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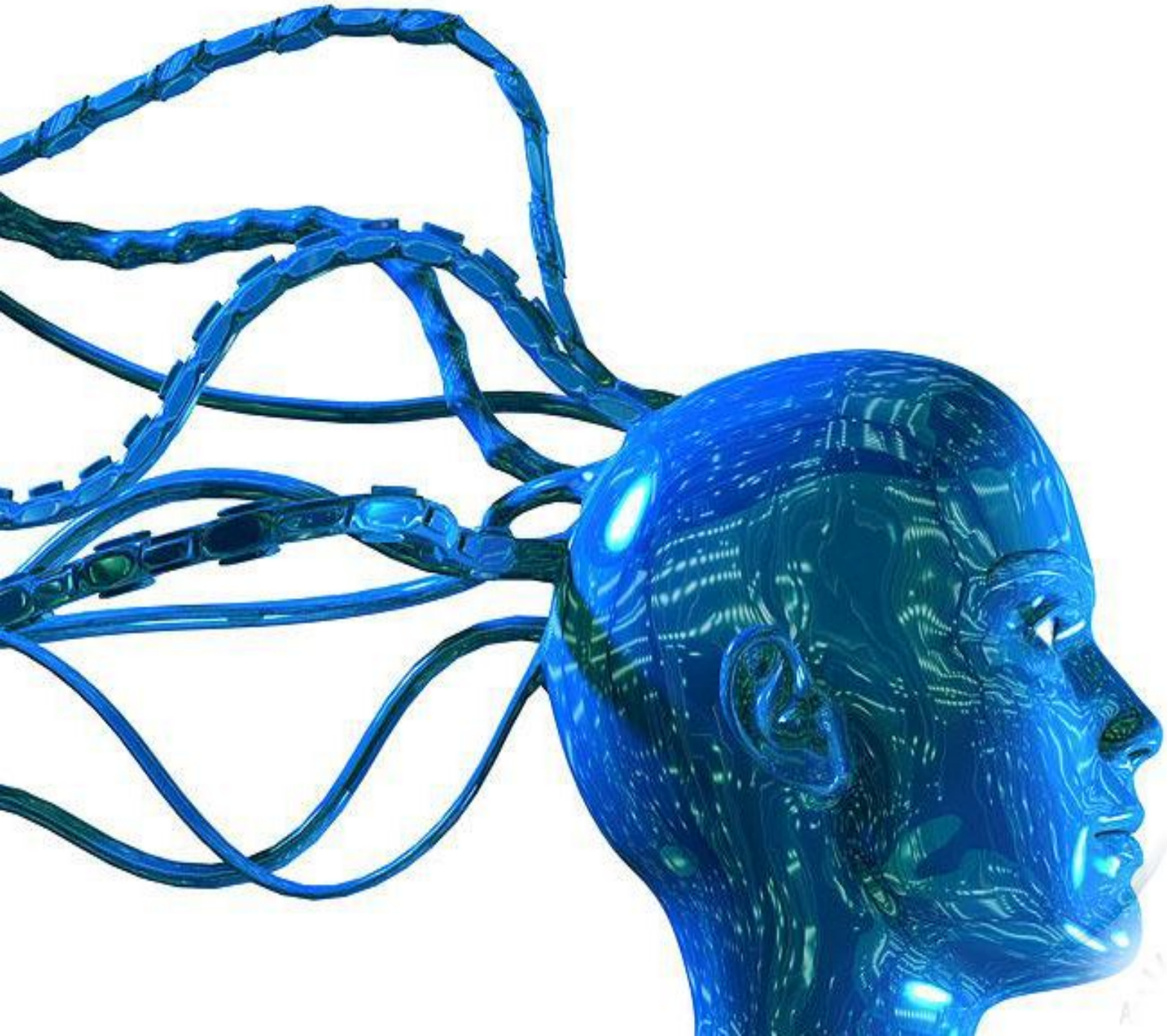

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Scientific articles

Artificial Societies: A new Tool to understand how a Society works

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Abstract. The methodology of artificial societies, coming from the sophisticated development of so called agent based models, is going to be breakthrough in social sciences. In the paper I try to show it on the examples of mathematical economics and related topics. The growing complexity of mathematical models can be overcome by construction of artificial worlds and following computer experiments. The first non trivial results are in place. Some intriguing questions and problems are formulated, answer on which one can expect under application of the new methodology.

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Where mathematical modeling faces a limit.

Mathematical modeling of a real world is a practically universal methodology. One considers serious or modern theory if it based on mathematical model. It is easy to list numerous examples of these theories in any field of research. The economic science is not an exception. Let me mentioned for example widely used general economic equilibrium theory, which one can consider as a part of theory of games. Taking leading economic journals one can see a lot of mathematics.

But it is clear that mathematical modeling has its limits. Reality is too complicated to be modeled as precisely as one wants to have. Making more realistic mathematical models we produce monsters, which it is impossible to analyze by standard methods of logics.

Economic science is developing to the direction of getting closer to natural sciences. Now it is possible to make experiments in the sphere of economics, what was difficult to imagine a century ago. The first breakthrough was done when laboratory economics appeared after Vernon Smith's methodology and related activity. The next crucial step is connected with the quick development of virtual worlds and artificial societies. One can raise much broader set of questions, which are impossible to formulate in mathematical terms.

Let me illustrate the thesis by the mathematical model of an economy, which is a combination of the well-known economic models.

In the modern economic literature one uses a notion of an (economic) agent. The agent is autonomous to make its decisions. The standard classification of the decisions is the following.

1d. An agent chooses a so-called consumption basket of all types of goods and services.

2d. An agent chooses a jurisdiction to live.

3d. An agent chooses profession and a firm to work.

4d. An agent votes for (a) a political party, (b) economic policy, (c) providing of a certain bundle of public goods, (d) creation or modification of jurisdictions.

5d. An agent decides to participate in clubs, including such club as family.

6d. An agent chooses investment portfolio.

The listed decisions of all agents define a total demand in the society.

The total supply of the society one can define by the following actions and mechanisms.

1s. Production of goods and services by institutions.

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2s. A mechanism of jurisdiction's creation and modification.

3s. Professions and jobs.

4s. Political system, type of democracy.

5s. Clubs' formation.

6s. Investment policy.

The basic approach of a main stream's theory consists of defining a kind of equilibrium and finding properties of the equilibrium. The economics literature is full of brilliant models equalizing demand and supply for every point, indicating in the above list.

For example, the point (1d – 1s) gives the very famous Arrow – Debreu model of the general equilibrium, which is classic. The theorem of an equilibrium existence is based on Kakutani fixed point's theorem, optimality of the equilibrium yields from Kuhn – Tacker separation theorem, the proof of finite number of equilibrium states uses some facts of algebraic geometry. The point (2d – 2s) leads to the Tiebout model, (Tiebout Ch. (1956)), which is so popular now that came to the top of topics in terms of citations. The technique to prove equilibrium's existence of theorem is very sophisticated, see Caplin and Neilbuff . The point (4d – 4s) generates a number of relatively simple graceful models, most of them the reader can find in Person and G. Tabellini.
The same situation one sees in the other points.

But if you try to combine all these points into one model you create a monster from the mathematical point of view. It is absolutely impossible to prove something putting all the notions into one wrap. There are a number of attempts to combine just some of the listed points, two or three, to obtain substantial results. No results to be mentioned as visible.

What is an artificial society?

Because of computers there is a natural way to overcome complexity of mathematical models. A computer model can be as complex as possible. There are no near limits, just a computer's memory and human efforts. One calls a computer model of real society as the artificial society.

An artificial society consists of *agents,* which act in *an environment*, following given *rules*. According to the standard terminology the artificial society is a particular case of, so-called, *agent – based models*. Agent – based model are widely used in a number of fields for analysis of problems like, for example, transportation flows, city design, mass services, etc. So, the agent – based model is not necessarily should consider as an artificial society.

Agents in an artificial society perform relatively autonomously. They *make decisions, act* and *interact* with other agents. Agents make decisions as a reaction on the environment and actions of other agents. The key word is an *interaction* between agents. One calls it as social ability of agents and therefore we can talk about an artificial society, as a particular case of agent – based models.

Historically the first example of artificial society was Neumann's cellular automates. The simplest society of cellular automates was proposed by Conway (see Conway J. (1970)), called "Life". The game "Life" looks very simple according to the rules of behavior of agents (black cells). Nevertheless the cellular automata shed new light on the problems, which it is difficult to understand by other methods. See, for example, Hu Bin and Debing Zhang (2006). To the paper we will return below.

I don't go to the history in details. One can find it in the seminal book of Epstein Joshua M. and Axtell Robert (1996) "Growing Artificial Societies". The authors develop the methodology of Artificial Societies, based on relatively simple SugarScape model, which became very popular thanks to the book. The SugarScape model is really very simple, even in comparison with a set of finite automata of von Neumann or Cetlin type, see Цетлин М.Л. (1969). Nevertheless one can see the richness of questions and problems to be raised, discussed and experimented in terms of the SugarScape model.

By the way Epstein and Axtell compare cellular automata with environment or space in their sugarscape model. Under this vision the sugarscape model is the agents traveling among cellular automata.

The SugarScape model.

Let me start with the original version of the model.

At any moment *t* there is finite number of agents located in the space.
Space is a two dimensional lattice of equal cells.
At any moment *t* each cell *(x,y)* has: (1) an agent *a* *($a_t(x,y) = a$)*, if agent *a* is located in the cell (x,y), or no agents otherwise *($a_t(x,y) = empty\ set$)*.
(2) quantity $r_t(x,y)$ of "sugar".

An agent is born with two parameters: vision (number of cells in the lattice to look around) and level of metabolism (quantity of sugar to eat per unit of time to survive). An agent can carry any amount of sugar. An agent dies if it has not enough sugar to eat. The authors explore a number of rules how an agent can be born. For example,

simultaneously with its death a new agent is born with randomly choused parameters and location. So the total population of agents stays constant in this case.

Rules for agents.

- Look out in the four (eight) lattice directions and identify the unoccupied site having the most quantity of sugar.
- Move this site and collect all the sugar at this new position.

Based on the simple version of the SugarScape model authors produced a number of experimental calculations and received results, which are consistent with common understanding of human society's features. It looks wonderful, because in the version there are no interactions between agents, which one treats as a basic property of human society.

For example, there is a fundamental problem, which challenged many thinkers of all times. It is distribution of wealth among members of society. The distribution is always quite uneven in any existent society. And the problem is strengthening nowadays because inequality is growing as among people as among countries. The authors of the book find that "under a greate variety of conditions the distribution of wealth on the sugarscape is highly skewed, with most agents having little wealth."

The agents compete to each other for the sugar and the macro structural result is a concentration of population in sugar – rich arias. Even in this simple version of the Sugarscape model without interactions between agents, authors explore a way, how to avoid the concentration of population, particularly with phenomena of pollution.

The pollution can be introduced as an impact of collection and eating of sugar. So each cell contains sugar and the level of pollution. An agent moves to a free sell with maximum sugar to pollution ratio. The rule changes the picture dramatically. First of all the number of deaths increases and second, distribution of population across territory becomes more even.

In advanced versions of the Sugarscape model different types of interaction between agents and some complexities are introduced. In allows analyzing a great variety of phenomena, taking place in human societies. Sex, Culture, Conflicts, Decease, Heritage and a number of others properties of human society can be investigated in terms of the Sugarscape model.

Especially interesting findings coming from the Sugarscape model one can see in sphere of economics. The authors make the model more complicated introducing the second good "Spice".

In the Sugarscape model with two commodities the agents' rules of behavior are getting more complicated. An agent moves to the neighboring empty sell, where augmented welfare is maximal. The welfare function of an agent is defined on the two goods. So, in this respect the behavior of agents looks similar to their behavior in the case of one good. But an agent has new possibility to exchange by commodities with another agent, if it would be beneficial for both.

Under condition of finite time horizon one can formulate the Sugarscape model as a standard Arrow – Debreu model, basic one in the general equilibrium theory. Namely, an agent a has the initial endowment $w_{a,t}(x,y)$, where for every t and given (x,y) pair $w_{a,t}(x,y)$ shows a quantity of sugar and spice, (x,y) is the cell of its location at the moment $1,\ t = 1,2,\ldots,T$. Then it is possible to compare an equilibrium state of

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the Arrow – Debreu model and the results of calculations for the Sugarscape model. The author of the book made a lot of calculations, starting from different initial locations of agents. Always mean price of exchanges of sugar and spice between agents tends to the equilibrium price. But final position of agents depends on their initial location. In particular it means that the two absolutely identical agents with the same initial endowment can be in different positions finally. It confirms once more the unevenness of distribution of wealth, independently on the variety of initial conditions and variety of genetic characteristics of agents.

In this connection the remark of the authors about principal difference between the equilibrium in the sense of general equilibrium theory and the equilibrium (called statistical equilibrium) of the Sugarscape model looks a little bit strange. They mentioned that according to the general equilibrium theory identical agents with equal endowment have equal behavior and equal meaning of the utility function in an equilibrium state. It is correct. But after that they state that in the Sugarscape model identical agents with the same endowment finally come to very different positions. To be exact, in the Sugarscape model agents have different endowment, because into definition of the endowment it is necessary to include its location.

Collective goods' economics.

The methodology of "Artificial Societies" is perfectly fitted to the economics of collective goods. The collective goods are products of interactions or mutual actions of agents, by definition. The notion of collective goods appeared relatively recently. Pioneering works in the field belong to the two Nobel prize winners in Economics Samuelson and Buchanan. See, Samuelson, P. A. (1954), Buchanan, J. M. (1965).

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The process of production, distribution and consumption of collective goods is collective by definition. It does not regulated by market, although for production it is necessary to use private goods operated on a standard market. The volume of tangible and intangible collective goods, which turned out in the modern economics, is growing and is now more then one/third of GDP by share in most countries. Needless to say, that these estimations are very conditional because collective goods are not measured in market terms. Sometimes the cost of production of collective goods is huge, like in the case of infrastructure, sometimes – close to zero, like in the case of marriage.

One of the basic problems in the economics of collective goods is a group formation. Below I show the formation of pairs to produce and consume a collective good, one can call "share time". Details see in Макаров В. Л. (2007).

So, there is an artificial society of agents where the problem of every agent is to split its time onto two parts. The first part's time uses to produce a private good and the rest of time spends with a partner, whom it is necessary to find. The partner should agree to spend exactly the same piece of time, which the agent wants to.

Notations.

N – total number of agents;

i - number of an agent;

w_i – total reserve of time, the agent has;

$(w_i - c_i)$ - quantity of private good, produced by the agent;

x_i - quantity of private good, consumed by the agent;

c_i - time of the agent, which it spends together with a partner;

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a_i - level on propensity to be alone;

$u_i(x_i, c_i) = a_i * x_i + x_i * c_i$ - utility function og the agent;

$d(i,j)$ - characteristics function defined on pairs (i,j) with additional condition that if $d(i,j)=1$, then $d(i,k)=0$, $dk,j)=0$ for all others k;

Social planner's problem.

As usual it makes sense to take understandable enough criteria of optimality, to have possibility to compare different approaches and calculations. Here the criteria is the sun of all individual utility functions. After that one can formulate the optimization problem to find maximum this sum of utility functions of all agents.

Namely,

To find: $\{(x_i, c_i)\}$, $i = 1,2,...,N$; $d(i,j)$, $i = 1,2,...,N$, $j = 1,2,...,N$, $i = j$, such, that

$x_i = w_i - c_i$

$c_i = c_j$, if $d(i,j)=1$,

$c_i = c_j = 0$, if $d(i,j)=0$,

$sum_i(u_i(x_i, c_i))$ achieves maximal value.

Every agent tries to choose the partner, who agrees for interaction with minimal deviation (measured by meaning of utility function) from optimal c. Thus the agent makes an order for all other agent accordance the parameter. The real interaction (deal) happens, when both participants agree.

Rules of interactions between agents.

Every agent calculates best for herself period of time to be together. Namely she solves the problem of the function $a_i * x_i + x_i * c_i$ maximization over variable c_i , where $x_i = w_i - c_i$. The first order conditions give $c_i = (w_i - a_i)/2$. Consider the value c_i as desirable.

