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NEW INTERDISCIPLINARY KNOWLEDGE FOR THE ECONOMICS OF SUSTAINABLE DEVELOPMENT

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Abstract. *The purpose of the article is to substantiate the interdisciplinary foundations of a new direction of economic science – physical (spatial) marcoeconomics. Research methods – methods of system analysis and system design, interdisciplinarity methods, based on a combination of natural and economic laws, as well as patterns of functions of complex ESES (ecological-social-economic system). Results – regularities of functioning of complex ESES are revealed, the basics of physical macroeconomic analysis are substantiated. The method of function of ecological supply of the Earth is offered.*

This article proposes a concept of the creation of physical macroeconomics of sustainable development that expands the system of coordinates in the research in economic science as it takes into account physical parameters of biosphere terrestrial space in economic development.

Physical macroeconomics studies the models of commensurability of biophysical and value estimates on the way to the formation of sustainable economy development of ESES.

Key words: *spatial macroeconomics, function of ecological supply of the Earth, physical-economic modeling, sustainable development, biosphere stability, new physical-economic knowledge.*

Introduction. Providing economy with natural resources of the natural environment for a long time was not perceived as its dependence on the laws of nature. At the same time, it follows from the laws of physics that quantitative estimates of all processes in natural systems have an energy expression and are spatially determined. Economy is built in the space of biosphere. Therefore, it is important for its sustainable development to take into account the determinants of physics of the terrestrial biosphere. Contemporary physical economy explores economic phenomena and processes in close relationship with the energy-matter and bio-information flows coming from the outer space. This makes it possible to find a cognitive basis for spatial modeling of biomass preservation of living matter in the process of economic activity.

Since biosphere, that initially is sustainable systemic entity, is interpreted as a planetary ecosystem, it is transformed into the ESES from the time when the society with its economy has become a geological transforming factor of its development. This holistic dynamic planetary system, consisting of natural and socio-economic subsystems that are its territorial components must become, in our opinion, the object of study of contemporary physico-economic science. Such necessity is caused by the fact that the level of organization of biosphere has some threshold values that cannot be overstepped while carrying out economic activities. These threshold values that must become the object of modeling of spatial-economic processes, are the energy criteria of stability of the biosphere that, according to the postulates of nonequilibrium thermodynamics, appear to be the parameters of preservation of its natural orderliness, that is, negentropy. As they are one of the sources of formation of the primary value in the ESES, they must become the object of special attention for the contemporary science of sustainable development of the world. This is why physico-economic methodology is the methodology of obtaining knowledge about physical space within whose boundaries economic activity is carried out in order to determine for such activity the optimal limit (volume), to develop non-market mechanisms for preservation of biodiversity (biomass) of living matter and to substantiate the qualitatively new laws of value and the laws of money turnover. Biological productivity of the Earth is functionally dependent on the level of its natural capitalization. In that context introduction of the spatial coordinate of the Earth's natural capital in contemporary physical economy is important, as it allows to take into account spatial particularities of physico-economic working capability of the Earth.

Setting the problem. In the light of the latest developments in natural sciences, the world economy must be considered as built in the terrestrial space of the biosphere. It appears to be an intermediate link between the biosphere and the terrestrial landscape systems that are interconnected by constant exchange processes of solar energy and the inflows from the outer space, which brings about natural orderliness and is the source for production of the new living matter as natural capital. At the same time, proceeding from the need for its greatest possible conservation for the future generations, the problem arises of physico-economic modeling of the conditions of its stability. This requires identification of the energy factors of its reproduction and has to proceed from the laws of V. Vernadsky’s theory. On the other hand it is necessary to take into account the phenomenon of negentropic sufficiency of biosphere preservation.

Thus, the system-synergetic approach based on the new physico-economic knowledge must become the basis for further integration of scientific knowledge for restructuring the domain of economic science in general. In this context, particular attention should be given to the problems of substantiating the new laws and functions of sustainable development of the ecological socio-economic system (ESES) as a qualitatively more complex object of research and a system design in the latest physical economy.

