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EVALUATION OF INVESTMENT AND INNOVATIVE DEVELOPMENT OF UKRAINIAN ECONOMY: EVOLUTIONAL APPROACH

The development of industry in Ukraine depends on effective government regulation. It manifests itself in the creation of conditions for sustainable economic growth based on investment and innovation, and the tax system that convenient for taxpayers. However, in modern conditions Ukraine occupies one of the last positions among the emerging market economies by purchasing power party gross domestic product (GDP) per capita [23]. There are reduced total investments in the economy, the share of the costs of implementing the scientific and technological work in the total GDP etc. [21].

One of the sets of regulatory instruments of socio-economic development, which is actively used by different countries of Organization for Economic Co-operation and Development (OECD) and major emerging national economies of Brazil, Russia, India, China and South Africa (BRICS), are tools of tax policy[18; 26; 27].

Problems of socio-economic development using the methods of tax policy need to be addressed in Ukraine. And in order to tax regulation has become more predictable in the domestic institutional environment, the economic and mathematical instruments, which allow substantiating the use of some tax measures in the long term, are used.

In economic thought of developed countries the impact of tax policy on the rate of GDP growth is often studied from the standpoint of the neoclassical approach by assessing the factors of production – capital and labor – in the process of taxation (K. Judd [1], J. Corsetti, N. Roubini [2], Ch. Chamley [3]).

Accordance to the views of the tax neoclassic the incentives of investment and innovation development of industrial enterprises should be considered in an evolutionary approach. It reflects the change in the behavior of economic agents in the conditions of the government policyand used as in Western economic thought (S. Bowles [4], R. Nelson, S. Winter [5], J. Hodgson [6]), and representatives of the Russian and Ukrainian economic schools (B. Maevskiy [7], V. Makarov [8], O. Suharev [9], V. Vishnevskiy [10]). This methodology may be useful from the standpoint of research tools of tax policy to stimulate investment and innovation activities of industrial enterprises in Ukraine.However, the use of the evolutionary approach for the analysis of tax instruments in the promotion of investment and innovation has not received sufficient development [24].

The objective of this study is to provide an improved evolutionary model, which is based on agent-oriented approach and describes the inertial scenario of the investment and innovation development of Ukrainian economy.

To estimate the tax incentive investment and innovative development of the industry it is proposed to investigate the socio-economic system, which consists of the components of the innovation economy, that interacting through causal relationships (Fig. 1). It is assumed that such components are

(1) the government, namely: tax sector, through which the governmentforms tax politics; budget sector, through which the government allocates public goods;

(2) economic agents as business entities;

(3) R&D sector, where research institutions form knowledge and provide the creation of an innovative product;

(4) households as a set of individuals.

Nominated on the basis of assumptions, an evolutionary model of tax incentives for investment and innovation enterprise development of industry is developed. Its formal description is based on

determining the form of the production function of economic agents, the value of which depends on the growth rate of the economy;

imposingof restrictions, which relate to the behavior factor of selected subjects;