After that given (for example, randomly chosen) agent looks at all agents in her neighborhood. The neighborhood is defined by the ability of the agent to see around (length of horizon). She make a proposal to the agent, whose desirable meaning is maximally close to her desirable meaning. The chosen agent accepts the proposal if there are no other more desirable ones in her neighborhood. The period of time, which agreed agents spend together, is equal to arithmetical average from the two desirable periods. In the case when the deal is not made, the second agent makes a proposal to her desirable agent around. The process is finished when there are no agents who want to make a proposal. The natural question appears: comes the described process to optimal solution of the social planner's problem or not?

The answer on the question one can receive by making calculations according to the methodology of "artificial societies". We made a number of the calculations, where the space was two - dimensional lattice. It is clear that in principle the process does not come to the maximum (to the solution of the social planner problem). But it is interesting to know the dependence of the meaning of the criteria on the parameters, initial conditions and random details.

We limited ourselves by the case where all agents have the same reserve of time and different propensities to be alone. No essential surprises were discovered. The results are consistent with intuition. For example, longer horizon to look around - closer to maximum, all other conditions are equal. Longer horizon, less dependence on the initial location of agents. Practically maximum was never reached. It is also

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understandable, because the arithmetical average is not ideal solution of the deal between two agents. The other more sophisticated rule consists of maximization of the sum of the two individual values, which does not concede with arithmetical average.

Collective behavior of agents (continued).

There are a big variety of the collective behavior types. Staying in the language of simple cellular automata it is possible to study the relatively complex group behavior. The paper Hu Bin and Debing Zhang (2007) brilliantly demonstrate, how the world of cellular automata can be used for explanation of group behavior focused on the loyalty to a group (firm) of its members. The member of the group can have different orientations, for example with motivation to earn money (Economic Being) or motivation to feel comfortable within the group Social Being).

There is the lattice of the finite number of cells. Each cell represents one member of the group.

The loyalty is measured by the three levels: “high”, “normal” and “low”

From here a group can be divided further according to two generalized sets of characteristics, and which result in differing motivations: One group being "economic", and the other being "social". According to the theory on employee behaviors", Economic Beings are motivated by material and monetary gains. Social Beings are motivated by social status and the respect of their colleagues.

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Competition between political parties.

As I said above, the attempts to take into consideration many factors come to a model, which is difficult to study by a mathematical method. In the section I illustrate the thesis by the important example of the very famous Tiebout model. See, Tiebout Ch. (1956).

The Tiebout model deals with people located in finite number of jurisdictions (regions, towns, etc). Every citizen makes a decision to stay in the jurisdiction where he/she lives or to move to another jurisdiction to maximize her utility function's value. The decision is based on the following information about jurisdictions: a package of local public goods, provided by the jurisdiction and level of taxes in it. In the wide literature dedicated to the Tiebout model one can find numerous results about existence of equilibrium and optimal properties of the equilibrium states.

The situations is getting much more complicated when you incorporate into the model political process of elections. Every political party wants to win elections, and hence to attract as many votes as possible. A formalization of the political process leads to a modification of the Tiebout model, which looks like an artificial society. In the modification agents make the following actions. They move from one jurisdiction to another and they vote for one or another political party or vote for an offered issue in the case of direct democracy.

So, let me formulate the modification based on the paper Collman, Ken, John H. Miller and Scott E. Page (1997) and Данков А. Н. и Макаров В. Л. (2002).

So, there are N inhabitances, each lives in one of the jurisdictions $j = 1,2,...,G$.

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The political process is represented by n political parties, which operate in all jurisdictions. Each party k $(k = 1,2,...,n)$ works out and offers to voters its platform $p_k = (p_{ki})_{i=1,2,...,I}$. The platform does not depend on the jurisdiction and formally is I – dimensional Boolean vector, where $p_{ki} = 1$, if the party stays **for** an issue i and $p_{ki} = 0$, if the party agitates against the issue. A meaning of the issue in the list may be quite different, like a war in Chechnya, taxes on property or ban of producing human clones.

Every person has her own opinion on all the issues. The opinion is expressed be a number , which may be positive or negative. Let $v_{ai.}$ be the number. The opinions v_{ai} are uniformly distributed on the interval [-1,+1].

Knowing v_{ai} , one can calculate a utility of an agent a, if the platform p_k comes true. Namely,

$U_a(p_k) = sum_i (p_{ki} * v_{ai})$

An agent votes under various political systems. She votes for the party, which offers a platform with maximal utility for her. Or she votes for the issue, which gives maximal utility.

The world political practice shows different ways of converting individual votes into political decisions. Simplest way is called *referendum* and direct democracy. The result of referendum is a policy (platform) $p= (p_i)$, where quantity of people with $v_{ai}>0$ is greater then quantity of people with $v_{ai}<0$ for all i. So, in the case of direct democracy there is no room for political party. People vote not for a party but for issues.

Next one is a form of representative democracy called *direct competition*. In practice direct competition forms *presidential power* under the rule "the winner receive everything". Formally in our term it means that people vote for parties and the party with maximum votes takes an office.

The third one, we take into consideration, is a proportional representation. It is another form of representative democracy called *a parliamentary power*. Every political party, which took part in the election, receives an influence proportional to the number of votes for the party.

Questions, we want to receive the answers.

1. What regime is better (in terms of the total welfare function) and under what conditions?
2. What influence of number of political parties on the value of the welfare function?
3. What influence of number of jurisdictions on the value of the welfare function?
4. What type of party's behavior is better in terms of welfare function and in terms of probability to win or to pick up greater number of votes?

Of course, the number of questions to be raised is much greater. Nevertheless one can propose, that purely mathematical approach will fail to answer the mentioned questions.

So, the behavior of agents is described above. They vote and move if necessary. The behavior of political parties is more complicated. A political party has its platform, which lies in the base of the party. But a party can change its platform to attract more voters. So it is necessary to define the neighborhood of the platform, inside which the

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party keeps its base. There are more flexible parties then others, depending on the size the neighborhood of its platforms.

It is clear, that one can organize the process of simulations by different ways. One of the ways is the following.

1. One starts with defining the initial conditions: a realization of random distribution of agents between jurisdictions and random distribution of opinions (v_{ai}) among agents.
2. The platforms of all political parties are given.
3. Every party tries to find correction of its platform, which brings greater votes. For that the party chooses so called focus group (randomly chosen given number of people). The focus group shows, which policy in the neighborhood gives maximal number of votes.
4. The population votes for the presented programs.
5. Points 3 and 4 can be repeated several times.
6. The results of the election are presented to the population. In means that in the case of referendum it is indicated winning issues in the each jurisdiction. Presidential election gives policies of wining party in the each jurisdiction. And in the case of parliamentary election the each jurisdiction calculates the policy, which should be realized.
7. The agents move to preferred jurisdictions, knowing situation in all jurisdictions.
8. The process begins again from the point 3 and is repeated a given number of times.

The final distribution of the population between jurisdictions and the meaning of the welfare function compared with the solution of the social planner's problem.

Detailed results of the simulations the one can find in Данков А. Н. и Макаров В. Л. (2002). Here I mention the two most interesting ones. The calculations show that in the case of one jurisdiction presidential regime gives better results in terms of welfare function when the number of parties is lower. If the number of parties is much greater then two, the parliamentary regime is better. In the case of multiple jurisdictions both regimes gives better results under several jurisdictions in comparison with one.

Needless to say, that the results are rather qualitative. One can calculate more precise outcome trying to obtain optimal number of parties and jurisdictions under different regimes.

Artificial Societies and Virtual Worlds.

One can find the evident connection between Artificial Societies and Virtual Worlds. In some sense we can consider an artificial society as a certain type of a virtual world. So the virtual world is a broader concept with less definite boundaries.

Principal feature of the virtual world is an involvement of one or more participants in the experiments. One objects the statement by giving the famous example of the "Star Wars", where there is no involvement of a spectacular into the move's running. But here we have rather an exception then the rule. Nevertheless the example "Star Wars" shows, that it is possible to obtain new scientific results by this instrument. Namely, we can mention the power – law distribution of wealth (in Star Wars and other related games.) as a final outcome of the whole procedure. Indeed it was checked that practically always the end of the war takes place when the distribution of power

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coincides with the distribution of wealth. Under the condition there is no incentive to continue the war.

Virtual Worlds are not for scientific purposes only as one can see. Moreover they are basically for other purposes.

What for Virtual Worlds?

- Commercial Gaming.
- Socializing / on line community building.
- Education.
- Political Expression Instrument for political debate
- Military Training
- And finally the tools for research, for better understanding of natural worlds.

So we are on the eve of mixture of natural world and virtual one. The virtual world is going to be part of natural one. For a human being it will be difficult to distinguish between natural reality and virtual one. See, for example, the popular movie "Matrix". It can be a source and cause for mental deceases. So, we come to the analogous logical circle: construction of the virtual world, containing inside the virtual world of the, so called, second order. Recall, that the first logical circle one receives in terms of the artificial societies: a perfect artificial society, which is an exact copy of the natural society, must include itself as a proper part.

An ambitious agenda for the future research.

In the terms of artificial societies one meets the opportunity to formulate the problems, the answers to which the mankind is waiting for centuries. Why the formulation in the terms of artificial societies is more promising, then in standard terms? Because

Let us illustrate the statement by a number of examples.

1. One of the puzzled and difficult questions is related to the problem of finite duration of agents' life. Why an agent does not live forever? Why it is more efficient to have the process of birth of new agents, their education, and absorption of knowledge from other agents, instead of accumulation of the knowledge in one agent? So, we are talking about an evolution between agents versus an evolution within an agent.
2. The same question one can ask about the groups of agents. Why is it so big diversity in the duration of life of different types of groups? Some groups live during on generation, like gangs, classmates, busyness' alliances. The others exist for centuries, like empires, nations, religions, etc.
3. In terms of artificial societies one can easily formulate the question: what happened to the society, if the reincarnation takes place. It means that one agent can live number of times, keeping identity. It looks like a mixture between finite and infinite agents' life cases.
4. Why a human being must change a kind of activity during a day, year and life? In this respect the human (animals) society differs from a society of robots.
5. It is easy to imagine a population of agents, where there are no sexes or number of sexes is more then two. What happened then? Is it efficient in some

sense in comparison with the traditional population? What are possible advantages?

6. Who knows, may be the instrument of artificial societies will produce better way of future human development, new models of society and so on. Remember, Leonardo da Vinci used to say that he does not copy a reality but construct it.
7. Other sciences like psychology and philosophy find new arguments for understanding, how emotions, conscience, consciousness, evolve. Neuroscientists recognize six basic emotions: anger, disgust, fear, joy, sadness, and surprise. And the instrument of artificial societies gives more adequate language for definitions of the concepts. It is interesting problem to expand these concepts from individuals to groups. What is memory of the group, what is its consciousness, where the memory of the group is located, and so on?
8. At the end I would like to discuss the urgent problem, which is coming, first of all, to the community of economists as a sound challenge nowadays. It is the problem of happiness, its measurement. The journal "Economist" raised the issue in its publications at last number of year 2006. There is a common statement that a rich country in terms of GDP is not necessarily happiest one. Standard macroeconomic indices like GDP her capita, personal income, individual consumption, general wealth per capita and so on can't serve anymore as basic parameters for measuring prosperity of a country its general success, its superiority over other countries. People want to get life happier rather then richer. A person feels happy if he/she belongs to the top part of the group, he or she considers as very important. It means that the society should be organized in such a way that creates a sufficient number of such groups. As it mentioned by the journal "Economist", in USA there are more then 3000 Halls of Fame. I wrote in Макаров В. Л. (2007) about production of collective

goods, which are not included into GDP. One can count it as a first step in the direction of the correction of the standard macroeconomic indices.

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Agent-based model “How having natural recourses affects innovative economy”

© *Zulkarnay I.U., Gizatov N.R. (Ufa)*

The paper uses agent-based modeling to study “resource curse”. Resource curse deals with the fact that countries rich in natural resources usually demonstrate low degree of technologic development, low level of life of their citizens, and high inequality in private income. The findings are proved by econometric research.

Regressive impact of rent on economic motivation of economic agents was mentioned by Adam Smith, who wrote that lack of correspondence between reimbursement and efforts in rent economy forms social parasitism, so called renter mentality [1].

Econometric research by academician V.M.Polterovich demonstrates that despite correlation between the presence of natural resources and low degree of economic development, countries with developed institutions are free from resource curse. This leads to a conclusion that the presence or absence of institutions, rather than resources, is the determinant of successful economic development, including its innovative component. Note, however, that “correct” institutions of Sweden formed when its coastal shelf oil was not yet discovered and did not place Sweden in the list of richest countries in oil and gas.

A number of interrelated questions emerge in discussing the link between the economic results of countries and the presence of natural resources. These questions deal with absolute and relative amounts of natural resources.

1. If all countries had considerable and equal amounts of natural resources, would they all be subject to renter mentality or would they start intensive development since all of them were in equal situation?

2. If all countries had equally minor amounts of natural resources, would they have to start intensive development or would they all be subject to renter mentality, albeit at a low consumption level?

3. If some countries had considerable and others – smaller (yet sufficient for self-provision and economic reproduction) – amounts of natural resources, would both categories of countries be subject to renter mentality or relative wealth in natural resources would cause poorer countries start intensive development?

4. If some countries had considerable and others – extremely minor amounts of natural resources, would it inevitably lead to rent-seeking behavior of the former and the intensive development of the latter? In other words, would the three factors: relative difference in countries' provision of natural resources, sufficient provision of the former and insufficient provision of the latter, cause the above assumed behavior.

Our agent-based model implemented in NetLogo deals with looking for the answers to these questions.

The model describes two types of agents: country and resource. Agents "countries" have the following life cycles and properties:

- Production of goods for life support of population.
- Assessment of profit of production.
- Assessment of the stock of natural resources inside the country.
- Assessment of the stock of natural resources of other countries for potential import.
- Well-timed reaction on decrease in the quantity of resources by implementing innovations.
- Trade of natural resources.

Our model contains 4 agents of the type "country". All of them are endowed with similar properties and differ only in the quantity of natural resources. In other

words, simulated countries are identical in territories, economic climate, density of population, economic conditions for import and export of natural resources.

Agents of the type "resource" obviously have no life cycle but have a property – to decrease. The size (number of units) of decrease in natural resources at a certain step depends on the quality of institutional conditions in the country that owns the resource and on the volume of export to the countries that need the resource. Note that countries directly interact with their resources and receive an access to the resources of the others through the owner-country.