At one time, as it is known, the methodological revolution in theory of value had become its link with the category of "wealth maximum utility". Thus, the value category received a somewhat subjective interpretation, and economic science began to be based on the premise that the value of wealth is a function of its maximum utility for the market-driven economic consumer. If we consider economy as a complex ESES, then, according to V. Vernadsky, the priority must be to evaluate the "biophysical choice" in preserving stability of the terrestrial landscapes ecosystems that guarantees preservation of the planet's natural capital and production of absolute added value and for that reason the physics of marginalism comes to the foreground.

Thuse, physico-economic science is based on the principle of improvement of the society, taking into consideration and exploring the phenomenon of universal (absolute) added value that is of natural and not of social origin. In this context, the overriding task of economy of sustainable development that must become life-preserving by its nature is to perform its mediation function in transforming bioinformation coming from the outer space to Earth's surface into efficient work. In such case, it will be safe to say that noospheric model of the economy is formed.

Globalization of the present day ecological-economic and climatic changes present new requirements to the construction of such a model of economy that would take into account the biosphere reproductive capabilities. This gave rise to the need for elaboration of the interdisciplinary methodology for the study of the natural space of economy that would bring to a common standard biophysical and value criteria for preservation of the planet's natural capital. These problems can not be resolved without the applying scientific concepts and fundamental laws of biosphere development discovered by V. Vernadsky in the latest macroeconomic analysis. Such approach must be based on the premise that assessment of the function of preservation of the Earth's biosphere natural capital is as important as that of the production function of this capital in the economy.

Thus, the necessity of paradigm shift in economic science in the 21st century is caused by the following needs:

- Knowledge of nonlinear complex processes in the system "nature-economy-nature";
- Accumulation of new knowledge in the modern natural sciences;
- Regard to the phenomena of emergence and synergy as attributes of a complex system;
- Identification of relations and conditions of self-organization of dissipative systems;
- Inclusion of the laws for conservation of the Earth's biosphere in macroeconomic analysis;
- Study of economy in ecological and social plane;
- Supplementing the theory of economic reproduction, proceeding from the regularities of conservation of the "pellicle of life" (V. Vernadsky).

The analysis of recent researches and publications. Today, the are right interesting concept for construction (building) qualitatively new models of the economy of sustainable development (Solow, 2007; Daly, 1996; Giampietro, 1994; Costanza, 2004; Cleveland, 2010 etc.).

Especially valuable, in in our opinion is the paradigm of the stationary economy, proposed by the world-famous American scientist Herman Daly (Daly, 2014; 2015).

As correctly believes H.Daly, "Adopting a steady-state economy at the macro level (while, of course, allowing for improvements in V allocation at the micro level) helps us to avoid being shoved past the economic limit." and "The prevailing obsession with economic growth puts us on the path to ecological collapse, sacrificing the very sustenance of our well-being and survival. To reverse this ominous trajectory, we must transition toward a steady-state economy focused on qualitative development, as opposed to quantitative growth, and the interdependence of the human economy and global ecosphere." (Daly, 2014).

The purpose of the article is to substantiate the interdisciplinary foundations of a new direction of economic science – physical (spatial) marcoeconomics.

Setting the objectives. We support and join this paradigm with some additions - the modern physical and economic methodology. Developing this methodology today, it is possible to come to the creation of the system of an effective, preventive in its content management of ecologically sustainable development of economy, which envisages

prevention and evasion of the new environmental changes in terrestrial ecological systems and preservation of their natural productivity and, therefore. ensuring sustainable functioning of the Earth's biosphere.

Research material and methods. It is obvious that the world economy can not grow indefinitely in the physically limited space of terrestrial biosphere. It has to pay regard to the conditions of biosphere self-organization and its active environments. At the same time one must be aware that biosphere is the only self-sufficient and stable organism in the world and this is why economy and humanity as its components may survive only by way of preserving it.

