MODEL OF MANAGING OF THE PROCEDURE OF MUTUAL FINANCIAL INVESTING IN INFORMATION TECHNOLOGIES AND SMART CITY SYSTEMS

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ABSTRACT

Mathematical model for finding management strategies investing in information technologies and systems that associated with the concept of Smart City is presented in the article. The model proposed by the authors, first of all, should be considered as a component of intellectual system of decisions support in tasks of analysis of various strategies of mutual financial investing in information technologies and Smart City systems. The model is conceptually constructed on the solution of a bilinear dynamic game of quality with several terminal surfaces, and its distinctive feature is the fact...
that discrete equations, which setting the dynamics of the game, been written using arbitrary coefficients. The results of experiments that performed in the environment of simulation modeling Matlab/Simulink are present in the article. Operability and adequacy of the model for tasks of analysis of various strategies of investing in information technologies and Smart City systems were confirmed by results of simulation modeling.

**Keywords:** Smart City, optimal strategies of investing, the differential game, decisions making support system

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1. INTRODUCTION

The growth rate and the number of investment projects in technologies of Smart Cities and, in particular, in information technologies and systems that associated with rapid urbanization and digitalization of urban infrastructure, according to many analysts in this area, will increase for many more years [1, 2].

This circumstance formed a stable demand not only for modern information and communication and geo information systems, but also has given rise to a separate direction of scientific publications, which associated with researches on the effectiveness of investing in digital technologies Smart City, as well as appropriate equipment, variety of products and services in the field of intelligent systems of electric and water supply, monitoring of the environment, etc.

The procedure of investing in innovative projects, for example, in the field of information technologies (IT) and Smart City systems, is often characterized by a high degree of uncertainty and riskiness.

As been noted by many experts in the field of investing in Smart City projects it is advisable to use the potential of various computerized decision support systems (DSS) in the tasks of analysis of various strategies of the investors to improve performance and effectiveness of evaluating of such large projects [3]. Especially it’s relevant for large interstate or interregional Smart City projects. In modern DSS is possible to use various adaptive algorithms with elements of self-learning, in particular, in the tasks of analysis of investing strategies in Smart City, for implementation of which the financial resources of different parties are attracted.

The filling of the DSS and their individual modules that directly responsible for the analysis and solution of specific investment tasks, is carried out by introducing separate program-algorithmic blocks. Blocks can include own adaptive algorithms for economic and mathematical models. However, many of available on the market analysis of investment projects of software products (this applies in particular to projects for investing in Smart City) do not allow to optimize the procedures that associated with finding various variants of strategies in the mutual financial investing of the parties in the project [3, 4]. In this regard, the development of new economic and mathematical models for DSS is relevant that will allow adequately describe real processes of financing Smart City that caused of the growing level of competitiveness of various players in this market.

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2. LITERATURE REVIEW AND PROBLEM POSING

The number of interesting studies [5-7] over the past few years is dedicated to issue of choosing effective strategies of financial investment in Smart City. The development of intelligent computing technologies [5] has led to an independent field of research, which are devoted to the application of expert systems [8, 9] and decision support systems (DSS) [10, 11] in the tasks of determining rational strategies for investing in the field of IT, and partially Smart City. As shown by the analysis of the mentioned publications [8, 10, 11], the authors in most cases did not offer real recommendations in the process of searching rational strategies of mutual financial investing in similar spheres of human activity. And besides, as the authors themselves acknowledge [9, 11], the proposed models lack the adaptivity properties, that is, require adjustment even in the case of slight change of list of initial parameters and boundary conditions of the analysis of attractiveness for the investor of the Smart City project.

In [4, 5] the authors showed that united in a single whole of all aspects of Smart City technological infrastructure will contribute to successful development of Smart City. New IT that including the widespread use of smartphones, the growing popularity of online transactions and P2P-technologies, will give to municipal authorities of Smart City the opportunity to effectively interact with citizens. In [5, 6] was shown that investment of funds in technologies of mobile applications and distributed sensor systems is effective way to directly interact with citizens.

The foregoing and caused the problem that associated with the need to develop new adaptive models for DSS [12] in the tasks of determining rational strategies of mutual financial investing in Smart City projects. Based on our previous experience and approaches, which we described in earlier publications on this topic [13-15], we can affirm that the use of methods of the theory of multi-step and differential games of quality with several terminal surfaces [15] is sufficiently effective approach in solving this class of tasks.