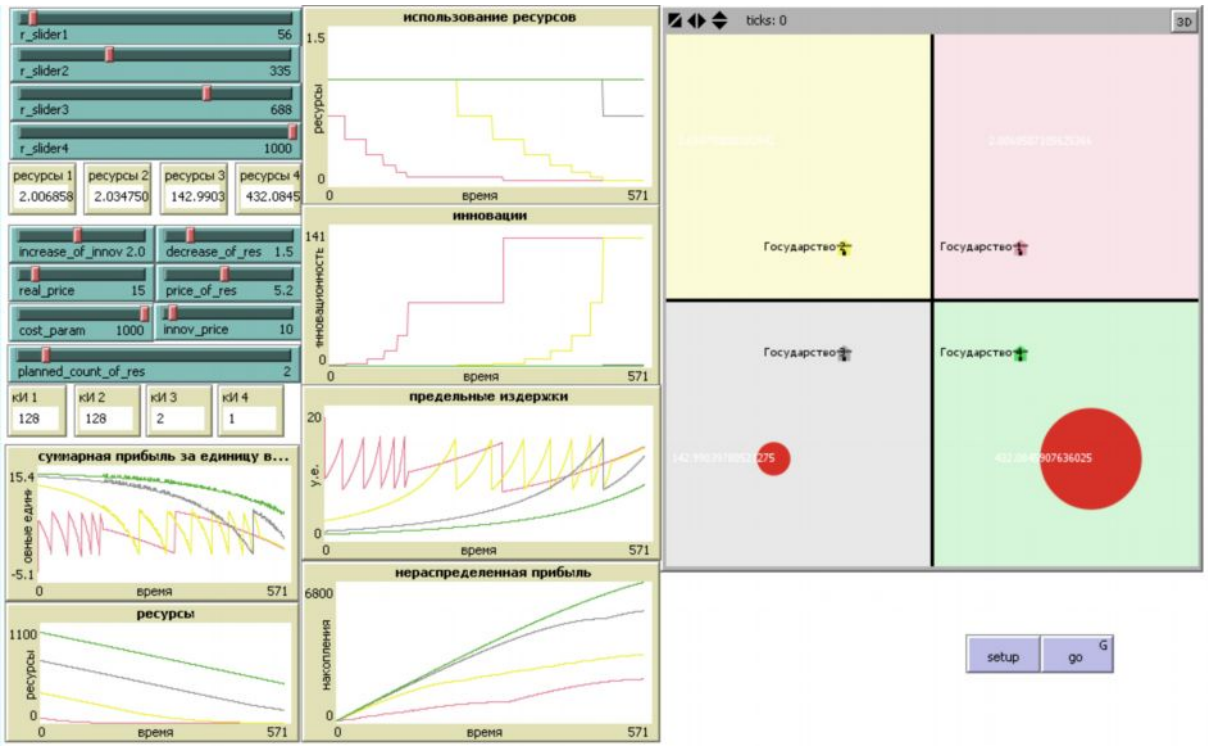

Figure 1. Interface of the model. All countries have different endowments of natural resources and different intensity of development

Let us look at the interface of the model The quantity of natural resources is set in regulators *r_slider1, r_slider2, r_slider3* и *r_slider4*. The quantity of resources is visualized in the model by circles, with diameters proportional to the value of the quantities. Monitors for the output of the current number of resources in the country

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are placed below the regulators. To set the usefulness of a forthcoming innovation and of a decrease in resource intensity of production, which employs the innovation, we provide for regulators increase_of_innov and decrease_of_res respectively. Further, there are regulators for model calibration. These regulators reflect relations between countries and resources: revenue from the production for life support of population in conventional units; price of a unit of natural resource; coefficient regulating the threshold value of the ratio of the current quantity of natural resources to the initial quantity (above this value a relatively poor country imports from a relatively rich country). Monitors "*кИ1*", "*кИ2*", "*кИ3*" and "*кИ4*" represent coefficients of intensity of development, i.e. the character of innovation in production.

Graphs in the model demonstrate: aggregate profit in a unit of time (profit from production and selling resources); change in the amount of resources; amounts of resources; intensity of development (innovative character); marginal cost of production; total profit accumulated in the course of model simulation (undistributed profit).

A shift to the consecutive level of innovation occurs in a country which loses total profit in a given moment of time. Total profit in a unit of time is calculated in the model as:

$$profit = price_p - \frac{K_{cost}}{R_{sum} \cdot R_i \cdot kI_i} + N_i \cdot price_{res}$$

where $price_p$ is the price of all goods, produced in a country at one step. Produced goods do not differ in types and prices; are the same in all countries; and are regulated in the interface of the model by regulator *real_price;*

K_{cost} is parameter set by regulator *cost_param;*

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R_{sum}, R_i are respectively total stock of resources and the stock of resources in the analyzed country;

kI_i is the coefficient of intensity of development, reflecting the quality of institutional conditions;

N_i is the quantity of resources for export or import. In case of import the value of N_i is negative;

$price_{res}$ is the price per unit of resource, set by regulator price_of_res.

The condition for introducing a current innovation in a country:

$$price_p - \frac{K_{cost}}{R_{sum} \cdot R_i \cdot kI_i} + N_i \cdot price_{res} \le 0$$

where kI_i is a variable parameter, which is multiplied by a parameter from regulator *increase_of_innov* during the shift to consecutive innovation.

Each country also has a parameter dr (the amount of consumption of resource in one step of the model), which decreases *x* times after implementation of a current innovation; *x* is set in regulator *decrease_of_res*.

Let us analyze the work of the model and conduct emulations to find the answers to the questions set in the beginning of the paper.

1. *If all countries had considerable and equal amounts of natural resources, would they all be subject to renter mentality or would they start intensive development since all of them were in equal situation?*

The scale of resources in the model allows setting the value of 0 to 1000 conventional units of resources. Since improvements in technology lead to lower use

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of resources in future, depending on the degree of innovation of production, 0.5 or even fewer units of resources may be sufficient for producing a unit of good. At initial stage with a starting coefficient of innovations each country uses 1 conventional unit of resource in a unit of time.

Figure 2. All countries have considerable and almost equal resources and do not introduce innovations

As is shown on Figure 2, countries with considerable amount of resources and in similar situation do not introduce innovations. The countries proportionately spend their resources and accumulate profit. At first, the marginal cost curve gradually and proportionately rises up, but with time increases its speed of growth. This may be explained by the fact that the amount of resources in the system (i.e., aggregated volume of resources in the 4 countries) decreases considerably. Moreover, the amount of resources in each particular country falls, too. Therefore, production of

each consecutive good under given strategy creates raising costs. Yet, so far marginal cost is lower than the revenue from selling goods, the country continues receiving profit and does not implement innovations in production.

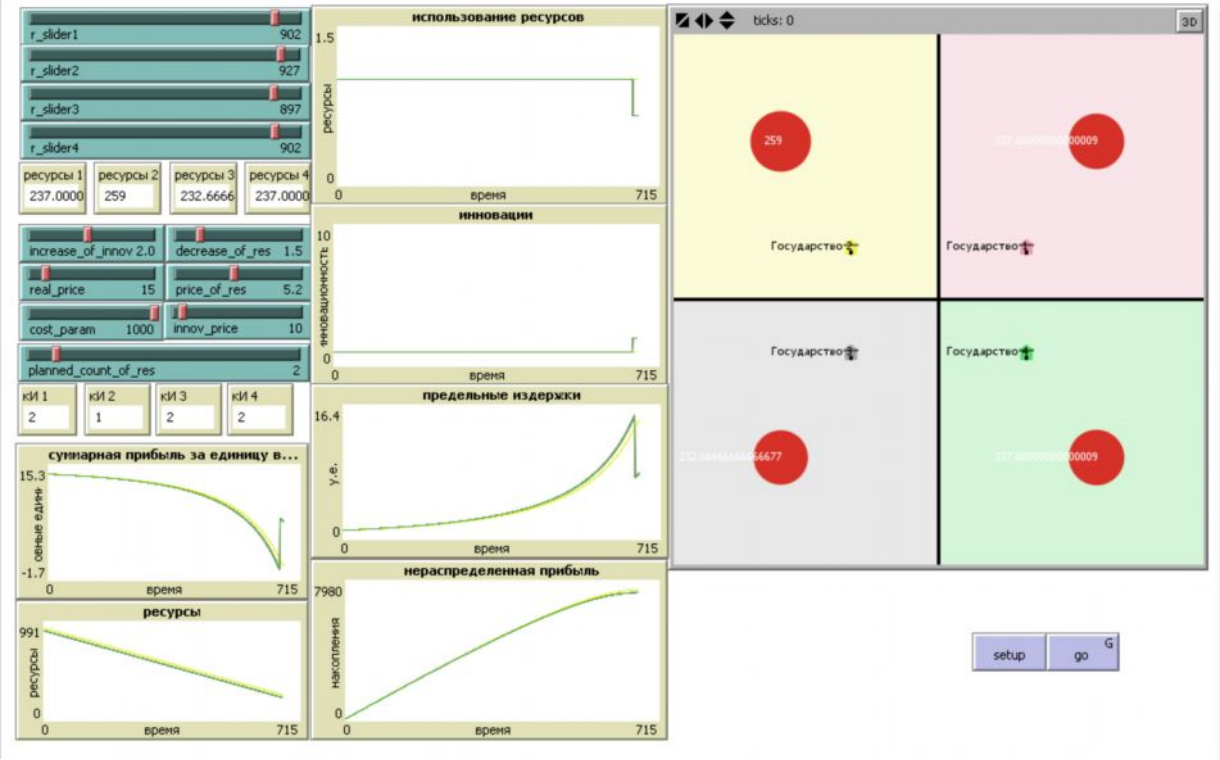

Figure 3. Three out of the four countries introduce the first innovation facing the deficit of resources

Figure 3 demonstrates a situation when three countries introduced the first innovation. Country 2, marked yellow in the model, initially had 927 units of resource, currently possesses 259 units and continues existing without innovation. The countries, which introduced the first innovation two steps before, initially had 897-902 units and currently possess 232-237 units of resources. This implies that under given initial data the threshold level for the shift to the first step of innovations is in the range of (237 - 259) units of resources. As is seen on Figure 3, countries 1, 3 and 4 decreased the use of resources and marginal costs. Two regulators - decrease_of_res and increase_of_innov - reflect correspondingly the change in the

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quantity of resources used at one step and the usefulness of innovation. The first regulator demonstrates how many times fewer resources will be used by a consecutive technology. In this simulation the regulator is set at 1.5. In other words, if initially the country employed 1 unit of resource at each step, after implementation of the first innovation it will use only 0.67 units. The second regulator shows how many times marginal costs will decrease owing to the shift to a new level of technology. In this simulation regulator is set at 2, i.e., the use of a new innovation decreases marginal costs 2 times.

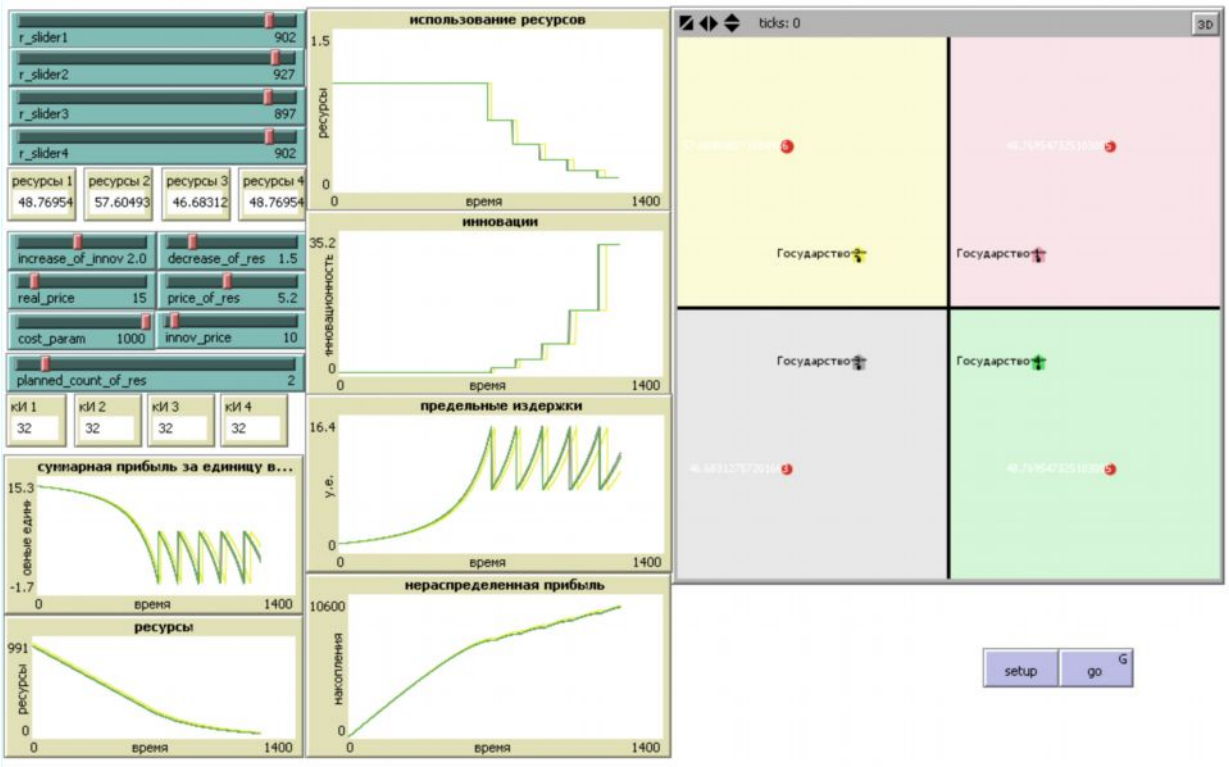

Figure 4. All countries introduced several levels of innovation and decreased the use of resources

Figure 4 shows the same simulation, but the stock of resources had noticeably decreased in all countries. All countries rose 5 steps of innovational ladder, the costs fell twice 5 times, and the use of resources decreased considerably.

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The shift to a new step of intensity and decrease in consumption of resources occur at the same moment of time (Figure 5), when a consecutive innovation is implemented. However, the two graphs are not symmetrical, since the variables depend on different coefficients, regulated from the interface.

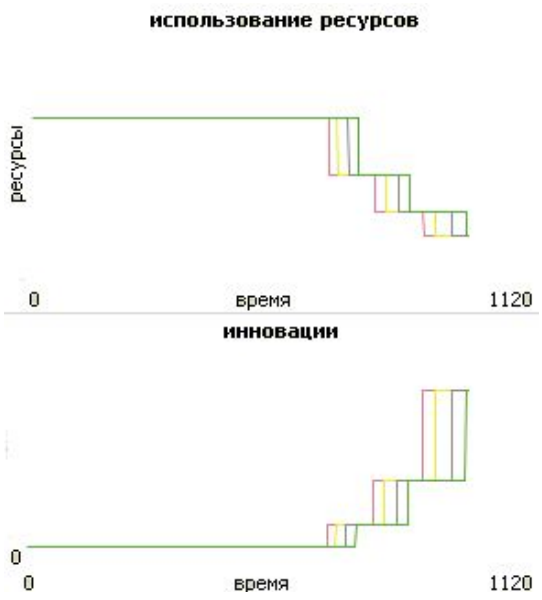

Figure 5. Use of resources and intensity of innovations

The graph for the total profit in a unit of time in this simulation is symmetric to the graph of marginal cost (Figure 6). The graphs stop being symmetrical when there is trade of natural resources, which leads to additional positive profit for one country and negative profit for another.

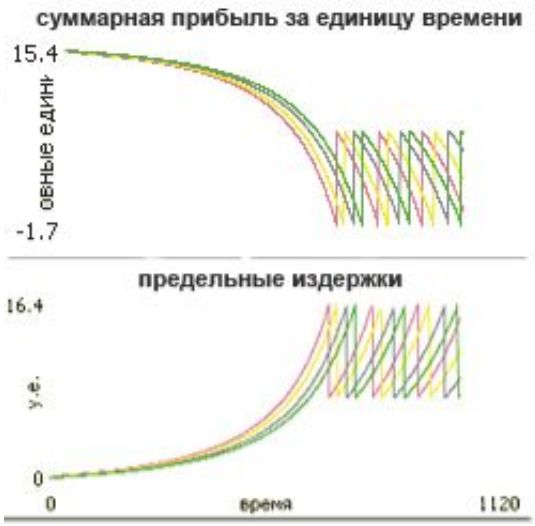

Figure 6. Total profit and marginal cost in a unit of time

It may be concluded that while the country has enough stock of natural resources for its existence, it preserves renter mentality.

Resources are spent extensively during a long period of time. However, in case of considerable decrease in the amount of resources the country has to lower marginal costs by implementing innovations. Yet, it if happens too late, the system does not have efficient amount of resources even under strongly innovative production. Therefore, in our model the country decides about the change of strategy not only according to the data on its resources but also assesses the data on resources that may be bought from other countries. The extensive way inevitably leads to rent-seeking and helplessness when at once natural resources disappear. Consequently, it is important to make quantitative assessment of the resources in possession and timely react to the implementation of innovations leading to lower resource intensity.

2. *If all countries had equally minor amounts of natural resources, would they have to start intensive development or would they all be subject to renter mentality, albeit at a low consumption level?*

Let us change only initial figures of the amounts of resources and keep all the values of the previous simulation. We set the values in the range of [51 - 60] in each of the four regulators and start the model (Figure 7).