Therefore, there are three globally important functions of biosphere that play an especially critical role in further development of economy and humanity in general. These are its biological productivity that ensures food supply, keeping up hydrologic and atmospheric composition of the environment optimal for human life support and biological cleaning of terrestrial space for the economy and humans [21].

At present, regretfully, economic science shrugs off contribution of natural factors in the support of the humanity's wellbeing as value of the biosphere's life-supporting functions is not appraised.

This anthropocentric error can be corrected by *expanding the system of coordinates in the research in macroeconomics*. As we have noted earlier, the first step on the way to it must be the *paradigm of incorporation of economy in the biosphere space*. This paradigm is based on taking into consideration physical parameters of its terrestrial space, because the exceptionally important task of the latest economic science is assessment of the state of preservation of energy supply of geobiocoenosis and its inclusion in macroeconomic analysis. Without taking this into account biosphere will lose its functionability and, therefore, energy budget of terrestrial surface (according to S. Podolynsky) will be becoming more and more deficient [17].

The result of this is the world has found itself in the frenzied whirlwind of the unending environmental changes and cataclysms. Aside from the progressing signs they acquire the new qualitative properties and produce the ever-growing effect on the socioeconomic processes giving rise to the new inflation spirals and downturns in the world economy. What is the way to get out from the grip of these new threats and challenges that like the tsunami attack the entire environmental-economic space of the Earth? What are the motivating mechanisms with whose aid it would be possible to reorient the new geological force – humanity – towards environmentally sustainable economic activity? How to ensure sufficient knowledge for the construction of the life-preserving (antienthropy) model of economy? Indeed, losses from the environmental changes are considerably higher than the growth rate of the world economy. Thus, with the average annual growth of the world gross product by 5% annual losses from the environmental changes grow by nearly 30%. Simultaneously the volume of terrestrial photosynthesis production drops because of the high spatial natural resource intensity of the world economy. Economy competes with nature as it occupies more and more of those niches that belong to natural populations. The continuous declining volume of terrestrial photosynthesis production is the result of the much too high pressure of economy on the biosphere's terrestrial space. For it is well known that today extraction of useful minerals attains 25-30 tons per planet's inhabitant 7% of which is used as raw material for various industries and the rest contaminates atmosphere, creating waste heaps, waste waters, polluting the environment. The area of forests, fresh water resources decrease disastrously, biological diversity shrinks, ocean waters become polluted, soil becomes exhausted, ozone layer shrinks too [15]. *All these phenomena have ceased to be the external effects in economy*

a long time ago and appear to be the endogenous factors of the financial-economic and ecological crises existing permanently today.

Thus, it is fair to say, that today the objective limits of human understanding of macroeconomic phenomena and processes are changing.

First of all it is necessary to take into account spatial determinants of the development of economy in the Earth's biosphere that are physical-economic in their substance and determine the need for elaboration of physical-economic methodology for the studies in the latest science of sustainable development of the World.

This methodology initiated by the great Ukrainian scientist S. Podolynsky back in the 19th century is a promising branch today in developing the post-neoclassical economic science and must lie at the base of fundamental research and models of modern economy. One of such models must be the noospheric model of economy, whose realization requires understanding of the phenomenon of existence of organic world through taking into account indicators of preservation of the Earth's biosphere and the latest achievements of natural sciences and their use in the up-to-date macroeconomic analysis [18,19].

Now, in our opinion, physical economics must concentrate attention on the study of forces ensuring movement of the complicated natural-economic systems in the biosphere terrestrial space. Thus, physical-economic methodology today is an interdisciplinary methodology of understanding of the laws and indicators of the biosphere terrestrial space and their application in the system of spatial macroeconomic analysis of sustainable development. Its principal designation is taking into account the results of monitoring the photosynthesizing capacity of the Earth's surface for application of the new assessments and prevention mechanisms in the newest science of sustainability.