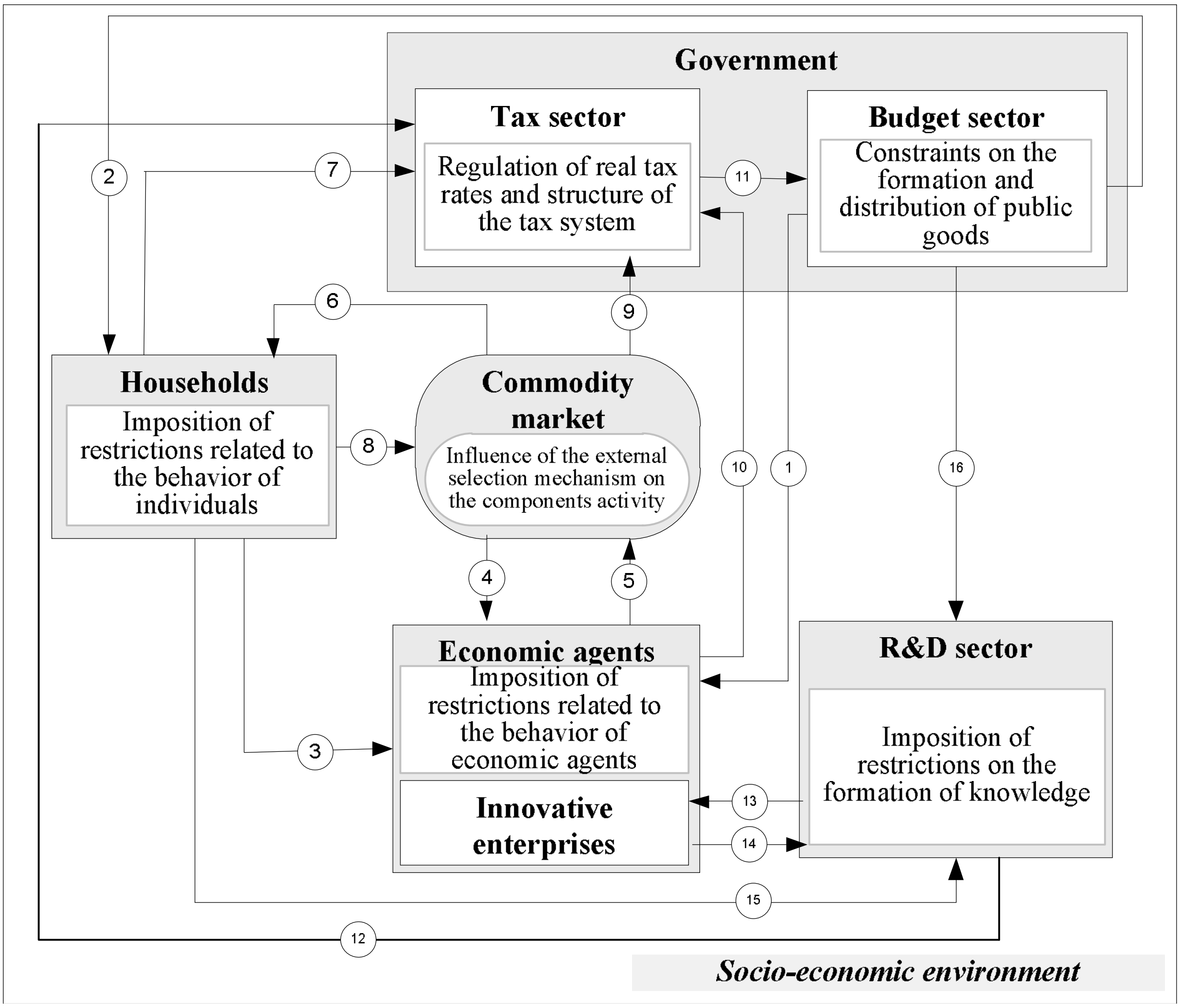


Fig. 1. Causal diagram of the innovation economy

imposing of restrictions on the budget and tax sectors of socio-economic system;

introduction of prerequisites and restrictions on the operation of socio-economic components of the system.

All agents (*I*) in the socio-economic environment are divided into categories [11, p. 215-234]:

producers of knowledge (*S*)–R&D sector;

transporters of knowledge (*Z*) – innovation-active agents (innovative industrial enterprises) that are actively implement innovations that are developed by R&D sector;

consumers of knowledge (*C*) – enterprises that can adopt approaches to improving the efficiency of its own production in innovative companies. Innovations of transporters of knowledge contribute to the quality of technology or routines.

So each agent i, $i \in I$ refers to one of the categories: $s \in S$, $z \in Z$ and $c \in C$. Agents of any category appear randomly and can use the material resources (stream 4, Fig. 1), which are consumed in the market for goods and services with the aim of production. Manufactured products are sold on the market (stream 5, Fig. 1).

However, goals of economic agents are different.

The objective of the innovative enterprises is production and dissemination of knowledge among consumers. According to the performing research [12, 13, p. 21] the economic activity of these agents is described by the Constant elasticity of substitution production function (CES-function) of the form

$$Y_{t+1}^{z}=\xi^{*}\cdot\left[\left(E_0^{K^Z}\cdot\exp\{\eta^{K^Z}\}\cdot K_{t+1}^{Z}\right)^{\frac{\sigma-1}{\sigma}}+\left(E_0^{L^Z}\cdot\exp\{\eta^{L^Z}\}\cdot L_{t+1}^{Z}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}+\varepsilon^{*}, \quad (1)$$

where Y_{t+1}^{z} – the final product of innovative enterprises; ξ*– parameter of neutral efficiency of technologies; $E_0^{K^Z}$ –the initial level of capital efficiency of innovative enterprises; η^{K^Z} – technical progress due to the capital factor of innovative enterprises; K_{t+1}^{Z} – physical capital of innovative enterprises at time t+1; σ – elasticity of substitution between production factors of innovative enterprises; $E_0^{L^Z}$ – the initial level of efficiency of innovative enterprises labor; η^{L^Z} – technical progress due to the labor factor of innovative enterprises; L_{t+1}^{Z} – labor as a payroll on innovative enterprises at time t+1; ε*– random errors of observation, that can take place under the influence of different factors of socio-economic environment.

The objective of the consumer enterprises is the production as a result of consumption as much as potential technology. Their economic activities described by CES- function, the form of which is similar to the production function of innovative enterprises:

$$Y_{t+1}^{C}=\xi\cdot\left[\left(E_0^{K^C}\cdot\exp\{\eta^{K^C}\cdot t\}\cdot K_{t+1}^{C}\right)^{\frac{\sigma-1}{\sigma}}+\left(E_0^{L^C}\cdot\exp\{\eta^{L^C}\cdot t\}\cdot L_{t+1}^{C}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}+\varepsilon, \quad (2)$$

where Y_{t+1}^{c} – the production of finished goods company-consumers of knowledge; ξ– parameter of neutral efficiency of technologies; $E_0^{K^C}$ – the initial level of efficiency of capital companies; η^{K^C} – technical progress due to the capital factor of enterprises; K_{t+1}^{c} – physical capital agents consumer knowledge at time t+1; σ– elasticity of substitution between production factors of enterprises; $E_0^{L^C}$ – the initial level of labor efficiency of enterprises; η^{L^C} – technical progress due to the labor factor of enterprises; L_{t+1}^{c} – labor used by agents as knowledge consumer; ε – random observation errors, which may occur under the influence of various factors of internal and external environment.