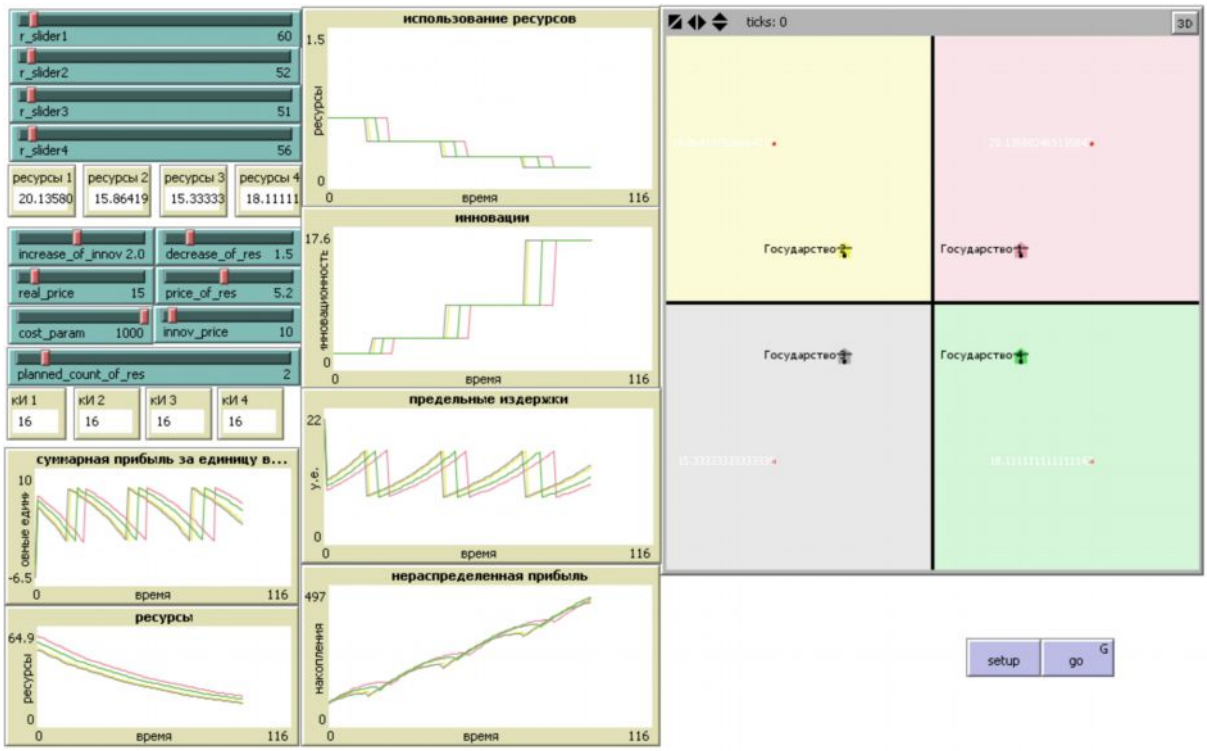

Figure 7. All countries have minor and almost equal endowments of resources

Marginal cost of a unit of good grows fast in each country. When marginal cost reaches the revenue from a unit of good, each country is forced to introduce the first innovation. As a result, the costs decrease twice and the use of resources falls 1.5 times. In several steps marginal cost reaches the revenues again, and again this causes introduction of an innovation, etc. After a large number of steps our model has 4 coexisting countries that consume considerably fewer resources that in the beginning and intensely employ innovations. We see that all the countries have successfully

managed rigid conditions of resource deficit and started to introduce innovations right away. Otherwise all the 4 countries would have lost their resources and viability.

3. If some countries had considerable and others – smaller (yet sufficient for self-provision and economic reproduction) – amounts of natural resources, would both categories of countries be subject to renter mentality or relative wealth in natural resources would cause poorer countries start intensive development?

Let two countries have resources in the range of [352-355] , and other two countries – in the range of [863-897].

As is demonstrated on Figure 8, at first all the countries have renter mentality. Resources gradually disappear and marginal cost increases. Note that marginal cost of the relatively poor countries grows faster due to approaching exhaustion of resources. At a certain moment relatively poor country starts implementing innovations. Rich countries continue extensive production. They also start selling resources, which gives them additional profit and shifts the moment of the introduction of the first innovation even further.

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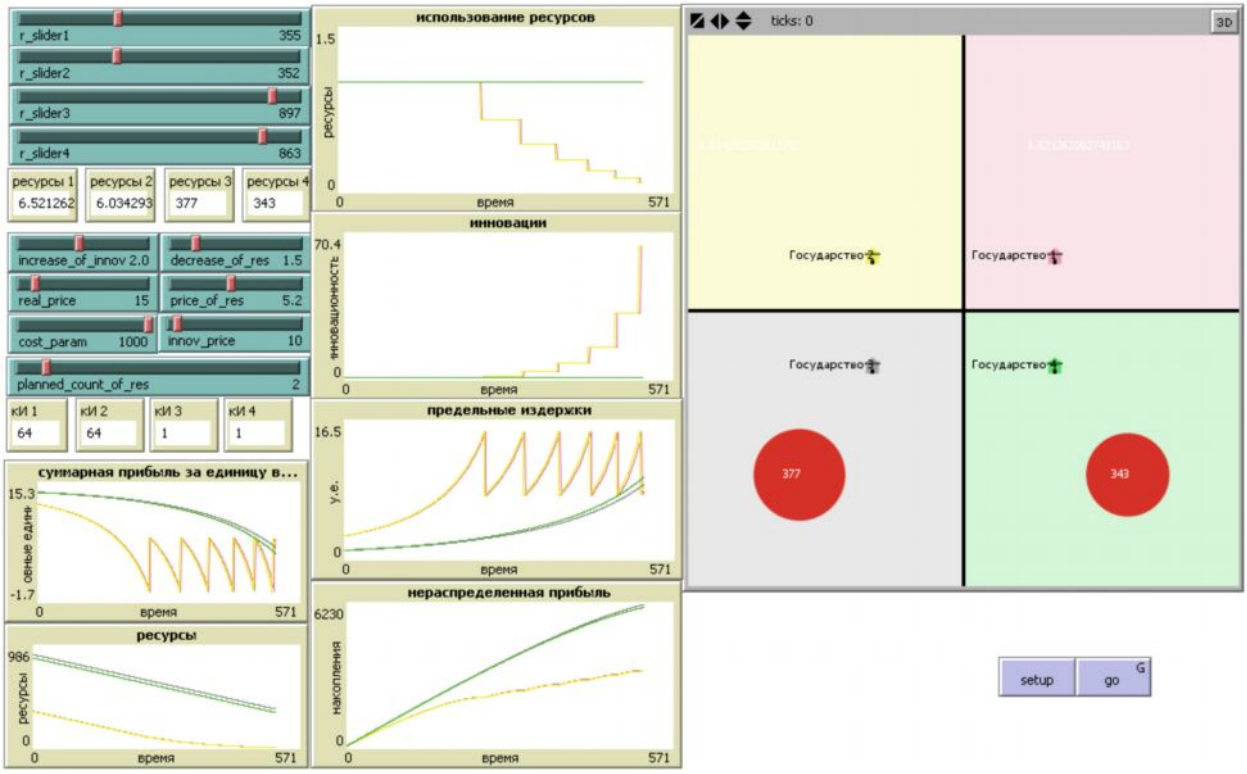

Figure 8. Two countries have considerable and almost equal endowments of resources. Other two countries have sufficient for their existence and almost equal endowments of resources

4. If some countries had considerable and others – extremely minor amounts of natural resources, would it inevitably lead to rent-seeking behavior of the former and the intensive development of the latter? In other words, would the combination of the three factors: relative difference in countries' provision of natural resources, sufficient provision of the former and insufficient provision of the latter, cause the above assumed behavior.

Let two countries have resources in the range of [34-43] and other two countries – in the range of [863-897]. The amounts of resources in poor countries are so small that they introduce innovations at the very first step. Very soon their resources are exhausted and they have to export from the countries with considerable resources. Additional costs cause innovative development, and within a short period of time poor countries raise 6 steps of innovation ladder. As is seen from Figure 9, this is

accompanied by unchanging total profit per unit of time; additional profit from selling resources, and unnoticeably rising marginal cost in rich countries. No wonder that countries with considerable amount of resources become resource dependent and countries with vanishing resources start intensive development.

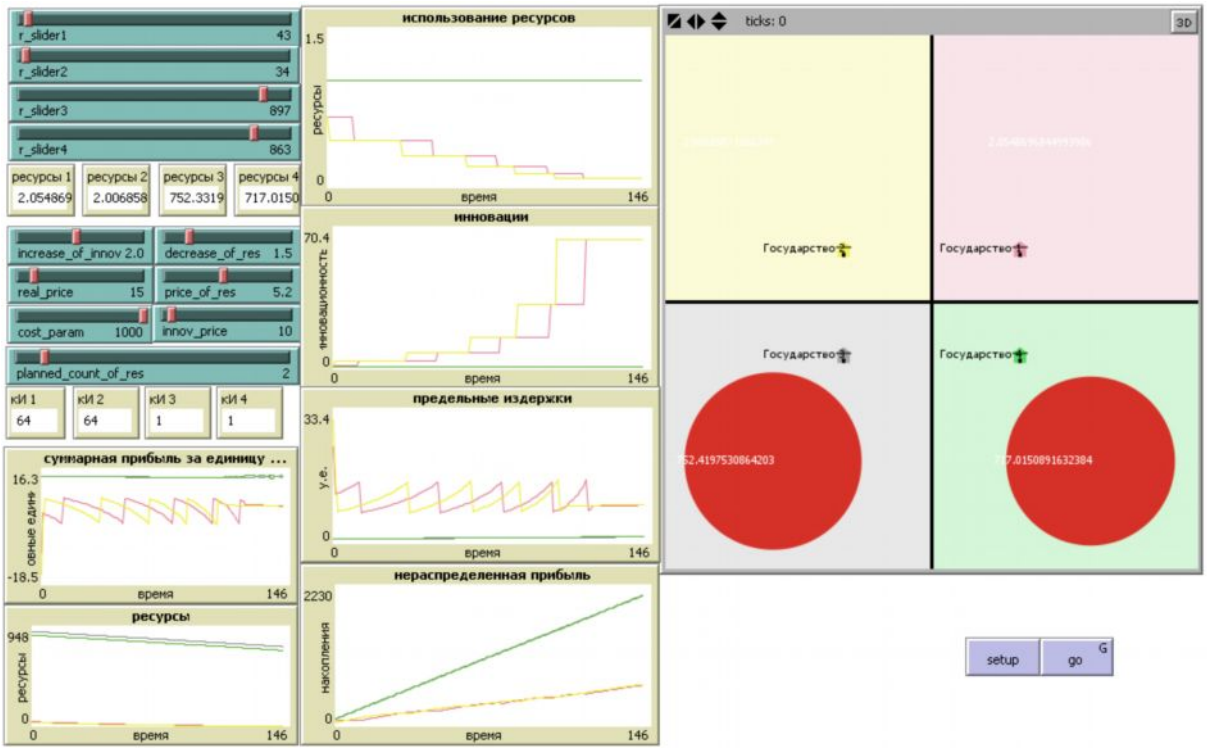

Figure 9. Two countries have considerable and almost equal endowments of resources. Other two countries have minor and almost equal endowments of resources

To sum up, the simulations prove the hypothesis that lack of resources in a country causes implementation of innovations. Large amount of resources decelerates the speed of implementing innovations, which becomes a negative factor for the security of economy. It may be concluded that the presence of considerable amounts of resources leads to renter mentality and formation of related institutions. Weak institutions, in their turn, cause low efficiency of resource use and a growth in resource consumption which is inadequate to the growth in production.

Deceleration of innovative component of economy due to the presence of considerable quantity of natural resources is a phenomenon of a negative external effect.

A normative conclusion coming from the revealed dependency implies that to improve innovative direction of the Russian economy it is necessary to artificially introduce institutions, which compensate for the external negative effect of the presence of natural resources. The development of such institutions is the goal of our future research.

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Developing the structure of universal simulation model of mass scenes in socio-culture

© Lavrov A.A. (Moscow)

The analysis of scientific research in computer modeling and creation of information systems for implementing mass scenes in socio-culture, conducted in our previous article in this journal, allows finding the approaches for theoretical and practical justification of developing the structure of universal model in this sphere. The model incorporates special features and the requirements of the field. Universality of the model is based on unified general theoretical principles for creating different types of computer models for the variety of mass scenes.

Development of realistic computer model of mass scenes required theoretical research of various aspects of interactions between the participants of mass scenes in the physical world and transferring these aspects to computer model. The methods of analysis and synthesis were employed. Using modern views on mass scenes I conducted a decomposition of actual mass scenes into their elementary components. Then these components were used to construct a universal model of mass scenes. The model corresponded to credibility criterion.

The construction of simulation models and the analysis of scientific literature revealed that any computer model of mass scenes contains a number of similar elements, with specific links between their components. The results of experiments and the study of scientific literature enabled creating baseline computer model of mass scenes. The model may serve a starting point for developing any type of mass scenes using the principle of constructor.

In search of the common model of mass scene in socio-culture, the author of this paper analyzed over 200 scientific sources. Most of these works deal with certain components of mass scenes (behavior of individuals in a crowd, behavior of a crowd, visualization, interaction of a crowd with the environment etc.). A limited number of papers analyzed mass scene as a whole and aimed at creating a complete model of

mass scene. These types of works served as a basis for studying approaches to model mass scenes in socio-culture.

It was revealed that most of the works modeling mass scenes in socio-culture were applied studies and did not deal with the issue of developing a universal model for mass scenes. Note, however, that two major elements of mass scene (crowd and environment) were present in most of the analyzed models. Incorporating environment is a major requirement for obtaining a credible model. Other formal requirements for credibility of mass scene were preserved in the above literature.
The analysis demonstrated the need to create a universal informational model of mass scene in socio-culture, which would include all the necessary elements of mass scene and their components.

The author obtained the following model of mass scenes (Fig.1), which was tested in simulations and in a number of commercial projects on computer modeling of mass scenes [3; 4; 5; 6; 7; 8; 9; 10; 11].

Figure 1 demonstrates baseline computer model of mass scene, described in a unified modeling language (UML).

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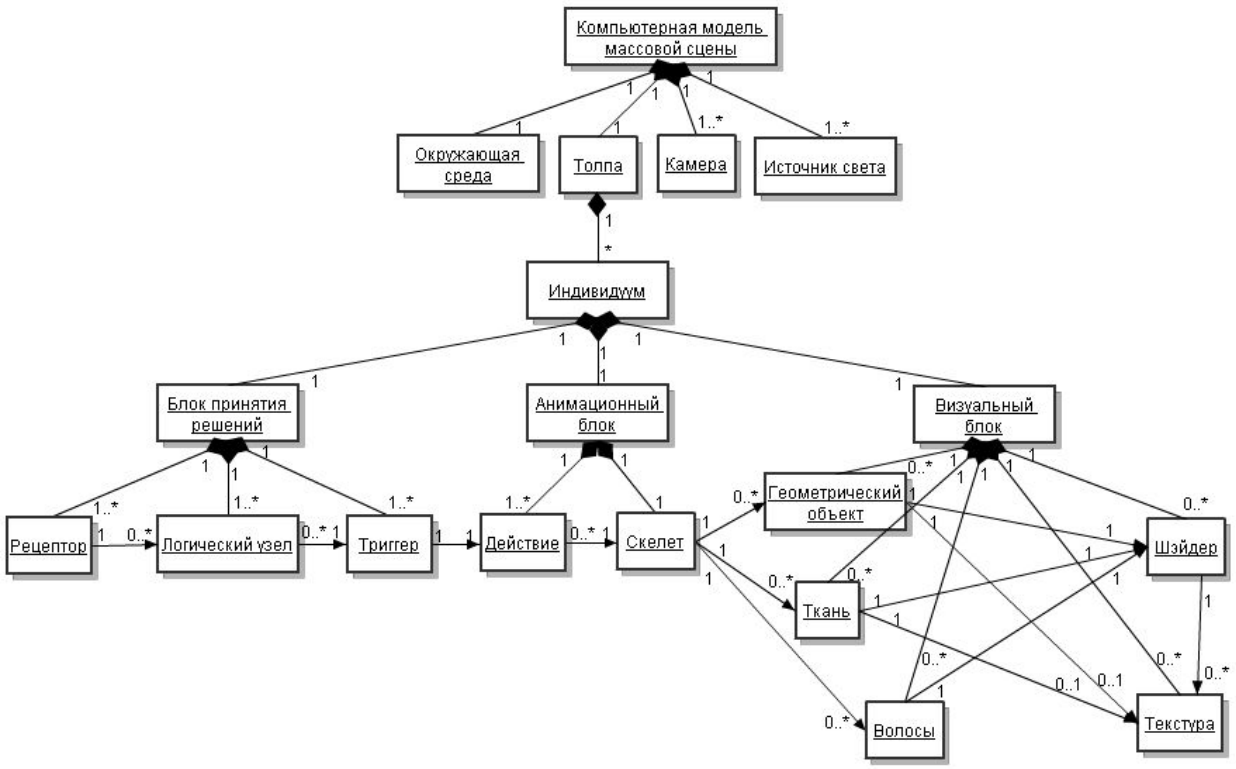

Figure 1. Structure of universal computer model of mass scene in socio-culture

In our description computer model of mass scene consists of four basic elements:

Crowd

Environment

Camera

Source of light

Crowd is the key element of mass scene.