As it is known, the "work" of the living matter ensuring its stability is the aggregate annual production of living matter of the landscapes which today is estimated at the value of 750 trillion US dollars. Of course, this estimate can not be perceived as the full value of such ecosystems. To this end biosphere, unlike the factories and companies "produces" its merchandise during 3.9 billion years without stopping for the "repairs". Pushing such analogy further, the present day value of the Earth's ecosystems can be assessed by comparing it with the production of biosphere during this long period. According to the estimates of scientists this value will amount to $5.5 \cdot 10^{30}$ J or $2 \cdot 10^{24}$ US dollars [7].

The quantitative measure of living matter is biomass and its annual production. Biomass is a quantity of living matter per area or volume unit of its location (g/m; kg/ha; g/m^3, etc.). annual production of living matter, as it is known, is the actual biomass buildup in the area unit per time unit (for example, t/ha per day or year). That is, it is that amount of added value whose source is nature of the biosphere terrestrial space.. these indicators must be reflected in the models of of the newest macroeconomics to prevent the risks of loosing the newly produced added value through the absence of an appropriate accounting and assessment. Failure to take into consideration the value of newly created products of living matter as the natural capital of the Earth is the reason of the "distorted reflection" of subsequent processes taking place in the economy. This, in the long run, leads to the emergence of new inflationary spirals and crisis phenomena therein that can not be overcome with the aid of loans from the international financial institutions.

According to the laws of nonequilibrium thermodynamics, functionability of each terrestrial ecological system (TES) is determined by the amount of free energy.

Free energy can be said to be a fraction of the internal energy of the system, that can be spent by the system to perform the work and be replenished in the process of contact with the environment:

$$F = E + (T\sigma - Ts) \quad (1)$$

where F – I free energy of the system;
E – internal energy of the system;
T – temperature;
σ – negentropy;
s – entropy;
(Tσ - Ts) – negentropy budget of the system (Pbn).

Thus, a model of the natural local market existing in each terrestrial ecological system can be shown in Fig. 1

As shown in Fig. 1, the curves of supply and demand intersect at point M since the main limiting factor for functioning of each local natural market is the budget limitation A0B0 determined by the volume of natural orderliness δT having the price Pbn. That is the "market mechanism" of biogeocenosis.

As it is known, the theory of macroeconomics appeared after the Great Depression and, therefore, is a relatively new science. Evidently, in the process of its development its functions and objectives kept on changing along with the changing world. Thus, before S. Keynes the main task of the state in economy was establishment of the conditions for development of the market. At the same time Keynesian scientific school has brought in some corrective amendments: the state must enter the market and participate actively in it: buy, sell, etc. It is quite predictable that the question arises: how objectives and functions of the theory of macroeconomics have to change under the conditions of permanently existing world financial-economic and environmental crises that have become the attributes of the 21st century? Are the traditional functions of macroeconomics determined by the neoclassical and neo-Keynesian scientific schools sufficient under these conditions?

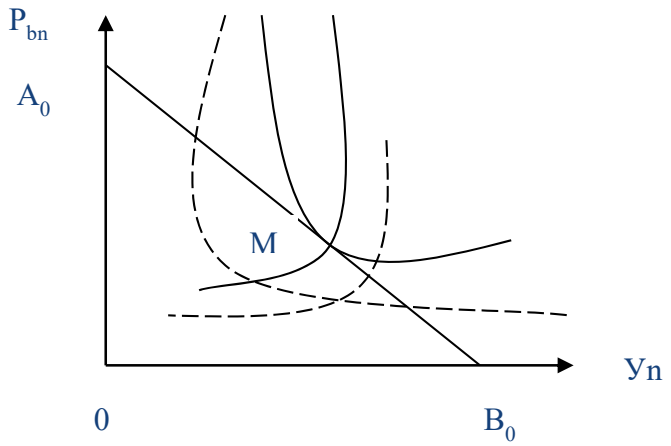

Fig. 1 Model of the natural local market

According to the postulates of neo-Keynesian school the main functions of the theory of macroeconomics are those that determine the principles and ways that the state must follow in economics in order to resolve such problems as [19]:

1) slump in production;
2) unemployment (the problem of incomplete use of resources of the society);
3) goods and services prices – inflation, deflation, etc.;
4) commodity prices (wages, %);
5) interrelations of national economy and foreign economic environment, such as:
a) closed economy – export, import;
b) open economy – foreign exchange rate, trade balance;
c) production factors (labor, capital, technology).

