УДК 336.22:352

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INDUSTRIAL CITY DEVELOPMENT
UNDER THE INFLUENCE OF LOCAL TAXATION

Introduction

The Ukrainian economy will not be able to take a worthy place in the world's economic space without the solution of problems concerning effective industrial production development. The production facilities of Ukraine are concentrated in industrial cities, where the lack of investment resources leads to exploitation of obsolete fixed assets at the industrial enterprises with a high degree of physical deterioration and natural environment pollution, which negatively affects the health status of population, fertility and mortality rates, life expectancy. Functioning in the framework of the state industrial policy, an industrial city has to be given certain economic levers and financial resources to address these problems at the local level. One of the most powerful economic levers is taxation, which at the city level is represented by an institute of local taxation.

Forming an effective and self-sufficient local taxation system is one of the main tasks of Ukrainian tax system improvement. Nowadays the collection of local taxes and fees is regulated by the Tax code, with the introduction of which the situation in the sphere of local taxation has not significantly changed: the code does not provide for the significant sources of tax revenues and the levers of influence on socio-economic development at the local level. The scientific interest is how to form the local taxation system, appropriate for use at solution of problems of territories, in particular industrial cities.

Industrial city problems

Problems of industry rise acute in the places of its concentration – industrial cities, which act as territorial-economic complexes. Let's consider the main problems of industrial cities in Ukraine by the example of Donetsk city.

In recent years, 65-70% of the city investments in production (non-environmental) fixed assets and 90-95% of the investments in environmental fixed assets have been carried out at the expense of the own funds of enterprises [1-4]. Attracted investments in industry has been not enough to change the situation with obsolescence and physical deterioration of industrial fixed assets – the wear rate of the fixed assets in industry in Donetsk city over 2005-2010 has been approximately 55% [5, 26-27]. A trend towards a fall in investment financing has made it impossible to improve the situation – the decline of investment activity and the resulting decline in the value of fixed assets in industry has been tracing over the recent few years [5]. In the city, where industrial enterprises are city-forming, such a situation is threatening taking into account the prospects of socio-economic development.

Another problem is derivative from the previous one. Through the domination of metallurgical, fuel-energy and chemical industries with the use of physically worn out and obsolete fixed assets in the production process there is an issue of pollutant emissions into atmospheric air from stationary pollution sources in the city. In recent years, pollutant emissions have decreased, remaining one of the largest in the country [2]. Although mentioned decrease was not the result of environmental activities of industrial enterprises, but it was connected with the closure of certain productions and workshops [6]. According to the results of the conducted research, a high level of pollutant emissions has a negative impact on the health status of residents, fertility and mortality rates, life expectancy [7]. When the rapid transition of in-

dustry of the city (and the country as a whole) to a higher technological level seems to be impossible, it becomes obvious that the increase of investments in the non-environmental fixed assets (production facilities) will lead to the increase of pollutant emissions into atmospheric air. At this stage, taking into account the institutional peculiarities of Ukraine, the atmospheric air pollution restraining as a negative externality can be carried out by the application of the "end of pipe" way [8, 235] through the direct financing of industrial enterprises or urging them to finance cleaning measures for their own account, in future combining this strategy with others, founded on partnership and a voluntary basis [9, 24-26].

The structure of financing of the enterprises capital needs in the market economy consists of self-financing, external or attracted funds and state support, and in conditions of crisis the share of self-financing and state support growing, and the share of borrowed funds declines [10, 22-24]. High level of self-financing with the active regulatory intervention of the state in economic process is the basis of the industry development of Ukraine at the present stage[1] [10, 6]. Regulatory intervention is conditioned by the industrial policy of the state, aimed at changing the industrial structure in the directions, which, in hopes, have the best prospects for economic growth than in the conditions of market equilibrium[2] [11, 7]. However, functioning in the framework of the state industrial policy, industrial city must be guaranteed by certain set of economic levers and financial resources for the solution of the tasks set before it. One of the most powerful economic levers is taxation, which at the level of a city is presented in the form of local taxation.

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[1] Long-term bank loans remain difficult to access for industrial enterprises through the high rate of interest, and investors do not risk investing in the industry with a high degree of fixed assets deterioration and long payback period, despite the presence of finance sources, because they prefer branches of economy with fast turnover of capital.

[2] To support government intervention R. Musgrave stressed that private market can not ensure justice between generations, and government should do it [15, 153].

Proposed tax solution

The foundation of local taxation and local finance in general is based on the theory of fiscal federalism, developed by R. Musgrave (1959) and W. Oates (1972), that considers the problems of the allocation of public sector functions between different levels of government, including the provision of local public goods and services through the application of the mechanism of local taxation [12, 4]. In accordance with the principle of tax autonomy, local taxes should cover at least a half of local expenditures [13, 16]. One of the main principles of fiscal federalism is the principle of fiscal equilibrium, proposed by M. Olson, according to which the expenditures and corresponding revenues must be in the competence of one and the same authority [14, 482-483]. If we consider local taxation as a response to the need of meeting local needs, the use of a separate local taxation system by each community is quite reasonable, because there are no two absolutely identical local communities. In OECD countries fiscal federalism is considered in the aspect of tax competition of different territorial communities, which have the authority to set their own taxes and fees. Taking into account the fiscal policy at the local level, physical and legal persons choose an acceptable set of public services and their payments in the form of local taxes, moving from one community to another [16].

In Ukraine the process of choosing local communities by residents and businesses is under the influence of the factors other than tax factor, because there are no significant differences in taxation at the local level. According to the norms of tax legislation, local taxes include: tax on immovable property, other than land plot, single tax, fee for parking vehicles, fee for implementation of certain types of entrepreneurial activities, tourist fee [17]. In Donetsk city in 2011 local taxes and fees amounted to 3% of the local budget tax revenues [18], that indicates the weakness of the fiscal function implementation by the local taxation in the industrial city. Concerning a regulatory function of the local taxation, local self-government bodies have the right to a slight change of tax rates within the limits established by the Tax code, and the provision of benefits on the fee for parking vehicles and tourist fee (the received benefit sums have not

been earmarked) [17]. It is obvious that the regulatory action of such benefits does not have a significant impact on the functioning of the local economic system. Thus, the local taxes and fees, which according to the Tax code of Ukraine are the own revenues of local budgets, does not perform fiscal and regulatory functions to the extent possible to make a significant influence on forming the city budget or regulating the economic agents' behavior.

In this context the relevant question is how to enable both functions of taxation on the city level with a view of achieving the desired level of economic growth and increase social welfare from a utilitarian point of view[1], which requires municipal authorities having sufficient tax powers at the local level. Depending on the functional feature of the city it is expedient to explore the possibility to transfer the relevant taxes and fees with granting them the status of local to the competence of municipal authorities considering the characteristics of the city economy. In an industrial city such taxes may be personal income tax, corporate income tax in part of industrial enterprises (or industrial enterprises income tax) and environmental tax on pollutant emissions into atmospheric air from stationary sources of pollution, which are applicable at the local level in different countries of the world[2].

Because of the complexity of real experiment and unpredictability of its consequences, when studying the influence of local taxation on the city development as a complex economic system scientists usually use such a tool of economic analysis as modeling. Let's consider the models, suitable for application during the study of the city development depending on the tax policy at the local level.

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[1] Taking into account institutional peculiarities of Ukraine, at first it is expedient to explore the ways of maximizing social welfare of local community inhabitants in whole and only after attainment of this condition move to a single inhabitant.

[2] In Ukraine, according to the norms of the Tax code, proposed taxes are national taxes [17]. In accordance with the Budget code their tax revenues are divided between the state budget and local budgets of different levels due to the established proportions [19].

Existing city models – a brief analysis

Three main types of models are usually used for the study of tax policy at the local level [20]:

(1) an open economy with mobile households;

(2) an open economy with mobile households and firms;

(3) a closed economy with households and firms.

An open economy with mobile households is the usual Tiebout's framework of small open communities with mobile residents, but without enterprises (firms) [21]. The main assumptions of the model are the full mobility of inhabitants (consumer-voters), their full awareness, a large number of communities, indifference to employment opportunities (residents receive income from dividends), and the limitation of community size (the existence of an optimal community size and the desire of local authorities to achieve it and to keep). Local taxation is considered as a price of a public good like a regular price of goods and services in the private market, and migration costs are also taken into account as a fixed restraining factor in decision making about moving to another community: "Just as the consumer may be visualized as walking to a private market place to buy his goods, the prices of which are set, we place him in the position of walking to a community where the prices (taxes) of the community services are set" [21, 422]. If production functions show constant returns to scale, and if indifference curves are regularly convex, the optimal solution is possible. But Tiebout's hypothesis may not be considered as really true under existing conditions because of limited competition and communities' decision-making concerning local public goods on the basis of political processes.