The total production of finished goods of industrial enterprises amounts to

$$Y_{t+1}=Y_{t+1}^{z}+Y_{t+1}^{c}. \quad (3)$$

Capital factor of innovative enterprises included in their production function. It value accounts as the cash flows that come from the use of the acquired knowledge, and is determined by a combination of non-current assets and working capital of innovative enterprises as well as costs for future periods:

$$K_{t+1}^{Z}=M_{t+1}^{Z}+\lambda R_t^{Z}+(\beta^{*}F_{t+1}^{K^Z}+I_{t+1}^{K^Z})\cdot\frac{k_{t+1}^{Z}}{N^{Z}}, \quad (4)$$

where M_{t+1}^{Z} – non-current assets of innovative enterprises at time t+1; λ– share of profits invested in production, 0 ≤ λ ≤ 1; R_t^{Z} – profit of innovative enterprises after taxation at time t; β*– coefficient of effective distribution of funds between R&D sector, industrial and social systems, 0 ≤ β* ≤ 1; $F_{t+1}^{K^Z}$ – public investment in capital of innovative enterprises at time t+1; $I_{t+1}^{K^Z}$ – investments in innovative enterprises from other funding sources at time t+1; k_{t+1}^{Z} – the number of innovative enterprises that consume knowledge and use them as innovations at time t+1; N^Z – the total number of innovative enterprises.

It is assumed that $M_{t+1}^{Z}=K_t^{Z}$.

Sum of innovative enterprises profit prior-taxation can be represented as

$$X_t^{Z}=\psi^{*}\cdot\Psi_0^{*}\cdot\ln K_t^{Z},$$

where X_t^{Z} – profit of enterprises as knowledge transporters prior taxation at the moment of time t; ψ*– part of the capital, directed at the economic activity of innovative enterprises asknowledge transporters in order to create profit; Ψ_0^{*} – approximation parameter, $\Psi_0^{*}>0$.

Sum of profit of innovative enterprises after taxation can be represented as

$$R_t^{Z}=X_t^{Z}-T_t^{K^Z},$$

where $T_t^{K^Z}$ – the corporate income tax of innovative enterprises at time *t*.

Capital factor of consumers of knowledge is part of their production function, taking into account the cash flow that comes from the use of innovation as technology in the economic activity. The sum of its capital is defined similarly to calculations of capital for innovative enterprises, namely as a set of negotiable and non-negotiable funds of enterprises and costs for future periods.

In general the capital factor, that means net book value of fixed assets (machinery and equipment) of enterprises,is expressed as

$$K_{t+1} = K_{t+1}^Z + K_{t+1}^C. \quad (5)$$

Innovative enterprises interact with the R&D sector (streams 13-14, Fig. 1) to maintain competitiveness in the market of goods and services through the introduction of an innovative product, that are developed by the R&D sector. Therefore the aim of the R&D sector is to produce as much as possible knowledge and pass it to innovative enterprises.

The probability of new knowledge occurrence is given by logistic function as

$$P_t = P_{\min} + \frac{(P_{\max} - P_{\min})}{1 + \exp\left[a_1 - a_2 \dfrac{F_t^{K^S} + (1-\lambda^Z)R_t^Z + (1-\lambda^C)R_t^C}{F_t^{K^S} + R_t^Z + R_t^C}\right]},$$

where P_t – the probability of occurrence of new knowledge at time *t*; P_{min} – the minimum probability of new knowledge occurrence; P_{max} – maximum probability of new knowledge occurrence; $F_t^{K^S}$ – public investment in the activities of R&D sector at time *t*; R_t^Z – profit of innovative enterprises after taxation at time *t*; R_t^C – profit of knowledge consumers after taxation at time *t*; λ – share of prof its, that is invested in production, $0 \le \lambda \le 1$;a_1, a_2– parameters.

For the first time such type of function was used by P.F. Verhulstin the modeling of the population dynamics. In modern economic theory the logistic function is used in foreign and domestic researches (by R.M. Nizhegorodtsev [14] for the analysis of technological structures; by G.Y. Silkina [15] for the simulation of the propagation of innovations).

All agents are equal bearers of knowledge, and all kinds of knowledge are equivalent in the sense that the consumption of knowledge is 1.

Innovation isgenerated from knowledge. Knowledge as innovation is transmitted to innovative enterprises. Since not all knowledge can be transformed into innovations, then there is their complete forgetfullness. The probability of occurrence of knowledge innovation is subject to an exponential distribution.

Households form labor resources used by economic agents (stream 3, Fig. 1) and used in the R&D sector (stream 15, Fig. 1).

There are relations for each category of agents, that shown in Table.

