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Доц. В.П. Оліферчук; магістрантка М.В. Руда; магістрантка М.Г. Риндик – НЛТУ України

Еколого-економічний аналіз життєвого циклу надання послуги газопостачання в НЛТУ України за допомогою програмного забезпечення SimaPro

Здійснено еколого-економічний аналіз життєвого циклу надання послуг газопостачання. Встановлено рівень впливу процесу газопостачання в Національному лісотехнічному університеті України на стан навколишнього природного середовища. Визначено екологічний індекс життєвого циклу газопостачання і на його підставі зроблені висновки щодо екологічних слідів, які мають місце в даному процесі.

Ключові слова: життєвий цикл, газопостачання, програмне забезпечення SimaPro, еколого-економічний аналіз.

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TAKING INTO ACCOUNT STOCHASTIC FACTORS IN THE GLOBAL ENVIRONMENTAL ECONOMIC MATHEMATICAL MODELS

The necessity of analysis of environmental economic factors for modeling of global processes is motivated. On the basis of improvement of J. Forrester's model, feasibility of taking into account stochastic factors during mathematical modeling of such processes is proposed.

Keywords: mathematical model, environmental economics, stochastic factors, system of differential equations.

Introduction. The necessity for changing the conventional economic mentality and the need for framing a new environmentally-benign economic conception of the world were first mentioned at the Soviet-American symposium "Economic aspects of the Environmental Protection" (the city of Tsakhkadzor, October 19, 1997) in the report by Yu. Tunytsya "Environmental-and-Economic Assessment of the Production Process as a Factor of the Environmental Protection" There was substantiated the advisability of employing market approach to solving the problem of the Environmental protection and sustainable use of natural resources. The then presented problem of overcoming environmental-and-economic contradictions of the market economy by means of harmonization of interrelations between the human society and nature, has remained up till now a problem of great importance, and the study of inherent basic contradictions between merely economic and environmental requirements is an all-important task to do [5].

Pre-conditions for problem formulation. It is well-known that human environment and natural resources constitute physical basis both for economic and environmental systems. But the classic economic system considers natural resources to be the only factor that forms the raw material basis for various sectors of economy whereas the environmental economics of nature use treats this issue as a triune process of use, protection, and reproduction of integrated components of the environmental–and–economic system–the Environment and natural resources. Nature use as well as the whole process of production of material goods is accompanied not only by financial costs but also by environmental impacts: time-and-spatial alterations of the

Environmental quality as well as the quantity and quality of natural resources. These changes may be either of positive or negative character: deterioration of environmental conditions, increase or decrease in the quantity and quality of natural resources. The environmental changes can influence the economic results of material production and non-material sphere; therefore environmental costs (aggregate expenditures and losses both in the sphere of nature use and nature conservation as well as economic activity in general) need to be taken into consideration, these costs are inevitably to be growing up. Appropriate compensation costs for recovering high-quality environmental conditions should be in keeping with the intensity level of natural resources use and the Environmental pollution. The understanding and realization of this fact will make it possible to keep balance between the ecological and economic systems as well as to ensure a steady socio-economic progress of the human society; on the other hand, disregard for these facts may result in degraded quality of the Environment, natural resources depletion, needs for additional environmental costs, possible environmental losses and in the long run to the slowdown of socio-economic development if it does not cease at all [6-18]. Thus, the severity of the problem is in the fact that market economy ruins Nature while Nature destruction ruins the economy itself. The absence of the environmental component in the classic economic system can be explained by the fact that the considerable part of environmental impacts from economic activity is not subject to accurate economic assessment [1].

Mathematical model. Hence, further socio-economic advance of the society is impossible without solving the present-day environmental problems. The existing natural systems are rather resilient and robust, however, these qualities of theirs may not be long lasting. At the early stages of the society's development, effects of human activity on the Environment were insignificant and did not produce any marked changes to the Environment, but today's anthropogenic pressure is so intense that humans cannot afford to neglect (as it was before) its adverse effects. The extent of human impact on various components of the biosphere is increasing year after year, and these results in changes of vitally important parameters of the Environment. Accordingly, the construction of environmental-and-economic mathematical models of the global development of the modern world is a pressing task to do [2]. The difficulties of such modeling involve an adequate reflection of environmental and economic laws, a full set of statistics data, the resolution of the issues of allowing for functional extrapolation and other similar problems [3].