The model of an open economy with mobile households and firms is applied for the study of tax policy in a particular city. The general equilibrium static model of an open city economy may be an example [20]. Tax revenues, joined with exogenous grants (grants-in-aid), are used to purchase a single pure public good (G), by which the infrastructure of the city is meant, and which benefits households and firms within the city. Aggregate output of a

common consumption good produced within the city (X) is defined by using the Cobb-Douglas production function with factors such as land (L), endogenously provided all-purpose public good (G), and a composite input, computed by production function with constant elasticity of substitution (CES), consisting of the cost of labor (resident workers (N) and non-resident commuter managers (M)) and capital (K). The model is designed to determine the local taxation influence on the working place choice for workers and the area of the location choice for firms. Questions inherent in the solution of industrial city problems are not considered in the research.

The model of a closed economy with households and firms implies the presence of both the households and enterprises in a city without possibility to move beyond city boundaries. The third approach is the most suitable for the study of fiscal policy in a large city with suburbs. According to this approach the city economy is presented as a dynamic model of a typical American city, focused on the analysis of the evolution of the urban territory [22]. The object of research is the city as a closed system. In accordance with the author of the model, the founder of a system dynamics method J. Forrester, system within certain limits should be able to generate any situation for analysis. Through a number of assumptions inherent in typical American cities (in particular the method of population, housing fund and enterprises grouping, the peculiarities of local taxation and others) forming a local taxation system in Ukrainian city on the principles presented in research [22] is not possible, however, the conceptual approach to the modeling of a city system, introduced by J. Forrester, is suitable for use in modern conditions of Ukrainian city.

In the above models the main attention of scientists was given to attempts of solving the problems of the city development, taking into account social and economic processes, excluding the role of the city in the natural system. In particular J. Forrester claims that any separate city is small enough to influence the environment [22, 25]. Nowadays we cannot agree with this view at a city. In the model of the world D. Meadows addressed environmental problems at the forefront in solving the issue of mankind

going out of the planet natural limits [8]. To construct a model of the influence of local taxation on the industrial city development it is appropriate to take into account the scientists' expertise on the modeling of the environmental component of the territories development.

One of the latest Ukrainian scientists' researches, devoted to the modeling of the industrial city, provides the model for developing the territorial economy scenarios, taking into account the ecological factor, and selection of the best option [23]. In the model the city is represented by the combination of the reservoirs that determine the processes of local development, as the enterprises fixed assets (average annual cost of fixed assets with the division on the enterprises fixed assets and environmental funds), engaged in production (the average number of employed at the enterprises) and environmental pollution. To choose the development strategy two target values are used – production output and mortality rate, and also one regulation tool is used – rate of investments distribution between investing in fixed assets and environmental funds. Production output in the model is estimated in terms of production function with constant elasticity of substitution (CES). Issues of taxation and tax policy are not considered in the research, but employed modeling approaches on the basis of the method of system dynamics, determination of the main reservoirs, city development indicators, and optimization criteria are suitable and can be extended and applied for the modeling of the local taxation influence on the development of an industrial city.

In one of the latest research works of our country's scientists, devoted to the impact of taxation on industrial activity, tax regulation by environmental taxes is considered in detail at the state level [24, 312-332]. With a view of studying the regularities of environmental taxation influence on the activity of industrial enterprises in Ukraine (in the form of the industrial production output), the author proposed a model of tax ecological regulation of the industrial enterprises activity with the account of environmental factor and state regulation in the form of levying an environmental tax on industrial enterprises. The model considers one of the most acute problems of Ukraine as a whole and industrial city in par-

ticular – atmospheric air pollution by pollutant emissions. The industry activity is estimated in terms of Cobb-Douglas production function with the neutral technical progress. A model of the industrial activity regulation by environmental taxation is built for Ukraine as a whole, but the approach to the environmental taxation can be applied at the local level.

The analysis of models shows that each of them has disadvantages, which do not allow applying them for the solution of the research tasks in given economic setting. The fundamentals of the models [20; 21; 22] do not correspond to the conditions of taxation and institutional peculiarities of Ukraine; in addition, they do not include the environmental component of the city development. In research [20] the target function is the inhabitants' utility function, which is difficult to measure in practice. In the model [23] taxation is not included, therefore, the regulation by tax levers is not provided. In the research work [24, 312-332] the model of environmental taxation influence on economic development at the state level is given. In connection with the above, there is a need to develop a new model of the local taxation influence on the industrial city development that corresponds to the conditions of Ukraine and is suitable for application in practice.

Building the model

The hypothesis of the research is that in an industrial city, which has peculiar problems and features of development, it is possible to achieve an increase in tax revenues and economic growth during a certain time interval at the expense of changes in tax policy at the local level.

Taking into account the hypothesis of the research, considering the institutional peculiarities of Ukraine, the model of industrial city development under the influence of local taxation is proposed, developed in the framework of neoclassical economic theory. The model includes industrial city problems such as the shortage of investment resources that has a negative influence on availability of fixed assets, and through them to production output, as well as environment in the form of pollutant emissions into atmospheric air that has a direct negative impact on the health status of population,

life expectancy, and therefore human capital as a factor of economic growth.

The simulation object is industrial Donetsk city. The scientific interest lies in the study of local taxation influence on city development.

The model is an improvement and adaptation of the proposed in [23; 24, 312-332] models to the objectives set in the study, and coming out of following assumptions.

(1) The city is presented as an economy system of a closed type with a feedback, as in research [22]. The impact of exogenous factors on the system is eliminated.

(2) The value of products, services and works sold (hereinafter – products sold) in the city is considered to be the analogue of the city's gross domestic product (hereinafter – GDP) (the analogy is based on the fact that the growth of GDP depends on the growth of production output if resources remain unchanged within a certain time interval); investment distribution between investments in production fixed assets and environmental fixed assets is introduced on the basis of a coefficient; environmental fixed assets are not introduced into production function, because they are not a factor of production, and they are involved in the process of pollutant emissions cleaning and the reduction of production harmful impact on the environment, as in research [23].

(3) The value of industrial products sold is represented by Cobb-Douglas production function; capital is given as the average annual value of fixed assets in comparable prices; it is assumed that the current funds in necessary amount are provided by financial system that is not considered; environmental pollution is represented in the form of pollutant emissions into atmospheric air from stationary sources of pollution, as in the research [24, 312-332].

(4) With a view of introducing a realistic restraining effect, a fixed factor is given in the form of a distribution of workers between industrial and non-industrial sectors of the city, as in scientific study [21, 419].

(5) The number of employees depends on city inhabitant quantity, as in the research [25]. In addition, an assumption of the free labor existence is introduced.

(6) A part of city inhabitants works and receives a salary, another part do not work and

receive social assistance that in the model is considered to be exogenous factor and is not separately indicated (assistance from the state budget and extra-budgetary funds); the population distribution according to age identity and elasticity of choice between work and leisure is not considered, as in the scientific study [20].

The assumptions that distinguish the proposed model from other existing models consist of the following.

(7) The model is designed for the analysis of the local taxes and fees influence on the industrial city development. The idea is put forward to use as local taxes the taxes that form the basis of local budget revenues, have the greatest impact on investment activity in the city and reduction of negative externalities, which for industrial city are represented in the form of environmental pollution. Three taxes are suggested to form the local taxation system:

1) industrial enterprises income tax[1] with the possibility of the provision of earmarked investment tax benefit, which remains at disposal of industrial sector enterprises in order to fund raising for increasing the fixed assets value, including environmental fixed assets;

2) environmental tax on pollutant emissions into atmospheric air from stationary sources of pollution, which reflects the relation of pollutant emissions into atmospheric air with the receipt of investments in the capital of environmental protection, with the possibility of providing earmarked environmental tax benefit to industrial sector enterprises in order to fund raising for increasing the environmental fixed assets value;

3) personal income tax as the main source of local budget forming that depends on the change in the number of employees and their wages.

Other taxes and fees, as well as governmental and intergovernmental transfers, are not considered.