These are the factors that describe the state of the national economy in general. Macroeconomic analysis shows the way out of the poor condition of the national economy and what "medications" it needs under the conditions of instability [2].

In modern textbooks the subject of neoclassical macroeconomics is linked not so much with the wealth as with the choice (economics is a science of choice). The main thing, as they say it, is distribution of economic resources so as to ensure the maximum GDP production. With the limited resources the problem of choice arises and this attaches economic meaning to the resource because the price of an unlimited resource = 0. the more a resource is limited the higher is its price. At the same time the systemic crisis of the world economy existing today is a proof of the fact that *certain qualitatively new conditions* have appeared that determine formation of cycles in it the and thus have an impact on its restoration. What can be attributed to these qualitatively new factors of the development of economy in the 21st century?

This is, first of all, the ever increasing deficiency of not only environmental resources, but the restorative functions of the entire terrestrial biosphere because of its loss of living matter biomass of ecosystems.

Thus, the objective modern world requires restoration of reality in the theory of macroeconomics by way of taking into consideration the new factor – productivity of natural capital in the terrestrial biosphere. For economic theory of the use of space (*spatial economics*) concentrates its attention only on such dimensions of economic life as distances, areas and transport costs functions. W. Isard made a good point saying that entire classical and neoclassical economic theory has limited itself to the study of the wonderland disregarding any natural-spatial characteristics [4]. However, in our opinion it is through the study of the spatial function of the Earth's natural capital in economy it would be possible to come to balancing the oppositely directed "interests" of the environment and economy. In this context we speak of the qualitatively new spatial paradigm of the formation of the economy of sustainable development that in its essence is a physical-economic paradigm.

A study of economy as a component of terrestrial biosphere requires taking into consideration the environmental conditions for conduction all economic processes in its space. That is, it is not the "rational behavior of economic man" or the "invisible hand of Adam Smith" that play center stage, but "behavior" of the terrestrial part of biosphere within whose bounds economic activity is conducted and its capacity to perform the environment renovation functions. As to the principle of non-intervention (Lasser Sair) in the market self-organization – since the society with its economy became the geological transforming factor of biosphere development (according to V. Vernadsky), the very subject of study in the theory of macroeconomics becomes complicated – from the open to the world economy national economies to the similarly open terrestrial and external space of biosphere, that is, to complicated ecosocioeconomic systems (ESES). This is why in the latest macroeconomic analysis it is necessary to pay attention also to the conditions of self-organization and, therefore, stability of these complicated ESES. Under such conditions knowledge and

postulates of neoclassical science of market economy are not sufficient [6]. If, according to the neoclassical theory of macroeconomics each market agent is striving to maximize his gains (rational behavior of the economic individual) and self-interest of one individual confronts self-interest of another individual and they reconcile at some point (as the market-clearing price balances supply and demand), then, evidently the question arises – how to interpret different economic processes and phenomena not only from the standpoint of their usefulness for the economic consumer but, first of all, from the standpoint of their usefulness (or harm) for reproduction of the terrestrial biosphere space wherein economy functions.

Thus, it would be fair to say that since economic activity of the society became a geological transforming factor in biosphere (which has been proved by V. Vernadsky in the 20th century), the theory *of macroeconomics must also take into account the effect of spatial-biosphere productivity of natural capital of the Earth that has a spatial-biosphere determinancy of the impact on economic development*. Why has this problem appeared? Because economy "functions" in the space of terrestrial biosphere and, for that reason, must take into consideration its determinants. Natural resources that come from that space to economy have the same hand in the formation of *added value* as the economic resources produced in the branches of the economy.