The impression of "human race" as a weakly organized amorphous totality of people appeared analogous to impressions of amorphous physical masses. Although crowd consists of multiple individuals, it is observable and is described as actions of one subject. In practice, however, words "crowd" and "mass" are used non-strictly, sometimes as synonyms. The study of scientific sources made the author conclude that this is not always correct. The term "mass" may be regarded as a generalization, determining certain abstract social unity of people. The term "crowd" demonstrates a

concrete totality of people in a mass in a certain situation. In this sense it may be noted that any crowd is a mass, but not any mass of people gathered in the same place is a crowd. Consequently, this paper analyzes crowd in socio-cultural scenes.

Since this research regards crowd as a concrete totality of members of certain mass in a given situation, one model of mass scene includes only one crowd. A number of generalizations about crowd were conducted in the course of research in order to create baseline computer model of mass scenes and use it as a reference guide in creating specific computer models of mass scenes.

International scientific literature accumulated large experience of studying mass scenes, which generally correspond to the framework of well-known approaches of social psychology [2; 13], the fundamental science in studying crowd and its properties.

As any phenomenon, crowd may be classified according to different grounds. A large number of classifications of crowd exist in the literature [1; 12]. Creation of a credible computer model of socio-culture requires understanding possible types of mass scenes and their key characteristics. For our purposes of modeling it is interesting to consider the experience of research of those internal and external characteristics of mass, which reflect its inner processes. A number of general characteristics of different types of mass may be noted in this regard.

External characteristics of crowd (its reflection):

- scale of mass scene;
- way of implementing internal and external communication;
- internal substructure;
- character and way of interaction with outside world;
- geometric and time parameters;
- size of ground occupied by crowd.

As for internal characteristics, the system of internal and external links is crucial for our model. In socio-culture this is scenario for the actions of a given crowd.

Summing up, we may conclude that the principle for modeling may include the component for physical reflection of elements (visual block) and the system of external and internal links that determine the order of interactions between elements and external factors (making decisions and actions).

Element **crowd** incorporates unlimited number of **individuals**.[1] The computer model in this paper does not have limitations on minimal and maximal number of individuals, since this research does not focus on quantitative indicators of a crowd.

Each individual interacts with others and with the environment. For these purposes an individual must include:

- **Decision making block** (unique for each individual), which enables governing of the behavior of individuals and the crowd as a whole.
- **Animation block** (unique for each individual), which provides for direct action of individual in making a certain decision.
- **Visual block** (unique for each individual), which reflects major elements of an individual on screen.

Decision making block consists of three components:

- **Receptors** (in theory, their number is unlimited) allow receiving information about other individuals and surrounding objects from the environment, and transfer this information to decision making block in a form, suitable for computer analysis. Receptors enable individuals adapt to the environment.
- **Logical nodes** (in theory, their number is unlimited) are building components for a complex network of decision making. The logical network is built from these nodes. The nodes keep intellectual potential of each individual.

[1] Separate, unique in a given crowd, computer characters («virtual actors»).

- **Triggers** (in theory, their number is unlimited) receive the results of decision making from logical nodes and start corresponding actions. Triggers are the final element of decision making.

The three basic components allow creating an individual, who will adaptively react to environmental changes and will make various decisions. Such individual looks credible.

Animation block includes:

- **Actions** (in theory, their number is unlimited) are certain sets of animated movements that are started up by triggers in corresponding situations in the environment or inside individual.
- **Skeleton**[2] is a link between intellectual, animated and visual parts of an individual. Skeleton transfers decisions and actions to the visual part of individual. Individual may have only one skeleton. There is a visual movement of geometric parts of the body and of other components of individual.

Visual block of individual is more important in socio-culture than in other applications, since the results of modeling of mass scenes in socio-culture is a high quality video or image.

To reach high credibility of visual component of individual in computer model the author did the research of scientific literature and used his personal experience. This enabled revealing the following components of the visual block of individual:

- **Geometric objects** (in theory, their number is unlimited) allow to reproduce solid forms of individual (e.g., parts of body, clothes, objects in hands etc.). Shaders are used for geometric objects (at most one shader per object).

[2] A metaphor from the field of computer graphics. Appeared due to similarity between the functions of skeleton in the real world and the movement of dots of geometric objects in computer graphic.

- Shaders[3] (in theory, their number is unlimited) enable modeling absorption and dispersion of light at the surface of geometric object, stacking of texture, reflection and refraction, shading etc. Textures are fixed to shaders (the number of textures per shader varies from zero to infinity).

- Textures[4] (in theory, their number is unlimited) use shaders to give the surface of geometric objects color, facture, imitation of shape etc.

- Clothes (in theory, their number is unlimited) are necessary for visualization of objects from clothes. When individuals are located far from camera, in most cases simple geometric objects are used to model clothes. This differs from standard geometric objects and enables simulate clothes. The approach is employed in modeling observable components of clothes (cloaks, flags, ribbons etc.) at close-ups.

- Hair (Set of hair cuts, in theory, their number is unlimited).

When individuals are located far from camera, in most cases simple geometric objects are used to model hair. However, when individuals are located at close-ups, the approach is not justified and simulation of individuals' hair is required.

Components of visual block have stronger interrelation than components in the above described blocks. This is explained by the necessity of the presence of certain elements to represent other elements. Furthermore, the elements closely interact in simulations.

To sum up, we obtained a universal structure of computer model for mass scenes in socio-culture, which may be used in developing mass scenes of various types.

[3] The program of one of the steps of graphic conveyer, used in three-dimensional graphics to determine final parameters of an object or an image.
[4] Raster image put at the surface of polygons constituting 3D objects. Gives color or imitation of shape to the surface.

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The Influence of the Crisis on Gender Structure of the Users of Social Networks

© Bobkova I.A. (Moscow)

The article describes the changes in the gender structure of the users of social networks in the World Internet and the Russian segment of Internet in the year of depression (2008- 2009).

Social networks are the most dynamically developing segment of Internet as a whole and of Russian Internet in particular. The largest networks are top-3 popular sites by the number of visits a day and by coverage of the audience.

The time the users spend in the Internet, their activity in searching for new networks and in discussing urgent problems increased in the year of the crisis (2008-2009). About one third (31,8%) of the users turn to social networks for work purposes, a quarter (26,3%) – for entertainment, 21,8% use social networks for communication and 10,1% spend their free time in social networks.

According to the research by J`son & Partners Consulting (Fig.1), men are the most active part of Internet users. The share of men in dating services is 60-65%. They are mainly young men aged 26-28 with average monthly income 9-15 thousand rubles. However, the picture is different in social networks and communication servers – this is the only non-specialized part of Internet for mass users where women are prevalent (about 60%).

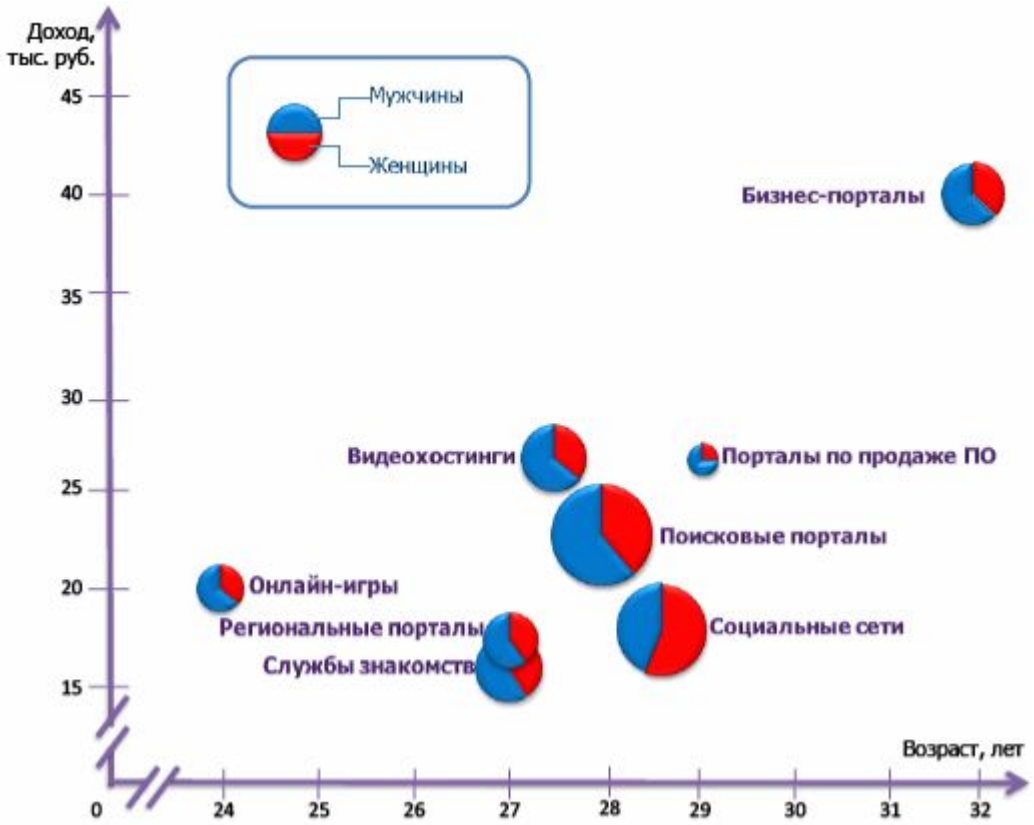

Figure 1. The structure of the users of Russian Internet (Source: J`son & Partners Consulting)

We may note that social networks have "women's face". Women became major users of social networks in 2009: over 50% of users of Twitter, Facebook, and over 60% of users of MySpace, Classmates, Bebo are women (Table 1).

Russian Internet demonstrates similar tendencies. The number of women-oriented sites of the Russian Internet increased twice in recent year (102 %). While regional audience of these sites rose 26%, the share of visits from Moscow and St.Petersburg decreased 10-11%. Yet, the users from Moscow (including Moscow region) and St.Petersburg are 30% of the users of women's sites. Women are 49,8% of urban population regularly using Internet.

Table 1. Gender structure of social networks users (% of total users)

Social network	Men	Women	Gender not specified
Facebook	40	56	4
MySpace	35	64	1
Bebo	29	68	3
Twitter	42	57	1
LinkedIn	37	55	8
Flickr	41	54	5

Preferences of women's audience of social networks differ by age: young women prefer VKontakte, LiveInternet; women over 30 – odnoklassniki. Similarly, the topics for discussion differ: cosmetics, beauty, music in the younger group and family relations, health, children in the older group. Women of older age more frequently use social networks for search of work.

As is shown on Fig.2, women's audience kept increasing within the crisis year (September 2008 to September 2009). In certain months the growth of users was over 10%. The fall was noticed in January and May-July 2009, which are the periods of the New Year and the first week of May vacations, and summer vacations in schools and universities. According to Public Opinion Fund, the visits to the sites in women's Internet increased 11% in the second half of 2009.

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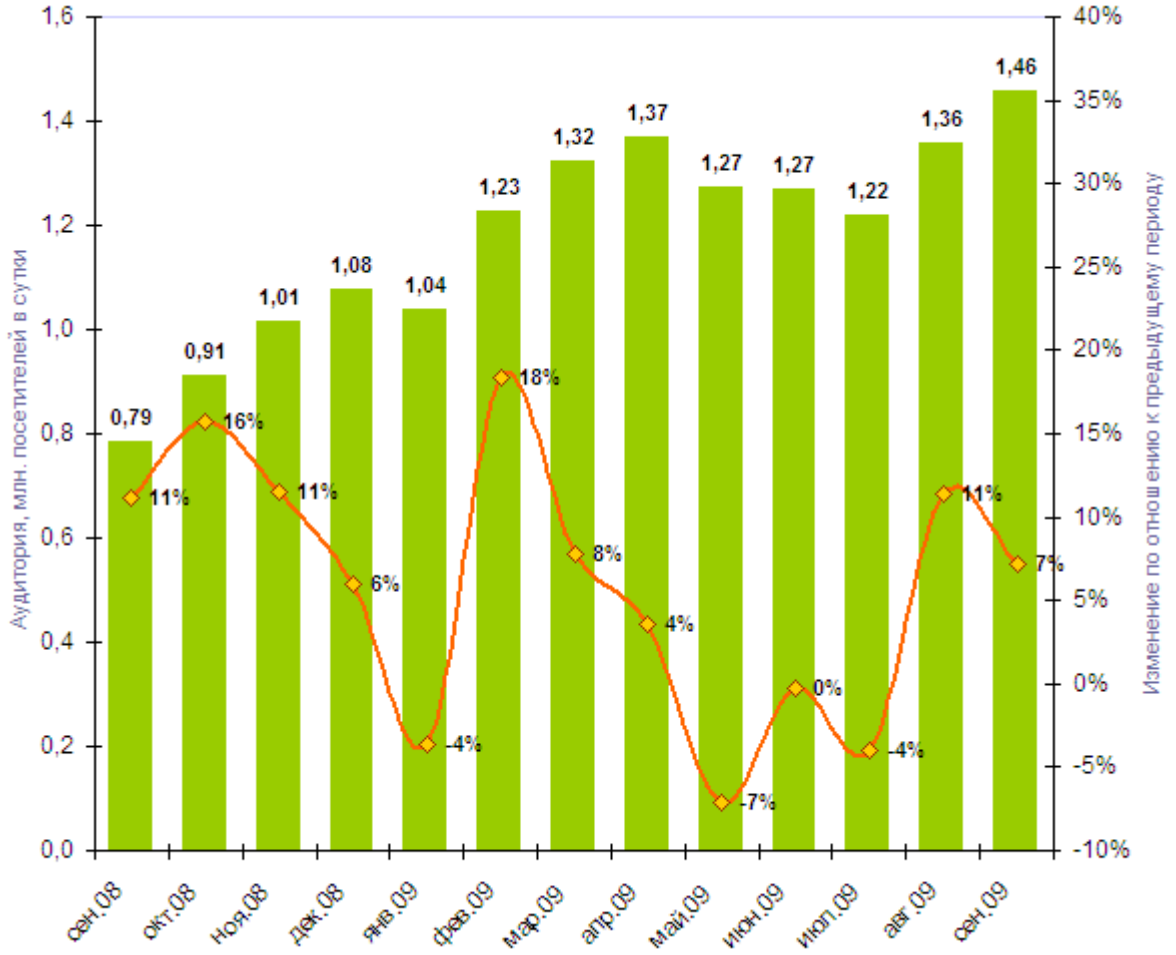

Figure 2. Dynamics of daily audience of women's part of the Russian Internet, September 2008-September 2009. (Source: Rumetrika)

Women are 60% of users of social networks and sites for communication in the Russian Internet. Mainly they are women below 30 with average monthly income 15-20 thousand rubles. 45% of Internet users over 30, which were surveyed by Rumetrika and Public Opinion Fund, said that they have a profile in one of social networks. Most of women with a profile in social network use social networks at least several times a week. As for women below 30, 86% of them have a profile in social networks.

The attitude of women users of social networks towards advertisement differs from that of the users of typical women's sites. Therefore, investment of advertisers into women's sites, especially by topics "real estate", "tourism" and "cars" was increasing during the whole year (Source – service of contextual advertisement "Begun"). Women use banners and advertisement links more frequently than men.