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[1] It is a tax on operating income of enterprises of extractive and processing industries, production and distribution of electricity, gas and water [26] – a similar approach is used in the Tax code for tax exemption of certain industry income (light industry, shipbuilding industry, etc.) [17].

(8) Reflection of processes that influence on city's socio-economic development in the model is based on the use of production function (production output in industrial and non-industrial sectors is represented by Cobb-Douglas production function), and the city is to a certain extent modeled under physical laws. Therefore, the task to trace the use and allocation of received tax revenues does not apply.

(9) The economy of the city is divided into three sectors: a population sector, industrial sector and non-industrial sector; a block of local taxation is introduced separately (Fig. 1)[2]. In addition, the block of city's functional indices is calculated in the model. The industrial sector includes enterprises of extractive and processing industry, as well as those, the main economic activity of which is production and distribution of electricity, gas and water [26]. Other enterprises are operating in non-industrial sector.

Population sector. For population indicator the average number of city resident population is taken that grows with the increase in the number of born and reduces with the increase in the number of dead in a given year. In the model the harm to the health of industrial city population caused by atmospheric air pollution is measured in value terms referring to as second expenditure category proposed in [7, 5], namely as lost profits in the form of underproduction of GDP due to premature death or disability to work.

In *industrial sector* industrial capital and labor cooperate; the result of their cooperation is the industrial production output. It is assumed in the model that the value of products sold is equal to the production output. Investments depend on the gained profit and the value of industrial products sold in the current year. Investments are allocated to two destinations: capital

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[2] The link between local taxation and city population in Fig. 1 is shown with a dashed line, because taxes in the model do not have a direct impact on population, but considered to be one of the criteria for city's socio-economic development, on which the welfare of the inhabitants and providing them with social services according to the utilitarian function of public welfare [27, 488-489] depends, and their amount is taken into account in the model as one of the criteria of social welfare.
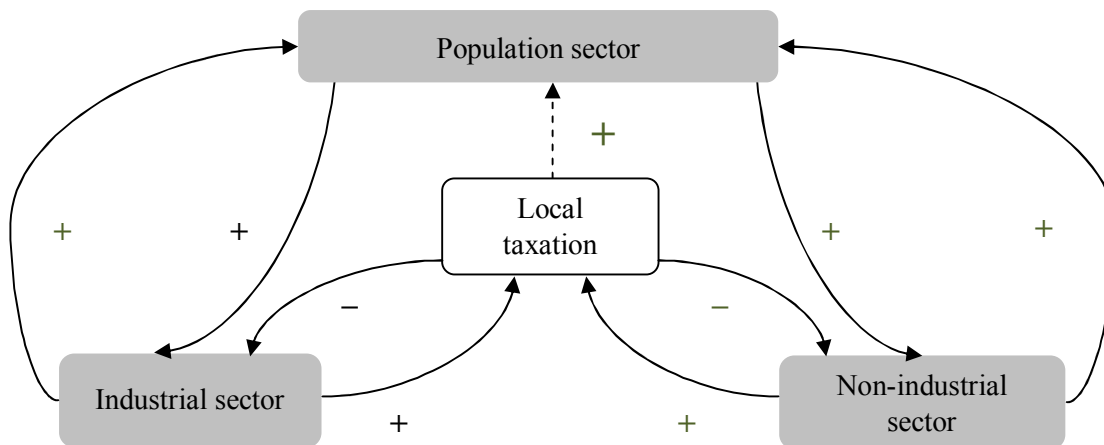
Fig. 1 Causal scheme of the model of local taxation influence on industrial city development

investments in environmental and production fixed assets. Investments to environmental fixed assets reduce pollution of atmospheric air from stationary sources of pollution. According to the assumption of the model, based on statistical data available [2], pollutant emissions into atmospheric air are only carrying out by enterprises of the industrial sector. The average number of regular employees in industrial sector is determined on the basis of needs in the maintenance work on fixed assets, and is introduced into the model by the formulas of increase or decrease in the number of employees. In addition, the number of employees disabled to work year-long through pollution of the atmosphere is not introduced into production function. Losses from underproduction of GDP grow subject to an increase in the level of temporary disability to work due to air pollution.

Non-industrial sector (production of which may or may not have a material embodiment, but also has its cost, as services in the spheres of health, education, trade, etc.) provides city development along with industrial sector, they co-exist within a single territory and complement each other. Modeling of the non-industrial sector is carried out by the analogy with industrial, but it is simplified, given the research focusing on industrial sector.

Local taxation block consists of three offered local taxes with the mechanism of tax benefit granting. Tax rates, used in the model, are not nominal but effective (actual norms in consideration of tax benefits, overpayments, debts, etc.).

Functional indices of the city include the value of products sold, the value of fixed assets, the fixed asset investments, the number of regular employees and temporarily disabled to work through the atmospheric air pollution in the city, calculated as a total result of activities in industrial and non-industrial sectors all together.

On the basis of data describing the development of Donetsk in 2005–2010, the system-dynamic model of industrial city development under the influence of local taxation is built, with the help of which a forecast for the next 15 years (from 2011 to 2025) is made. The length of the simulation period is 1 year; $t \in [1,n]$, t – the number of simulation period. The time horizon $n = 21$, and consists of the basic interval (2005–2010), on the basis of which the conclusion about model reliability is drown, and the forecast interval (2011–2025).

The city development is described in the form of economic-mathematical model with the use of system dynamics methods that allows tracing changes in the system under the influence of local taxation. System dynamics is applied when there is no need or opportunity to study the impact of individual objects, and it is sufficient to determine a system behavior at the level of aggregated values. All the indicators and processes are represented in the form of interrelated indicators computed with the use of tools, such as the "stocks" and "flows" between them [28, 54]. The model is formalized in the form of a differential equations system and implemented in the Powersim software environment (Fig. 2). The legend of the main indicators is given in table 1.
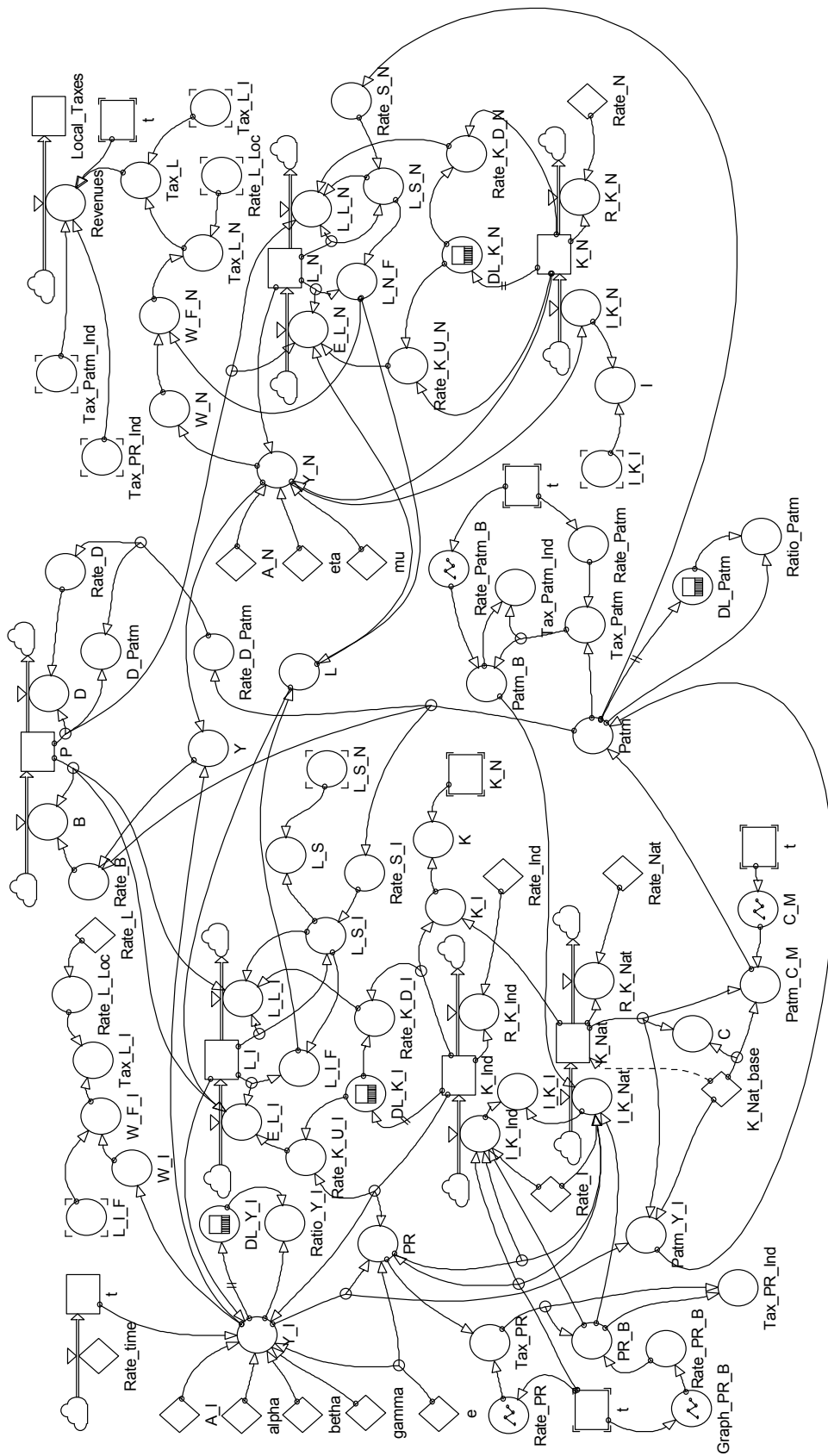
Fig. 2 The flowchart of Donetsk city development under the influence of local taxation, implemented in the Powersim software environment