Obvious is the fact that the newest macroeconomics (we shall call it "physical" or "special macroeconomics", as economic phenomena and processes it studies not only in temporal, but in spatial coordinates of biosphere as well) must be based on the qualitatively new (complicated) *model of circulation* of resources, products and income. Today macroeconomics has to investigate not only the question, for example, what effect on economic well-being of the poor and well-to-do people is produced by the changes in the interest rates, unemployment level or inflation rate in the state. It must also clarify how the existing deficient aggregate supply of natural resources and adverse changes in land fertility influence on the level of interest rates, cash flows or macroeconomic stability in general. The important problem that has to be resolved by the newest theory of spatial macroeconomics of sustainable development, in our opinion, is the problem of recognizing the effect of spatial resource flows in terrestrial biosphere involved in the formation of added value on the economic processes.

Results. We shall depict the main macroeconomic proportions existing in every national economy proceeding from its study as a complicated ecosocioeconomic system with the terrestrial subsystems of biosphere in its core that keep on exchanging energy, matter and bio-information with its external space (Fig. 2).

As follows from Fig. 2, complication of the subject of study requires examination of all socioeconomic processes in close interdependence with the exchange natural processes within a certain space, which predetermines appearance of the new elements of spatial macroeconomic proportions.

Such elements are investments and saving of bio-information on the Earth's surface, productivity of terrestrial ecological (landscape) systems and the volume of aggregate ecological supply of the Earth. Why do we incorporate exactly these elements in the pattern of macroeconomic proportions of the national economy that we explore from the standpoint of physical-economic approaches? Just because they are in line with the criterion of physical-economic effectiveness of functioning of ecosocioeconomic system of the state under the conditions of limited natural resources and ecological wealth. These elements reflect the state of interaction of the national economy with spatial development of the terrestrial part of biosphere where it is located.

Spheres of macroeconomics	**Economic entity**	**Interaction of physical (real) and monetary economy**	**Interaction of national economy with spatial macroeconomics**
Production sphere	Households	Investments and savings	Investments and savings of the Earth's natural capital
Consumption, gross accumulation on net exports	Consumption and savings	Labor productivity and real wages	Productivity of terrestrial ecosystems
Labor remuneration, net taxes, gross profit	Business enterprises		Volume of aggregate environmental supply of the Earth
	Gross net investments		
Employment sphere			
Natural norm of unemployment and its actual level	State		
	Budget receipts and outlays		
Sphere of prices			
Commodity and money supply			
Sphere of foreign economic activity			
Export and import of goods and services			

Fig. 2. Macroeconomic proportions of national economy as a complex ecosocioeconomic system of the state [16].

Thus, constructing of the diagram of circulation of resources, products and income in spatial macroeconomics it is necessary to take into consideration the following physical-economic postulates:

1) national (and world in general) economy is a component of the terrestrial space of biosphere functioning in isometric and not in adiabatic regime of interaction with it;

2) it is interpreted as a complicated ecosocioeconomic system (ESES) (three-tier system) that takes into account regularities of preservation of the space of terrestrial biosphere stability in its core and exchanges with the external space of biosphere the flows of energy, matter and bi-information;

3) it is based on the systemic-synergetic approach to determination of the conditions of self-organization of the complicated ESES which provides the possibility to ensure a maximal stability of the resources' flow from the external biosphere to the core of the terrestrial ecological system (TES) and prevents a decline of its natural productivity.

As it is known. a continuous reproduction of the natural environment occurs through the mediation of energy, living matter and bio-information exchange processes. This natural

circulation takes place between the spatially local terrestrial ecological systems (the terrestrial part of biosphere where economy functions) and the external surface of biosphere. If a setback occurs in such circulation, this predetermines *a decline of natural resource flows for economy* in the long-term perspective and, in the result, essential changes in the resources' market which in the long run will lead to deformation in other markets and to the structural changes in the national market in general.

