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ABSTRACT

This paper examines the actual problems of social and economic development of big cities. To assess the efficiency of this development, we have made a methodology, based on a system dynamics approach which meets the modern requirements. One of the main elements of the methodology is a system dynamics model of urban development. This model helps to determine the efficiency borders of this development, the cost of urban growth, tariffs on the urban infrastructure services. The results of such calculations by the example of St. Petersburg (Russia) are given in the paper. The elaborated methodology allows us to create mechanisms for managing urban development, directed to raise living standards of city dwellers.

Keywords: Big City, Sustainable Urban Development, System Dynamics Model

JEL classifications: B4, C6, R1, O1, O2

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1. INTRODUCTION

Big city, concentrating the interaction between social, political, economic, scientific and technical factors, can be considered as a complicated spatial socio-economic system. The modern period of big cities development is characterized by the fast changes of their features, the instability of processes, occurring in them. During such periods the survival of a big city as a system is mainly determined by its material and structural characteristics, forming system sustainability, and the price of management errors during these moments is great. However, now there is no adequate mechanism, allowing researchers to estimate the influence of modern conditions on the standard of city dwellers' living and on the efficiency of the development of big city social and economic sphere.

The assessment of social and economic efficiency plays a significant role in the working out of the administrative and management programs of urban development. But in practice the notion of a big city (as an object of management) is chiefly limited by administrative approaches, which do not provide for the system consideration of city actual problems, for the execution of complex social and economic assessments and forecasts of its development and the consequences of this development. Present approaches to the social and economic efficiency assessment of urban development have unsystematic, fragmentary character and ignore modern quickly changing conditions of cities functioning and development. The processes, the elements and the features of a big city, which have the attributes of system cause-effect relation, are not included in the present sphere of management. The underestimation of these factors leads to the hard social and economic consequences, which show up at the realization of unreasonable management decisions on the development of big cities.

The problems of management of big cities as territorial social and economic formations are considered in a great number of works of Russian and foreign scientists. The researchers' attention to the system features of big cities has recently raised. However, many questions of the management of urban socio-economic systems are not solved and require further researches. In particular, the problem of the efficiency assessment of social and economic development of big cities as complex dynamic systems and the problem of consequences assessment of their development are not worked out yet.

Results of such assessments can form a scientific basis for the elaboration of the system of standards, which will reflect the limits of big cities sustainable development in modern conditions. The existing standards were worked out mainly during the period of stable development of big cities, when the determining role was played by management influences, instead of internal processes, occurring in cities.

The improvement of the methods of urban development efficiency assessment is an actual scientific problem, which has great social and economic significance and increased practical importance in modern conditions.

The purpose of this research is an elaboration of a methodology of the complex efficiency assessment of big city social and economic development, which is based on a system dynamics approach and allows the efficiency borders of urban development to be estimated. The efficiency borders of big city development are understood as top and bottom limits of its sustainable development.

A big city as a socio-economic system acts as *an object of the research*. In this paper big cities are understood as cities with the population of more than one million people (within official city limits), which essentially differ from small and average cities in their territorial and functional structure. St. Petersburg (Russia) is chosen as a test area of the research.

The theory and practice of the management of big cities social and economic development, including the mechanisms for assessing the efficiency and the sustainability of urban development, the forecast of this development and its consequences, are *a subject* of this research.

The scientific novelty of this research consists in a combination of the system dynamics approach and efficiency assessment of urban social and economic development. The most essential propositions and results of our research, possessing the attributes of novelty, are as follows:

1. The methodology of complex efficiency assessment of urban social and economic development is worked out, which is focused on the account of social, economic and ecological factors;

2. The system dynamics model of big city development - the model of "urban effect", is offered, which allows us to carry out a complex efficiency assessment and forecast of urban development on the basis of the system dynamics approach;

3. The efficiency borders of urban social and economic development are estimated by the example of St. Petersburg. These borders show the limits of its sustainable development;

4. The indicator "the cost of urban growth» is offered. This indicator can serve as an economic tool of urban migration policy;

5. The mechanisms for regulating St. Petersburg social and economic development, which ensure the sustainable development of the city, are elaborated on the basis of results of the carried out complex efficiency assessment.

This paper consists of ten sections. In sections 2 - 4 we consider theoretical bases of efficiency assessment of urban social and economic development, the factors, doing this assessment actual and indispensable, the evolution of approaches to the assessment. We describe the features of the present stage of urban social and economic development, which show the necessity of transition from

searching the optimum sizes of a city to the assessment of efficiency borders of its development, consequences of their infringement.

Next, in the fifth section of the paper we present the methodical tool, which was created to realize a new approach to the efficiency assessment of urban development in practice - a methodology of the complex efficiency assessment of big city social and economic development, including the model of "urban effect".

The testing results of this methodology by the example of St. Petersburg are introduced in the sixth, seventh and eighth sections. In the ninth section we answer a question of how the received results of the research can be carried to concrete actions, to the mechanisms for regulating city social and economic development, directed towards the achievement of its sustainable development. The tenth section is final.

2. SOCIAL AND ECONOMIC DEVELOPMENT OF BIG CITIES AND INNOVATIVE PROCESSES PECULIAR TO IT

The high influence of urban social and economic development on the life of city dwellers and relations between them makes the management of this development indispensable.

The process of management should be started with the definition of the word combination «social and economic development of a big city». The analysis of the literature on regional, urban economy has shown, that there is no universally recognized definition of this concept. In this paper *social and economic development of a big city* is understood as a directed (progressive or regressive), qualitative and/or quantitative change of socio-economic system of the big city, influencing on the life of city dwellers and relations between them.

It is necessary to notice, that in this paper social and economic development of a big city is considered as a qualitative and quantitative change of the urban economy system, and that this development can be both progressive and regressive. Moreover, we emphasize the high social importance of changes in economic systems, which directly influence on the life quality and health of city dwellers. The larger the scale of economic development is, the more people feel its consequences. In turn, this points at the high importance of forecasting and analysing the consequences of social and economic development, especially of such large settlements as big cities.

Big city development is a multidimensional process, which is usually considered as a combination of various social and economic aspects, which are closely interrelated. On the one hand, the efficient economy acts as a major condition of high life quality of urban population (including a high level of health services, normal conditions of habitation, food, rest, etc.). It is well known, that the

improvement of population health is, first and foremost, a derivative of the positive dynamics of social and economic conditions (Kogut et al., 1994). On the other hand, the organization level of the national economy is caused, first of all, by the degree of society development, including the level of its scientific and technical progress.

Being a dynamic object, a city goes through the different phases of its development.

It should be noted, that usually the process of development is considered as a dialectic interaction between its progressive and regressive lines[1]. Then the process of economy development is treated as an economic process, including the periods of economic growth and recession, which form business cycles. Under such consideration economic development has a cyclic character.

However, the process of development can be considered only as a progressive change of economic system. Such approach is often met in the literature, which is devoted to the questions of management of various socio-economic systems development[2].

In addition, structural alterations, the change of development content, the acquisition of new characteristics by an economic system can be considered as its qualitative change. If the change is quantitative, then there is an economic growth or recession.

During urbanization there is a consecutive and versatile complication of big cities as peculiar social and economic organisms, which is accompanied by the further specialisation of urban activities. Today it is not already enough to consider any concrete aspect of urban economy or their combination. It is necessary to analyze the elements of urban economy in their interrelation and interaction. Regularities, according to which the branches of urban economy and interconnection between them are built in an integrated socio-economic system, are also important.

For example, the solution of waste disposal problem in the conditions of territory shortage in big cities is impossible without the reformation of production and consumption structures, directed on the material resources saving, the application of easily utilizable materials, the development of waste recycling system. The incineration of garbage makes urban environment dangerous for residing and demands heavy investments and operating costs.

Studying a big city as a complex socio-economic system, it is necessary to distinguish from all set of its elements the backbone ones, without which the system ceases to exist as an integrated organism. For a big city it is possible to define the following backbone elements:

1) territorial resources;

2) population;

[1] See the definition of the concept “development” in the Great Soviet encyclopedia (1979).
[2] See, for example, in O'Sullivan and Sheffrin (2003).

3) civil engineering and transport infrastructure;

4) housing stock.

The enterprises, ensuring city dwellers by jobs, goods and services of the first necessity, are also necessary for a big city existence (these enterprises are backbone in case of consideration a city as a closed system without external streams).

Besides, the dynamics of development and functioning, the high concentration of interactions are peculiar to big city socio-economic system. The dynamism of big cities development is shown in the transformation of functional structure, in territorial growth, re-planning, building renovation, in the enrichment of urban environment, in the inflow of new population.

The late 20th century was the age of economic globalization. The first part of the 21st century will be the age of the city, the "Urban Age" (Grizans, 2009). The world reached an invisible but momentous milestone in 2006, when the United Nations formally acknowledged, that for the first time in the history of humanity more than 3,0 billion people, half the global population, lived in urban areas. While the world urban population grew very rapidly (from 220 million to 2,8 billion) over the 20th century, the next few decades will see an unprecedented scale of urban growth in the developing world. This will be particularly notable in Africa and Asia, where the urban population will double between 2000 and 2030. By 2030, the towns and cities of the developing world will make up 80 percent of urban humanity (Martine, 2007).

The results of urbanization in Russia in XX - XXI centuries are also quite impressive. Since 1926 the number of cities with the population of 100 thousand people and more has increased from 20 in 1926 up to 167 in 2007, including big cities - millionaires - from two (1926) up to eleven in 2007. In 1926 about 18 % of all population of Russia lived in cities, in 1939 - 33 % and in 2007 - already 73 %.

Thus, the modern innovative processes of urban development show themselves, first of all, in two basic aspects:

- the functioning and development of big cities as difficult socio-economic systems with the set of direct relations and feedbacks;
- the dynamism of big cities development.

Speaking about innovative processes of urban development, it should also be mentioned, that the intensification of human settlements polarization in planetary scale, uneven urban development in the conditions of international integration result both in positive and in negative consequences in cities social and economic development at different levels of management:

1. *In planetary scale* the territory of the Earth is populated extremely irregularly: big cities concentrate a significant number of people in the limited territory, while the population density in other

territory is much lower. On the one hand, it leads to the decrease in costs of urban development and maintenance, caused by the additional savings, which arise at the shared use of urban public resources (so-called economies of agglomeration (economies of scale, location economies), which are described, for example, in O'Flaherty (2005)). On the other hand, the polarization of human settlements brings to the reduction of controllability of poorly and not urbanized areas in connection with the low density of their population, to the decrease in territorial integrity of countries, to the deterioration of natural resource use conditions in underpopulated areas;

2. *At the level of a big city:* in comparison with smaller types of settlements big cities provide the population, living in them, with relatively better living conditions. However, in big cities there is a bad environmental quality, urban population feels different kinds of urban stress, for example, commuting stress (e.g., Koslowsky et al., 1995).

3. THE ASSESSMENT OF INNOVATIVE DEVELOPMENT PROCESSES OF BIG CITIES

The negative tendencies in social and economic development of big cities stimulate searching for the ways of overcoming them, in particular searching for the optimum size of a big city, at which these negative tendencies will be minimized. The problem of city optimum size estimation is widely taken up in Russian and foreign scientific literature. This problem has acquired a great popularity just after the end of World War II, when (mainly in industrialized countries) the rapid growth of big urban agglomerations was observed.

According to the views of urbanists of the XXth century, the optimal (Latin *optimus* - the best) city is a city, which size is most economical with a view to the organization and exploitation of communal services sector. Such cities usually have favourable environment for life activity.