Table 1

The main indicators of the model of local taxation influence on industrial city development

Indicators	Designation
Stocks of the model	
Average annual number of resident population in the city, thousand pers.	P
Average annual value of production and environmental fixed assets in industrial sector, respectively, mln. UAH	K_Ind, K_Nat
Average annual value of fixed assets in non-industrial sector, mln. UAH	K_N
Average number of regular employees (not including temporarily disabled to work through atmospheric air pollution from stationary sources) in industrial and non-industrial sectors, respectively, thousand pers.	L_I, L_N
Local tax revenues, mln. UAH	Local Taxes
Flows with the tempo	
Number of born, thousand pers./year	B
Number of dead, thousand pers./year	D
Investments in production and environmental fixed assets in industrial sector, respectively, mln. UAH/year	I_K_Ind, I_K_Nat
Variables and constants	
Production output in the city, industrial, and non-industrial sectors, respectively, mln. UAH	Y, Y_I, Y_N
Before-tax operating income of enterprises in industrial sector, mln. UAH	PR
Investment tax benefit rate (tax benefit rate of industrial enterprises income tax)	Rate_PR_B
Proceeds from industrial enterprises income tax, mln. UAH	Tax_PR_Ind
Average annual value of fixed assets (fixed capital) in the city, mln. UAH.	K
Number of employees disabled to work yearlong through the pollutant emissions into atmospheric air from stationary sources of pollution in the city, industrial and non-industrial sectors, respectively, thousand people	L_S, L_S_I, L_S_N
Average number of employees in the city, thousand people	L
Proceeds from personal income tax in the city, industrial and non-industrial sectors, respectively, mln. UAH	Tax_L, Tax_L_I, Tax_L_N
Pollutant emissions into atmospheric air from stationary sources of pollution, thousand tons	Patm
Environmental tax benefit rate (tax benefit rate of environmental tax on pollutant emissions into atmospheric air from stationary sources of pollution)	Rate_Patm_B
Proceeds from environmental tax on pollutant emissions into atmospheric air from stationary sources of pollution, mln. UAH	Tax_Patm_Ind

Comparison between the actual data and the data obtained during simulation experiment shows that the simulation results accurately reflect reality, and reliability testing confirms this conclusion: the mean error of the simulation results does not exceed 10,5 % (table. 2)[1]. Certain difference between the model and the studied city system is connected with the inclusion of only significant factors and parameters in the process of model building, the absence of external influences on the system, existing in reality, and introduction of assumptions.

On the basis of the fact that the reliability testifying yields positive results, the conclusion is made about validity of regularities that form the model basis and possibility of model application for conducting experiments in determining the influence of local taxation on the industrial city development with the immutability of all the other conditions.

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[1] In connection with changes in supervision organization in 2010 as regards the scope of survey units, the actual data and simulation results in terms of number of regular employees are provided for 2005–2009.

*Comparison of the modelling results for Donetsk city with the actual data
on the main indicators of the city development (a mean value for 2005-2010)*

Average annual number of resident population in the city, thousand pers. (P)		Production output in the city, mln. UAH (Y)		Average annual value of fixed assets, mln. UAH (K)	
Fact	Model	Fact	Model	Fact	Model
988,399	987,253	120972,7	120276,8	49609,01	48550,76
Average number of employees in the city, thousand pers. (L)		Proceeds from personal income tax, accumulated to the city local budget, mln. UAH (Tax_L)		Pollutant emissions into atmospheric air from stationary sources, thousand tons, (Patm)	
Fact	Model	Fact	Model	Fact	Model
338,004	322,852	613,86	576,36	116,2	112,6

Testing and analysis of modelling results

The development of the city, described by the model, can be performed in different versions depending on the tax authority and tasks at the local level. The main variables (regulators) that affect the functioning of the city under different scenarios are the rates of investment and environmental tax benefits $Rate\_PR\_B \in [0,1]$, $Rate\_Patm\_B \in [0,1]$. During the simulation experiment the four scenarios of industrial city development are considered.

1. ***The inertia scenario*** is simulated on the basis of maintaining the existing tendencies of the city development. By assumption (7), local taxes consist of industrial enterprises income tax, environmental tax on pollutant emissions into atmospheric air from stationary sources of pollution and personal income tax. All the local tax revenues become the receipts of the city budget. The tools of tax regulation are not applied, and their basic values are equal to zero: $Rate\_PR\_B = 0$, $Rate\_Patm\_B = 0$.

The analysis of simulation results should be started with the indicators of industrial sector of the city through the fact that forming of local taxation system and using of fiscal levers are intended to solve the problems of an industrial city in the application of tax resources mobilized in the city, and regulators in optimization scenarios affect exactly the indicators of industrial development. The results received allow making the following conclusions (Fig. 3)[1].

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[1] The trends of development relative to the selected indicators are given. For the convenience of perception, the scale of the vertical axis is provided in normalized form.
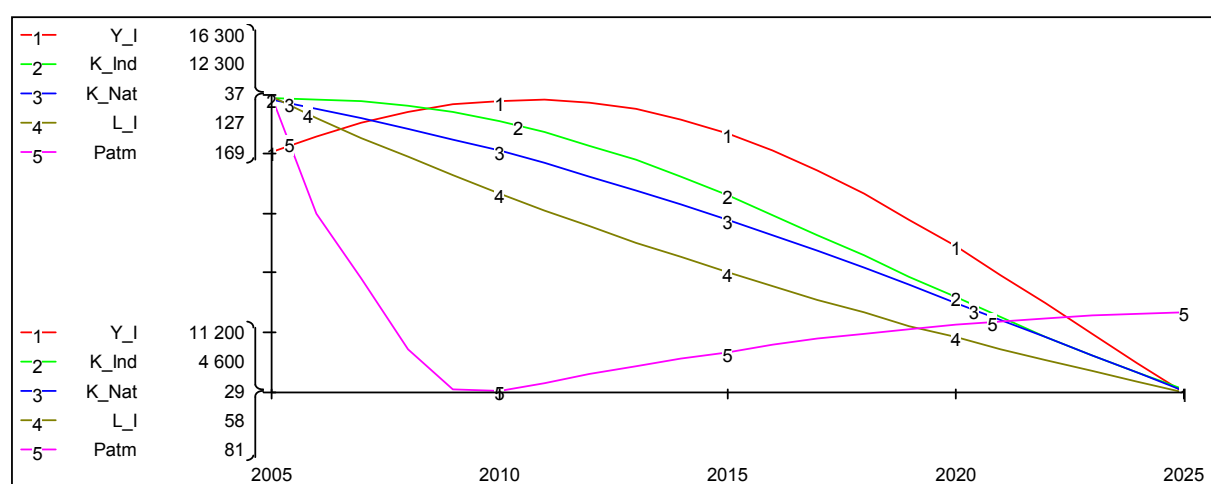

Fig. 3 Main indicators of development of the city industrial sector (inertia scenario)