One of the first attempts of such economic-and-environmental modeling was Forrester model [7] that contains five time-variable parameters: P – Earth's population size, V – productive capital (capital assets), S – share of agricultural capital in the total productive capital, R – non-renewable natural resources, Z – environmental pollution. These parameters determine 20 specific functions that describe the interaction of the most important economic-and environmental factors of the society's development.

1) Change in the population size. Reflects the balance between birth-rate B and death-rate (with consideration for the main demographic characteristics)

$$\frac{dP}{dt} = B - D = f_1(B, D). \tag{1}$$

2) Differential equation for a decrease in non-renewable natural resources

$$\frac{dR}{dt} = -PR_M = f_2(P,V,S,M_S,E_R). \tag{2}$$

It is believed that natural resources are depleted at the rate which is proportional to population size growth and to a certain factor R_M that takes into account the slowdown of resources extraction rates with a rise of living standards' M_S. This dependence is related to natural resources use, namely for manufacturing consumer goods the demand for which is asymptotically approaching saturation as the population's standard of living M_S rises. In its turn, Ms is expressed through the parameters P, V, S and the function $E_R(R_R)$ which reflects the increase in the cost of mineral resources extraction as their supplies decrease.

3) The dynamics of capital investment is described by the equation

$$\frac{dV}{dt} = PC_V V_M(M_S) - \frac{V}{T_V} = f_3(P,M_S,C_V,T_V). \tag{3}$$

The function $V_M(M_S)$ describes the growth of the population's financial resources investments into production as a result of rising living standards M_S; constants C_V and T_V are the coefficients identified on the basis of study of investment processes and the processes of capital consumption (depreciation).

4) The dynamics of agricultural capital

$$\frac{dS}{dt} = \frac{S_F S_Q - S}{T_S} = f_4(S_F,F_R,S_Q,Z,T_S) \tag{4}$$

is described by the functions: S_F – impact of nourishment level F_R on the amount of agricultural capital; T_S – the length of time required for reallocation of capital; S_Q – relationship between agricultural capital and quality of life. In its turn, the quality of life is determined by the living standards M_S, the amount of food stuff per capita, population density, and the environmental pollution level *Z*.

5) The dynamics of population is modeled by the equation

$$\frac{dZ}{dt} = PZ_N Z_V - \frac{Z}{T_Z} = f_5(P,Z_N,V_R,T_Z). \tag{5}$$

The first item describes generation of pollution and is proportional to the population size *P*, constant Z_N which refers to normal pollution level, and the function $Z_V(V_R)$ – the rate of the environmental pollution with an increase of marginal capital. The second item characterizes the process of natural decomposition of pollutants T_Z, and identifies the length of time required for an n-fold decrease of the pollution index providing no fresh portion of pollutants is added.

Consideration for stochasticity in mathematical modeling. Since time change in the major portion of parameters that appear in the differential equations (1)-(5), is of random character, this mathematical model can be improved. Enter the stochastic coefficients γ_i, that express the probability for corresponding phenomena (processes) to appear. In so doing we assume that $0 \le \gamma_i \le 1$, $(i = \overline{1,5})$. The boundary value $\gamma_i=0$ corresponds to the unfeasibility of the process while $\gamma_i=1$ – shows the certainty of its occurrence. The relations so modified produce a system of differential equations, which is the stochastic model of global development ……

$$\ldots \begin{cases} \frac{dP}{dt} = \gamma_1 f_1(B,D) \\ \frac{dR}{dt} = \gamma_2 f_2(P,V,S,M_S,E_R) \\ \frac{dV}{dt} = \gamma_3 f_3(P,M_S,C_V,T_V) \\ \frac{dS}{dt} = \gamma_4 f_4(S_F,F_R,S_Q,Z,T_S) \\ \frac{dZ}{dt} = \gamma_5 f_5(P,Z_N,V_R,T_Z) \end{cases} \ldots\ldots \tag{6}$$

Changes in Forrester function's behavior at different values of stochastic coefficients are presented in Fig. 1.

The data to determine functional relations between the system's parameters are averaged data of the world's statistics. For boundary values $\gamma_i = 1, \left(i = \overline{1,5}\right)$ we obtain (Fig. 2) the analog of Forrester model curves [7]. All the curves have well-defined peaks (the living standards curve approximately in 1960, the population size curve – in 2020, capital investments – in 2040, the environmental pollution level – 2050).