Analyzing the efficiency of cities of different sizes, experts compared building costs in them with per capita expenses for municipal economy objects maintenance. The following conclusion of the well-known Soviet theorist of town-planning V.G. Davidovich was typical for the post-war period: «Small cities are unprofitable, too big ones are inconvenient and unprofitable» (Davidovich, 1959, p. 67). He considered cities with the population of 50 - 200 thousand people as "optimal" ones. He defined urban settlements with the population of less than 10 thousand people as "too small" and with the population of more than 400 thousand people as "too big".

Modern scientists also observe the complication of living conditions by city growth. So the Swiss scientist P. Berosh notes, that in terms of urban environment quality a critical boundary of city population is at the level of 500 - 600 thousand people. In the point of transport services efficiency this threshold is at the level of 200 thousand people without the underground and at the level of 400 - 600

thousand people with underground. Taking into account these and other reasons, the best living conditions are found out in the cities with the population of 300 - 400 thousand people.

However, as the size of a city increases and many characteristics of its environment deteriorate, other features improve (for example, employment opportunities, which are so important for the population). Workplaces are especially significant for the cities in developing countries, where the population of small and average cities is frequently doomed to the chronic unemployment. The variety of workplaces, opportunities to find a high-paid job in a city usually extend with the increase in its size. It happens because of the concentration of administrative and financial functions, high technology industries, etc. in the city. According to the European urbanists, if employment is chosen as a basic criterion, the top limit of the optimum or, maybe, appropriate city is moved up, to the level of 1 million people.

In the early nineties of the XX-th century the famous Russian economist Mezshevich (1990) offered an approach to achieve urban sustainability with the help of management methods, which are based on "balancing the multiversion long-term plans of the enterprises of the key urban economy branch - industry" (p. 90), which is:

- a city-forming branch, influencing on all aspects of urban life;
- a main sustainability "violator" or "stabilizer";
- a priority consumer of territorial and social resources;
- a major source, forming the budget of a big city.

On the basis of long-term plans of industrial enterprises development M.N. Mezshevich suggested calculating their demand for territorial and human resources, making economic evaluations of these resources and determining standards of their use, which are used to regulate resource consuming by the system of payments. And at that, searching for the optimum borders of urban development in terms of efficient industrial development, the scientist considered city population first of all as a labour resource.

This approach is elaborated for big cities with plan-based economy at the industrial development stage, it does not take into account peculiarities of social and economic development at the present stage. Therefore, it demands improvement and adaptation to the new conditions of postindustrial stage of urban development.

The above-named approaches consider urban development with a view to one of municipal economy spheres, and as a rule, with a view to industry, however, in general there is no city size, which is equally "the best" for all. The German economist Boventer (1975) writes, that there is no optimum, which is independent of a concrete way of economic development. Therefore, all optimum sizes are

relative - the absolute optimum does not exist. The optimum city size is not often the same for an industrial enterprise and for a city planner. The size of a city can be differentially evaluated by various groups of urban population, for example, by old residents and by recent rural migrants.

The problem of searching for the optimum size of a city is very complicated, it demands to take into account a great number of characteristics. «It is wrong, - writes the modern Russian eminent scientist Lappo (1989), comparing big cities with small ones, - to speak only about the positive aspects of the ones and only about negative features of the others. Small cities as well as big ones have positive and negative characteristics at the same time. There is one more consideration: to reveal objectively the merits and drawbacks of different settlement pattern forms it is necessary to elaborate proper assessment criteria with scientific validity» (Lappo, 1989, p. 89).

Today the main criterion of such assessments is a sustainability of urban development, which makes it possible to lower negative consequences of big cities social and economic development to the least possible level.

There is no conventional definition of the concept «sustainable development»; its interpretation depends on a field of knowledge, in which it is applied. Sustainable development is an eclectic conception, covering a wide range of views (Grizans, 2009). In economics sustainable development means a process of changes, in which the use of resources, investments direction, the orientation of scientific and technical development and institutional changes are coordinated with each other and strengthen present and future potential for the satisfaction of human demands and desires[3]. In many aspects, it is a question of the maintenance of human life quality.

In the modern conditions of social and economic development there is a reorientation of scientific researches from searching the optimum size of big cities (a stationary guiding line), which is mainly determined by the purposes of their development, to estimating the conditions of urban sustainable development (a dynamic guiding line). Nowadays, former approaches are not suitable for the management of social and economic development of big cities, which are promptly growing both by quantity and by population size. Now it is not required to search the certain optimum population size, which is adequate to specific purposes such as industry development, but it is necessary to consider a big city as a complex developing socio-economic system with a set of direct relations and back actions. Innovative processes of big cities development demand new forms of their assessment.

[3] For the definition of Sustainable Development, see the web-based encyclopedia “Wikipedia”. Available from: http://en.wikipedia.org/wiki/Sustainable_development (viewed January 28, 2011).

Formally the innovative forms of urban development assessment are not declared yet, but really they exist, they should be realized and filled with economic and social substance. It is offered to refer the estimation of the following items to the innovative forms of urban development assessment:

1) the efficiency borders of urban development;

2) the cost of urban growth.

The Efficiency Borders of Urban Development (The Limits of Urban Growth)

The estimation of the efficiency borders of urban social and economic development should be referred, in our opinion, to the innovative forms of urban development assessment. As economic categories, these borders are the upper and lower limits of urban sustainable development. Earlier the question of searching for the efficiency borders, which allow city government to focus on the achievement and maintenance of urban sustainability, was not explicitly raised, though there was a necessity for their determination. The problem of efficiency borders assessment is virtually undeveloped and demands its solving.

The efficiency borders of urban social and economic development can be estimated almost for any of its characteristics (population size, the level of city dwellers' income, enterprise efficiency, etc.), however, the key one is a population size. Therefore, in this paper the main attention is devoted to the estimation of efficiency borders for the population of St. Petersburg.

It is important to note, that in this research the interpretation of the concept "efficiency" (or more exactly "economic efficiency") corresponds with the generally acknowledged definition: economic efficiency is a productivity of economic system (in this paper, the socio-economic system of a big city), which represents a ratio of useful resulting effects of its functioning and development to spent resources.

The indicator of economic efficiency and, consequently, the efficiency borders of social and economic development can be estimated at different levels of management: population, enterprise, city as a whole. The enterprise efficiency is characterized by the production of goods or services with the least costs. At a level of a city economic efficiency is a ratio of the produced regional gross domestic product (GDP) to costs (on labour, financial, territorial resources of the city).

Speaking about social and economic efficiency, it is possible to state, that from city dwellers' point of view the most efficient urban system is a system, which meets city population requirements to the greatest degree, guarantees the highest standard of living (in this paper - the highest degree of satisfaction with the services of social, engineering and transport infrastructures of a city).

We offer to consider the upper and lower efficiency borders of big city development for its population. *The upper border* is a maximum size of urban population, which can "be located" on the limited city territory with a certain standard of living. So, the lower the city dwellers' standard of living is, the more population can live within the city borders, and vice versa: the higher standard of living is, the less city dwellers can "be accommodated" on the limited city territory. This limitation acquires special importance by considering a big city as a closed socio-economic system, first of all, in terms of territorial resources.

It is offered to estimate *the lower efficiency border* of big city social and economic development by the means of a break-even point, which corresponds to the urban population size, at which total costs of city maintenance and development will be equal to its incomes (to the part of its regional GDP, going on the recovery of these costs). If these total costs exceed city incomes, it will become unprofitable and will not be able to function and develop sustainably without external support.

The share of city incomes, which goes on the recovery of the expenses on its maintenance and development, plays a big role at the definition of the lower efficiency border. This share directly depends on the structure of incomes distribution in a city, on the proportion of accumulation to consumption, on the purposes of social and economic policy, conducted by the city government. In terms of social and economic development the basic cities function is a maintenance of generally accepted living standard of city dwellers. It is well known, that the life quality of population is, first of all, the derivative of positive dynamics of social and economic conditions. The effective economy acts as a major condition of high level medical care, normal conditions of living, food, rest, etc.

It is important to note, that the economic evaluation of efficiency borders can be done at different levels of management: population, enterprises, city. Each level has its borders; at overstepping them economy cannot efficiently function and develop any more.

As an example it is also possible to consider efficiency borders for the following indicators:

1. An income level of population. In our opinion, the lower border of this indicator conforms to the size of city dwellers' living-wage, the upper border coincides with the average monthly wage, which is maximum among the kinds of economic activities. The city dweller with the pecuniary gain lower than his living-wage can not live in the city, he has to leave it and move to other region, in which his incomes will be higher than his living-wage.

2. A level of enterprise profitability. At overstepping the lower border of the profitability level (which is offered to estimate as a balanced financial result of enterprise activity per product unit) enterprises cease to function efficiently, and they are compelled to move in other regions or to be

closed. The maximum profitability of city enterprises among urban economic sectors or among the kinds of economic activities can act as an upper border of this indicator.

3. Budget efficiency. We offer to consider budget efficiency borders separately for population and for enterprises. In both cases a zero value is assumed as a lower border of the indicator. The upper budget efficiency border for population is a maximum allowable value of tax payments to the city budget from its population in the total pecuniary gains of the population (a difference between the average population pecuniary gain per capita and the living-wage). The upper budget efficiency border for enterprises is a maximum allowable value of tax payments in the total enterprise output (a difference between the total output and its cost).

At overstepping the lower budget efficiency border the city budget gradually loses the ability to fulfill its basic functions, including the function of urban infrastructure maintenance and development; at overstepping the upper border the tax burden becomes so heavy, that taxpayers can not effectively function and develop under such conditions in the city.

4-6. Building density, an indicator of vital space, a provision of city dwellers with greenery for general use. Overstepping the upper border of building density (a ratio of buildings total floor area to a land lot area), crossing the lower border of the indicator of vital space (we offer to calculate it as a difference between a land lot area and a building area per person, living on this land), and also violating the lower border of the city dwellers provision with greenery for general use reduce urban environment comfort, make it stressful, lead to the growth of an incidence rate among city dwellers and bring to social tension increase as a whole in the city.

It should be noted, that the values of these indicators can considerably differ in urban districts. We offer to use their value for city suburbs as a lower border and their value for central districts as an upper border of these indicators.

7. Population density. The indicator "population density" is estimated as a ratio of the size of population, living on city territory, to its area. Population density considerably varies among big cities of the world (thousand people per sq. km): Tokyo – 14,1; Moscow – 9,8; Delhi - 8,1; New York - 6,7; Beijing - 5,6; London - 4,8; St. Petersburg - 3,2; Los Angeles - 3,1[4]. Population density is also different in various districts of a city. Therefore, in our opinion, the lower border of this indicator can also be its value for city suburbs, and its value for central districts can be considered as an upper border of the indicator.

[4] The data of UNO are given for 2008.

At overstepping the borders the development of a big city becomes inefficient, unsustainable, which carries negative social and economic consequences (for example, a growth of tariffs for housing and communal services). Consequently, it is necessary not only to estimate the borders, but also to detect the consequences of their crossing and to elaborate management mechanisms for keeping them.

The approaches to the estimation of lower and upper efficiency borders of urban development and also the list of indicators, which we offer, are not final and demand perfection and development.

First of all, it is important to state the problem of estimating the efficiency borders of big city development in terms of science-based valuation criteria, taking into account elaborations, executed earlier in this sphere. Further we shall consider existing approaches to the assessment of big cities development and retrace their evolution.

The Cost of Urban Growth

The estimation of the efficiency borders of big city development for its population is tightly connected with the problem of migration. This question acquires greater importance, if it is taken into account, that, as a rule, the population of St. Petersburg is replenished, first of all, by a positive migration balance and then by its natural increase.

As an economic tool of city migratory policy we offer to use a concept «the cost of urban growth». We understand by city growth the increase of its population, by the cost of urban growth the cost of a city newcomer (for constant residing) provision with the standard of living, generally accepted in the city. The cost of urban growth is determined by a set of factors: a level of migrant provision with residential floor area, with the services of city transport and engineering infrastructures, with the services of educational institutions, with medical services, etc. The decisive factor for parameter value is a standard of living, achieved by a migrant.