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This may be explained by natural curiosity, variety of women's interests and the fact that women are focused not only on professional problems but on everything which is related to family. The joint survey by Rumetrika and Public Opinion Fund is particularly interesting in this regard. Most of women respondents said that they consider advertisement in social networks ineffective. 26% of respondents noted that they just ignore such advertisement and 20% are annoyed with it, since it disturbs them from communication for which they use the Internet.

The preferences of women below and above 30, who visit social networks, differ as well. Young women and older women prefer different sites. Older women are more often oriented at using Internet for practical purposes. They make purchases in Internet shops more frequently, they write reviews of interesting goods, they use social networks as "continuation" of daily communication. At the same time women below 30 use Internet just for communication. Young women and older women discuss goods in different ways: 20-30-year olds prefer blogs, and older women – personal, friendly communication.

On average, women have 20 to 49 contacts in social networks. Young women have more contacts than older women. 25% of respondents below 30 have more than 200 contacts, while only 4% of women around 40 have the same number of contacts.

Although almost three quarters of young women mentioned "communication" as the main purpose for using Internet, only one third of older women did so. Young women are more inclined to post their pictures in the Internet than write reviews about products (correspondingly, 78% and 53%), and older women naturally have opposite preferences.

According to the survey by SheSpeaks, older women more frequently participate in sociological survey. Young women-users of women's sites more frequently respond to somebody's post than those aged around 40 (correspondingly, 63% and 50% of respondents). The same tendency is with writing their own blog (respectively, 46% and 27%). Most popular social networks among young women are Facebook

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(65%) and MySpace (63%), among older women Classmates.com (42% if compared to 19% of respondents below 30). The similar situation is in Russian Internet with social network sites VKontakte and Odnoklassniki.

Table 2. Participation in social networks by women of different age (% of respondents), the data of Rumetrika and SheSpeaks

Parameter	Women below 30	Women above 30
Most preferred network	VKontakte	Odnoklassniki
Topics of discussion	Cosmetics, beauty, music	Family, health, children
Usage of network	Communication	Reviews, contacts
Have profiles in social networks	86%	45%
Search for communication and connections as major purpose	73%	31%
Tendency to post pictures	78%	26%
Tendency to write consumer reviews	53%	68%
Over 200 contacts	25%	4%
Establishing friendly contacts in networks	14%	20%
Using network for job search	7%	16%

The problems discussed by women this year did not differ much from usual problems: relations (31,2%), health, beauty, personal care (over 20%), family, children, fashion, renovation of home (12-18%). Job search and issues of economic crisis might have worried women, but were not widely discussed by them. At the same time older women started to use social networks for job search slightly more frequently.

Conclusions

To sum up, the following conclusions may be made about the year of crisis.

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1) Internet audience and audience of social networks increased both worldwide and in Russia.
2) The preferences of users of social networks changed towards globalization almost in all countries (including Russia), worldwide social networks moved to higher positions in ratings.
3) In 2009 social networks obtained "women's face" - women's audience in most of the largest networks rose to 60%.
4) The number of typically women's services of the Russian Internet increased twice during the year (102%).
5) Surveys demonstrate that 45% of women over 30 have their profiles in social networks, in case of younger women the corresponding figure is 86%.
6) Despite the crisis the range of most frequently discussed topics by women is the same – most prevalent are relations between men and women (32%), then follow health and children.
7) The number of users who turned to social networks in searching for a job increased during the last year. More than 30% of respondents who were looking for a job with the help of the Internet used social networks; women over 30 turned to social networks in job search twice more often than younger women.
8) Job search is most frequent in the following Russian sites: Vkontakte, Moi mir, Odnoklassniki, Moi krug, Planeta Rambler.
9) Expenditure on advertisement in social networks rose 119 % during the year, while in other Internet resources this expenditure decreased.
10) Women are indifferent towards advertisement in social networks, as they try not to interrupt their communication, which was the primary goal of their using the networks. However, in other Internet resources women are more frequent users of Internet banners than men.

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Systematization of the Experience of Teaching the Foundations of System Analysis and Imitational Modeling to Students of Social Sciences

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The article systematizes the four-year experience of teaching the foundations of system analysis and imitational modeling to students of the department of public administration of Moscow State University. We analyze the program of the course; educational goals and tasks; methodology of employing systematic and dynamic approach to teach imitational modeling to the students of social sciences; and the results obtained with the help of the course.

To understand special features of managing complex adaptive systems it is necessary to introduce modern active elements of teaching management. These elements are visual; they give experience of making complex decisions in management; promote the development of systematic thinking and enable understanding of the essence of complex problems. System dynamics is a universal method for systematic thinking and modeling the behavior of complex socio-economic, biologic and other systems.

1. First steps. The idea of teaching imitational modeling and system dynamics appeared after the study of D.Yu.Katalevsky in MA program in 2004-2005 in в Nelson Rockefeller College of Public Affairs and Policy, University at Albany (State University of New York). Studying in the post-graduate school of the department of public administration in 2005 – 2008, Katalevsky developed a course “Introduction to System Thinking and Imitational Behavior”. Originally the course was regarded as a subject, mainly aimed at adapting the principles of system thinking and the foundations of system dynamics, and implementing them in the process of decision making in management. This was largely explained by social science feature of the

course and the need to teach it to students, specializing in "public administration" and "anti-crisis management". However, later the course was considerably enlarged and supplemented by cases from business and public administration, by imitational models (system dynamics and agent-based), and by numerous imitational games.

Methodologically, the course was regarded as innovational: it was planned to use simulators and imitational games, on various materials by leading Russian and western researchers for self-study, optional reading lists. The format of lectures provided for spending a considerable amount of time for discussions and for employing a variety of models from the experience of public administration. We believe that the approach allows to effectively teach future administrators according to the Russian state educational standard.

A certain success of the course was considerably predetermined by the tradition of research and teaching imitational games as 1) an independent discipline, and 2) within social and natural science courses in Moscow State University under the supervision of Mikhail Mikhailovich Kryukov, Dmitry Nikolaevich Kavtoradze, Vladimir Nikolaevich Sidorenko and others. The presence of experienced researchers allowed using more than 30-year experience of employing imitational games in teaching various disciplines (from biology and ecology to economic theory) and borrowing certain original ideas, which received a successful approval. A.I.Ivanova who was an assistant in lectures and seminars provided invaluable help for the development of the course.

In 2009 D.N.Kavtaradze, supported by the dean of the department of public administration A.V.Surin, created Laboratory on imitational modeling and games. The course "Foundations of imitational modeling in public administration" became a discipline in this laboratory for the 4-5th year students studying in the department. Later the course was considerably enlarged by related disciplines, such as foundations of agent-based modeling, social networks in management. Currently, the

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course is given together with other members of the department, in particular, with Vladimir Viktorovich Solodov.

2. The purpose and structure of the course. Originally given to the 5th year students in the first semester of the academic year 2005-2006, the course was aimed at making strategic decisions in organizations. The main purpose was to acquaint students with major principles of system thinking, in particular, with the concept of feedback in management.

The basis for the lectures were methodologies for scenario planning [1]; development of strategic plan of organization [2] (an example of preparing the strategy for development of the department of public management of Moscow State University); study of basic archetypes of systems offered by Peter Senge in his book "Fifth Discipline" [3], analysis of works by Jay Forrester, John Sterman and others on counterintuitive behavior of systems. Under kind permission of Professor of London Business School Kim Warren business simulator LoFare Simulator was employed during the course. This was the first use of the simulator for teaching Russian students, majoring in public administration [4]. Students did homework to master the methodology of developing cause-effect diagrams and use them for analyzing a large range of problems in administration.

In 2006-2010 the course was enlarged: it included adapted foreign cases (e.g., case "Kaybab Plateau"), and specially developed cases in the filed of public administration ("Traffic accidents and safety on roads"), business (cases on strategic management of companies "Euroset" and "Microsoft" [5]), imitational models and games («Fishing», «Response», «COMPAS» [6] etc.).

An important part of the course is material on management complexity and barriers for making decisions by modern administrators. We believe that preparation of highly qualified specialists currently is impossible without teaching students not only knowledge but *skills* of administration. Unfortunately, Russian and to a large

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extent western system of education aim primarily at preparation of "theorists" in administration: the key feature of such system is "filling" students with information on various kinds of administration approaches, schools of management, theories of administration etc. Although wide theoretical background is necessary for any modern specialist, an important issue is *creating administrative skills*, with the most important skills of *information analysis* and *decision making*.

According to numerous research in dynamic decision making, regardless of their age, experience and qualifications people making decisions are equally bad in copying with situations even with low degree of complexity.

This justifies the necessity to search for a new approach in teaching. Peter Senge calls it learning by doing [3]. Employing the concept of "learning by doing" in educational process requires active use of imitational games and trainers, allowing for developing the skills of making administrative decisions in situations with high uncertainty/ambiguity, lag effects, time constraints in decision making. Consequently, the course on system analysis and introduction to imitational modeling, taught at the department of public administration, was developed with consideration of the following goals:

1. Demonstrate complexity and ambiguity of making administrative decisions in dynamically complex environment.
2. Teach practical implementation of instruments of decision making (cause-effect diagrams of feedback, system dynamic and agent-based models), allowing for complex analysis of administrative situations and for effective decisions.
3. Develop skills of administrative decisions in dynamically complex environment.

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When the above goals are successfully reached, the quality of preparation of students majoring in administration increases and they become better specialists. Indeed, after studying the course students become able to:

- better conceptualize the complexity of administrative environment and, consequently, become more careful in decision making through taking into consideration counterintuitive behavior of systems and possible side-effects of administrative interaction;
- effectively master soft system dynamics skills, learn how to create cause-effect diagrams and understand the problem on the language of "feedback";
- study the foundations of imitational modeling, create small simplified models for primary analysis, and correctly demonstrate behavior of generalized system (albeit the course is not aimed at developing modeling skills, which is studied in a more specialized course);
- develop decision making skill in a dynamically complex environment and team work. This is implemented through participation in several imitational games, conducted within the course.

3. Program of the course. The program of the course is based on the logics developed by the experience of teaching. We believe that the below proposed program enables effectively reach the goals.

The course on foundations of imitational modeling was primarily taught to students in the 4-5th years. By the time of attending the course, the students had good knowledge of theoretical foundations of decision making, instruments for strategic analysis, etc. Therefore, convincing them of non-trivial character of decision making in a complex environment was rather hard. Introductory lectures devoted to

counterintuitive behavior of systems and side-effects of administrative interactions were taken very skeptically by students, despite numerous examples of corresponding academic research and real life. Moreover, the largest part of the audience was convinced in its high effectiveness of decision making, although this confidence was not based on actual administrative experience.

To deal with the problem we decided to construct the program of the course so that the first lectures demonstrated the student low effectiveness of decision making in a dynamically complex system. Consequently, at the first two lectures that were linked together, the audience was divided into small groups and each group participated in an imitational game. The total time of the lectures was 2,5 - 4 hours (optimal time 3 – 3,5 hours).

We recommend to use such game as “Fishing”, STRATEGEM, «Econet ABC», «LoFare Simulator» as suitable imitational trainers. The major criterion for the choice of an imitational trainer is complexity and speed of game dynamics, which keeps the players tense during the whole game. The results of the game are highly probable to be far from optimal. At the end of the game it is necessary to conduct debriefing and receive the feedback from students. Specialists in imitational modeling and games (e.g., M.M.Kryukov, D.N.Kavtadze) believe that conducting the game *may not be considered complete* without the feedback. The participants of the game are usually frustrated by the failure and dissatisfied by the results. Therefore, the talk should be made constructive and start from discussing the reasons for the failure (linear thinking, underestimation of the feedback, simplified mental models).

This enables effective preparation of students for perception of the lectures (see Table 1).

Table 1. Program of the course

Lectures 1-2. Imitational game /trainer. Fishing (variations - Response, STRATAGEM). Debriefing and feedback from the participants. *Results*: students are convinced in their inefficiency of making decisions in administration. Previous stereotypes are destroyed, the readiness for perception is formed.
Lectures 3-4. Administration in dynamically complex environment. Definition of dynamically complex environment. Sources of making inefficient decisions (experiments). Counterintuitive behavior of systems. Linear thinking and mental models. Small games on cognitive peculiarities of making decisions. *Result*: justification of the need to change to thinking on the basis of feedback.
Lecture 5. Introduction to creating cause-effect diagrams. Simple cause-effect diagrams. Analysis of a case on counterintuitive behavior of systems. *Result*: acquaintance with the rules for creating cause-effect diagrams. Introduction to the foundations of concepts of complex systems.
Занятие 6. Archetypes of systems (according to the works of P.Senge). Study of 3-4 basic archetypes of systems with examples from business and public administration. Case on one archetype for self-study in a group. *Result*: acquaintance with archetypes of systems, training of the skill to construct cause-effect diagrams of feedback.
Lecture 7. Case «Kaybab Plateau» (self-study in groups duringt he lecture). Comparative analysis of work and mistakes. Demonstration of the model Kaybab plateau. Debriefing.

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Result: training of the skill of modeling cause-effect diagrams during the work of expert group.
Lecture 8. Introduction in systematic and dynamic modeling. Concept of "flows" and "storages". Study of simple models. *Results*: introduction to the foundations of simulation modeling. Software (Vensim/Anylogic)
Lecture 9. Model of F.Bass (description of the model and sensitivity analysis). Model for the spread of epidemics and diffusion of innovations. Presentation and analysis of several models of D.Katalevsky.
Lecture 10. Kim Warren and the concept of "strategic architecture" of organization. Dynamics of personnel in consulting organizations (the basis for cases are materials of research by McKinsey). *Result*: acquaintance with the recent approaches in modeling the strategy of organization, developed by leading business schools (London Business School, MIT).
Lecture 11. Effects of increasing returns to scale and managing the growth of a company (cause-effect diagrams). Game by A.Ivanova «Market racing». *Result*: acquaintance with the concept of increasing returns to scale; study of practical aspects of applying system dynamics for forecasting the outcome of competition at high-technology markets.
Lecture 12-13. Agent-based modeling (introduction). Comparison of system dynamics and agent-based modeling. The strong and weak features of each method. *Result*: study of agent-based modeling and its key features.

Lecture 14. Consulting students on cause-effect diagrams for their final works. Detailed analysis of students' works and methodology for constructing diagrams and models. *Result*: developing "soft" skills of conceptualization and analysis of complex systems.
Lecture 15. Agent-based modeling: examples (study of a number of models). Perspectives of modeling. Unified system dynamics and agent-based models. *Result*: acquaintance with agent-based models and "know how" of agent-based modeling
Lectures 16-17. Conference at the end of the course: presentation of final works of students (in groups). Lecture 18. Exam

As was above noted, the core of the course is system dynamics, effectively amended by a large range of imitational games. Note, however, that application of system dynamics in teaching has both advantages and difficulties.

In her work "Modern methods of teaching administration of natural resources", 2008, Ivanova A.A. conducted research of educational effectiveness of system dynamics methods and imitational games compared to traditional forms of teaching students majoring in "management". The research was based on the survey of lecturers in management, administration of natural resources, public administration; and of students and graduate students (altogether 22 interviews with respondents).

On the one hand, the survey revealed that system dynamics has a number of advantages compared to traditional methods of analysis and approaches to solve administrative problems. In particular, the methodology becomes a universal

approach allowing to study a wide range if issues; quickly conceptualize a complex problem and apply system approach for its solution; effectively incorporate the consequences of feedback. The method was noted to be visual, making students deeply understand the essence of the problem and learn independent thinking, instead of employing mechanic memory and commonplace patterns.

At the same time, the survey proved the existence of certain difficulties, so called *barriers to learning*. Indeed, respondents mentioned the need of large time and personnel resources for the use of imitational models and games. Experts pointed out such problematic fields as the necessity of high concentration of lecturer's efforts and, labor intensiveness in preparation to lectures; the requirement to have due technical resources.

Altogether we can note that considerable positive experience has been accumulated in applying system dynamics in teaching students who major in administration. This experience has been continuously proved by positive comments by students. Yet, preparation of the course requires considerable intellectual and time efforts. These are efforts on the part of lecturer (besides traditional materials the course provides for the use of imitational models and games), as well as efforts on the part of students (without active student participation in the teaching process it is impossible to learn game and modeling method).