The analysis of publications on this subject confirmed the relevance of the issue of further development of adaptive models and corresponding algorithms for DSS in the tasks of discrete and continuous mutual investing in Smart City.

3. GOAL AND OBJECTIVES OF THE STUDY

Research goal is model for the module of computer system of decisions making support in the course of discrete mutual investing in information technologies and Smart City systems.

To achieve the research goal, it is necessary to develop:

An adaptive model of search of rational strategies for managing mutual investing for various ratios of parameters of investment process in information technologies and Smart City systems;

A simulation model in the Matlab/Simulink environment to solve the task and perform simulation modeling for various strategies of investing in information technologies and Smart City systems.

4. MODELS AND METHODS

Let's consider such situation. Investor from sphere of IT (an example is considered for investing in IT infrastructure of Smart City) of the country, where more strong currency ($1$) is used in money circulation, having free financial resources (hereinafter the $FRE$), tries to choose the most preferable variants of its placement in Smart City technologies. To do this, he has to choose himself counterparty. Default the counterparty uses more weak currency – $VL2$. Как было определено целью статьи рассматривается пример инвестирования в ИТ
4.1. Model that describing the interaction of players

Interaction of players occurs when these assumptions are fulfilled (hereinafter the following summands: a) \( RG1 \) manages financial resources (hereinafter the \( FRE \) ) \( h \), estimated in \( VL1 \); b) \( RG2 \) manages \( FRE \) \( q \), estimated in \( VL2 \); c) during the interaction the ratio \( VL1 \) to \( VL2 \) (exchange rate) \( k_d \) remains constant. We denote by \( u \) and \( v \) \( (u \in [0,1], \ v \in [0,1]) \) – control actions of parties; \( f_i \) – share of resource \( RG2 \) that allocated for the repayment of own debts and for own functioning.

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Smart City. However, the proposed model is sufficient universal and can be scaled for more major tasks that are solved with the provision of relevant DSS, for example, at mutual investing of regions (\( RG \)) of different states. In the process of interaction, the investor and counterparty try to achieve their goals, in particular, each side (or the player from the point of view of the apparatus of game theory) strives to increase own capital.

Basically, the process of interaction of players (hereinafter referred to as \( RG1 \) and \( RG2 \) we describe it as: \( RG1 \), having some free (\( FRE \)), increases them by a factor of \( g_1 \) times (\( g_1 \) – growth rate of resources \( RG1 \)). Further, for example, with the provision of DSS, takes decision, which part of these resources will be allocated to active operations. These operations are to placement of the invested resources \( (1 - f_i(t)) \cdot u(t) \cdot g_i(t) \cdot h(t) \) (\( f_i \) – share of resource \( RG1 \) that allocated for the repayment of own debt and own functioning) in investment projects of Smart City. We believe that similarly arrives and \( RG2 \) towards \( RG1 \). Such assumptions are made in the proposed model: a) \( RG1 \) manages financial resources (hereinafter the \( FRE \) ) \( h \), estimated in \( VL1 \); b) \( RG2 \) manages \( FRE \) \( q \), estimated in \( VL2 \); c) during the interaction the ratio \( VL1 \) to \( VL2 \) (exchange rate) \( k_d \) remains constant. We denote by \( u \) and \( v \) \( (u \in [0,1], \ v \in [0,1]) \) – control actions of parties; \( f_i \) – share of resource \( RG2 \) that allocated for the repayment of own debts and for own functioning.