The statement of the problem of estimating the cost of urban growth is not new, but it was posed at the industrial stage of urban development, therefore, its solving met the criteria, which were adequate to that development period.

So the Russian scientist Mezshevich (1990) determined capital investments in labour resources as a cost of newcomer provision with dwelling, with social and communal services, with the services of city engineering and transport infrastructure. He asserted that «The distribution of these costs between urban economy branches is the following: habitation - 38%; the objects of social and communal services (including the objects of recreation and tourism) - 20%; engineering infrastructure - 16%; transport - 23%; other branches (landscape gardening, land development) - 3 %» (p. 122).

Other scientists also carried out similar calculations. For example, the Estonian scientist E.Veski considered the calculation of labour-power reproduction costs as a basis of the evaluation of labor utilization efficiency. According to his calculation technique the costs of social infrastructure per capita and per person, engaged in industry, are estimated (an engaged person is regarded as a primary resource of social production, which directly creates gross product and national income for the benefit of general population).

The logic of other (Leningrad) approach is focused on the calculation of territory expenditures to provide a new city dweller with all necessary facilities. This work was executed by the civil engineering and construction institute "LenNIIProekt" on the basis of the General plan for Leningrad and Leningrad region development for 1986-2005 years (the authors are V.F. Nazarov, A.G. Dynkin, T.G. Alyoshina and others).

However, in these approaches the costs of provision a new city dweller with the standard of living, generally accepted in the city, are calculated fragmentarily, without uniting them in one system, without taking into account their interconnection. It is required to create a new approach to the estimation of the parameter «the cost of urban growth», adequate to modern conditions of urban development. In our opinion, the consideration of a big city as a dynamically developing socio-economic system should be the basis of this new approach.

4. APPROACHES TO URBAN DEVELOPMENT ASSESSMENT: FROM THE ESTIMATION OF INDIVIDUAL INDICATORS TO THE VALUATION ON THE BASIS OF MODELS

The strong influence of big cities economy development on people, living in them, on their relations causes natural desire to govern it. The results of reforms, implemented in Russia, show the necessity of return to planning the economic development of big cities in consideration of past experience, but at a new, higher level. The system guidelines, helping to evaluate the direction and effectiveness of social and economic development, have been lost during the reforms of the Russian society. Today only fragmentary macroeconomic, social, humanistic and often emotional assessment criteria are used (Zhiharevich, 2000). It is very difficult to evaluate social and economic situation, the direction of urban development, the efficiency of urban policy adequately without the innovative approach, which takes into account the experience of the Soviet planned economy and the innovative processes of modern big cities development.

At the same time the orientation and the effectiveness of a policy, pursued by city government, depend mainly on that coordinate system, with the help of which the efficiency of urban development is evaluated, on that guideline, by means of which desirable development directions are compared with

factual ones. Exactly the efficiency assessment of big cities social and economic development acts as such a system of coordinates, such a guideline.

The assessment permits to reveal problem areas in urban development, to analyse the reasons of negative development tendencies, and also to compare a level of development efficiency of different cities. It is required to forecast urban development, social and economic consequences of this development. On the basis of the forecast long-term managerial decisions are accepted, economic-organizational, investment and normative-legal mechanisms for increasing the efficiency of big cities development are elaborated.

The standard assessment method of economic development of a region, a big city is a production level analysis mainly with a help of the parameter "regional gross domestic product" (regional GDP) as an absolute value and per capita. Today such assessment is one-sided and insufficient. The approaches to economic development assessment, developed by international organizations, consider not only a production volume, but also such criteria as the level of education, public health services, the state of environment, the presence of equal opportunities in economic sphere, the level of personal liberty and life culture.

The human development index (HDI) and other similar indicators can be used for interregional comparison, as well as for international analysis. This index was elaborated by the United Nations to assess countries development. It ranges countries from 0 to 1. To calculate the index three parameters are applied:

- life expectancy at birth as an index of population health and longevity;
- knowledge and education (an adult literacy rate and the average duration of schooling);
- per-capita income (taking into account currency purchasing power and the decrease of marginal income utility).

Along with integrated indicators of urban development individual ones are also estimated. Among them are:

- national income per capita;
- the consumption level of certain material benefits;
- the degree of incomes differentiation;
- an average lifetime;
- the level of physical health;
- the accessibility of education;
- the degree of population happiness.

In spite of using the big set of integrated and individual indicators, the assessment is carried out fragmentarily, without their systematization. This makes the assessment subjective: like the set of indicators, like the result of the assessment.

Moreover, these assessment methods do not allow researchers to trace the change in the proportion between the elements of socio-economic system. They do not consider links between parameters, what is caused by the absence of system approach to the analysis of urban development.

The works by O.G. Dmitrieva, dedicated to regional economic diagnostics, develop the above mentioned assessment methods.

The assessment of a region state, the detection of "regional diseases", "pathologies", painful points and bottlenecks are understood by diagnostics. To find the bottlenecks of development the given region should be compared with other regions of the same set or group.

The diagnostics of region social and economic development is made both in statics and in dynamics. The diagnostics of region dynamic qualities is based on the assessment of its sustainability, the degree of which is determined by the period of distribution of the received diagnostic conclusion in time (Dmitrieva, 1992).

The diagnostics of a certain region can be carried out by various methods. O.G. Dmitrieva distinguishes analytical, expert methods and diagnostics on models. The diagnostics of a certain region (or a city) should be started with analytical methods. At the final stage of data collection expert methods are applied. If new factors and phenomena are revealed, analytical methods should be used again.

Expert diagnostics is a set of diagnostic techniques and forms of diagnostic information gathering, when the information, received by contact methods (by questioning of experts, sociological researches, direct observations), serves as a basis of diagnosis.

Along with the integrated social and economic indicators, which reflect a development level, a standard of well-being, the simulation of socio-economic systems is applied in the methodology of economic assessment as a method of indirect cognition with the help of objects-substitutes. It is an analytical research of a regional model, the model of a city. During this research the up-to-date level of social and economic development is evaluated, and also the ways of its increase are searched.

At regional model constructing region economy can be considered as a system, which consists of elements. The structure and the quantity of these elements can vary. Most frequently regional models belong to the models of resource type: resources (labour, financial, natural resources, ect.) are exhausted, resources are supplemented. The state of an urban economic system is described by variables (population, production assets, housing stock, land resources, etc.). External influences and

managerial decisions determine the dynamics (the rate of change) of the simulated system (the speed of resources supply and depletion).

In 70th years of XX century Forrester (1969) constructed the mathematical dynamic model of a typical American city, which is focused on the analysis of urban territory evolution and takes into account the set of feedforwards and feedbacks between city economy subsystems. This model gave an opportunity to predict urban development, to analyze the influence of various city administration programs.

The scientist came to the conclusion, that city's ability to live is determined by many interconnected and interacting subsystems, in which the relations between elements can not be described by linear functions.

In those days J. Forrester's system dynamics model of urban development was innovative, and later his followers developed it.

Along with advantages the above-mentioned approaches to the assessment have a number of essential disadvantages:

- social and economic dynamics (especially structural and cyclic changes in big cities development) is not studied enough. This implies the transition from the static models of certain city economy branches to the dynamic models of urban social and economic system;
- there is virtually no economic approach to the assessment: the expenses of big cities social and economic development are not estimated or estimated fragmentarily. There is no system approach to the estimation of urban development costs. Only a regional GDP as a sum of gross added values of city economy branches is calculated systematically. The results of urban development are evaluated, but the price, for which they have been achieved, is not considered;
- the efficiency assessment of big city social and economic development, based on the cost-benefit analysis, is not performed. Nowadays this analysis is carried out fragmentarily without taking into account interrelations between urban economy branches;
- the assessment is mainly carried out in comparison with a previous level of urban development or with other cities, but not in comparison with a normative development level. The indicators of social and economic development can improve or worsen, but to evaluate a tendency adequately a comparison with development standards can also be necessary, a comparison with analogues can be insufficient;
- in most cases the assessment is made in pure theory without orientation to the practical application: the elaboration of the mechanisms for increasing cities development efficiency, the forecast of cities development consequences, first of all, for population.

New conditions of urban development demand innovative forms of its assessment. The usage of the system dynamics approach to the efficiency assessment of urban development can act as such a form. *The essence of the system dynamics approach is in studying the changes of social and economic phenomena in their interrelation and interaction, in searching for the management mechanisms, which are capable of handling these changes.*

Modern methods of studying dynamically developing socio-economic systems become worthless without the system approach. With the increase in people concentration on a limited territory connections between city subsystems become closer, the self-recovery potential of urban environment reduces and becomes more and more sensitive to influences on it. As a rule, external reserves of big cities development are exhausted to the limit, therefore, in big cities it is already impossible to influence on one process not affecting others, not provoking a whole number of chain reactions. And at a high population density the speed of these chain reactions is maximal. Now it is necessary to start the mobilization of internal reserves, including the improvement of management quality.

In the process of assessment it is necessary to sort out backbone elements, without which a city as a system ceases to exist. Not only time intervals of city functioning, but its life cycle must be considered.

It is necessary to analyse not only separate elements of big city socio-economic system, but their whole set, connections between them. For example, to raise city dwellers' living standard investments in a whole complex of the enterprises of city social, engineering and transport infrastructures must be attracted. Then there is a question of searching for investment sources. The increase in the expenditures of budgetary funds will finally lead to the growth of city dwellers' tax burden. The mobilization of private investments raises the problem of searching for the sources of their recoupment, the solution of which usually results in the increase in prices for the services of urban infrastructure enterprises. Besides, city infrastructure development will inevitably entail the growth of demand for territorial resources. Consequently, the evaluation of city territorial reserve is needed for its development. Thus, the analysis on the basis of the system dynamics approach puts an important question: which living standard of urban population a city can "allow" itself and at what cost?

The risks (connected with the deficit of urban territory, labour, with the shortage of financial resources for the realization of large-scale plans of city government, etc.) grow steadily without solving these problems, without taking into account system features of big cities at forecasting, planning and making management decisions. As a result, management plans are not implemented, and the debalanced state of urban socio-economic system leads to the constant growth of prices, paid by urban

enterprises and population, to the growth of social and economic expenses, which would be possible to avoid by the system dynamics approach to city management.

Besides, the efficiency assessment of big cities development must be complex, i.e. it must consider economic, social and ecological aspects of urban development. It must take into consideration the interests of urban population. One of the drawbacks of modern city models is an insufficient account of social factor. Since the basic purpose of cities social and economic development is a rise in living standards of its population, the projects of urban economy objects development must be accompanied by the evaluation of consequences of this development for the city dwellers and urban environment. The problem of searching for the sources of financing these projects must be well elaborated, because population pays finally for all.

However, efficiency assessment is in itself "dead", if an inverse problem is not considered: under what conditions the efficiency of city development will meet relevant requirements or such conditions are unattainable at all; how many resources are required to achieve a planned living standard of city population. The characteristic feature of big cities development is a constant shortage of resources for their development and, first of all, territorial ones. It is not enough to make plans of city development, it is necessary to determine not only requirements, but also the possibilities of its development, including the availability of its territorial, labour and financial resources.

The assessment of urban development on the basis of individual and integrated indicators states a problem, diagnoses it, but it does not give enough information for the management of this development. It does not answer the questions: what is to be done to influence on city development to make it efficient; what are the borders of parameters change, in which urban development will be sustainable; what are the consequences of development for a city.