Maintaining of trends, existing in 2005-2010, leads to a fall in industrial production in coming years. Decrease in the value of fixed capital through the reduction of the fixed assets investments in industrial sector of the city outstrips a drop in production and is the reason for it. A cut in environmental capital investments impacts on the cleaning quality loss of pollutant emissions into atmospheric air from industrial enterprises, and, despite a decline in production, emissions are growing. Therewith, the number of employees on industrial enterprises decreases. In the non-industrial sector there is a tendency to production output growth along with an increase in the value of fixed capital and the number of employees (Fig. 4).
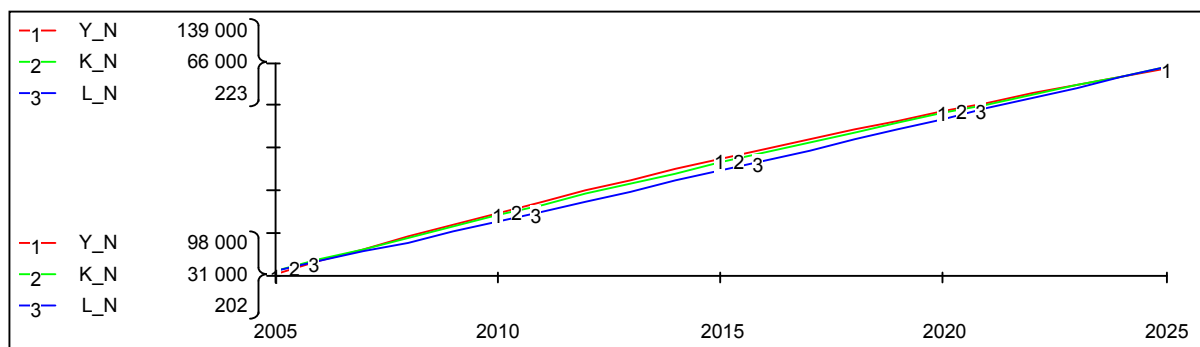

Fig. 4 Main indicators of development of the city non-industrial sector (inertia scenario)

From the analysis of population sector indicators and functional indices the following conclusions about the functioning of the local system can be made. Despite a decline in both the death and birth rates, the decline in birth rate outstrips the decline in death rate that leads to a reduction in the number of resident population. The GDP of the city is increasing during the whole period of simulation due to the rise in non-industrial sector, which compensates for the decline in industrial sector. A significant imbalance in sectors development during the forecast years testifies to a possibility for the city of losing its industrial function (Fig. 5).
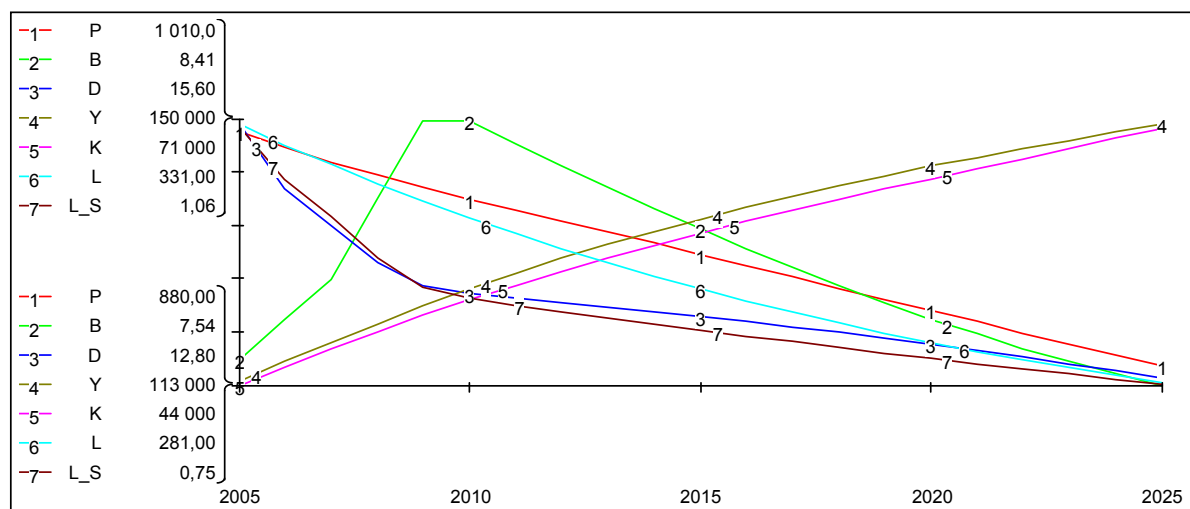

Fig. 5 Functional indices of city development (inertia scenario)

Such a succession of events is not desirable because the industrial sector of Donetsk has its huge industrial and scientific potential, expressed in the presence of enterprises and their production capacities, specialization of production, technological level, experience and qualifi-

cation of personnel. The basis of this potential was formed with the involvement of large investments, mostly – state ones (starting from the times of the Soviet Union). The city complex is highly integrated into the global economy and has a large export value for the national economy. Production, concentrated in particular in Donetsk and Donetsk region, remains the locomotive of the state economic development.

To remedy the situation, alternative variants of city development on the basis of the optimization criteria with the help of tax levers of regulation at the local level are needed to be created.

2. ***The production scenario*** assumes the maximization by the production output criterion. Based on the assumption that the increase in industrial product sales has a positive influence on the growth of the employee's wages in industry and raise tax revenues of the budget, and hence – the socio-economic component of the city inhabitants' welfare, the criterion of optimization is a function of:

$$Y\_I_t(Rate\_PR\_B) \to \max,$$
$$t \in [m+1, n]. \quad (1)$$

The value of the investment tax benefit, which at the time of optimization has the form of a constant, is $Rate\_PR\_B = 0,92$. Therefore, to maximize the value of industrial products sold in the last year of the simulation time horizon it is necessary to put the earmarked investment tax benefit at the industrial enterprises disposal in order to increase investments. The tax benefit in the forecasting interval is fixed and amounts to 92 % of the receipts from industrial enterprises income tax[1].

The additional investments have an ambiguous impact on the development of the city industrial sector (Fig. 6). In the forecast interval the value of industrial products sold increases due to the growth of investments, and that is the criterion of optimization and the goal of investment tax benefit provision. The increase in the number of employees is a response to the increase in the value of capital. Pollutant emissions into atmosphere are rising for two reasons: the increase in industrial production and reduction of the environmental capital. Investments are not enough for the environmental capital growth that negatively affects the quality of pollutant emissions cleaning.
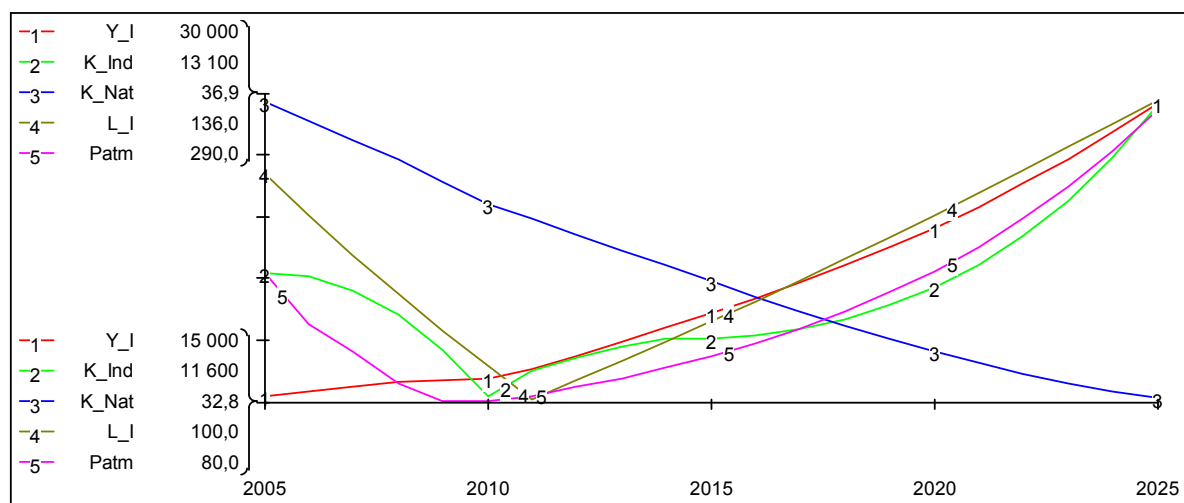

Fig. 6 Main indicators of development of the city industrial sector (production scenario)

The provision of the investment tax benefit to the industrial enterprises does not significantly affect the functioning of the city non-industrial sector, so it is not considered in the analysis of simulation results with other scenarios of development.