Table

Calculation of the employed population

Factor	Designation	Category (*X*)		
		R&D sector (*S*)	Innovative enterprises (*Z*)	Consumer enterprises (*C*)
Labor as a payroll on enterprises	*L*	$L_{t+1}^S = H_{t+1}^S \cdot w_{t+1}^S$	$L_{t+1}^Z = H_{t+1}^Z \cdot w_{t+1}^Z$	$L_{t+1}^C = H_{t+1}^C \cdot w_{t+1}^C$
The economically active population of working age	*H*	$H_{t+1}^S = H_t^S \cdot \Omega_t$,	$H_{t+1}^Z = H_t^Z \cdot \Omega_t$,	$H_{t+1}^C = H_t^C \cdot \Omega_t$,
The current value of wages	*w*	$w_{t+1}^S = w_t \cdot \Delta w_t^S$	$w_{t+1}^Z = w_t \cdot \Delta w_t^Z$	$w_{t+1}^C = w_t \cdot \Delta w_t^C$

Designations: H_{t+1}^S– economically active population of working age from the category of producers of knowledge at time *t*+1; H_t^S – an economically active population of working age from the category of knowledge producers at time t; L_{t+1}^{S} – labor of knowledge producers at time t+1; w_{t+1}^{S} – the current value of wage of knowledge producers at time t+1; H_{t+1}^{Z} – an economically active population of working age from the category of innovative enterprises at time t+1; H_{t}^{Z} – an economically active population of working age from the category of innovative enterprises at time t; w_{t+1}^{Z} – the current value of innovative enterprises wages at time t+1; H_{t+1}^{C} –economically active population of working age from the category of consumers enterprises at time t+1; H_{t}^{C} –economically active population of working age from the category of consumers enterprises at time t; w_{t+1}^{C} – the current value of consumer wages at time t+1; Δw_{t}^{S} – changes in wages of producers of knowledge at time t; Δw_{t}^{Z} – changes in wages of innovative enterprises at time t; Δw_{t}^{C} – changes in wages of knowledge consumers at time t.

The overall size of the economically active population of working age is

$$H_{t+1} = H_{t+1}^{S} + H_{t+1}^{Z} + H_{t+1}^{C}. \quad (6)$$

Labor factor, expressed payroll, generally defined as

$$L_{t+1} = L_{t+1}^{S} + L_{t+1}^{Z} + L_{t+1}^{C}. \quad (7)$$

Taxes on household's labor (stream 7, Fig. 1), consumption (stream 9, Fig. 1) and the incomes of economic agents (stream 10) and R&D sector (stream 12, Fig.1)comes in the tax sector,where is implemented state fiscal policy.

Function of total tax revenue in the budget is

$$T_{t+1}^{G} = \Sigma T_{t+1}^{K} + \Sigma T_{t+1}^{L} + \Sigma T_{t+1}^{V}, \quad (8)$$

where T_{t+1}^{G} – the total tax payments to the budget at time t+1; ΣT_{t+1}^{K} – income tax at time t+1; ΣT_{t+1}^{L} – tax on personal income and payroll chargesat time t+1; ΣT_{t+1}^{V} – consumption tax at time t+1.

Enterprise income tax of enterprises is defined by

$$\Sigma T_{t+1}^{K} = \tau^{K} \cdot X_{t+1} \ , \quad (9)$$

where τ^{K} – the income tax rate.

Tax on labor is defined by

$$\Sigma T_{t+1}^{L} = \tau^{L} \cdot L_{t+1} \ , \quad (10)$$

where τ^{L} – the effective tax rate on personal income and accrued payroll.

Calculation of consumption tax as value added tax (VAT) is done by the formula

$$\Sigma T_{t+1}^{V} = \tau^{V} \cdot V_{t+1} \ , \quad (11)$$

where τ^{V} – value-added tax rate; V_{t+1} – total consumption of gross output at time t+1.

According to the performing research[16, p. 116] consumption of the gross output means the value of goods that sold to consumers for a certain period of time t+1, and is calculated as a percentage of GDP:

$$V_{t+1} = \varphi \cdot Y_{t+1},$$

where φ – the share of consumption in GDP.

In this case consumers are the agents of both production and social spheres.

The calculation of the tax indicators is performed according to the initial condition $\tau^{K} \cup \tau^{L} \cup \tau^{V} \subseteq \tau$, where τ is the total tax rate, $\tau \in (0;1]$.

Formed government revenues (stream 11, Fig. 1) are redistributed through the budget sector to economic agents (stream 1, Fig. 1), households (stream 2, Fig. 1) and in the R&D sector (stream 16, Fig.1) in the form of public goods.

Public investment (F_{t+1}) depends on the tax revenues to the budget and satisfies the relation

$$F_{t+1} \le T_{t}^{G} \ .$$

Then

$$F_{t+1} = F_{t+1}^{K} + F_{t+1}^{H}, \quad (12)$$
$$F_{t+1}^{K} = \theta_{K} \cdot T_{t}^{G},$$
$$F_{t+1}^{H} = \theta_{H} \cdot T_{t}^{G},$$

where θ_K – the share of money that the government invests at the development of the activities of the research institutions and enterprises; θ_H – the share of money that the government invests in human capital; $\theta_K + \theta_H \le 1$, $\theta_K, \theta_H > 0$.

Value θ_K is defined as the ratio of public expenditures for financing of economic activities to the total value of budget revenues, multiplied by the share of taxes in total revenues.