4. Difficulties in learning the foundations of system dynamics among Russian students. Major difficulties that students meet in learning the foundations of creating system dynamics cause-effect diagrams may be divided into several groups:

- At first many students can not correctly build outlines of the feedback: variables are related with each other but there is no feedback.

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- Incorrectly named variables: students use such terms as “growth”, “improvement, worsening”, “fall, decrease”, “fauna”, “climate”, “nature” etc.
- Links between variables are wrong, ambiguous, directed in the wrong way.
- Duplicated links, diagram becomes a “tangle”.

To reach student understanding of the above mentioned issues in creating correct cause-effect diagram it is necessary to jointly analyze mistakes and, if necessary, organize individual consultations. An effective way is a game-exercise “Living Loops” [7], which demonstrate behavior of variable in a closed loop of feedback depending in the total number of negative links in the loop. It is useful to employ other games, which develop system thinking, such as “Thumb Wrestling”, “Warped Juggle” [7] etc.

The above games-exercises enable participants to use their own experience for better perception of the material. This was continuously proved within our course. Owing to the exercise “Living Loops” students learnt correct interpretation of cause-effect diagrams and forecasted the behavior of the system depending on its behavior in time. Physical movements and visual perceptions during the game, personal involvement in the process, making guesses and their proof or refutation, positive or negative emotions – all this raises the participants of the game on a qualitatively new, systematic level of understanding material. Therefore, it is recommended to use small exercises with games with large educational potential in teaching process.

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5. Modeling: problematic field and cause-effect diagrams.

As their final task of the course, students traditionally prepare projects in groups. The projects may be based on any topic and need to (1) demonstrate an urgent problem in the filed of public or business administration, (2) describe the implemented administrative action, its positive consequences and hidden side-effects, (3) offer their ways of solving the problem with application of system approach. The approach demonstrated its effectiveness in teaching the foundations of system dynamics, since it:

- makes students actively use skills on constructing cause-effect diagrams, anchoring the knowledge and the experience on conceptualization of complex systems;
- teaches students the skills of team work;
- develops scientific approach to solve typical administrative problems (below is the list of the themes of student works).

For example, the following projects were conducted by the 5th year students of the anti-crisis management faculty of the department of public administration of Moscow State University in the autumn semester of 2009: “Climate change and global warming”, “Moscow real estate market: mechanisms for price creation”, “Muslim migration and its consequences for Western Europe”, “Strategy of development for Starbucks Coffee Company”, “The research of the factors for the growth of the cost of open joint-stock company Vympelcom”, “The reasons for the death of Ancient civilizations (Assyria, Inca, Maya, Aztecs)”, “Obesity problem in the US and the ways to solution”, “Swine influenza epidemic – who benefits?”

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During the lectures the students analyzed ecologic problems, bad habits (alcohol smoking), mortgage crisis, regional wars and conflicts (Iran, Lebanon), traffic jams in mega polis, creation of antibiotics and struggle with viruses, legislation, education, price policy, export, taxes, fast food etc. Some students made additional optional research and analyzed their own career expectations and plans.

Finally, let us note that it is necessary to introduce teaching of system thinking in all directions of education system. The subject may be taught from primary school (this is the idea of the founder of system dynamics Jay Forrester, who is currently involved in the project K12 – to introduce system dynamics to elementary and middle schools in the US). Imitational games and modeling (system dynamics) are undoubtedly most effective forms of study for this purpose. Their potential is still not fully revealed in the Russian educational practice. One of the barriers is insufficient preparation and qualification of teaching staff in this method. There are also objective difficulties related to the application of the method, such as technical sources in the class, labor intensity of preparation to lectures, experience of lecturer in organizing imitational games and creating models.

System dynamics as a method of modeling complex systems, combined with modern developments in imitational business games, may become an affective supplement to traditional forms of teaching. The authors of the methodology described in this paper actively participated in several winter schools and workshops on imitational games. As a result, we continue to amend the course on imitational modeling by various simulation exercises. We also plan to enrich the course by cases in system dynamics and agent-based modeling in different topics in administration. According to the results of the questionnaires, students highly assessed the course and recommended enlarging the part of the course, devoted to demonstration and analysis of applied models in business and public administration.

The authors hope that these efforts will promote the spread of the course in the department of public administration. In this way students of final years of their undergraduate study, who already know the method of modeling, will be able to analyze administrative problems at qualitatively higher level with the help of imitational modeling.

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Agent-Based Model of Salary Size Influence on the Development of Economy

© Akhamadullin D.G., Gizatov N.R.(Ufa)

The article describes an agent-based model which allows studying the influence of the salary paid by employers on the rate of economic development. The analysis takes into consideration the impact of innovations introduced by employers.

Weak perceptiveness of innovations in Russia may be explained by various reasons. In particular, low density of population and large territory of Russia contribute to the absence of competition for land and resources. We may similarly note psychological, economic, and social reasons for non-perceptiveness of innovations. The problem of low level of innovative component of Russian economy has a long history. Large hopes were placed on market economy, which replaced the Soviet administrative command economic system. Yet, market economy in Russia did not provide for the expected innovative quality of economy.

Obviously, competitive relations are not the only cause for innovations. There exist a number of other factors, and a combination of those factors creates the innovative component for the economies of the developed countries. Mentality, labor skills, the role of the state, the absence or lack of natural resources are commonly noted among such factors.

This paper deals with modeling the incentive of innovations created by the following economic indicator – the ratio of the average salary to the consumer bundle. The idea was first introduced by academician D.S.Lvov and then was developed by academician R.I.Nigmatullin and corresponding member of the Academy of sciences D.E.Sorokin.

The main idea deals motivation for innovations in the West created by traditionally high level of revenues. Therefore, traditionally low salary level of employees in Russia becomes the reason for deceleration of innovative processes in the country.

In thought experiment for modeling the mechanism of deceleration of innovation processes we can study various cause-and-effect relations between low salary and deceleration of innovations. The research usually mentions social tension caused by income inequality; derangement of reproduction processes due to salary at the subsistence level; inability of consumers to buy produced goods and services, pay communal services at the due level etc.

Let us consider a national level enterprise, which gains profit due to low salaries. According to academician R.I.Nigmatullin, "Russian indicators on income inequality and other parameters commonly analyzed in international ratings (poverty, unemployment, average life expectancy for men, corruption, protection of property rights and individual rights, democracy, and personal liberty) are close to those of Nigeria. Under the circumstances the only source for innovations at the national level is the decrease of social expenditure, i.e., expenditure dealing with teachers, doctors, engineers, professors, army officers. The reason is not only intellectual backwardness. The explanation deals with egoistic class interest and lack of responsibility. Indeed, such economy is related to the risk of mass disorder" [1]. The increase in salaries is regarded as a solution to the situation.

Low salary level does not stimulate an employer to efficient work activity and does not create the environment for efficient development of work relations. Currently, average salary in Russia does not guarantee normal life conditions for employees and their family members. An important question for the analysis is salary increase by the means of social policy and budgetary regulation. Indeed, salary level in Russia is extremely low if compared to economically developed countries.

The works by academician R.I.Nigmatullin state that government needs to monitor the balance in the economy in general and, in particular, such parameters as costs, prices, profit, and salaries. The balanced policy should lead to excess profits used for investment in the development of production instead of its being used for embezzlement for personal purposes [1].

Depreciation in the value of labor decreases economic responsibility of the employers for their work and becomes a negative cause for quality and productivity of public work. Low salaries reproduce low pensions and allowances; do not allow the change over to market mechanisms in social sector industries, to the development of paid services, to successful implementation of pension reform and reform of housing and communal services, to efficient provision of target social assistance to low-income citizens.

In this regard, Lvov and Nigmatullin formulated a hypothesis that it is not "we live bad because we work bad", but "we work bad because we live bad".

To test this hypothesis with the help of agent-based modeling we developed a simulation model in the software NetLogo, where agents-employers act in two territories (for convention let us call them "Russia" and "the West"). Textile industries exist in both territories emulated in the model. Agents-employers are identical and the difference in their economic results is due to economic environment in which they exist. The states where agents act have only one difference – salary level. The minimal salary level in the West is twice higher than in Russia.

At the beginning none of the workers participates in the activity of emulated industries. Textile production is done manually, no sewing tools are employed. The same market is used, so the prices for goods are equal, and one curtain costs 150 monetary units.

Let one worker produce 10 units of good a month and receive 1,000 monetary units of salary in western economy and 500 monetary units of salary in the Russian economy.

In case of manual production employers have profit per worker equal 1,500 monetary units. This profit is calculated as:

$$Д = Ц * К \quad (1),$$

where *Ц* – is the price of sold good (in this example it equals 150 units), *К* – is the quantity of goods produced by one sewer a month (in this example it is 10 units).

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To increase total profit, employers hire more workers. More workers imply the increase in extra costs, i.e., the necessity to rent new spaces, buy new tools, attract workers from other industries and educate them. Consequently, we introduce the rule of increased marginal cost with increase in the scale of production and consider emulated industries as the total economy in each country. In this way the salary per worker increases 10 units. The salary per *i*-th worker is defined as:

$$ЗП_i = ЗП_0 + i * \Delta ЗП \qquad (2),$$

where

- $ЗП_0$ – is the size of starting salary (in this example 500 units in Russia and 1000 units in the West),
- $\Delta ЗП$ – is the increase in salary with hiring a new worker (in this example it equals 10 units).

The marginal profit from *i* –th worker is calculated as:

$$П_i = Д - ЗП_i \qquad (3)$$

Therefore, marginal profit will decrease with increase of workers and will equal zero with hiring of the 100th worker in Russian economy (Fig. 1).

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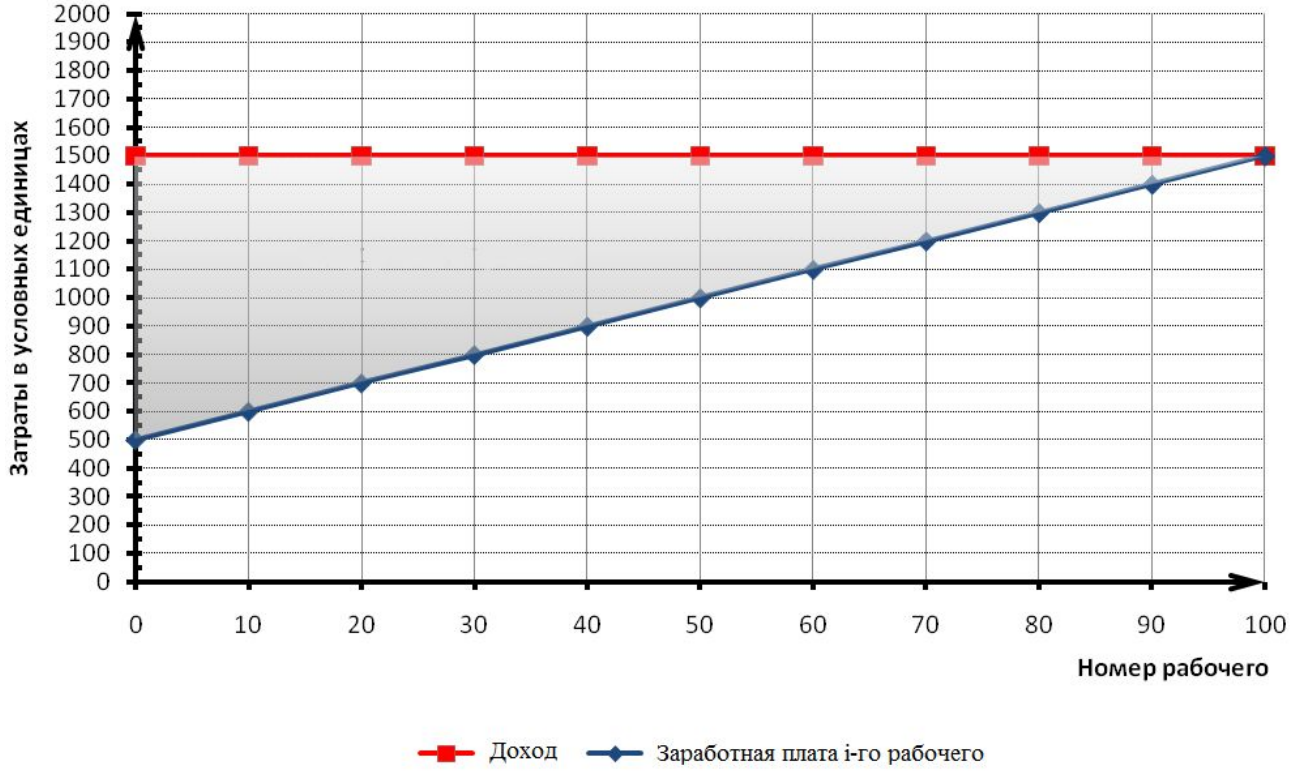

Figure 1. Marginal profit of Russian employer

The same situation will occur in the West with hiring the 50th worker (Fig. 2).

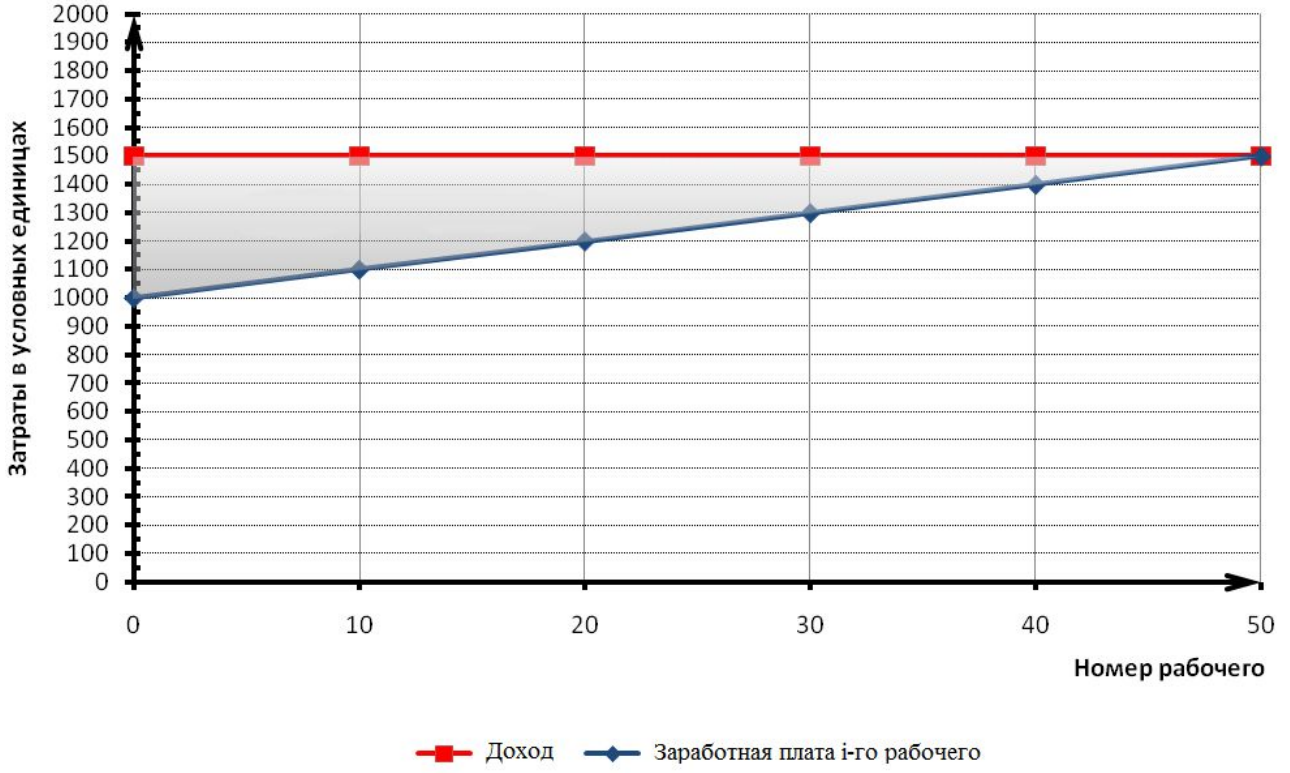

Figure 2. Marginal profit of western employer

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Employers can not hire workforce for further expansion, since the salary of a new worker will exceed the revenue from this worker. Strongly restricted after hiring of the 50th worker, western employer decides to increase productivity of each worker, or in other words, to increase the technological level of textile industry. Spending 500,000 units of money, employer buys sewing machines for each worker. During a month of work with the new equipment each worker produces 15 units of goods, i.e., productivity rises 50%. The result is the growth of revenues from each worker from 1,500 to 2,250 units (Fig. 3).