\[
\begin{align*}
    h(t+1) &= g_1 \cdot h(t) + [(1 - f_i(t)) \cdot (m_i(t) + p_i(t) - 1)] \cdot u(t) \cdot g_i(t) \cdot h(t) +
            [1 - (m_2(t) + p_2(t)) \cdot (1 - f_2(t))] \cdot v(t) \cdot g_2(t) \cdot \frac{q(t)}{k_d}; \\
    q(t+1) &= g_2 \cdot q(t) + [(1 - f_2(t)) \cdot (m_2(t) + p_2(t) - 1)] \cdot v(t) \cdot g_2(t) \cdot q(t) +
            [1 - (m_1(t) + p_1(t)) \cdot (1 - f_1(t))] \cdot u(t) \cdot g_1(t) \cdot h(t) \cdot k_d.
\end{align*}
\]
\[ u(t) \cdot f_1(t) \cdot g_1(t) \cdot h(t) \] resource that allocated to repay the debt, which prevailing in \( RG1 \) to the moment \( t \) to \( RG2 \);
\[ u(t) \cdot (1 - f_1(t)) \cdot g_1(t) \cdot h(t) \] resource that allocated for investing in IT Smart City at the moment \( t \);
\[ \{ g_2(t) \cdot (1 - (f_2(t)/k_d)) \} \cdot v(t) \cdot g_2(t) \cdot q(t) \] interest rate for InvR \( RG2 \);
\[ \{ (1 - (f_2(t)/k_d)) \} \cdot v(t) \cdot g_2(t) \cdot q(t) \] InvR \( RG2 \).

Similar summands will also be for the term (2). Thus, the value \( q(t+1) \) (in \( VL2 \)) at the moment \( t \) will be equal to the sum of such summands:
\[ g_2(t) \cdot q(t) \] value of percents \((\%)\) \( m_2(t) \cdot (1 - f_2(t)) \cdot v(t) \cdot g_2(t) \cdot q(t) \) for invested \( FRE \) \( RG2 \);
\[ (1 - f_2(t)) \cdot v(t) \cdot g_2(t) \cdot q(t) \] amount of InvR \( RG2 \);
\[ p_2(t) \cdot (1 - f_2(t)) \cdot v(t) \cdot g_2(t) \cdot q(t) \] the amount that characterizing the share of «returned» InvR \( RG1 \) in \( RG2 \);
\[ (1 - p_1(t)) \cdot (1 - f_1(t)) \cdot u(t) \cdot k_d(t) \cdot g_1(t) \cdot h(t) \] the amount of the «unreturned» asset (investment) in \( RG1 \) by player \( RG2 \);
\[ u(t) \cdot f_1(t) \cdot k_d(t) \cdot g_1(t) \cdot h(t) \] the amount that characterizing debt repayment \( RG1 \) to \( RG2 \);
\[ v(t) \cdot f_2(t) \cdot g_2(t) \cdot q(t) \] the amount that allotted by \( RG2 \) for debt repayment that prevailing of its to the \( RG1 \) at the moment \( t \);
\[ (1 - f_2(t)) \cdot v(t) \cdot g_2(t) \cdot q(t) \] the amount that allotted by \( RG2 \) for investing in IT Smart City at the moment \( t \);
\[ m_1(t) \cdot (1 - f_1(t)) \cdot k_d(t) \cdot u(t) \cdot g_1(t) \cdot h(t) \] interest payment for InvR \( RG1 \);
\[ (1 - f_1(t)) \cdot u(t) \cdot g_1(t) \cdot h(t) \] InvR \( RG1 \).

Interaction of players ends when conditions are met:
1) \( h(t+1) \geq 0 \); \( q(t+1) < 0 \); 2) \( h(t+1) < 0 \); \( q(t+1) \geq 0 \);
3) \( h(t+1) < 0 \); \( q(t+1) < 0 \); 4) \( h(t+1) \geq 0 \); \( q(t+1) \geq 0 \).

These conditions can be interpreted in this way: Condition 1. The situation of the loss of investment resources (capital) \( RG2 \). The player \( RG1 \) multiplied its capital by the amount of capital \( RG2 \). Condition 2. The situation of the loss of capital \( RG1 \). The \( RG2 \) multiplied its capital by the amount of capital \( RG1 \). Condition 3. The situation of the loss of capital \( RG1 \) and \( RG2 \) (default of both subjects of interaction). Condition 4. The ability of subjects to continue interaction.

The following question is considered in the article. How according to information about initial resources (capitals), rate of currency, growth rates of resources \( RG1 \) and \( RG2 \), interest rates for allocated capital, levels of payable balances and accounts receivable, determine the time of possible loss of capital (that is, InvR).