Value θ_H is defined as the ratio of public expenditures on financing of social activities by total budget revenues, multiplied by the share of taxes in total revenues.

Further public investment in capital allocated to spheres:

$$F_{t+1}^{K} = F_{t+1}^{K^S} + F_{t+1}^{K^Z} + F_{t+1}^{K^C} =$$
$$= \theta_K^S \cdot T_t^G + \theta_K^Z \cdot T_t^G + \theta_K^C \cdot T_t^G,$$

where θ_K^S – the share of money that the government investsat the development of the R&D activities; θ_K^Z – the share of money that the government investsat the development of innovative enterprises; θ_K^C – the share of money that the government aims at development activities of enterprises-consumers of knowledge, $0 < \theta_K^S + \theta_K^Z + \theta_K^C \le 1$.

Households spend part of their income (stream 8, Fig. 1) on consumption of goods and services (stream 6, Fig. 1), as well as direct part of the savings in the form of investment in the manufacturing sector (stream 3, Fig. 1).

The value of capital investments is expressed as a sum of money, which remains at the disposal of households after consumption:

$$I_{t+1}^{K} = \left(1 - \Delta I^H\right) \cdot I_{t+1}^{H}, \qquad (13)$$

where ΔI^H – the share of funds thatby households are invested in human capital.

The coefficient ΔI^H is determined for all agents as the average value of the share of total household expenditures in the overall structure of their costs.

Then for each category of agents such relations are valid:

$$I_{t+1}^{K^S} = \left(1 - \Delta I^H\right) \cdot I_{t+1}^{H^S},$$
$$I_{t+1}^{K^Z} = \left(1 - \Delta I^H\right) \cdot I_{t+1}^{H^Z},$$
$$I_{t+1}^{K^C} = \left(1 - \Delta I^H\right) \cdot I_{t+1}^{H^C},$$

where $I_{t+1}^{K^S}$ –private investments in the physical capital of R&D sector at time *t*+1; $I_{t+1}^{K^Z}$ –private investments in the physical capital of innovative enterprises at time *t*+1; $I_{t+1}^{K^C}$ – private investments in the physical capital of other enterprises at time *t*+1.

Value of private investmentsin the human capital is defined as

$$I_{t+1}^{H} = \Delta I^H \cdot L_{t+1}. \qquad (14)$$

It is assumed that the government can use a variety of techniques that promote the growth of investment in research and innovation. Such methods of tax incentives for innovation are

regulation of the volume and structure of innovation cost;

stimulationthe intensity of public and private partnership bonds [18, p. 160].

In addition, the tax sector affects the components of the simulated economic system indirectly by the application of the regulatory framework for all business entities.

The result of functioning of components of the innovation economy is a quantitative assessment of factors of economic growth that determine itsrate in terms of agents' behavior change in the socio-economic environment.

The mechanisms of formation of agents' behavior are evolutionary characteristics such as:

selection namely
internal selection of information;
external selection of agents;
variability namely
changing of agent's behavior;
changing of decision-making rules;
heredity namely
fixing of agents' behavior;
fixing of decision rules.

They have an impact on the each component's behavior in the socio-economic environment. Thus the economy is growing (or evolves) in a fast changing environment [17, p. 8].

External and internal selection is carried out according to the mechanism of selection. The influence of such mechanism is demonstrated in the ability of the selecting object to continue activities in the changed circumstances, when not adapted (i.e. uncompetitive ones) objects disappear and adapted objects survive [5].

Agents of the external selection are interactors:

producers of the knowledge (R&D sector);

transporters of the knowledge (innovative enterprises);

consumers of the knowledge (enterprises of different types of economic activity).

Objects of the selection are limited in their ability to consume some resources (material, financial, information etc.) from the surrounding external environment. However, their number can be increased by use of some information, that is useful for survival.

Internal selection objects are replicators:

ideas and knowledge at the level of the R&D sector,

innovative product, that can be developed and implemented in the process of production, at the level of innovative enterprises;

technology or routine at the level of other enterprises.

It is assumed that the knowledge and ideas appear randomly and can be used within a certain interval of time. At the level ofinnovative enterprises if knowledge is consumed it can go to the category of innovative product. If innovative product is used successfully, it can be passed as routine to other economic agents for use in their business.

The emergence of any new such replicators is possible at the level of each component of the socio-economic system. A set of them reflects the information content of components of the system, i.e. the standard models, procedures and activities.

The mechanism of variability is manifested in the established patterns of behavior and decision rules making at all levels of socio-economic system in such a way. There is a set of agents engaged in similar activities. Each of them has replicators, which generally may be the same, but there may be variations in their individual characteristics. So the economic activity of agent is not absolute replication of each other. In the case of changes in environmental conditions effect of the variability allows some of them to survive.

Evolutionary changes in the economic activity of agents is determined and conditioned by the evolution of factors of external and internal environment. Therefore the main sources of variability can be [19, p. 97]:

internal changes that may occur through specific and random "mutation" replicators (including through innovation and R&D, dissemination of best technologies);

external changes that lead to changes of (1) technologies through information exchange ("crossover" routines) with other agents (as a result of changing of suppliers, type of economic activity, a market segmentetc.), (2) management (patents, licenses, consulting recommendations, hiring of qualified staff), (3) the legislative framework.