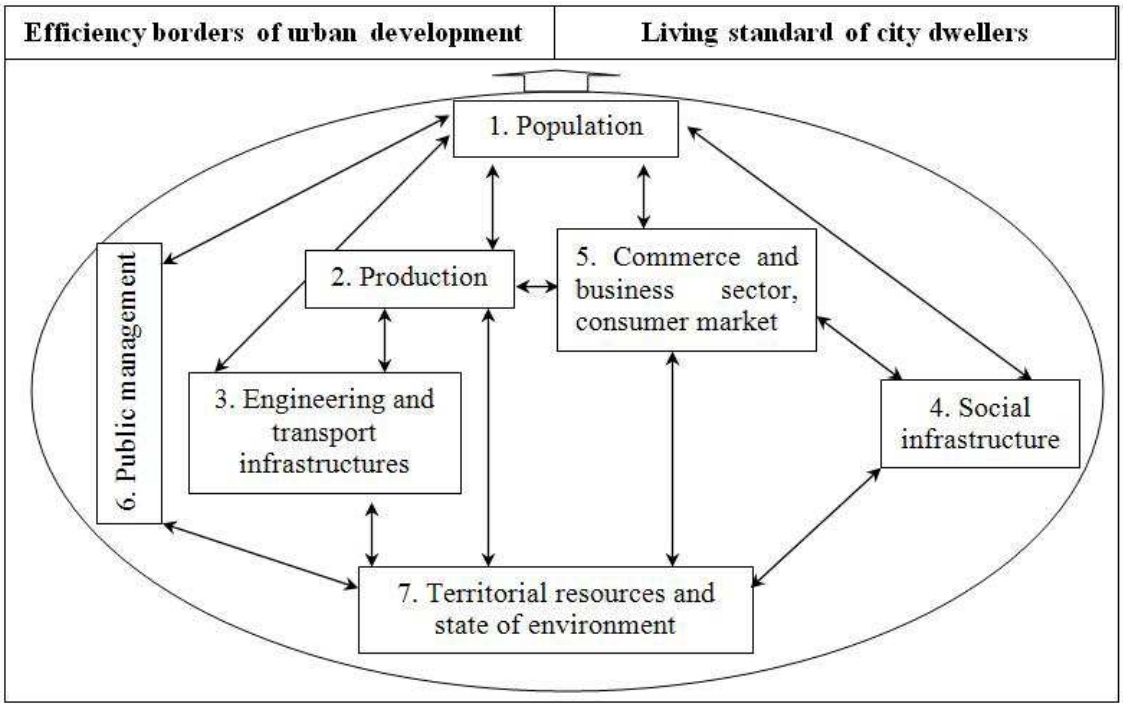
An attempt to answer these questions is included into the tasks of this research, which purpose is an elaboration of the innovative methodology - the methodology of the complex efficiency assessment of big city social and economic development, meeting up-to-date requirements and management conditions, allowing the efficiency borders of urban development to be estimated on the basis of the system dynamics approach.

5. THE SYSTEM DYNAMICS MODEL OF BIG CITY DEVELOPMENT - THE MODEL OF "URBAN EFFECT"

As stated above, the mathematical apparatus, used today for the assessment of urban development, is based on the elementwise assessment of individual parameters without joining them in an integral system, without taking into account time factor. In contrast to the above mentioned

approaches, in the system dynamics approach a big city is considered as a dynamically developing socio-economic system.

In this paper we apply system dynamics approach to the assessment of big city development, using a system dynamics model. We name this model *"the model of "urban effect"* (see Figure 1), because, simulating the processes of city functioning and development, it reflects the mechanisms of displaying various effects, peculiar to the city. The growth of city GDP, the change of population provision with housing stock floor area, housing density growth, etc. can be referred to these effects. The ultimate goal of making this model is the efficiency assessment of big city social and economic development on its basis.



Notes: Double arrow denotes interconnection between elements (blocks) of the system dynamics model; rectangle represents an element (block) of the model.

FIGURE 1: The Composition and the Structure of the System Dynamics Model of Big City Development – of the Model of "Urban Effect".

The subsystems (blocks) of the model of «urban effect» include the following:

1. Population: the size and the structure of urban population, its movement, labour resources;
2. Production: industry, agriculture, building, warehousing, science;

3. Engineering and transport infrastructures: the network of streets, water supply, sewerage system, gas supply, heat supply, electric power supply, sanitary purification;

4. Social infrastructure: housing stock, public health services, sports services, social security, education, professional training, culture and art, sanatorium services, tourism and hotel facilities, funeral services;

5. Commerce and business sector, consumer market: retail trade, catering, consumer services, commerce and business sector (financial and banking; legal, consulting services; insurance; news, advertising agencies; administrative institutions; real estate agencies; etc.);

6. Public management: the receipts and the expenditures of city budget;

7. Territorial resources and the state of environment: territorial resources, the quality of air, water, soil.

The backbone elements of the model, providing city vital functions, are the following:

- population;
- territorial resources;
- housing stock;
- engineering and transport infrastructures;
- enterprises, supplying city dwellers with first-necessity goods and services and with job (this element is backbone in case of considering a city as a self-contained system in the absence of outside flows).

The presence of backbone elements is necessary for the existence of a city as such. These factors provide vital functions of a city as a living organism.

The blocks of the model of "urban effect" can be divided into profitable, cost-based and resource ones. The blocks "Production" and "Commerce and business sector, consumer market" are profitable subsystems, the blocks "Engineering and transport infrastructures" and "Social infrastructure" are cost-based and the blocks "Population" (labour resources), "Public management" (financial resources) and "Territorial resources and the state of environment" (natural resources) are resource elements of the model. The profitable blocks "participate" in forming city GDP, the cost-based ones - in forming the total costs of creating the certain living standard of city dwellers. The resource blocks determine the borders of city development, its opportunity to form city incomes, an achievable living standard of city dwellers. Such division of the model subsystems makes the calculation of system parameters more evident and economically grounded.

The following *system parameters* can be calculated on the basis of the model of "urban effect".

1. The size of city resident population. This is an initial indicator for the whole model; it is determinative for almost all system parameters. There is no city without population.

For its estimation the following formula is usually used:

(1) $$dN/dt = (B(t) - M(t)) + (I(t) - O(t)),$$

where N is a size of city resident population, B represents the number of the born, M is a number of the died, I is a number of the arrived, O is a number of the left and t is time (year).

2. Regional gross domestic product (GDP). Regional GDP is a generalizing indicator of economic activities in a region (in a city), describing the process of goods and services production. GDP equals the sum of gross added values of city economy branches, calculated as a difference between production and intermediate consumption plus net taxes on products (a difference between taxes and subsidies for products). This indicator is well worked out and regularly estimated at the level of a country, a region, a big city.

To calculate a regional GDP the following formula is used in the model:

(2) $$GDP = Fi(N)*(AS*Nl + TI + PR + TC + CP + 0{,}11*TRF),$$

where GDP is a regional GDP, Fi (N) is a function, which is taking into account the influence of city economic significance on its regional GDP, Nl is a number of employees in city economy, AS is an average level of a nominal wage, TI are tax payments on the production of the enterprises of the block "Production", PR is a profit from the sales of products, TC are tax payments of the enterprises of the block "Commerce and business sector, consumer market", CP is a net profit of the enterprises of the block "Commerce and business sector, consumer market", TRF are tax and other payments to a higher-ranking budget system (to the federal budget, for example).

In the model of "urban effect" the effect of average per capita income growth with the increase in urban population size is taken into account with the help of function Fi (N). Big cities concentrate the surplus product of national economy. :The branches, mainly of tertiary and quaternary economic sectors, which are at the top of the nature-product vertical, are gathered in them. The underestimation of this factor would not allow us to carry out the scientifically based analysis of the dependence between cities population and their GDP per capita.

This effect was studied and described by P.R. Krugman. Krugman is a well-known American economist. In 2008 he won the Nobel Memorial Prize in Economics for his contributions to New Trade Theory and New Economic Geography. His theory explains the reasons of global economy urbanization. Large-scale production on the one hand and the struggle for the reduction of transportation costs on the other hand increase the attractiveness of big cities for population. At the same time the increase of urban population stimulates economy development and production growth,

which, closing a circle, lead to the further increase in population size. As a result, regions gradually are divided into hi-tech "central zones" and less developed "periphery".

For St. Petersburg the function Fi (N) is the following: (0,25*log (N) – 1,07). Its form was got empirically by analysing the dependence between the per capita regional GDP of Russian big cities and their population size. The value of the per capita regional GDP for St. Petersburg was taken as a unit. This formula, being a regression function, shows a per unit GDP rate, which depends on the economic significance of the city.

The coefficient of determination of this regression function is 60,7%, indicating that the change of the per capita regional GDP is explained by 60,7% by the change of city population size.

The correlation coefficient is equal to 0,78, allowing us to conclude that there is a strong direct relationship between variables.

According to Student's T-criterion (Student's t-test) the function parameter, which is equal to 0,25, is statistically significant, the second parameter (1,07) is not significant. The confidence probability of calculations is accepted at the level of 80%. By Fisher's F-criterion the function is not overall significant.

The unsatisfactory values of Student's T-criterion and Fisher's F-criterion are explained substantially by the lack of input data for the analysis. The extension of statistical database favours the growth of reliability and statistical significance of the regression function. The question about the form and the type of the relationship between the per capita regional GDP of a big city and its population size is an issue of a special research. For the big cities of other countries and for the world as a whole the type and the form of the relationship are sure to be different. For each big city it is necessary to determine the type of function Fi (N) as a result of an additional research.

3. The total costs of city maintenance and development. This parameter of the system dynamics model includes:

- the total maintenance costs of city economy objects;
- the total costs of city economy objects major overhaul;
- the total development costs of city economy objects.

The costs are summed up through the all cost-based subsystems of the model of "urban effect" - the blocks "Social infrastructure" and "Engineering and transport infrastructures". The costs of city economy objects maintenance and major overhaul are considered to be constant (they do not dependent on the change of city population size) and development costs are variable (they dependent on the dynamics of population size).

4. The cost of urban growth. We offer to estimate this indicator as an increase of total per capita costs for city economy development, caused by city population growth. Development costs depend on a population size: population growth leads to the increase in the demand for city economy objects services, and, hence, to the increase in the costs of their development. This indicator is used to answer the question, how much it costs to provide city newcomers (for constant residing) or newborn city dwellers with the living standard, generally accepted in the city. It is natural, that this indicator directly depends on the standard of living, with which newcomers (migration increase) or the newborn (natural increase) are provided.

5. The territorial reserve of urban development. This indicator is an important system parameter for the models of urban development, taking into account, that one of the main characteristics of big cities development is a permanent deficit of territorial resources. In fact, they act as a main limiter of urban development. And each object of city economy requires territory for its functioning and development.

The territorial reserve of urban development is calculated as a difference between city total area and its developed part. The demand for territorial resources is estimated both for the cost-based and for the profitable subsystems of the model of "urban effect".