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[1] To define a set of parameters that correspond to the optimal solution, a system unit package "Optimization" in Powersim software environment was applied, methods of which is based on the use of genetic algorithms.

Investment support does not remain unseen to the city as a whole (Fig. 7), but along with the increase in the value of products sold, in the value of capital, and in the number of employees, the negative consequences turn out to be impressive: a sharp reduction of population number in the city through the growth of death rate and the decline in birth rate, and an increase of the level of employees' temporary disability for work.
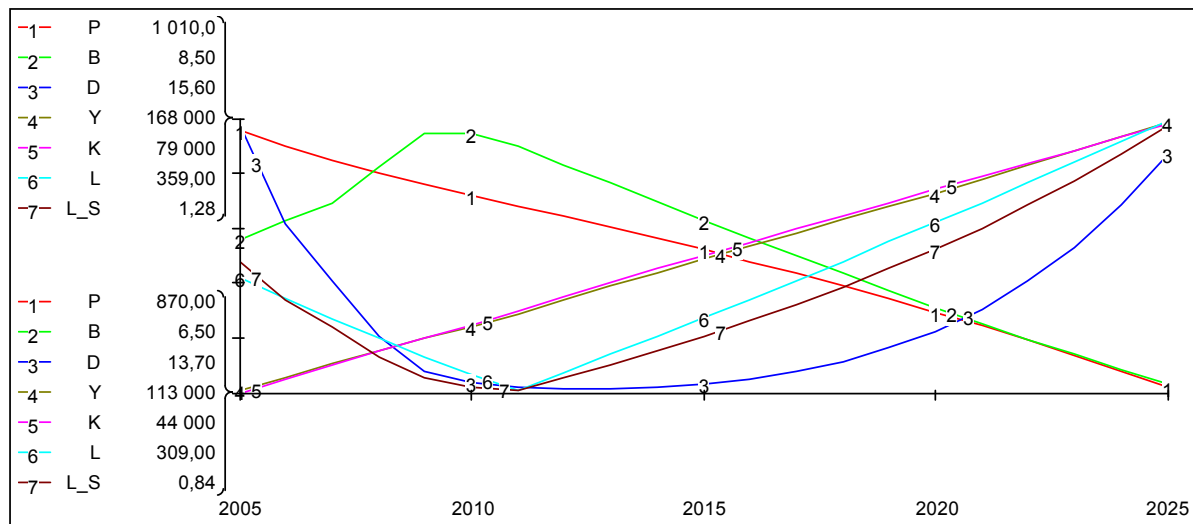

Fig. 7 Functional indices of city development (production scenario)

So, the production development scenario leads to the growth in the industrial sector according to the criterion of maximizing the production output, which is connected with the negative influence on the ecological component of the city residents' welfare.

3. ***The scenario of balanced development***. It is obvious that the growth of industrial production in an industrial city is quite probable and desirable thing, as well as the fact that the main problem of an industrial city is environmental deterioration. The application of the third scenario is designed to minimize an impact of the industrial production negative externalities on the residents. The mechanism of the investment tax benefit remains unchanged, but, in order to mitigate the consequences of the economic growth under the influence of investments in the form of pollutant emissions increase, a part of the environmental tax receipts – receipts from the environmental tax benefit – is invested in environmental capital (environmental fixed assets). The criterion of optimality is formulated to remain the function of production output monotonically increasing and the function of pollutant emission into atmospheric air from stationary sources of pollution monotonically decreasing over all forecasting interval:

$$\begin{cases} Ratio\_Y\_I_t(Rate\_PR\_B) \geq 1, \\ Ratio\_Patm_t(Rate\_Patm\_B) \leq 1, \end{cases} \quad (2)$$

$$t \in [m+1, n],$$

where $Ratio\_Y\_I_t$ is the growth rate of production output; $Ratio\_Patm_t$ is the decline rate of industrial pollutant emissions into atmospheric air.

The value of investment and environmental benefits, which at the time of optimization take on form of constants (in Powersim software environment have a view of constants), is $Rate\_PR\_B = 0,92$ and $Rate\_Patm\_B = 0,79,$ respectively.

The application of such benefits leads to the growth of industrial production output and to the fall in pollutant emissions over the whole forecasting interval (Fig. 8). Drop in emissions is due to the significant increase in the value of environmental capital, which directly influences on the degree of emission cleaning.
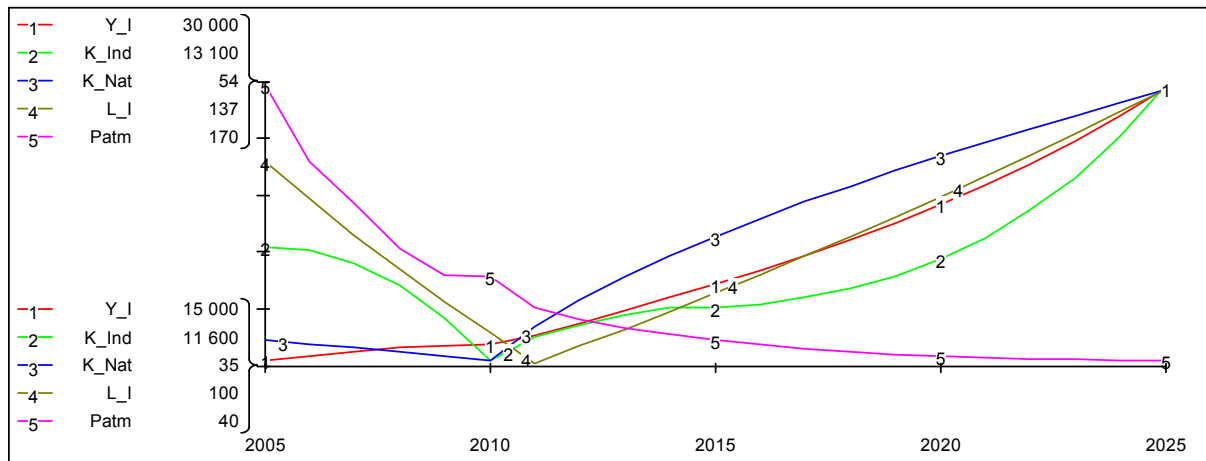
Fig. 8 Main indicators of development of the industrial city sector
(the scenario of balanced development)

The simultaneous provision of both benefits in given values increases fertility and declines mortality, reversing the population tendency in the city. The number of employees disabled to work because of pollutant emissions into atmospheric air from stationary sources is significantly lower than in the production scenario (Fig. 9).
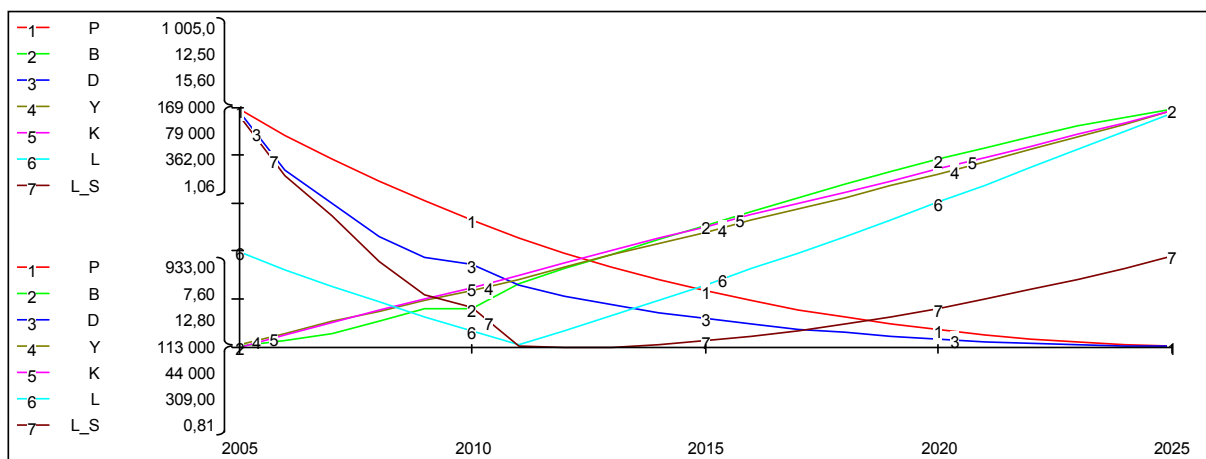

Fig. 9 Functional indices of city development (the scenario of balanced development)

Trends in the scenario of balanced development show the possibility of simultaneous achievement of economic growth and environmental welfare of the inhabitants with the help of such levers of influence on city economy as tax benefits. But this scenario requires significant tax expenditures: the rates of benefits are close to a unity. The problem lies in the fact that the large (with a view of budget forming) amount of tax revenues returns through tax regulation mechanism to the industrial enterprises for special-purpose financing. Another problem occurs in the form of a sharp rather than gradual reduction of receipts to the city budget. Given the peculiarities of the city as an inertial system, sharp changes in the economic and environmental indicators are difficult to implement and require tremendous effort and cost, and it is the hopping in indicators changes that the calculation of the optimality criteria for the forecast years shows (table. 3)[1].