We used the theory apparatus of multi-step games of quality as a tool for solving the task [13–17]. This approach allows to determine the areas of possible initial states of resources.
(capitals) of interacting objects. At the same time, we believe that the objects have the following property: if the interaction starts from these states, then at one of moment $t$ possible loss of capital, either by one side of the interaction, or the other, gives an answer to question posed. Multi-step game of quality with two terminal surfaces was solved to find such ranges. The solution consisted in determining the sets of preferences of the parties. And besides, rational strategies of the parties were found when investing in IT Smart City.

Within the framework of this article, we limited ourselves to considering a simple variant of interaction, which allows making qualitative conclusions about the financial state of the subjects. And also can be easily implemented algorithmically in any high-level programming language, what will be shown in other parts of our research.

### 4.2. The solution of the task

As was shown above for the convenience of exposition in the course of the article, will be «identify» $RG1$ as player (I), and $RG2$ – as player (II). The above interaction will be considered within the framework of scheme of position multi-step game with complete information [14, 15]. Since theoretically the apparatus of the games theory is sufficiently developed, we omitted some definitions that we cited in our earlier publications (in particular, the «pure strategy of the player» [13, 15], «position» [14]. We denote by $T = \{0,1,...\}$ – discrete set that characterizing the range of the time parameter. Also $u(t)$ – control action based on any information that the player has. It is accepted that $u(t,h(0),q(0))$– the value that determines the size of the resource (capital) $RG1$, which he allocated for the investing to IT Smart City $RG2$ at the moment $t$.

A set of preference for $RG1$ necessary to determine after defining the strategies in task 1. Taking into account that for the presentation of the proposed approach it is sufficient to confine ourselves to a qualitative description, set of preference $W_i$ $RG1$ we give by following: $W_i$ – set of such initial resources $(h(0),q(0))$ $RG1$ and $RG2$, which have such property.

Property: for initial states there is strategy $RG1$, which, for any implementation of strategy $RG2$, «leads», in one of the moments $t$, state of system $(h(t),q(t))$ to this, at which condition (3) will be fulfilled. We believe that $RG2$ does not have a strategy that can «lead» to the fulfillment of condition (4), at one of the preceding moments $t$. Strategy $RG1$ with this property is called optimal. The solution of task 1 is to find a set of preference $RG1$ and its optimal strategies. Similarly, the problem is posed from the point of view of the second player-ally. Because of the symmetry of the formulation of the tasks, it suffices to confine oneself to the solution of task 1. The solution of task 2 is analogous. The solution of task 1 is found with the help of the toolkit of the theory of multistep games with complete information [13, 16–19], which allows to find the solution of the game for various ratios of game parameters. We give the solution of the game, that is, sets of preference $W_i$ and optimal strategies $RG1$.

Suppose that for any moment $t$ the conditions are met:

$$g_1(t) = g_1; \quad g_2(t) = g_2; \quad f_1(t) = f_1; \quad f_2(t) = f_2; \quad p_1(t) = p_1; \quad p_2(t) = p_2.$$ 

The following quantities we denote by $z_1$ & $z_2$:

$$z_1 = (1 - f_1) \cdot (m_1 + p_1) - 1; \quad z_2 = (1 - f_2) \cdot (m_2 + p_2) - 1.$$
There are four possible cases:

a) \( z_1 \geq 0; \quad z_2 \geq 0; \)

b) \( z_1 < 0; \quad z_2 < 0; \)

c) \( z_1 > 0; \quad z_2 \leq 0; \)

d) \( z_1 \leq 0; \quad z_2 > 0. \)

In addition, it must be taken into account that possibly a different ratio of growth rates \( g_1, g_2, \) namely, maybe \( g_1 > g_2 \) or \( g_1 \leq g_2. \)

In case a) and \( g_1 > g_2 \) there exists a finite number of sets of preferences \( W_i^j \) of the first player-ally that having this property.

**Property:** if \( (h(0), q(0)) \in W_i^j \), then \( RG1 \) by \( i \) steps can get the fulfillment of condition (3), no matter how acted \( RG2. \) Moreover, \( RG2 \) has strategy that does not allow \( RG1 \) to obtain the fulfillment of condition (3) in fewer steps. In this case \( W_i^j \) we write as:

\[
W_i^j = \{(h(0), q(0)) : k(i - 1) \cdot h(0) \leq q(0) < k(i) \cdot h(0)\}
\]

Where

\[
k(i) = \left( \frac{g_1}{g_2} \right) \left( \frac{z_1 + z_1 \cdot k(i - 1) + k(i - 1)}{1 + z_2 + z_2 \cdot k(i - 1)} \right), \quad k(0) = 0;
\]

\( i = 1, ..., k^* - 1; \quad k^* : k(k^*) > (z_1 / z_2), \quad k(k^* - 1) \leq (z_1 / z_2), \) (such \( k^* \) exists).