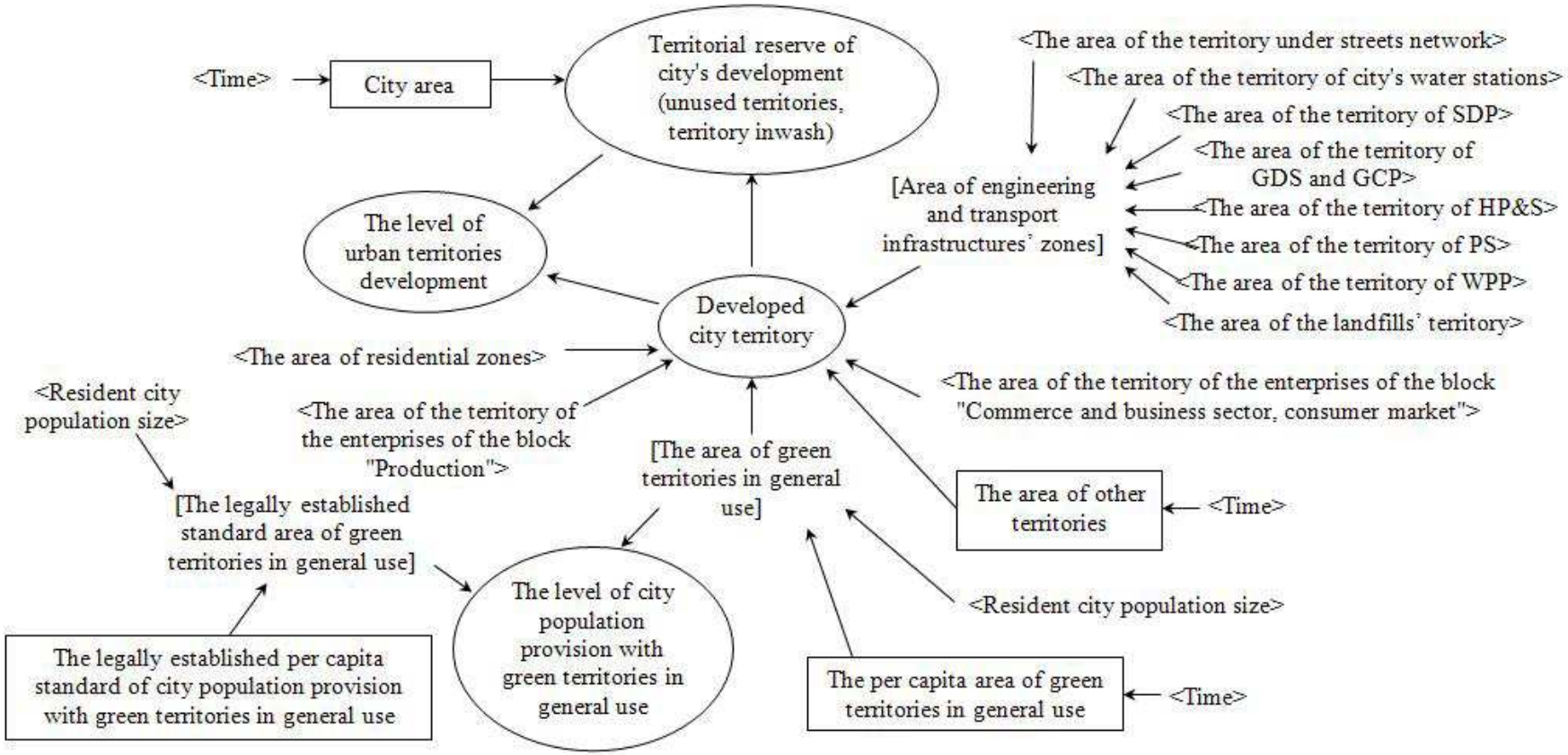
Each block of the model is in itself a complex system. The complexity of the model structure is caused by the purpose and the tasks of the research.

As an example in Figure 2 we give the composition and the structure of the subsystem "Territorial resources" of the block "Territorial resources and the state of environment" of the system dynamics model. In this figure the connections between indicators, considered in the model, are represented in the form of arrows. Each connection between model indicators corresponds to a formula.

The example of the formalization of connections between model indicators is given below:

$$OT = JZ + TI + PZ + TC + PT + TP, \quad (3)$$

where OT is a developed territory of a city, JZ is an area of residential zones, TI is an area of the territory of the enterprises of the block "Production", PZ is an area of green territories in general use, TC is an area of the territory of the enterprises of the block "Commerce and business sector, consumer market", PT is an area of engineering and transport infrastructures zones, TP is an area of other territories.



Notes: Rectangle represents an input exogenous variable; ellipse denotes an output variable – indicator; square brackets show a variable - level (it is required to specify an initial value); angle brackets denote a copy of a variable of another part of the model; SDP are sewage disposal plants; GDS and GCP are gas-distribution substations and gas control points; HP&S are heat producers and suppliers; PS are power stations; WPP are waste processing plants.

FIGURE 2: System Data-Flow Diagrams of the Subsystem "Territorial Resources" of the Block "Territorial Resources and the State of Environment".

The list of all formulas of the model of "urban effect" can be given as needed.

The model of "urban effect" allows us to estimate *the efficiency borders of big city social and economic development,* which are the top and bottom limits of its sustainable development as economic categories. The efficiency borders can be determined almost for any indicator of social and economic development. However, a key one for any city is a population size.

For city population size we offer to consider the upper and the lower efficiency borders of urban development. The upper border is a maximum size of urban population, which can "be located" on the limited city territory at a certain standard of living. And we offer to estimate the lower efficiency border by the means of a break-even point, which corresponds to the urban population size and at which the total costs of city maintenance and development is equal to its incomes (to the part of its regional GDP, going on the recovery of these costs). So by varying population size at the established standard of city dwellers' living it is possible to determine the optimal efficiency borders of urban development. The choice of a living standard should be made, taking into account the share of city incomes, which can be spent on the achievement of this standard.

$$N_V: TP \rightarrow 0;$$

(4)
$$N_N: SZ \leq dVRP,$$

where NV is a city population size at a zero territorial reserve, TP is a territorial reserve of city development, NN is a city population size at the lower efficiency border, SZ are total costs of city maintenance and development, dVRP is a part of a regional GDP, going on the maintenance and living standard rise.

Finishing the description of the model, it is necessary to emphasize, that in contrast to J. Forrester's model and other dynamics models of city development similar to it the model of "urban effect" provides for system calculation of the following parameters:

- economic (the incomes and the costs of city maintenance and development, the cost of urban growth, regional GDP);
- social (the whole set of indicators, assessing the standard of city dwellers' living);
- ecological (the indicators, reflecting the state of urban environment).

The distinguishing feature of the offered system dynamics model is an orientation to the efficiency assessment of urban development, to the determination of efficiency borders taking into account social, ecological and economic factors.

The simulation of various big cities development scenarios on the basis of the system dynamics approach allows us to carry out its (development) complex efficiency assessment. We can name it an

innovative form of assessment, which makes it possible to take into account modern conditions of urban development.

The application of the system dynamics approach reveals the disbalance, the discordance of private development plans, as it considers not a set of city economy sectors, but their system.

It is important to note, that the results of a forecast depend not only on a calculation method, but also on a quantity of considered indicators, on an adequate to the purpose and the research tasks reflection of reality by a model. And the attention should be mainly focused on the correctness of a model structure, on the reasonability of including these elements or other ones in the model, on the adequate understanding of the essence of an occurring phenomenon and process. It is very difficult to avoid mistakes at this stage, but a model should answer the purpose and the tasks of its creation.

The choice of a kind and a form of analytical dependences, including model coefficients, is frequently subjective, especially during modeling socio-economic systems, and it is determined in many respects by a researcher's view on a studied object. However, the consideration of coefficients not separately, but in system allows researchers to receive more exact parameters values. "A look from above" ensures the selection of coefficients values the most adequate to reality.

The lowering of the subjectivism influence on model quality can be partly achieved by a model complication, but with the growth of a model size the quantity of coefficients also grows.

Taking into account the priority of a socio-economic system essence over the ways of its formalization, it is necessary to note, that the model, we created, is first of all economic-organizational and then mathematical. Many modern system dynamics models are often oriented to a research method itself without the necessary analysis of the phenomenon essence.

It is also important to emphasize, that on the basis of the model of "urban effect" the assessment of social and economic development efficiency and not the assessment of social and economic development is made, though in the scientific literature these phrases are frequently used as equivalents. The usage of the concept "development efficiency" implies the estimation of the costs and the results of this development.

6. DATA

St. Petersburg (Russia) is chosen as a test area of the research, allowing us to test the model of "urban effect" in practice.

The information base of the research includes the legislative and normative acts of state and municipal authorities concerning the questions of social, economic, territorial development, town-

planning documentation. The main among them are the Constitution of the Russian Federation, the Town-planning code, the Land code of the Russian Federation, building regulations, etc.

The main data sources of model parameters are the following:

1. The annual statistical report "St. Petersburg in 2009", prepared and published by the Territorial Body of the Federal State Statistics Service in St. Petersburg and Leningrad Region in 2010;

2. The data of the Federal State Statistics Service, posted on its official website www.gks.ru;

3. The General plan of St. Petersburg till 2025;

4. The General plan of Leningrad and Leningrad region till 2005;

5. The materials of the Forecast of St. Petersburg social and economic development till 2025.

The total costs of city maintenance and development are calculated by multiplying per unit costs by corresponding volume parameters. As it was mentioned above, the unit costs of city economy objects maintenance and development are estimated on the basis of the cost-based subsystems of the model (the blocks "Engineering and transport infrastructures" and "Social infrastructure") and include:

- the unit costs of city economy objects development;
- the unit costs of city economy objects major overhaul;
- the unit costs of city economy objects maintenance.

The unit costs of city economy objects development are determined with the help of "The Book of the Aggregated Costs of Building, Engineering Equipment, Beautification and Landscaping of Cities of Different Size and Economic Specialization for All Geographical and Climatic Zones of the Country", prepared by the Central research and planning institute of town-planning (USSR, Moscow) in 1986. Information from the document "Progressive Unit Engineering-and-economical Parameters of Engineering Structures" (published by the Design institute on projecting urban engineering constructions "Lengiproengproject" (USSR, Leningrad) in 1989) was also used for the estimation of engineering infrastructure objects construction costs.

To convert costs in prices of 1984 into costs in current prices we used the indexes of construction budget recalculation, which are published by St. Petersburg Regional Center on Pricing in Construction Co., Ltd monthly. For example, to update unit costs in prices of 1984 to prices of 2009 we applied the indexes, published in the letter of St. Petersburg Regional Center on Pricing in Construction Co., Ltd of December, 14, 2009 № 2009-12i "About the enactment of the regional indexes of construction budget recalculation for application since December, 1, 2009".

By calculating the unit costs of major overhaul it was assumed, that they make up 50% - 60% of the unit costs of city economy objects development.

The unit costs of city economy objects maintenance was determined on the basis of St. Petersburg legislation, including the laws under the title "About the budget of St. Petersburg" over the period 2002-2009 (for example, the law of St. Petersburg of December, 01, 2008 № 730-129 "About the budget of St. Petersburg for 2009 and for the planning period of 2010 and 2011 years").

Besides, the data of All-Russia informational and analytical journal "Pricing and Budget Setting in Construction", published by Coordination Center on Pricing and Budget Setting in Construction (Russia, Moscow) and Regional Center on Pricing in Construction (Russia, St. Petersburg), are applied for the calculation of unit costs.

To estimate the total costs of city maintenance and development we also used the information and analytical reviews of the Government Committees of St. Petersburg, the data of the printings "Information Newsletter of St. Petersburg City Administration", "Real Estate and Construction of St. Petersburg", "Building Weekly".

The main difficulty of unit costs calculation lies in the absence of a uniform data source. Therefore, to carry out this research all spectrum of the accessible information sources was used. The priority was given to official publications.

Materials of theoretical and practical conferences, seminars, periodicals and source information, which we collected in the course of research execution, were also applied.

In this paper cost parameters are given in current prices. On the basis of the results of price dynamics analysis it is assumed, that over a period of 2009 to 2025 cost parameters will grow two times (ca. 5% a year) because of inflation.

The data are grouped into the subsystems of the model of "urban effect".

For the analysis of St. Petersburg social and economic development the data over the period of 1985 to 2009 were used. The forecast of social and economic indicators values was executed for the period from 2009 to 2025. The forecast was made with the help of the standard methods of mathematical statistics or on the basis of expert judgements: when the obtained equations were not suitable for the forecast by formal statistical criteria or by the logic of social and economic phenomenon development; the forecast was carried out on the basis of expert evaluations of the most probable development scenario. The forecast of levels values was executed on the basis of the model of "urban effect".