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[1] Growth rates are estimated on the basis of simulation results of the scenario of balanced development.

Table 3

Forecast growth rates of industrial production output and pollutant emissions
into atmospheric air from stationary sources in 15 years

Year	Ratio_Y_I	Ratio_Patm
2011	1,030	0,826
2012	1,040	0,919
2013	1,040	0,935
2014	1,040	0,945
2015	1,040	0,953
2016	1,040	0,960
2017	1,040	0,966
2018	1,040	0,971
2019	1,040	0,976
2020	1,040	0,980
2021	1,040	0,984
2022	1,050	0,988
2023	1,050	0,991
2024	1,050	0,995
2025	1,050	0,999
The average growth rate	1,04	0,97

According to the table 3, the growth rate of industrial production output is stable enough with an average of 104%, and the rate of decrease of pollutant emissions in large measure ranges from 83% to almost 100%. These results testify a sharp fall in emissions in the beginning of the forecast interval and show that the amount of environmental benefit received is critical at the end of the simulation time horizon. The solution of this problem can be found through the use of a new criterion that is applied in a following scenario.

4. ***The scenario of stable-sustainable development***. In this scenario, the term "stable" refers to the impact of regulatory parameters on the city system, which leads to its development in the form of increase in industrial production output with a constant rate. At the same time, the scenario assumes a constancy of development in view of the reduction in the anthropogenic load in the city in the form of reduction in pollutant emissions into atmospheric air. Given the importance of optimization criteria, obtained during the simulation in the scenario of balanced development, the purpose of further experimentation is hipping reduction of indicators that are optimized:

$$\begin{cases} Ratio\_Y\_I_t(Rate\_PR\_B_t) = \delta, \\ Ratio\_Patm_t(Rate\_Patm\_B_t) = \varepsilon, \end{cases} \quad (3)$$

$$t \in [m+1,n], \delta \in (1,\infty), \varepsilon \in (0,1),$$

where δ is a stable growth rate of the industrial production output, and ε is a stable decline rate of pollutant emissions into the atmospheric air from stationary sources.

Due to the rates intervals, the condition of monotone increase in industrial production output and decrease in pollutant emissions is obvious. When carrying out the experiment the value of stable rate of growth of industrial production output is the average of the table 3: $\delta = 1,04$. Through the fact that the decline rate of pollutant emissions significantly varies and to the end of the simulation time horizon almost reaches unity, a fall by 1% per year is assumed as its stable value: $\varepsilon = 0,99$.

To meet such a criterion the variable rates of tax benefits are applied, calculated from the condition of gradual decrease of the investment tax benefit rate and gradual increase of the environmental tax benefit rate, which allows avoiding fluctuations and abrupt changes both in the development of the city and in tax revenues of the city budget. Such approach allows us to reduce significantly the rate of investment tax

benefit in the forecast interval (from 92% to 60%) in comparison with the scenario of balanced development, in which the rates of benefits are constant. In turn, the environmental tax benefit increases gradually from 21% to 45% (table 4).

Calculated rates of tax benefits for the forecast period (The calculation is based on simulation results for the scenario of stable-sustainable development)

Year	Rate_PR_B	Rate_Patm_B	Ratio_Y_I	Ratio_Patm
1	2	3	4	5
2011	0,92	0,207	1,04	0,99
2012	0,92	0,212	1,04	0,99
2013	0,92	0,245	1,04	0,99
2014	0,91	0,285	1,04	0,99
2015	0,90	0,295	1,04	0,99
2016	0,87	0,310	1,04	0,99
2017	0,84	0,320	1,04	0,99
2018	0,81	0,335	1,04	0,99
2019	0,78	0,350	1,04	0,99
2020	0,75	0,362	1,04	0,99
2021	0,72	0,376	1,04	0,99
2022	0,69	0,395	1,04	0,99
2023	0,66	0,410	1,04	0,99
2024	0,63	0,430	1,04	0,99
2025	0,60	0,450	1,04	0,99

Owing to the application of proposed tax benefits in the industrial sector a simultaneous planned growth of production output occurs as a result of the investments growth in production capital and the reduce of pollutant emissions into atmospheric air from stationary sources through the increase of investments in the environmental capital. Along with the capital increase the number of employees grows (Fig. 10).
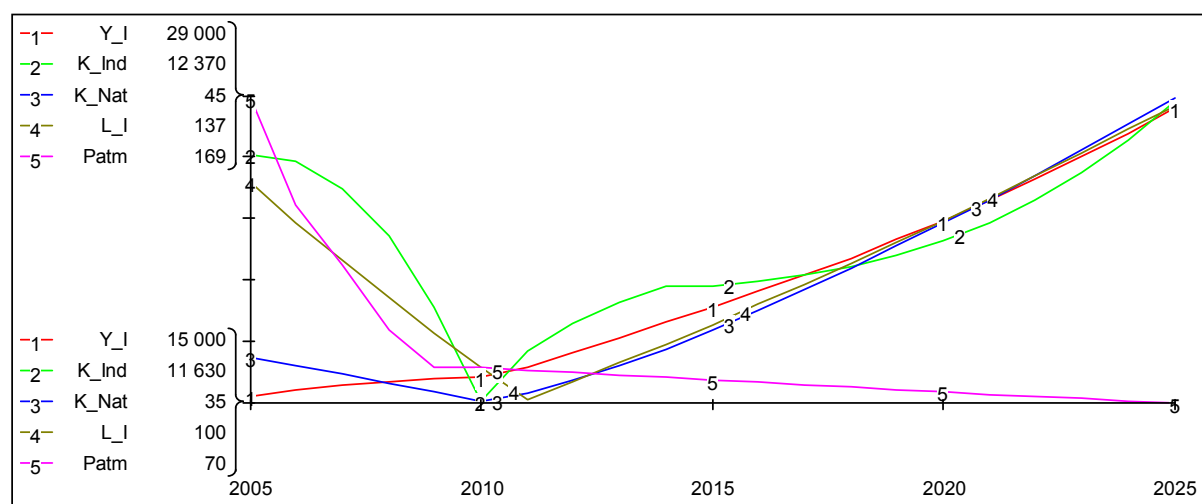

*Fig. 10 Main indicators of development of the industrial city sector
(the scenario of stable-sustainable development)*

Due to the increase of capital and labour, the GDP of the city grows (in the form of products sold). The growth rate of employees disabled to work is significantly behind the employees' growth rate. Fertility rates are close to the indicators of mortality, and obtained trend maintaining will lead to a reversal in the direction to fertility and city population growth in the near future (Fig. 11).
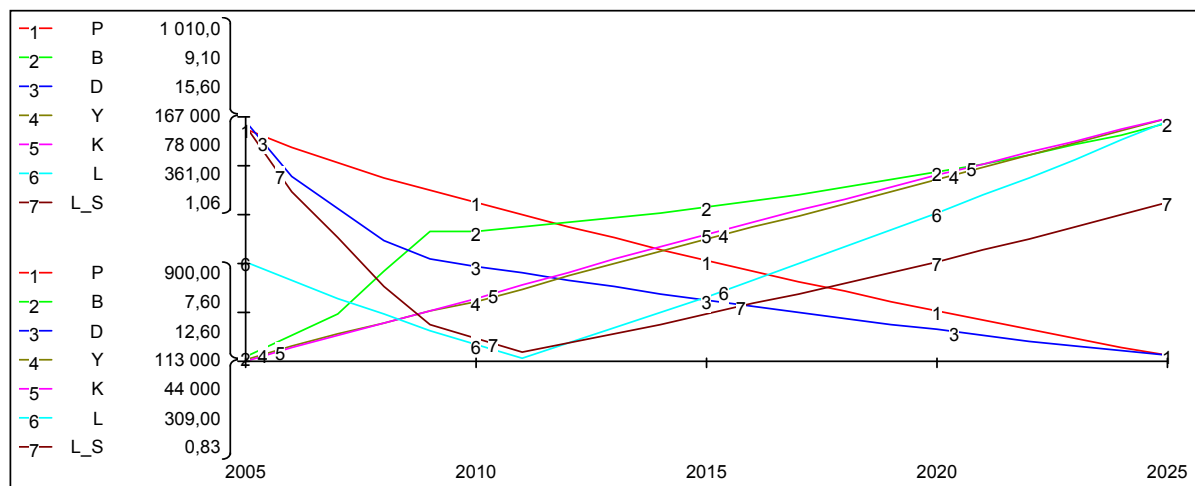