Set \( W_i^j (i = k^*) :\)

\[
W_i^j = \{(h(0), q(0)) : k \cdot (k^* - 1) \cdot h(0) \leq q(0) < (z_1 / z_2) \cdot h(0)\}
\]

Combining of sets \( W_i^j \) will determine the set of preferences \( RG1(W_i) \), that is:

\[
W_i = \{(h(0), q(0)) : q(0) \leq (z_1 / z_2) \cdot h(0)\}
\]

Moreover, from any state \( (h(0), q(0)) \) of this set \( RG1 \) can for finite number of steps (not more than \( k^* \) ) achieve the fulfillment of the condition (3).

In the case a) and \( g_1 \leq g_2 \) there exists a countable number of sets of preference \( W_i^j \) of first player-ally, who possess the following property. Property: if \( (h(0), q(0)) \in W_i^j \), then \( RG1 \) for \( i \) steps can obtain the fulfillment of condition (3), no matter how \( RG2 \) acted. \( RG2 \) has strategy, which does not allow \( RG1 \) to obtain fulfillment of condition (3) for fewer steps.

Set \( W_i^j \) we write as:

\[
W_i^j = \{(h(0), q(0)) : k(i - 1) \cdot h(0) \leq q(0) < k(i) \cdot h(0)\}
\]

Where

\[
k(i) = \left( \frac{g_1}{g_2} \right) \left( \frac{z_1 + z_1 \cdot k(i - 1) + k(i - 1)}{1 + z_2 + z_2 \cdot k(i - 1)} \right), \quad k(0) = 0.
\]

In this case \( W_i \) we write as:

\[
W_i = \{(h(0), q(0)) : q(0) \leq (z_1 \cdot h(0))\}
\]
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\[ z_* : z_* = \left( \frac{g_1}{g_2} \right) \cdot \left( z_1 + z_1 \cdot z_* + z_* \right) \]

where

Optimal strategy \( RG1 \) in these cases is the «allotment» of all capital for investment, on condition affiliation of resource \((h(0), q(0))\) to set of preferences \( RG1 \).

Sets of preference and optimal strategy \( RG2 \) is located absolutely symmetrically in these cases.

In case b) whole set \( R^2 \) is also preferable for \( RG1 \) and for \( RG2 \). In any strategy, players will be able to continue to interact.

In case c) and at the truth of inequality \((g_1/g_2) \cdot (z_1 + 1) \geq 1\), set of preferences for \( RG1 (W_1) \) are all valid initial resources, that is, \( R_{z^2} \). Set of preference \( W_2 \) does not exist in this case. Investing of all available resources in investments is optimal strategy \( RG1 \).

In case c) and at the truth of inequality \((g_1/g_2) \cdot (z_1 + 1) < 1\), set of preferences \( RG1 (W_1) \) we define as:

\[ W_i = \{(h(0), q(0)) : q(0) \leq (z_*) \cdot h(0)\}, \]

\[ z_* : z_* = (g_1/g_2) \cdot \left( \frac{z_1}{1 - (z_1 + 1) \cdot (g_1/g_2)} \right) \]

where

In this case, there exists a countable number of sets of preference \( W^i \) of first player-ally that possessing the property that if \((h(0), q(0)) \in W^i \), then \( RG1 \) for \( i \) steps can obtain the fulfillment of condition (3), no matter how \( RG2 \) acted. Moreover, \( RG2 \) has strategy, which does not allow \( RG1 \) obtaining the fulfillment of condition (3) in fewer steps.

Set \( W^i \) we write as:

\[ W^i = \{(h(0), q(0)) : k(i - 1) \cdot h(0) \leq q(0) < k(i) \cdot h(0)\}, \]

where \( k(i) = (g_1/g_2) \cdot (z_1 + z_1 \cdot k(i - 1) + k(i - 1)), \]

Investing of all available resources in investments is optimal strategy \( RG1 \).