The forecast was carried out taking into account the observed tendencies of the social and economic development of big cities in whole and St. Petersburg in particular, the plans and the forecasts of the Governments of the Russian Federation and St. Petersburg. These tendencies and plans are realized in the model of "urban effect" with the help of the system of coefficients (in the terms of

system dynamics - with the help of the system of input variables-regulators). These coefficients are important parameters of a system dynamics model because by their variation the character and the degree of management influence on the social and economic development of the researched big city can be analysed.

Parameters values, used for testing the model of "urban effect" by the example of St. Petersburg, can be given on request.

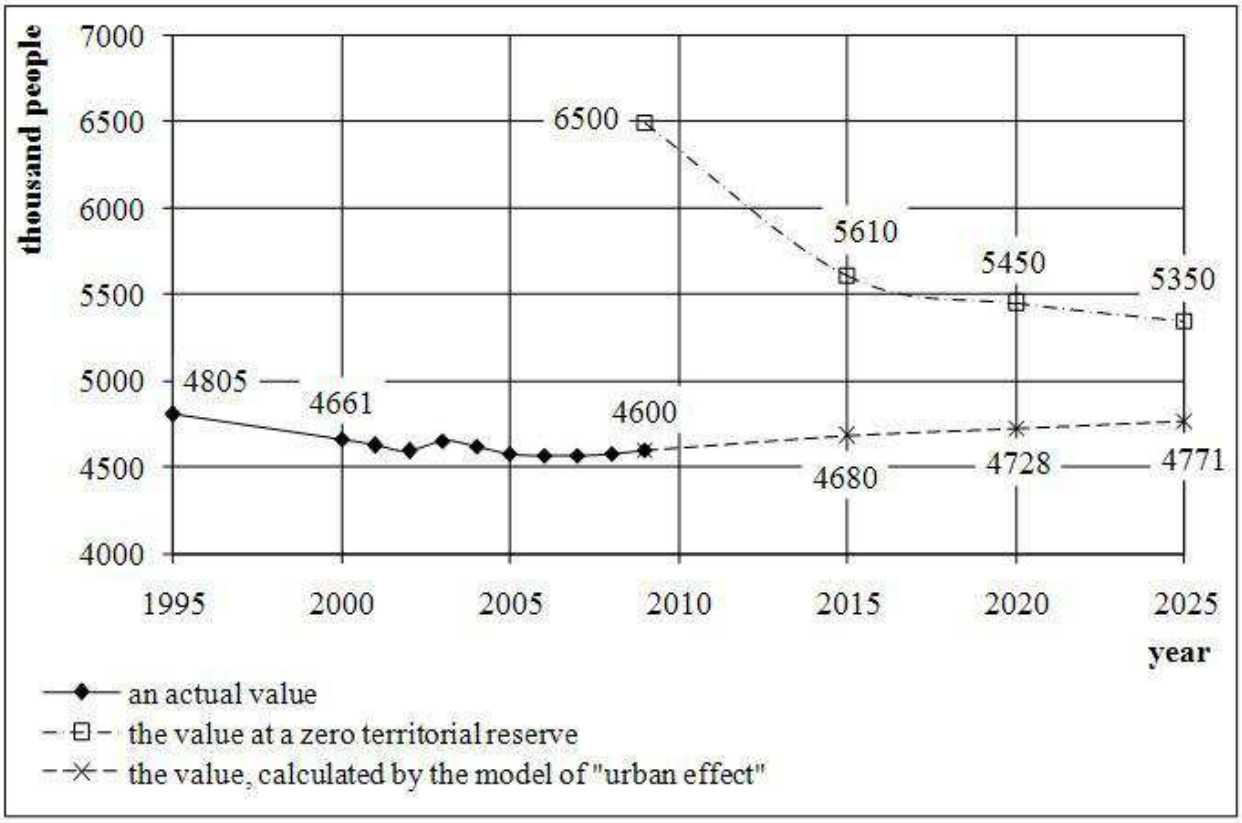
The parameters calculation and the assessment of regression and trend equations were executed with the help of the software product Statgraphics Plus 5.1. Figures, intermediate calculations were made with the help of the program Microsoft Excel 2007. The construction and the simulation of the model of "urban effect" were made with the use of the software product AnyLogic (version 5.2).

7. THE ESTIMATION OF URBAN GROWTH LIMITS

With the help of the model of "urban effect" the efficiency borders of big city social and economic development, which are the top and bottom limits of its sustainable development, can be estimated.

We begin with the analysis of the upper efficiency border of urban development, calculated by the example of St. Petersburg.

For big cities territorial resources act as a limiting factor of their development. The constant deficiency of free territories is peculiar to them. Having set a required living standard, it is possible to determine a city population size at a zero territorial reserve, in other words, the maximum population size, which can "be located" on the limited city territory. The relation between a living standard and city territorial resources is realized by the unit demand for territory of the elements of the elaborated system dynamics model. The higher the standard of city dwellers' living is, the larger the resources consumption is.



Notes: The standard of living constantly grows with the course of time.

FIGURE 3: The Dynamics of the Resident Population of St. Petersburg

Figure 3 depicts the evolution and the forecast (on the basis of the model of "urban effect") of the resident population size of St. Petersburg and also the dynamics of the city population size at a zero territorial reserve. The living standard is predicted to grow in perspective (till 2025), so the maximum population size, which can "be located" within fixed city boundaries, will go down. The values of the forecasted population size and the values of the population size at a zero territorial reserve will gradually approach each other.

To estimate the lower efficiency border of St. Petersburg social and economic development it is necessary to find a break-even point, which corresponds to the city population size, at which the total costs of city maintenance and development is equal to its incomes (to the part of its regional GDP, going on the recovery of these costs). If the total costs of city maintenance and development exceed its incomes, the city will become unprofitable and will not be able to function and develop sustainably without outside support.

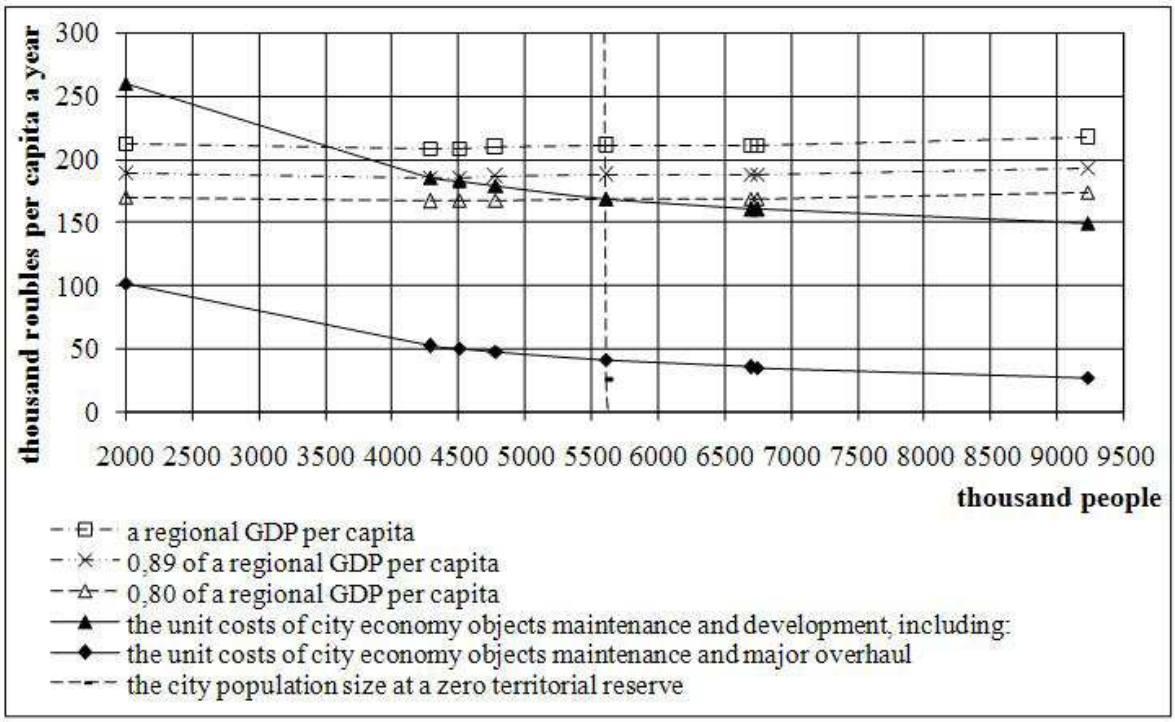


FIGURE 4: The Dependence of the Unit Costs of City Economy Objects Maintenance and Development and the City Regional GDP per Capita on its Resident Population Size (in 2015).

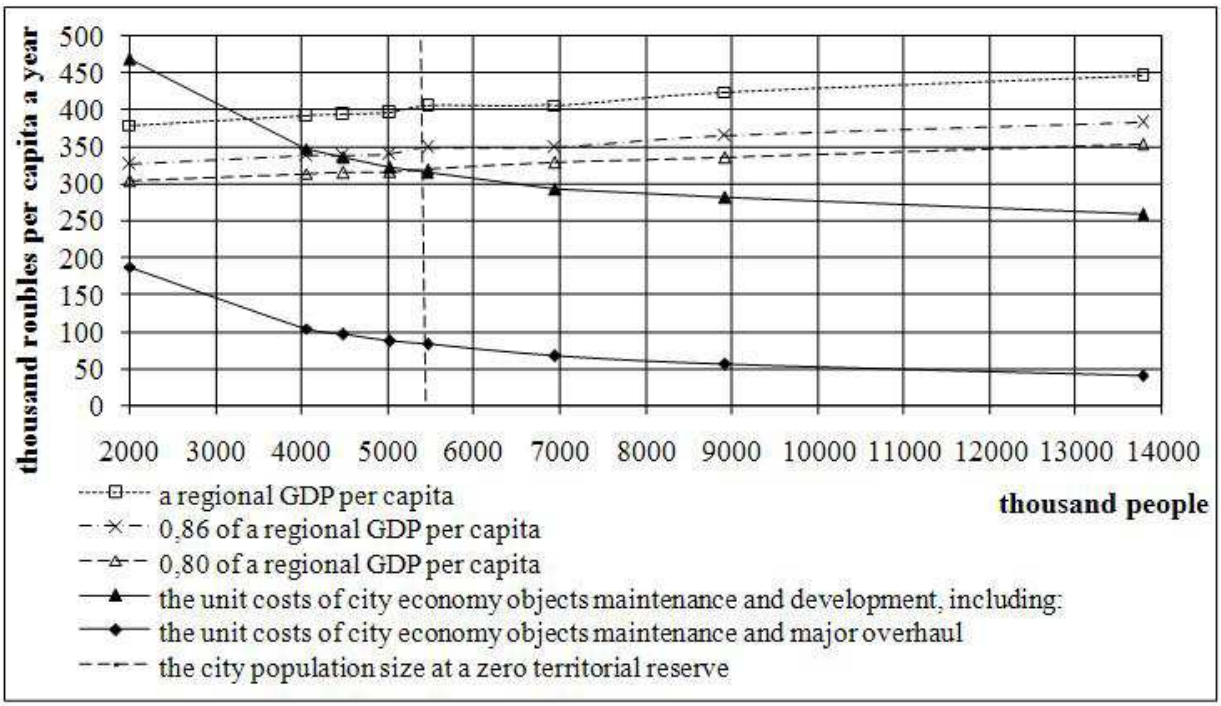


FIGURE 5: The Dependence of the Unit Costs of City Economy Objects Maintenance and Development and the City Regional GDP per Capita on its Resident Population Size (in 2020).