The mechanism of heredity (or reproduction) generates an optimal variant of decisions and manifests itself in maintaining of rules and behavior norms. It allows to components of the socio-economic system to implement their economic activity effectively. It facilitates the transfer (copying) of the key characteristics and is one of the basic values, which manifests itself in the fact that basis, as well as replicators of the respective components of the socio-economic system, is survived through the process of reproduction of the information.

These mechanisms influence on the behavior of agents of socio-economic environment.

The activityof R&D sector consists of the production of a new knowledge and its transmission. Graphically this behavior is shown on Fig. 2.

Knowledge transfer can occur from the agent of R&D sector to the innovative enterprise. So knowledge is transformed into innovation. Innovation at the level of innovative enterprises is converted into a routine and routines can be transmitted to other enterprises. Graphically this behavior is shown on Fig. 3.

Enterprises-consumers of knowledge accumulate technologies as routines. Graphically this behavior is described on Fig. 4.

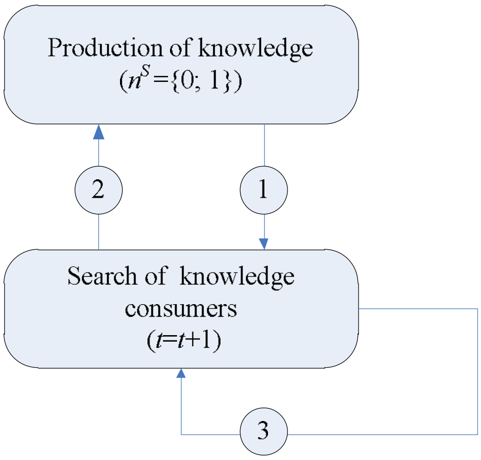
Time of emergence of evolutionary characteristics in the system is determined by the changes in the socio-economic system under the influence of internal and external factors. So it's assumed that it is a probabilistic value.

The evolutionary model of tax incentives for investment and innovation development of industrial enterprises is represented by basic formulas (1)-(14).

Thus the scientific interest is to study changes in the behavior of economic agents in the field of investments and innovations taking into account the tax policy.

Implementation of the model is made in the program Any Logic 6 with additional calculations in MS Office Excel 2007.

Primary data for the implementation of the model is the statistical information about Ukraine.



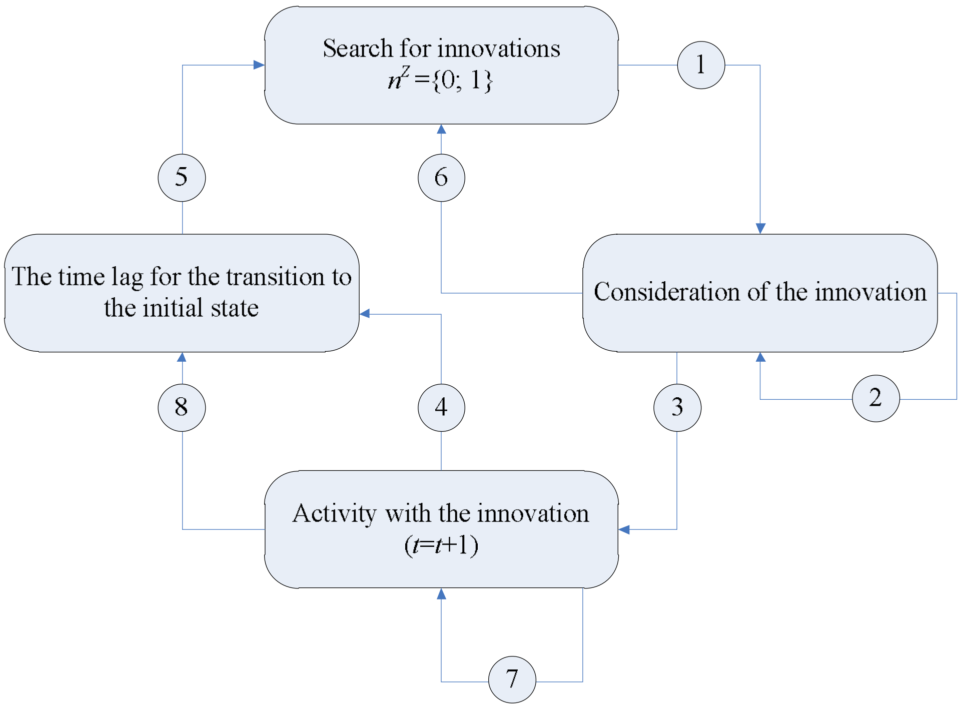
Designations:

1. Move to a state, in which the agent of R&D sector have a new knowledge for transfer tothe innovative enterprise. Such a transition occurs with a probability that depends on the amount of knowledge of scientific institutions. In turn the amount of knowledge depends on public financing ofR&D sector.

2. Go to the initial state. This transition occurs eitherwith the transfer of knowledge or after 12 months as a result of the forgetting process.