Therefore, considering economy as a subsystem of the terrestrial biosphere space, that is, as a complicated ESES, the diagram of circulation therein will have the following pattern (Fig. 3) [16]:

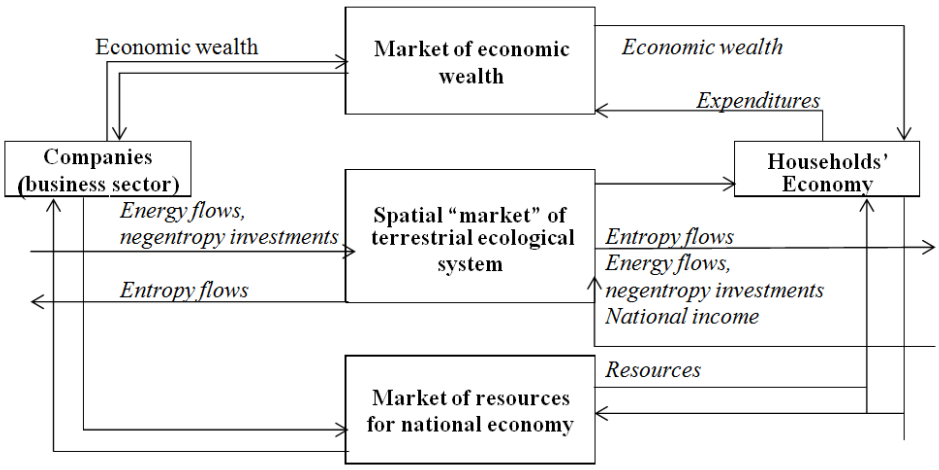

Fig. 3

As follows from Fig. 3, we transform a simplified model of closed private economy into the model of economy open to the terrestrial biosphere space. The link of the national economy with this space is realized through *the incoming flows of "investments" of negentropy*.

It follows from this diagram, that the volume of end-product of GDP of the national economy interpreted as a complicated ecosocioeconomic system depends not only on the economic and social, but on the biophysical and biogeochemical (spatial) factors.

This will mean on the macroeconomic level, that the volume of GDP produced in the national economy as in the complicated ESES is determined not only by the essentially economic components:

$$Y = C + I + G + NX \quad (2)$$

where C – consumption;
I – investments;
G – government procurement;
NX – net exports,

but by biophysical components of aggregate ecological supply of the ecosystems of all landscapes of the state territory as a complicated ESES as well:

$$Y_I = C_I + I_I - A_I \quad (3)$$

where Y_I – ESES ecological supply;

C_I – consumption of internal energy in the process of biophysical and socioeconomic work of the Earth in the ESES of the state;

I_I – negentropy investments (orderliness coming with energy of the Sun);

A_I – volume of negentropy formed in the result of biophysical and socioeconomic work in the ESES.

Thus, studies of interdependencies between the components of aggregate supply of ecological wealth and aggregate supply of economic wealth calculated on the basis of aggregation of relevant indices of meso-level ESES permit us to come to substantiation of the new macrolevel balances of spatial macroeconomics of sustainable development. However, these problems can be resolved only through modeling new physical-economic functions of economy as a complicated ecosocioeconomic system of the state.

Conclusions and prospects for further research. In summary, physical macro-economics of sustainable development expands the system of coordinates in the study of economic science of sustainable development as it takes into account physical parameters of the biosphere's terrestrial space and changes in productivity of the Earth's natural capital.

Functioning of economy within the boundaries of the global ecosystem, characterized by the limited opportunities for production of clean water and products of terrestrial photosynthesis demands to review the construction of macroeconomic models that must be based on taking into consideration the regularities of development of energy-substance exchange processes in each local territory.