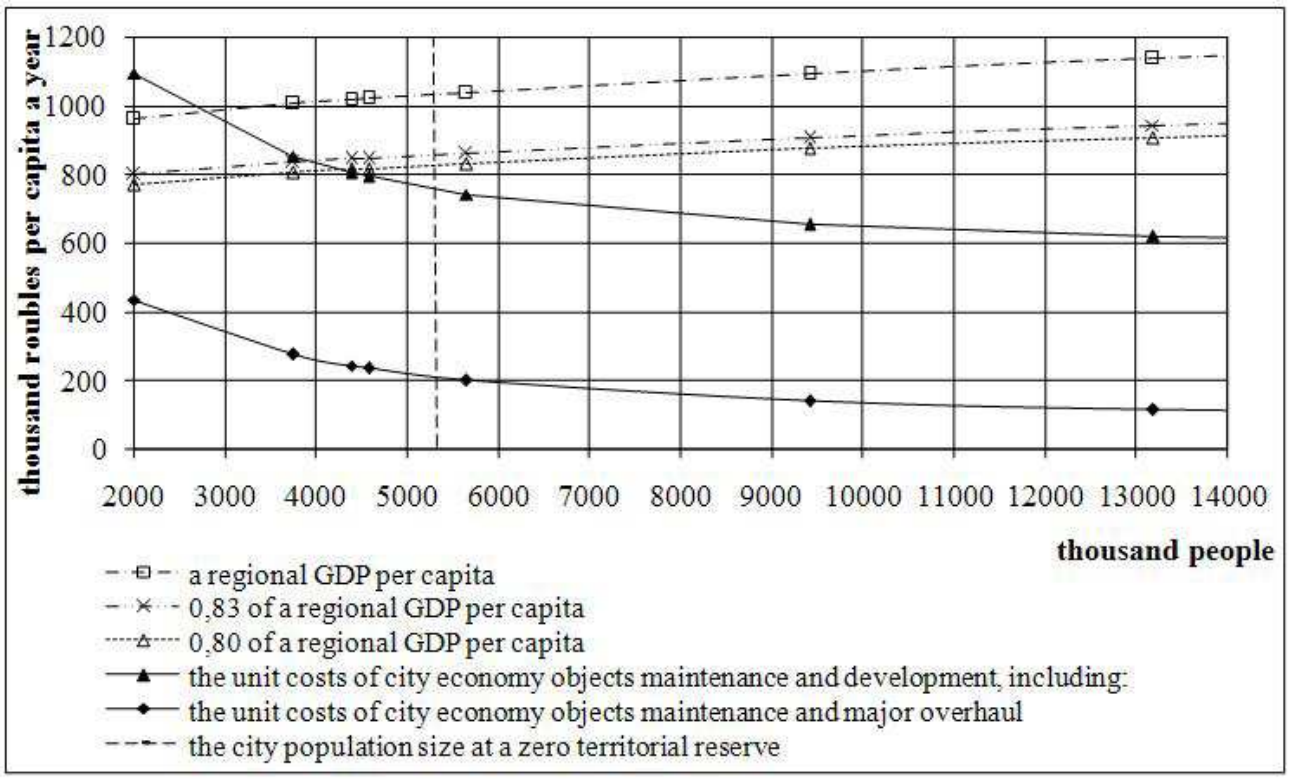


FIGURE 6: The Dependence of the Unit Costs of City Economy Objects Maintenance and Development and the City Regional GDP per Capita on its Resident Population Size (in 2025).

Figure 4 - 6 indicate, that the unit costs of city economy objects maintenance and development decrease with the increase of a city population size. As it was mentioned above, for the purposes of this research unit costs are divided into variable and constant ones. The first depend on a population size, the second do not depend. The costs of city economy objects development belong to the first group, the costs of their maintenance and major overhaul - to the second. The less a city population size is, the bigger part of constant unit costs falls on each city dweller. In turn, with the increase in population the unit costs of city economy objects maintenance and development tend to their constant component - to the costs of the maintenance and major overhaul.

The forecasted ratio between the constant and the variable components of the unit costs of city economy objects maintenance and development is given in Table 1:

TABLE 1: The Forecast (on the Basis of the Model of “Urban Effect”) of the Ratio between the Constant and the Variable Components of the Unit Costs of City Economy Objects Maintenance and Development

Year	Population, thousand people	The percentage of the component in the size of the unit costs of city economy objects maintenance and development, %	
		Constant component (the unit costs of city economy objects development)	Variable component (the unit costs of city economy objects maintenance and major overhaul)
2009	4600	77	23
2015	4680	73	27
2020	4728	71	29
2025	4771	70	30

The forecast, given in Table 1, shows the trend of the ratio change for perspective: with the resident population reduction the share of the unit costs of city economy objects development decreases and the share of the unit costs of their maintenance and major overhaul increases correspondingly.

The increase or decrease in the standard of city population living "moves" the unit costs curve upwards or downwards, respectively. Inflation also shifts the unit costs curve upwards (in the model of "urban effect" it is accepted, that from 2009 to 2025 a price level will grow two times because of inflation).

In contrast to the unit costs of city economy objects maintenance and development a regional GDP per capita grows with the increase in city population size. As it was mentioned above, such regularity is caused by the fact, that the big city is a financial and business centre, in which tertiary and quaternary economic sectors, accumulating the considerable volume of surplus product of the region and country economy, are widely represented. The bigger the city is (its population size), the wider the sphere of its influence is. The biggest cities of the world (for example, Tokyo, London, New York) exercise the influence over the whole world development. This regularity is taken into account in the model of "urban effect".

The part of a regional GDP, which goes to the recovery of city maintenance and development costs, plays a big role at the estimation of the lower efficiency border. The bigger this part is, the smaller the population size, at which the equality between city economy objects maintenance and development costs per capita and the corresponding part of a regional GDP per capita is achieved, is. In other words, the increase in the part of city maintenance and development costs in a regional GDP allows city government to provide more city dwellers with a certain standard of living (see Figure 4 - 6). It occurs, because with the decrease in a city population size the per capita costs of city economy

objects maintenance and development grow and, consequently, more money for their compensation is needed.

In view of the aforesaid it is possible to conclude, that the larger the size of city population is, the less money for achieving a certain standard of city dwellers' living is needed. And with the growth of a city population size its regional GDP per capita also increases. Due to economy of scale in big cities the per capita costs of city economy objects maintenance and development are smaller, and incomes (also per capita) are higher. However, almost in all big cities territorial resources act as a limiting factor of their growth.

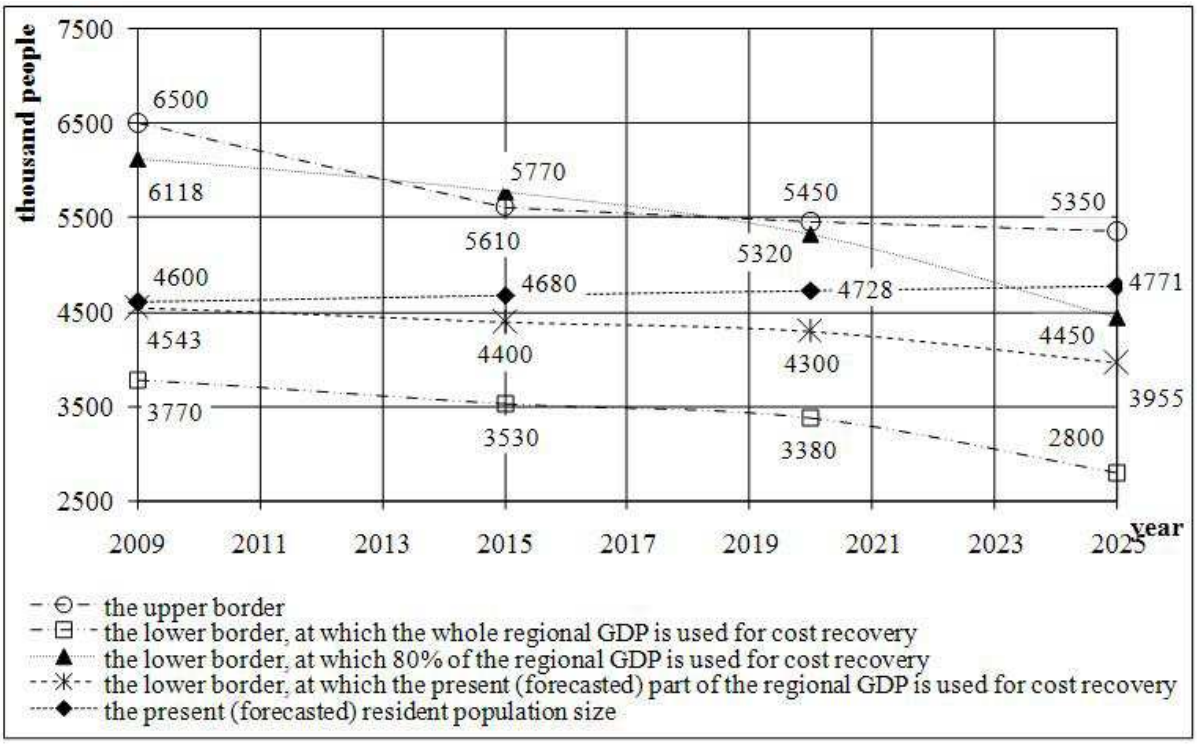


FIGURE 7: The Efficiency Borders of St. Petersburg Social and Economic Development for its Resident Population.

Figure 7 presents the estimation results of St. Petersburg population size, at which the equality between city economy objects maintenance and development costs per capita and city incomes per capita is achieved. And not to misrepresent the real situation (St. Petersburg is a donor for the budgetary system of the Russian Federation) tax and non-tax payments, which go to the budgetary system of the Russian Federation, were subtracted from the regional GDP, and the investments in fixed assets from the federal budget were added.

After the above-mentioned corrections we calculated the break-even points, at which the whole regional GDP, 80% of the regional GDP and the present (forecasted) part of the regional GDP were

used to refund the costs of city economy maintenance and development. The present (forecasted) part of the regional GDP, spent on the maintenance and rise in living standards, is equal to 0,90 in 2009, to 0,89 in 2015, to 0,86 in 2020 and to 0,85 in 2025. The use of the regional GDP for final consumption (for the recovery of city economy objects maintenance and development costs) will gradually reduce.

In this research the efficiency borders of urban development were estimated not only for a resident population size, but also for the following parameters: the income level of city dwellers, industry efficiency, budget efficiency, building density, an indicator of vital space[5], population density, a provision of city dwellers with greenery for general use, etc. The results of the calculation of the efficiency borders for the foregoing parameters by the example of St. Petersburg revealed the unsustainability of city territorial development (building density growth, greenery area reduction), demanding immediate state measures against it.

8. THE COST OF URBAN GROWTH AS AN ECONOMIC TOOL OF CITY MIGRATION POLICY

In our opinion, carrying out a science-based migratory policy of a big city is impossible without the calculation of the indicator "the cost of urban growth". It shows the cost of city newcomer (for constant residing) provision with the standard of living, generally accepted in the city.

Table 2 conveys the dynamics of the indicator "the cost of St. Petersburg growth", taking into account the forecasted growth of city dwellers' living standard.

TABLE 2: The Dynamics of the Cost of St. Petersburg Growth (in Prices of 2009)

Indicator	Measurement unit	Living standard, established by legal regulations	Living standard in year			
			2009	2015	2020	2025
The cost of urban growth, including:	thousand roubles per capita	815,8	159,3	445,4	592,5	835,4
	%	100	100	100	100	100
- the costs of housing stock construction	thousand roubles per capita	667,4	111,2	332,0	434,8	632,0
	%	82	70	75	73	76
- the costs of social infrastructure objects construction (excluding housing stock)	thousand roubles per capita	91,0	15,2	48,7	68,4	106,4
	%	11	10	11	12	13
- the costs of engineering and transport infrastructure objects construction	thousand roubles per capita	57,4	33,0	64,6	89,2	97,1
	%	7	21	14	15	12

[5] We suggest calculating the indicator of vital space as a difference between a land lot area and a building area per person, living on this land lot.