3. Time counter that define the deadline of forgetting of existing knowledge.

Fig. 2. The behavior of R&D sector



Designations:

1. Move to a state in which the innovative enterprise considers a knowledge of R&D sector. The transition occurs in a case when there is knowledge for transmission.

2. Selection: transition in which it is determined whether innovative enterprises takes knowledge or not. It's occurs with a certain probability, and other enterprises have a chance to pick up the available knowledge.

3. Variability: transition to a state in which an innovative enterprises works with existing knowledge. In this case, the knowledge transforms into the category of innovation.

4. Go to a state of inactivity. It's occurring in the case of obsolescence of the innovation through 18 months after its occurrence.

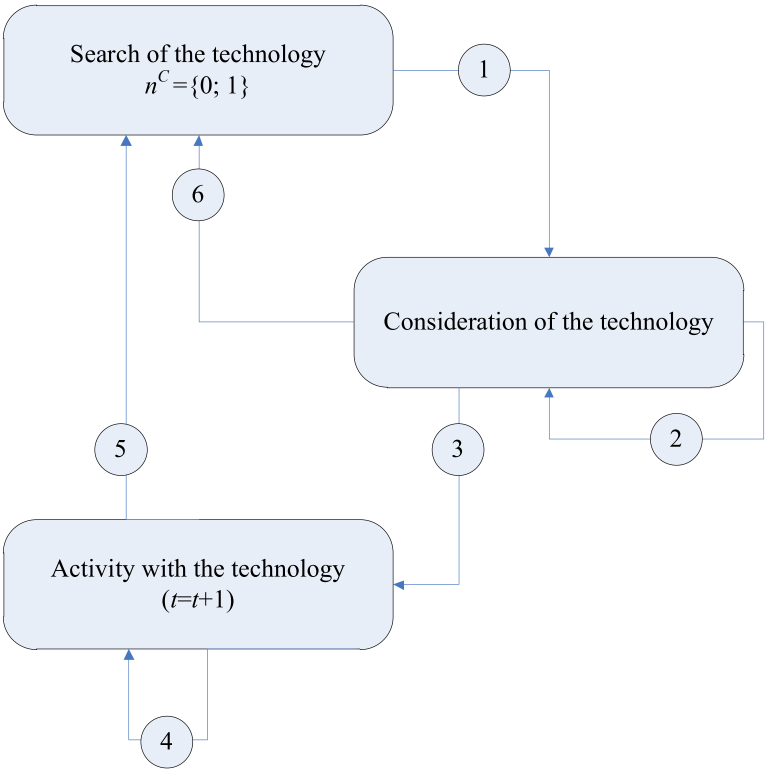
5. Go to the initial state. The transition occurs after 6 months. This term needs of innovative enterprises to implement of the innovation.

6. Go to the initial state. Thetransition occurs on a monthly basis and is required in order to check availability of knowledge in R&Dsector.

7. Time counterthat define the term of forgetting innovation.

8. Heredity: transition to a state of inactivity. The transition occurs when the innovation transforms in the technology.

Fig. 3. The behavior of the innovative enterprise



Designations:

1. Transition to a condition, in which an industrial enterprise considers available technology. Transition occurs in the case when there is an innovation for its transferas a technology.

2. Selection: transition, when an enterprise takes the technology itself or not. There is a chance to pick up available technology for other enterprises.

3. Variability: transition when an enterprise has been working with new technology.

4. Heredity: transition at which the technology can be transferred to other industrial enterprises.

5. Go to the initial state. The transition occurs when enterprise receives new technology.

6. Go to the initial state. The transition occurs on a monthly basis and is required in order to check innovations availability that can be used in the form of technologies.

Fig. 4. The behavior of the industrial enterprise

This approach is explaining how the behavior of agents has changed with time. Calculation results are presented in discrete time. Simulation period is 20 years. A program step is 1 year.

The behavior of each agent is influenced by such factors:

signals about the exchange of replicators at a meeting with agents from the same population;

signals about the exchange of replicators at a meeting with agents from other populations;

current replicators characterizing internal state of the agent;

changes in the state of agent's replicators.

At the beginning of each simulation there is given a certain number of interacting agents whose behavior changes for the specified model periods. These changes are associated with each of components replicators in the socio-economic environment.

The purpose of the experiment is to investigate the behavior of agents in a changing set of corresponding groups of replicators. So it is necessary to verify the proposed evolutionary model for accurate and adequate description of the real socio-economic processes and phenomena, and to identify trends in the development of Ukraine's economy in the long term in modern conditions.

Implementation of the model in real conditions allows comparing estimates and statisticaldata obtained over the same time interval in order to determine its accuracy.

The initial data are the indicators of the Ukrainian economy in constant prices in 2011 [20-21]. Tax rates vary according to the tax laws [22]. The share of state funding of public goods is taken at the level in 2005-2012.

The model is implemented in the base conditions to check its accuracy and reliability. Base data (2005-2012) are compared with data obtained with the help of the model at similar period of time. The correlation coefficient (Pearson) R and quadratic correlation coefficient R^2 are used to compare the original data with the statistics. Values of such coefficients for the social indicators are 96.46% and 93.04% respectively. Values of such coefficients for the economic indicators are 88.67% and 78.63% respectively, taking into account the smoothing of time series. In general the relative error of approximation is less than 15%, which indicates a strong correlation of statistical and calculated data, and confirms the hypothesis of whether to use this model in the given conditions.