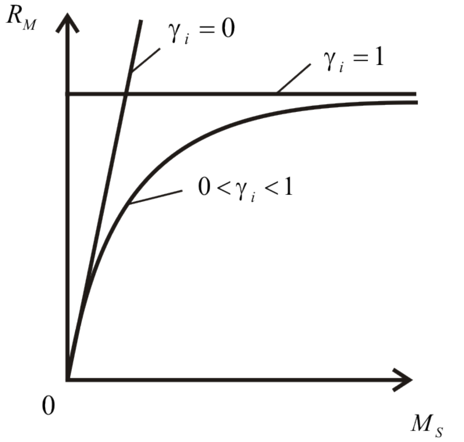

Fig. 1. Forrester function with consideration for stochasticity

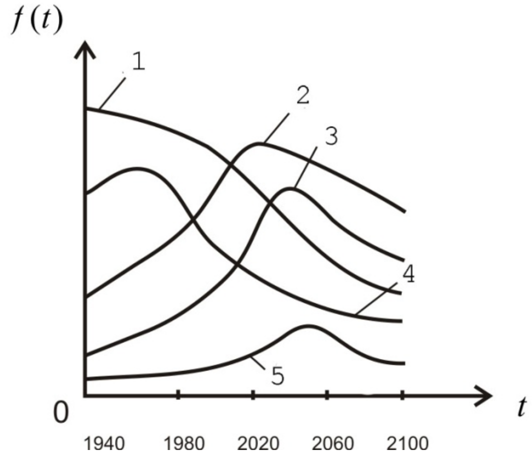

Fig. 2. Predicted trends of the world's development *(1 – natural resources, 2 – population, 3 – capital investments, 4 – living standards level, 5 – pollution level)*

Conclusions. The decrease in the amount of natural resources supplies causes industrial decline: an increase in the cost of raw materials, due to the depletion of their supplies, slows down the growth of capital investments and results in contraction of production. This has an effect on the living standards level, the impairment of which first leads to slower rates of its growth, and later on to a decrease in the population size. Thus, the society with market economy is facing the necessity of changing its mode of life and to adapt itself to the reproductive capacity of natural ecosystems. Important though the economic goals may seem, they are leveled by environmental problems. The contemporary society for the sake of its health and life must have a new goal – environmental standard with economic restrictions [4].

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Урахування стохастичності в глобальних еколого-економічних математичних моделях

Проаналізовано передумови врахування еколого-економічних суперечностей при математичному моделюванні глобальних процесів. З'ясовано потребу в прогнозуванні впливу екологічного ефекту на економічні результати матеріального виробництва і невиробничої сфери. Оскільки закони зміни функцій, що відображають взаємозв'язок найважливіших економіко-екологічних чинників розвитку суспільства, мають випадковий характер, запропоновано враховувати фактор стохастичності при математичному моделюванні таких процесів. На основі моделі Дж. Форрестера введено у відповідні диференціальні рівняння деякі стохастичні коефіцієнти, які характеризують імовірності проходження певних процесів та явищ. Модифіковані таким чином співвідношення утворюють систему лінійних диференціальних рівнянь першого порядку, яку запропоновано вважати стохастичною моделлю глобального розвитку. В часткових випадках при граничних значеннях стохастичних коефіцієнтів отримано аналог кривих моделі Дж. Форрестера. Зроблено висновки щодо прогнозованих тенденцій розвитку світу, наведено відповідні графіки.

Ключові слова: математична модель, екологічна економіка, стохастичні фактори, система диференціальних рівнянь.

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THE ASSESSMENT OF PROSPECTIVE APPLICATION OF MODERN LOGGING TECHNOLOGIES AND MACHINERY, BASED ON THE TECHNIQUES OF CALCULATING OPERATING COSTS

Successful development of Ukraine's forest sector is intimately associated with the improvement of logging operations efficiency. The current logging technologies and machinery, however, cannot be taken as being satisfactory in the field. The world's modern practice is ever increasing focus on the short-log method of logging which has a number of advantages. The proposed methodological approach to calculating operational costs when using promissing logging techniques and machinery in the short-log method, may find wide use under conditions of Ukrainian forest management units.

Keywords: technological process, machinery, operating costs, calculation, production efficiency.