Under present day conditions of reduced biological productivity of the Earth economy can not be limited to performance of production function only. The most important for it becomes performance of the new function – the function of preservation of natural capital and conversion of bioinformation that comes from the outer space to the Earth's surface into the effective work. This is why economic growth as the principal objective of the entire preceding economic life can not serve as a separate route marker to the future.

The important function of economy of sustainable development is the function of ecological supply of the Earth.

Environmental restoration function of biosphere is the prerequisite of the formation of terrestrial space for the economy. If this space will not be able to ensure the life-supporting functions of nature because of its destruction, then economy will suffer from the inflation processes through the continuous decline of the volume of resources flows coming to it. This is why it is useless to anticipate preservation of the stability of financial-economic subsystem of the world economy without ensuring *stability of biosphere*. If the volume of terrestrial production of photosynthesis declines with each coming year, it is obvious that the aggregate supply of various natural resources of the planet will decline too, particularly of such life-supporting resources as drinking water, etc.

Bearing this in mind, the present day stage of human civilization development requires a revision of some postulates of the neoclassical theory of macroeconomics and development of spatial macroeconomics of sustainable development.

The object of study of spatial macroeconomic analysis are the complicated ESES, as there is a close interdependence between the environmental (ecological) changes and economic fluctuations. It is especially important today to learn how to prevent adverse environmental changes connected with anthropogenic activity. Spatial macroeconomics

studies the models of commensurability of biophysical and value estimates on the way to the formation of sustainable development economy.

Spatial macroeconomics of sustainable development has a new added objective – preservation of stability of the exchange processes on the Earth's surface that is a spatially determined function. This function predetermines creation of the qualitatively new system of criteria for determination of macroeconomic proportions and indicators of sustainable development of the state's ESES.

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НОВІ МІЖДИСЦИПЛІНАРНІ ЗНАННЯ ДЛЯ ЕКОНОМІКИ СТАЛОГО РОЗВИТКУ

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Анотація. *Метою статті* – є обґрунтування міждисциплінарних основ якісно нового наукового напряму – фізичної (просторової) макроекономіки. Через призму новітньої фізичної економії досліджено економічні явища і процеси у тісному взаємозв'язку з енергетично-речовинними та біоінформаційними потоками, що надходять з Космосу до поверхні Землі. Зазначено, що господарська діяльність в кожній екологосоціогосподарській системі повинна здійснюватися у межах здатності локального біогеоценозу до самовідтворення. Кожна екологосоціогосподарська система (ЕСГС) є просторово детермінованою, тому її цілісність неможлива без її першооснови – територіальної цілісності. Усю сукупність природних ресурсів, а також екологічних благ охарактеризовано як акції (запаси) або потоки «корисної» реалізованої енергії Сонця, які потім втілюються в економічні блага. *Методами дослідження* - є методи системного аналізу та системного дизайну, міждисциплінарні методи, що поєднують природничі та економічні закони та закономірності. У статті зазначено, що екологосоціогосподарська система держави є відкритою не тільки до навколишнього природного середовища, але й до соціально-економічної підсистеми, яка, здійснюючи процеси природокористування, створює деякі кінцеві продукти. Залежно від режиму цього природокористування, який може весь час змінюватись, виникають флуктуації рівня негентропії в цій підсистемі, що впливає на величину вільної енергії природничої підсистеми, а отже, і на її працездатність. У термодинамічному відношенні еколого-соціогосподарські системи є відкриті (біофізичні) системи, в ядрі яких є ландшафтні системи, які в процесі функціонування проходять через велику кількість нерівно-

важних станів, що, у свою чергу, супроводжується відповідними змінами в термодинамічних параметрах їх розвитку. *Результати* – обгрунтовано метод екологічної пропозиції Землі в системі фізичного макроекономічного аналізу сталого розвитку.

Ключові слова: екологосоціогосподарська система, навколишнє природне середовище, фізична економія, природний капітал, капітал Землі, енергія, фізична макроекономіка сталого розвитку.

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