption, we find the value of the function $a(t) = F(G-Q)$:

$$a(t) = a_0 \left(1 - \frac{((G-Q) - 2(G-Q)_{opt})(G-Q)}{((G-Q)_{kr} - 2(G-Q)_{opt})(G-Q)_{kr}} \right) \tag{17}$$

and its maximum value:

$$a_{max} = a_0 \left(1 + \frac{(G-Q)_{opt}^2}{((G-Q)_{kr} - 2(G-Q)_{opt})(G-Q)_{kr}} \right) \tag{18}$$

The solution of the Cauchy problem for the system of equations (13) will be:

$$G = Q_0 e^{2t}, \quad Q = \frac{Q_0}{1+\gamma} (1 + \gamma e^{2t}), \quad (19)$$

$$V = \frac{a}{\gamma g - \gamma q} = \frac{a}{\gamma}$$

The value $Dy = y_g - y_q$ is called the growth of innovative thinking. Let us compose the ratio of the amount of innovative knowledge accumulated only through innovative thinking to the external source of the volume of innovative information $V = \frac{Q}{G}$ and find its derivative in the form:

$$V(t) = \frac{Q}{G} = \frac{\gamma}{1+\gamma} (\gamma + e^{-2t}), \quad (20)$$

$$V'(t) = -\frac{2}{1+\gamma} e^{-2t} < 0.$$

Under the same initial conditions, this ratio decreases over time:

$$\lim_{t \rightarrow \infty} V(t) = \frac{\gamma}{1+\gamma} = \frac{a}{a+\Delta y} < 1, \quad (21)$$

$$Q(t) = \frac{\gamma}{1+\gamma} G(t) = \frac{a}{a+\Delta y} G(t).$$

Let us define the intellectual distance between economies as the difference between our own arrays of innovative information:

$$a(t) = (G - Q) = G(1 - V) = \frac{\Delta y}{a + \Delta y} (e^{2t} - 1), \quad (22)$$

$$\Delta = \frac{2\Delta y}{a + \Delta y} e^{2t} > 0.$$

In the absence of innovative thinking ($\gamma q = 0$) and maximum propensity for intellectualization ($a = a_{max} \leq 1$), we will have the following inequalities, respectively:

$$Q = \frac{a_{max} G}{a_{max} + 1} \leq \frac{G}{2}, \quad (23)$$

$$\Delta = \frac{e^{2t} - 1}{a_{max} + 1} \geq 0,5 (e^{2t} - 1),$$

$$\Delta = \frac{e^{2t}}{a_{max} + 1} \geq 0,5 e^{2t}.$$

Therefore, under the same initial conditions, an economy with innovative thinking ($K = 1$) and G develops faster than Q at any given values of a , $V'(t) < 0$ (Fig. 3).

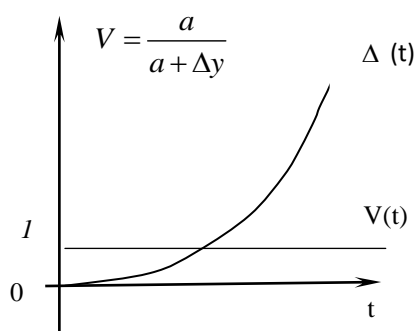


Fig. 3. Geometric interpretation of innovative economic development

Source: author's calculations based on [9, 11, 18]

The intellectual distance Δ is growing ($\Delta' > 0$), and the economy, without the condition of creative thinking, is lagging behind. This is due to the growth of innovative thinking Δy . Really at $\Delta y = 0, V = 1, \Delta = 0$

IV. CONCLUSIONS

Intellectualization has become the basis of the modern economy and has various manifestations that are projected at the level of the world economy. Intellectualization, which is closely linked to ICT and informatization, influences the development of all major forms of international economic relations, facilitating their intensification, improving the quality of interactions, and the emergence of new trends. This determines the directions of evolution of the world economic system. It can be said that the development of globalization of the world economy at the present stage is: the formation of the world information space and scientific and technological progress; economic integration; a new system of international division of labor; implementation of universal liberal-democratic values.

We emphasize that creativity is the creation of fundamentally new ideas. If we are to focus on popularization and increasing interest in creativity among the younger generation, then in the coming years we will face a boom in innovation in the country. Ukraine needs to be an innovative creative country in which everything is organized to unlock and develop a person's creative potential. It should be noted that the creative economy is a particular sector of the economy based on intellectual activity. Its main characteristics are:

- the high role of new technologies and discoveries in various fields of human activity;
- a high degree of uncertainty;
- a large amount of existing knowledge and the urgent need to generate new knowledge.

It can be said that the modern innovation economy is conditioned by a hierarchical structure, which is built on the level of innovative development, which is adequate to the size of its own array of innovative information with the creative group at the top. This array, its volume and content determines the development of an innovative economy through the intellectualization of society. The choice of the trajectory of innovative economic development depends on the development of sources of innovative information, and, of course, the laws of functioning of the economic structure.

The world economic system is like a comet with a core of developed economies and a plume of developing economies, ordered by their level of innovation. The process of development of innovative economies is associated with the consolidation and improvement of the use of intellectual potential, which depends on the volume and speed of the development of creative thinking.

Thus, the development of an innovative economy is based on the systematic phenomena and processes of the globalizing world throughout the history of its conceptual transformations.

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