1	P	1 010,0
2	B	9,10
3	D	15,60
4	Y	167 000
5	K	78 000
6	L	361,00
7	L_S	1,06
1	P	900,00
2	B	7,60
3	D	12,60
4	Y	113 000
5	K	44 000
6	L	309,00
7	L_S	0,83

Fig. 11 Functional indices of city development
(the scenario of stable-sustainable development)

In the simulation experiment, the criteria of application of the local taxation regulation function were: maximization of production output and minimization of industrial pollutant emissions. Since the increase in tax revenues has not been the task of the optimization, the indicator of tax revenues in the city is added to simulation results as an indicator of fiscal function of the proposed local taxation system and one of the criteria for socio-economic development[1] – the inhabitants' provision with public services according to the utilitarian function of public welfare. In line with results obtained during simulation under different scenarios (table 5) the following conclusions are made up.

In the inertia scenario indicators of production output, capital and labour in the industrial sector and in the city as a whole are the lowest. The number of disabled to work through the atmosphere pollution is low by reducing the number of employees. Local taxes in full amount enter to the city budget that has a positive effect on the budget revenues.

The provision of investment tax benefit in the production scenario stimulates the growth of industrial production output through the increase of production capital, and at the same time substantially worsens the atmospheric air quality that leads to the increase in morbidity and mortality, has a negative impact on the birth rate, and ultimately leads to depopulation. This is the scenario of an ecological catastrophe. In addition, provision of investment tax benefit reduces the revenues of the city budget.

In the scenario of balanced development the receipts of permanent investment and environmental benefits provided are enough for simultaneous growth of production output and reduction of pollutant emissions into the atmosphere. This is an ideal scenario, but for one remark: its implementation requires considerable financial resources from the city budget.

The scenario of stable-sustainable development does not show such rates of growth in production and fall in emissions as the previous

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[1] The larger amount of tax revenue corresponds to the greater value of the social welfare function, because tax revenues are considered from the point of view of equivalence to public services at the local level.

Main indicators of city development according to the different scenarios
at the end of the time horizon

Indicators	The results of different scenarios of development			
	1	2	3	4
Y_I	11203,36	29583,01	29694,07	28508,40
K_Ind	4684,72	13047,46	13084,91	12360,66
K_Nat	29,18	32,88	53,59	44,69
L_I	58,34	135,42	136,22	136,00
Patm	104,85	280,13	43,16	70,32
P	889,90	873,80	933,67	903,07
B	7,54	6,58	12,49	9,06
D	12,89	15,37	12,82	12,68
Y	149459,18	167600,33	168381,02	166918,85
K	70189,52	78533,14	78621,30	77883,27
L	281,85	358,82	361,01	360,14
L_S	0,75	1,27	0,91	0,98
Local_Taxes	13674,79	13293,38	13278,16	13682,67

one; however, there is a possibility for the considerable budget expenditures reduction due to a gradual impact on the economic system. Comparing the receipts of the budget in the inertia scenario (without the provision of tax benefits) with the receipts of the stable-sustainable development (provided their gradual changes), the budget revenues of the later one are higher through the positive impact of earmarked tax benefits receipts on economic growth and improvement of ecological situation in the city. The conditions of production growth, pollutant emissions fall and tax revenues increase are carried out over the same time interval. Applied mechanism of a gradual reduction of investment tax benefit will allow nullifying its rate in the laps of time, and the mechanism of the environmental tax benefit increase reflects the pattern of the expenses increase for environmental protection activities in the future. Such a scenario can be referred to as real.

Conclusions

Industrial city is the driving force that raises the welfare of country's population to a higher level, and territorial units with prevailing of energy-intensive environmentally dangerous production of metallurgical, fuel-energy and chemical industries are donors to the consolidated budget of the country. At the same time, in-

dustrial cities like a litmus paper show the most acute problems of industrial development from demographic to environmental. At the present stage of development of industrial cities and the country as a whole renunciation of the production of environmentally harmful industries in the short term is not possible, but the concept of the support of the economic activities, that have achieved competitive advantages due to the use of available natural resources and acquired many years' experience, seems to be reasonable. And stable rates of industry economic growth should not impede social development and environmental safety of the city – the focus on preventing from deterioration of environmental situation should be a prerequisite to economic growth in an industrial city.

The hypothesis of the research is as follows. In an industrial city, that has its peculiar problems and features of development, an increase in tax revenues and economic growth can be achieved over a certain time interval due to the changes in the tax policy at the local level.

Functioning in the framework of the state industrial policy an industrial city has to be provided with certain economic levers and financial resources for the solution of its distinctive tasks. One of the most powerful economic levers is tax regulation. However, its application requires having sufficient tax authority at the local level.

Depending on the city functional feature, the possibility has been studied of transferring to the competence of industrial city municipal authorities such taxes as industrial enterprises income tax, environmental tax on pollutant emissions into atmospheric air from stationary sources of pollution, and personal income tax with granting them the status of local and the possibility of tax benefits application (investment and environmental tax benefits). The rates of tax benefits, calculated during the simulation experiment in different scenarios, take on values: investment tax benefits – from 60% to 92%, and environmental tax benefit – from 21% to 79%. The proceeds received can be spent on special-purpose financing only.

The results of the economic-mathematical modeling confirm the fact that the presence of significant tax levers at the local level and the possibility of their application for the regulation of economic development contribute to the growth of socio-economic indicators of the city. Taking into account the above-mentioned, such recommendations on forming a local taxation system in an industrial city are made.

(1) In an industrial city, taking into consideration the peculiarities of functioning, based on the principles of fiscal equilibrium and tax autonomy, consider the possibility of transferring the proposed taxes to the local level, namely: industrial enterprises income tax, environmental tax on pollutant emissions into atmospheric air from stationary sources of pollution, and personal income tax, that require adopting an appropriate amendment to the Tax code. The transfer of such tax authority will allow using both fiscal and regulatory functions of taxes at the city level. This, in turn, will contribute to undertaking city's own tax policy and solution of social and economic problems.

(2) In case of adopting the transfer of proposed taxes to the local level, complement the list of tax benefits on local taxes and fees with the investment tax benefit on industrial enterprises income tax and environmental tax benefit on environmental tax on pollutant emissions into atmospheric air from stationary sources of pollution, upon the condition that tax benefit receipts can be spent on special-purpose financing only.

(3) Open special accounts for tax benefits receipts at the enterprises, financial resources of which ought to be spent only on increasing the value of fixed assets: receipts from investment tax benefit – on production and environmental fixed assets, and receipts from environmental tax benefit – on environmental fixed assets only. Therefore, the mechanism is proposed, through which it would be beneficial for enterprises to invest in fixed assets. In this case, the application for investment tax benefit contributes to the growth of economic activity in the city, and the mechanism of environmental tax benefit provision is intended to prevent from industrial pollutant emissions growing.

(4) Regarding the choice between variants of granting tax benefits, such a choice is based on the preference function that underlies a political decision-making, and if economist can not find out this function, he is unable to evaluate past decisions or improve future ones. Economist only specifies the set of possible alternatives, on the basis of which the decision-maker selects the best one, bearing in mind his preference function [29, 215]. According to the results of the experiment simulation, in one of the acceptable options the set of tax benefits rates is permanent (the scenario of balanced development), and in another one it is variable (the scenario of stable-sustainable development). One is called rather for solution of industrial and environmental problems, another one – industrial, environmental and budget problems. Choosing one or another variant of benefit taxation depends on goals set, and methods and terms of their achievement.

The significance of the results, obtained in the course of simulation, is presented in the opportunity of reflecting the impact of proposed local taxes on the city economy and outlining the main directions of forming the local taxation system in the industrial city.

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