Implementation of the model for the given conditions of simple reproduction reflects its correctness in the long term: the volume of production of industrial enterprises, including innovative enterprises, increased marginally: by an average of 0.018% per year, or by 0.334% at the entire simulation period. Capital value of industrial enterprises is constant 931.52 blnUAH at each stage of calculating. In general, the employed population of working age is reduced by an average of 89.5 thousand people per year or 1.7 mln people for the entire period. Such dynamics are caused by the insufficiency of public investment in human capital. As a result the labor supply is reduced; population,which starts to work,is declined; and the rate of people's retirement isincreased. In general, the reduction in tax revenues is observed at the level of 1.38% per year, or 24.11% at the end of the period (from 271.86 mlnUAHin 2006 to 206.29 mln UAH in 2025).

In view of the values of accuracy and reliability, as well as economic development trends of simple reproduction the proposed approach is used for further study of behavior change of agents in the real socio-economic conditions in Ukraine.

Output of new knowledge of R&D institutions, that will be used by industry in the form of innovation, increased by an average of 0.86% per annum or 0.76% in 2025 compared to 2005 due to reduction of the employed population in R&D sector (with 105.5 thousand in 2005 to 56.5 thousand in 2025) and reduction of the chances of creating new knowledge.

The total output of industrial enterprises in Ukraine, including innovative enterprises, is increased on average by 3.29% per year due to reduction economically active population, a slight increase of capital and industrial wages.

Total tax revenues are increased from 279.78 mln UAH in 2006 to 394.54 mln UAH in 2025 by an average of 1.89% per year. This trend is due to the growth of revenues from corporate income tax by an average of 1.41% per year, value added tax– 2.73% per year, individual income tax – 3.55% per year.

However the total number of employees people in industry, including innovation enterprises, and R&D sector has decreased steadily at an average of 2.83% in 2013-2025, or 43.72% in 2025 compared to 2005. According to the International Monetary Fund (IMF) forecast for the population of Ukraine, there is a negative dynamics of its development also: population is reduced from 45.5 mln in 2013 to 45.3 mln in 2018 declining on 0.08% at average.

Overall performed calculations are consistent with the forecasted values of the IMF in Ukraine [23].

Thus in 2025 the output of industrial enterprises is expected to increase in more than 1.9 times. It has positive impact on the growth of tax revenues (more than 1.4 times), including corporate income tax –in 1.28 times, value added tax– in 1.65 times, tax on personal income – in 1.94 times.

However, such public income is not enough to finance the sphere of production and human capital. Therefore, there is development of national economy with low rate in Ukraine. It eliminates the possibility of using of modern innovative technologies actually. There is decrease of the employment ofR&D sector in the structure of agents – in 1.87 times;of industrial enterprises, including innovative enterprises, – more than 1.77 times. Such negative trends are caused by insufficient supply of public goods, whereby there is a long decline in population quantity of Ukraine: on the one hand, it isdue to reduced fertility, and a population quantity that starts to work is decreased accordingly; by on the other hand, there is increased a level of mortality including employees people, that leads to their fast out flow.

The acceleration of economic growth in Ukraine requires the development of industrial enterprises on the investment and innovation base. So the basic directions of tax policy should be

(1) the partial transfer of the tax burden from the factors of production to consumption, environmental and resource payments.

This direction is reflected in the decline of real tax rates on profits of enterprises and individual income to 15%. These will provide incentives in capital inflows in the context of globalization, reducing tax distortions as a result of converting of the income taxation of individuals and legal entities.

To compensate losses of the budget from the reduction charges on wages there is appropriate to increase revenues from rental payments of the mining industry and significantly (in 5-6 times)increase the real revenue from environmental taxes. This increase will allow, on the one hand, to reduce the effect of negative externalities associated with environmental pollution, and on the other hand, to reduce the welfare losses due to high charges on wages;

(2) provide system-wide (rather than industrial or other partial) benefits, aimed at correcting of market failures in the field of scientific and technical progress, investment and innovation.

This direction is based on the use of investment tax credits, designed to maintain the activity of industrial enterprises in the sphere of innovations and investments [25]. To enhance tax incentives for the development of such enterprises there is recommended to usean investment tax credit in the form of discounts for qualified investments. Such investments must meet the strategic directions of economic development, including industry, and the priorities of social welfare of the country.

Thus, the proposed approach considers taxes as a tool to stimulate investment and innovation development of industrial enterprises. Accumulation of funds at the state level allowsto reallocating them to production and social spheres of the country in order to reach a higher level of socio-economic development. However, in modern Ukrainian conditions such funds are insufficient for innovative development of industrial enterprises, for R&D sector and for increase the living standards of the population. Therefore, in the long term there is a slight growth along with a reduction of research and development, as well as, of the economically active population. Accordingly, the direction of further research is the analysis of tax incentives for investment and innovation activities in industry and their impact on the development of neo-industrial development of Ukraine taking into account the institutional features of its socio-economic environment.

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