Set of preference \( W_2 \) does not exist in this case.

5. SIMULATION EXPERIMENT

Quantitative analysis of the parameters that obtained in the process of searching of rational financing strategies in information technologies and Smart City systems was carried out by simulation modeling in the Matlab/Simulink environment. Appropriate simulation model was constructed for this. The simulation model contains blocks for equations (1) and (2). Simulation model is implemented on the basis of the standard blocks of the Matlab/Simulink 2016a environment. The main results of the simulation are shown in Figures 1 and 2.

On the graphs of Fig. 1 and 2, the h-axis means «million $ (in our case \( VL1 \)). In Fig. 1 tangent of inclination angle is equal to «2». In Fig. 2 tangent of inclination angle is equal to

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«3». Q-axis means «UAH million» (VL2, for the case of the national currency of Ukraine, the current rate is 1 $ = 27 UAH).

1– Trajectory of the player’s movement; 2– Equilibrium ray

**Figure 1** Computational experiment №1

**Figure 2** Computational experiment №2

In Fig. 1 and 2, the trajectory of movement of investors is shown in green (Figure 1) or blue (Figure 2) dotted line (number of line 1). Equilibrium rays are shown in Fig. 1. and 2 red solid line with red round markers.

6. RESULTS AND DISCUSSION

The model of interaction procedure for players $RG_1$ and $RG_2$, set forth in the article, is a process of predicting the results of investing in IT and Smart City systems. Results that shown on graphs in Fig. 1 and 2, demonstrate the effectiveness of the proposed approach for predicting the results of discrete mutual investing in information technologies and Smart City systems. The graphs in Figure 1 correspond to simulation experiment, in which $RG_2$ uses non-optimal behavior $RG_1$ at the initial moment $t$. In this case, $RG_2$ can ensure that the state of the system will be brought on the terminal surface $RG_2$. The graphs in Figure 1 correspond to simulation experiment, in which the initial state of the system is on equilibrium ray (the red line). And both sides (players – $RG_1$ and $RG_2$), applying their optimal strategies «move» along this equilibrium ray. Such strategy satisfies simultaneously both parties in the process of discrete mutual investing in information technologies and Smart City systems. Thus, Figure 2 illustrates the «stability» of the system. We note that at minor deviations when choosing the implementation of the optimal strategy $RG_1$ (dotted line of green color), he will reach its goal, but somewhat later.

At this stage of development of our model, we performed the modeling for a small number of investment projects in information technologies and Smart City systems, because we were forced to focus on such projects in Ukraine with a small investment potential in this area. This circumstance is a definite drawback of the current stage of work in the framework of ongoing research.

Comparison of the results of our simulation experiments with the results that obtained by other authors [6, 8, 9], made it possible to conclusion on the acceptability of the approach outlined in the article.
The possibility of creating a competitive software product for the Android platform we are considering as development prospect of our research. This will allow potential investors to quickly evaluate projects without resorting to cumbersome calculations with using such system as Matlab/Simulink.

7. GRATITUDES
The work was carried out within the framework of promising developments of Department of Computer Systems and Networks of National University of Bioresources and Natural Resources Use of Ukraine.

8. CONCLUSIONS
Model for finding strategies for managing mutual investing in information technologies and Smart City systems was proposed. Every possible of correlation of parameters of mutual investment process in Smart City were investigated.

The developed model is proposed as component of information component of decision support systems in the tasks of analysis of various strategies of mutual investing in information technologies and Smart City systems. Within the framework of the article, the task of mutual investing in a large innovative project Smart City by players (parties) with different exchange rates of national currencies was investigated as particular case. Conceptually, the model is constructed on the solution of bilinear dynamic game of quality with several terminal surfaces. A distinctive feature of the model is fact that the discrete equations that setting the dynamics of the game, are written using arbitrary coefficients. The solution obtained has extended the class of problems that can be solved using the game theory, and in particular bilinear dynamic games of quality with several terminal surfaces.

Results of experiments are presented that performed in environment of simulation modeling Matlab/Simulink. The results of simulation modeling confirmed the working capacity of the model for the decisions support system in the tasks of analysis of various strategies of investing in information technologies and Smart City systems, and also its adequacy.

REFERENCES