Table 2 illustrates, that in comparison with the present structure of the cost of urban growth (in 2009) in the structure, estimated in case of city newcomer provision with a standard of living, established by legal regulations, the costs of engineering and transport infrastructure objects development have a smaller part in the total costs, and the costs of social infrastructure objects development have a bigger one. Such costs distribution indicates the underfunding of social infrastructure development in 2009. To fulfill legislative requirements the increase of capital investments in social infrastructure is needed.

And the forecast on the basis of the model of "urban effect" shows, that the costs of engineering and transport infrastructure objects development will gradually decrease, and the costs of social infrastructure objects development will grow.

According to our forecast in 2015 the number of new city dwellers will make 45,0 thousand people per annum, in 2020 - 39,0 thousand people, in 2025 - 35,0 thousand people (in 2009 it was equal to 57,3 thousand people). Then to provide city newcomers with the predicted standard of living in 2015 it will be necessary to spend 5102,4 million roubles, in 2020 – 6148,9 million roubles, in 2025 – 7116,3 million roubles (without taking into account the costs of housing stock construction, in prices of 2009). In case of newcomers number growth in perspective, the volumes of compensating payments will also increase in the future.

The question about the sources of city growth financing (about the financial resources, which are necessary to provide new city dwellers with a certain standard of living) is closely connected with the migratory policy of both a big city in particular and a country in whole. It undoubtedly demands a research, which will help to avoid unemployment growth in one regions of a country and human resources deficiency in others, to attract highly skilled foreign specialists in the country.

However, the necessity of searching for the sources of financing the construction of additional social, engineering and transport infrastructure objects for migrants and their families is obvious.

If a company is interested in the attraction of migrants, it must indemnify the costs of providing them and their families with a certain standard of living.

If the attraction of highly skilled specialists in the country pursues national interests, the state budget can refund these expenses, because the attraction of such specialists will be compensated by the state profit from their work in full.

Now we unfortunately observe an unfavorable situation, when lowly skilled foreign workers arrive in St. Petersburg. The attraction of these migrants for a low wage is profitable for companies. And the costs of cheap labour attraction weigh on city dwellers' shoulders, reducing their standard of

living. This problem is typical not only for St. Petersburg, but also for the majority of big cities in the world.

The provision of migrants with a certain living standard demands the involvement of not only financial, but territorial resources. With the increase in a living standard the demand for territorial resources per capita also grows. In 2009 the demand for territorial resources per man, who had arrived in the city for constant residing, was at the level of 33 sq. m, and as forecasted it will be equal to 39 sq. m in 2015, 56 sq. m in 2020 and 89 sq. m in 2025. These values include the consumption of territorial resources for the placement of social infrastructure objects (including housing stock, public service establishments), engineering and transport infrastructure objects, which are necessary to provide migrants with certain living conditions.

9. THE MECHANISMS FOR REGULATING ST. PETERSBURG SOCIAL AND ECONOMIC DEVELOPMENT

There is a necessity of incorporating complex assessment results into the mechanisms for managing urban development. The elaboration of measures to maintain urban development sustainability, based on complex assessment results, raises its (assessment) practical value.

The measures, which we worked out for St. Petersburg, can be applied to any other big city, adjusted for its local specificity. These measures can be referred to the three basic mechanisms for managing the development of socio-economic systems: organizational-economic, investment and normative-legal.

Within the framework of *the organizational-economic mechanism* for regulating urban development the following measures can be offered:

1. The systematization and the updating of the information on the volumes of capital investments in urban development; the systematic account and forecast of not only city incomes (a regional GDP), but also of its costs;

2. The unification of the set of urban social and economic development indicators, allowing researchers to track the dynamics of city territorial, labour and financial resources;

3. The increase in the period of data consideration at the analysis and the forecast of cities development (from 5-10 to 15-20 years);

4. The organization of the regular monitoring of urban social and economic development on the basis of the methodology, offered in this research.

The measures, belonging to *the investment mechanism* for regulating city social and economic development, are the following:

1. The increase in the part of city budget expenses, going on the city social, engineering and transport infrastructures development, up to 30%-50% and more. In 2009 capital investments made up only 19,0% of the total expenses of St. Petersburg budget (in 2008 – 21,4%, in 2007 – 14,1%);

2. The fixation and the control of the prices for city infrastructure services by state authorities.

The most socially and economically significant branches of city economy, which demand state regulation, including tariff policy development and realization, are city engineering and transport infrastructures, housing and communal services.

The performed calculations show, that the prices for the housing and communal services, which cover the costs of city housing stock maintenance (without taking into account the profit of the enterprises, providing housing and communal services), made:

- 29,4 roubles/ sq. m floor area a month in 2009 (for comparison: in 2009 the average size of the payment for housing services was equal to 32,6 roubles/ sq. m floor area a month);
- 40,1 roubles / sq. m floor area a month in 2015;
- 52,6 roubles / sq. m floor area a month in 2020;
- 75,5 roubles / sq. m floor area a month in 2025 (in current prices; under the assumption that from 2009 to 2025 the overall price level will grow two times).

The prices for engineering and transport infrastructures services have different measurement units; this does not allow us to calculate a common price for all provided services. So in this paper we estimate the recommended structure of the prices (without taking into account the profit of public utility enterprises). The price component completely covering the current expenses for infrastructure enterprises maintenance, should have made 74,4% of the total price size in 2009, and by 2025 it should increase up to 78,6%. The component, completely refunding the expenses for the development and the modernization of engineering and transport infrastructure enterprises, should have made 25,6% of the total price size in 2009, and by 2025 it should decrease to 21,4%. The growth of the price part, which goes on the current maintenance costs indemnification, is caused by the increase in engineering and transport infrastructure objects quantity as a result of the realization of the city government near-term plans for infrastructure objects construction. To maintain these objects additional financing will be required.

To avoid the ungrounded increase in the financial burden of city dwellers and enterprises the prices for the city infrastructure enterprises services must be fixed by state authorities, taking into consideration the actual, but not the normative expenses of enterprises.

One of the main measures of *the normative-legal mechanism* is an improvement of the system, which orders the normative values of city social and economic development indicators.

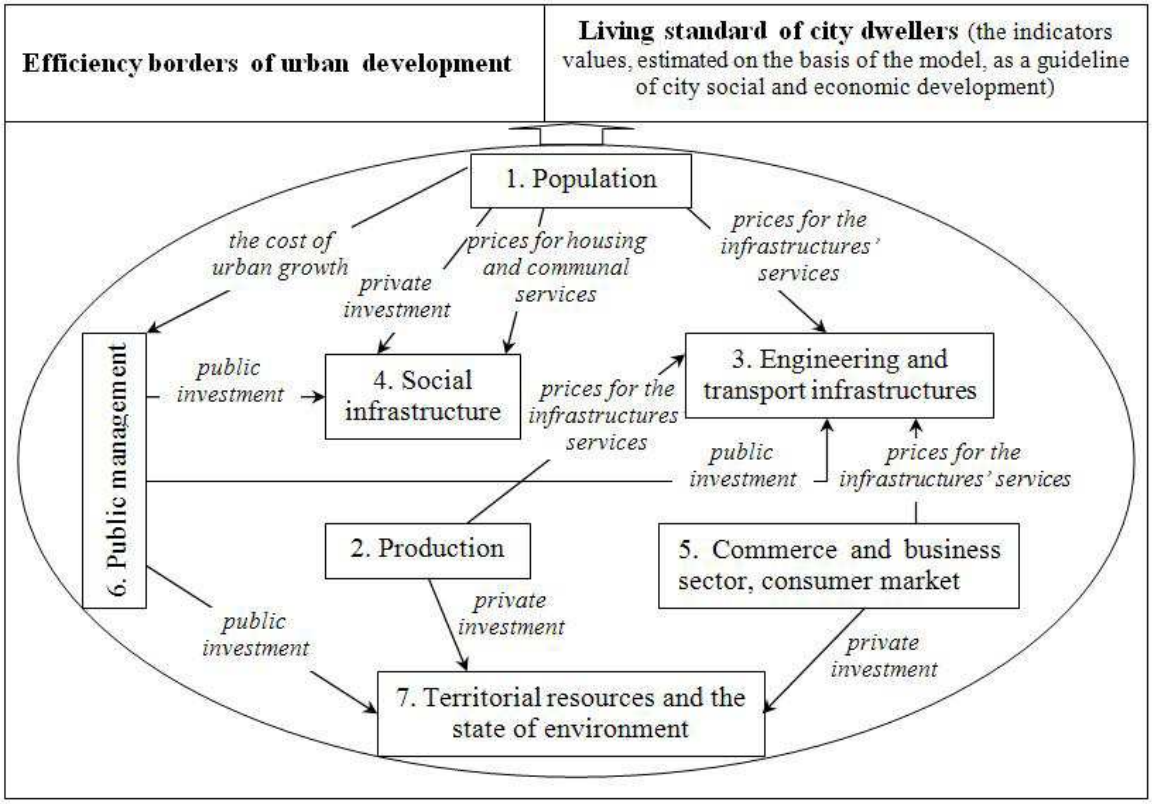
We offer to carry out the city development normalization on the basis of the system dynamics approach in two steps:

1. At the first step to assess the efficiency borders of city social and economic development the part of a regional GDP, which covers the costs of city economy objects maintenance and development, should be determined. This part and the standard of city dwellers' living are to be fixed by the city government;

2. At the second step according to the estimated efficiency borders (see Figure 7) the city government accepts the system of urban social and economic development indicators values, calculated with the help of the model of "urban effect".

This system of indicators values acts as a goal of city social and economic development. These values can serve as a guideline of the social and economic policy, pursued by the city government. The keeping of the efficiency borders allows city authorities to judge about the sustainability of city development.

The offered measures of increasing city development efficiency are generalized in Figure 8.



Notes: Arrow denotes connection between elements (blocks) of the system dynamics model; rectangle represents an element (block) of the system dynamics model.

FIGURE 8: The Mechanisms for Regulating Urban Social and Economic Development on the Basis of the System Dynamics Approach.

These measures realize theoretical propositions, considered in this paper, in practice. In particular, the practical importance of the research consists in the opportunity of working out city dwellers' living standards and of the determining the prices for city infrastructure services in view of urban socio-economic system dynamics.

In addition, the practical importance lies in the fact that the economic evaluation, executed in this paper by the example of St. Petersburg, can be also carried out for other big cities, taking into account their local peculiarities.

10. CONCLUSION

The fulfilled research, described in this paper, allows us to draw the following basic conclusions:

1. The efficiency of big cities social and economic development with its dynamism and the instability of environmental conditions can be complexly economically evaluated;

2. The complex efficiency assessment of big cities social and economic development on the basis of the system dynamics approach is feasible;

3. The keeping of the efficiency borders of urban social and economic development allows city authorities to make city development sustainable.

The main result of the research is the methodology, which we have devised to carry out a complex efficiency assessment of urban social and economic development on the basis of the system dynamics approach. It includes the following elements:

- the system dynamics model of urban development - the model of "urban effect";
- the estimation of the efficiency borders of city social and economic development with the help of the model;
- the construction of indicators system on the basis of the model, including the parameter "the cost of urban growth";
- the elaboration of the mechanisms for regulating urban social and economic development.

With the help of this methodology it is possible to find the efficiency borders of city social and economic development, to predict the consequences of their violation, to estimate the cost of urban growth.

The application of the system dynamics model as a methodical basis of complex efficiency assessment of big cities development will allow researchers to improve existing approaches by taking into account the system attributes of big cities and the dynamism of their modern development. It will help city government to achieve the final result of its activity - the growth of city dwellers' living standard.

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