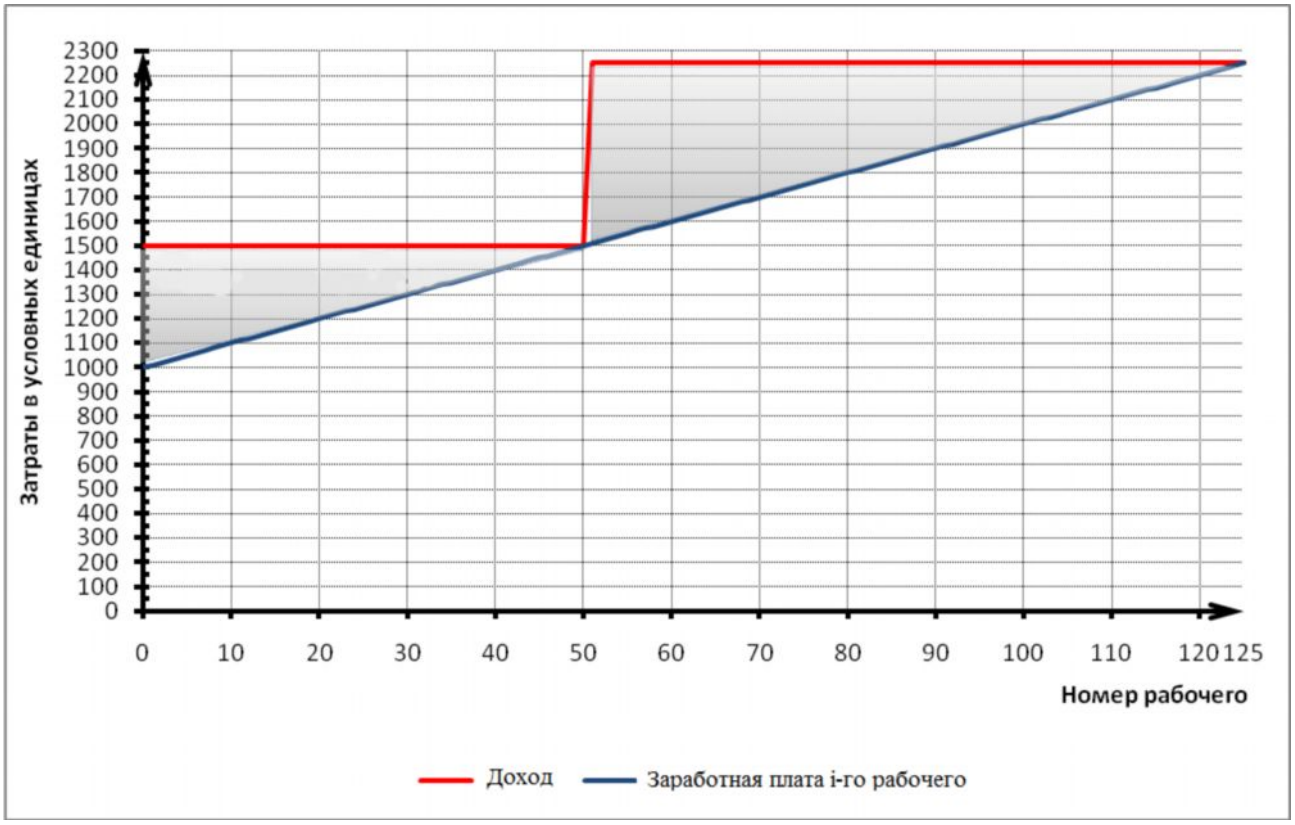

Figure 3. Introduction of innovations by western employer

Russian employer is restricted only after hiring the 100th worker, which is considerably later than in case of western employer. Russian employer raises the productivity of workers in a similar way (Fig. 4).

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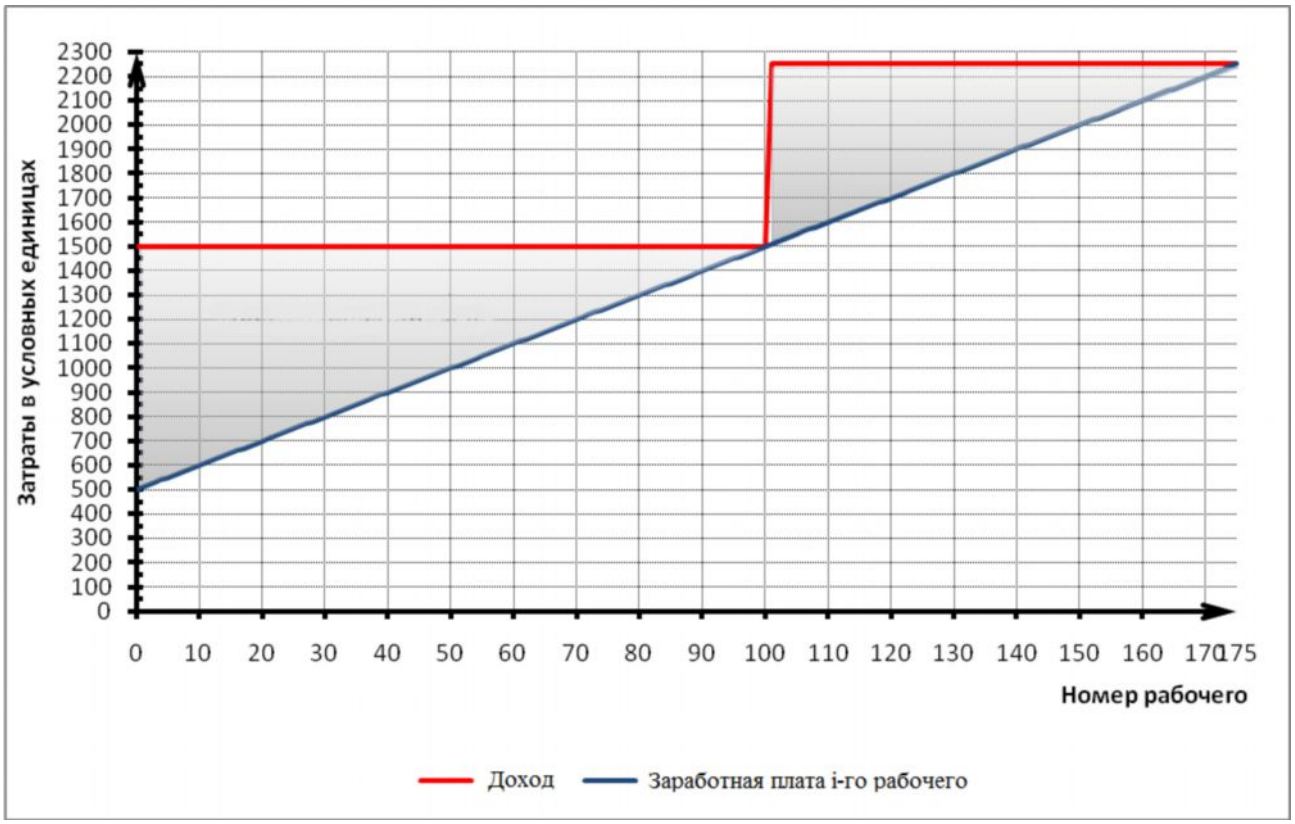

Figure 4. Introduction of innovations by Russian employer

Financially well-to-do agents are not so strongly motivated for production, as agents who desperately need money. However, this general tendency may have exceptions in each particular case.

In our model with marginal profit approaching zero; with growing marginal cost of hiring an additional worker and, hence, absence of possibility for further development by increasing the number of workers, western employer has stronger motivation for increasing her production by improving technology. However, Russian employer is quite satisfied with good profits and increases profits by hiring additional workers. Therefore, introduction of innovation occurs later in time.

Let us examine interface of the model. Starting parameters are set in the following way (Fig. 5):

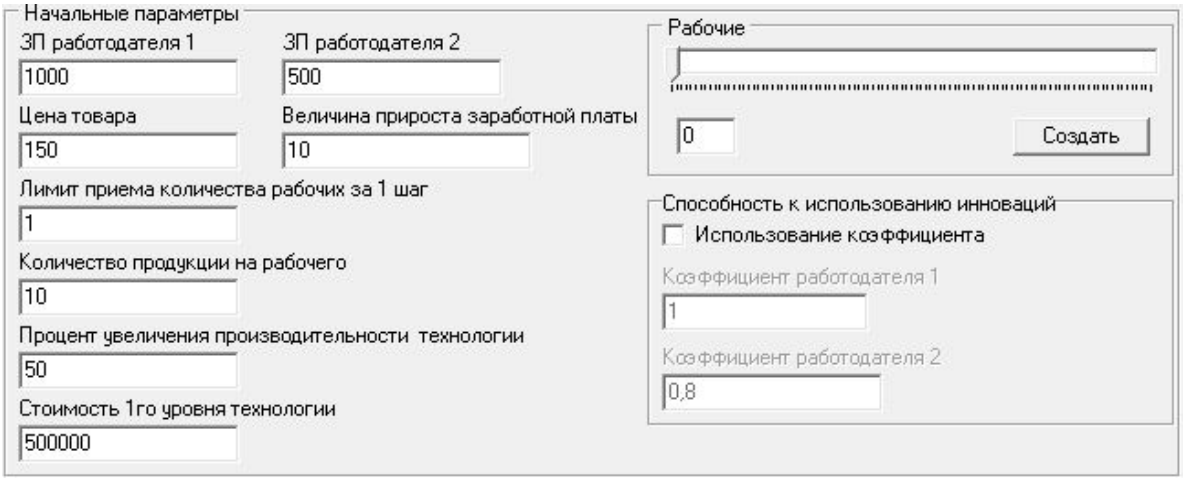

Figure 5. Starting parameters

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Interface of the realized model looks as follows (Fig.6):

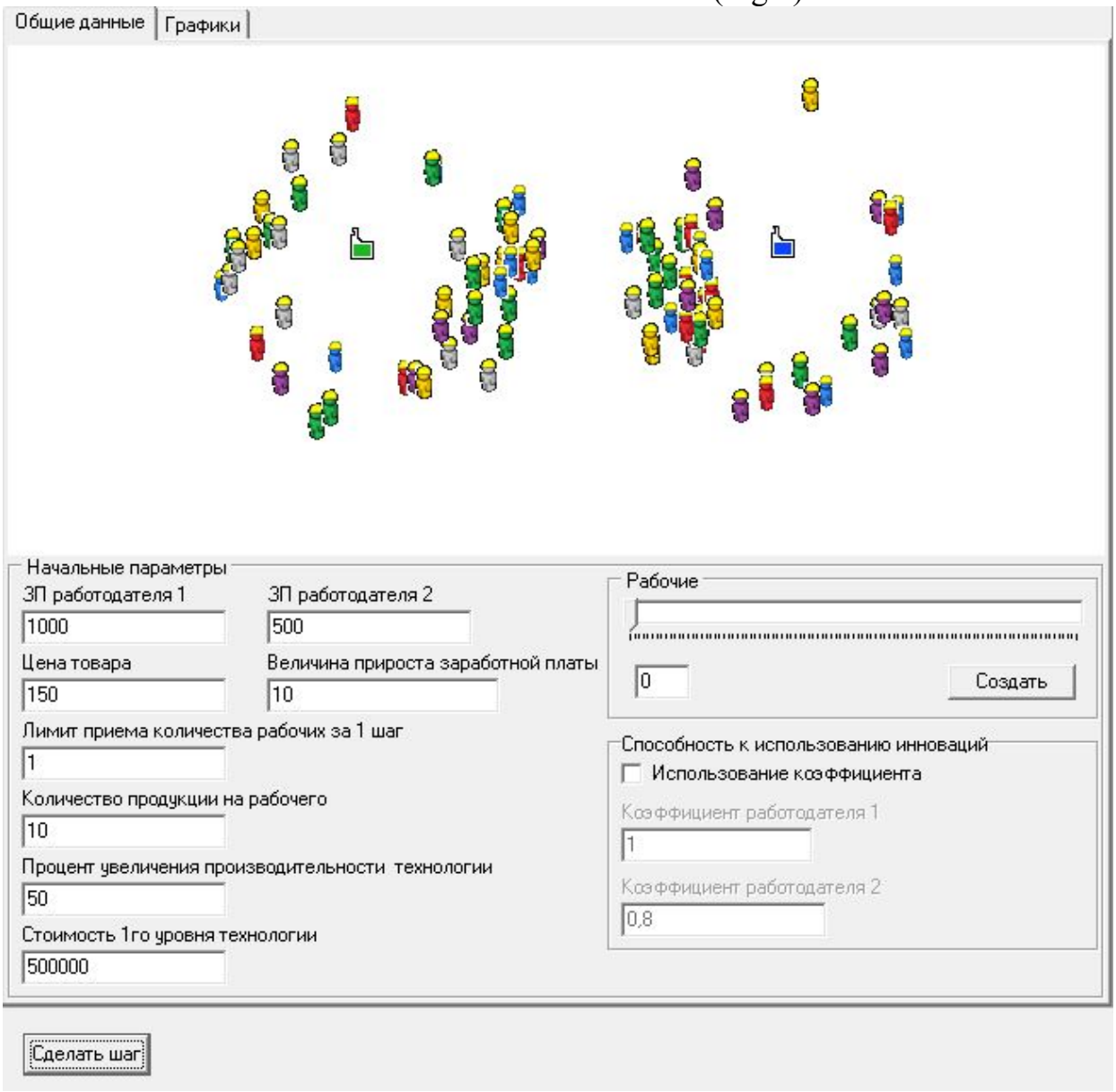

Figure 6. Interface of the model

Here «ЗП работодателя 1» (salary of employer 1) and «ЗП работодателя 2» (salary of employer 2) - are initial values of salaries, paid correspondingly, by the agents “employer 1” and “employer 2”. Index “1” denotes western employer and index “2” corresponds to Russian employer. The default value of the starting salary with employer 1 is 1,000 units, and with employer 2 - 500.

«Цена товара» (price of good) is the value at which employers sell one unit of their good. The default value is 150 for both types of employers.

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«Стоимость 1го уровня технологии» (the price of technology of the first level) is the price for introduction of innovation. By default it equals 500,000 units.

«Величина прироста заработной платы» (the growth in salary) is the value for the increase in salary due to hiring an agent "worker" by employers. By default each new worker will receive salary which is 10 units more than the salary of the previously hired worker.

«Количество продукции на рабочего» (goods per worker) is units of goods produced by each worker a month. The default value is 10.

«Процент увеличения производительности технологии» (percentage of productivity increase under the technology) is the percentage increase of the number of goods per worker after introduction of innovation. The default value is 50.

«Лимит приема количества рабочих за 1 шаг» (limit of hiring workers at one step) is the number of agents "workers" which may be hired by agent "employer" at each iteration. By default one agent is hired.

«Способность к использованию инноваций» (the capacity to use innovations) is the coefficient of efficiency of using innovations by agents "workers".

Creation of agents "employer 1" and "employer 2" is conducted at the start of the model. Creation of agents "workers" is done by pushing "create" button, which is placed in component «Рабочие» (workers). Similarly, the initial number of workers is set by the help of scroll box (Fig. 7). The default value for the initial number of workers is zero 0.

Figure 7. Creating agents "Workers"

The implementation of the model contains 6 graphs.

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1. The number of workers in the current moth.
2. Accumulated profits.
3. Profits in the current month.
4. Marginal profit in the current month.
5. Salary of the *i*-th worker of employer 1.
6. Salary of the *i*-th worker of employer 2.

The results obtained under implementation of the model with the default parameters looks as follows (Fig. 8):

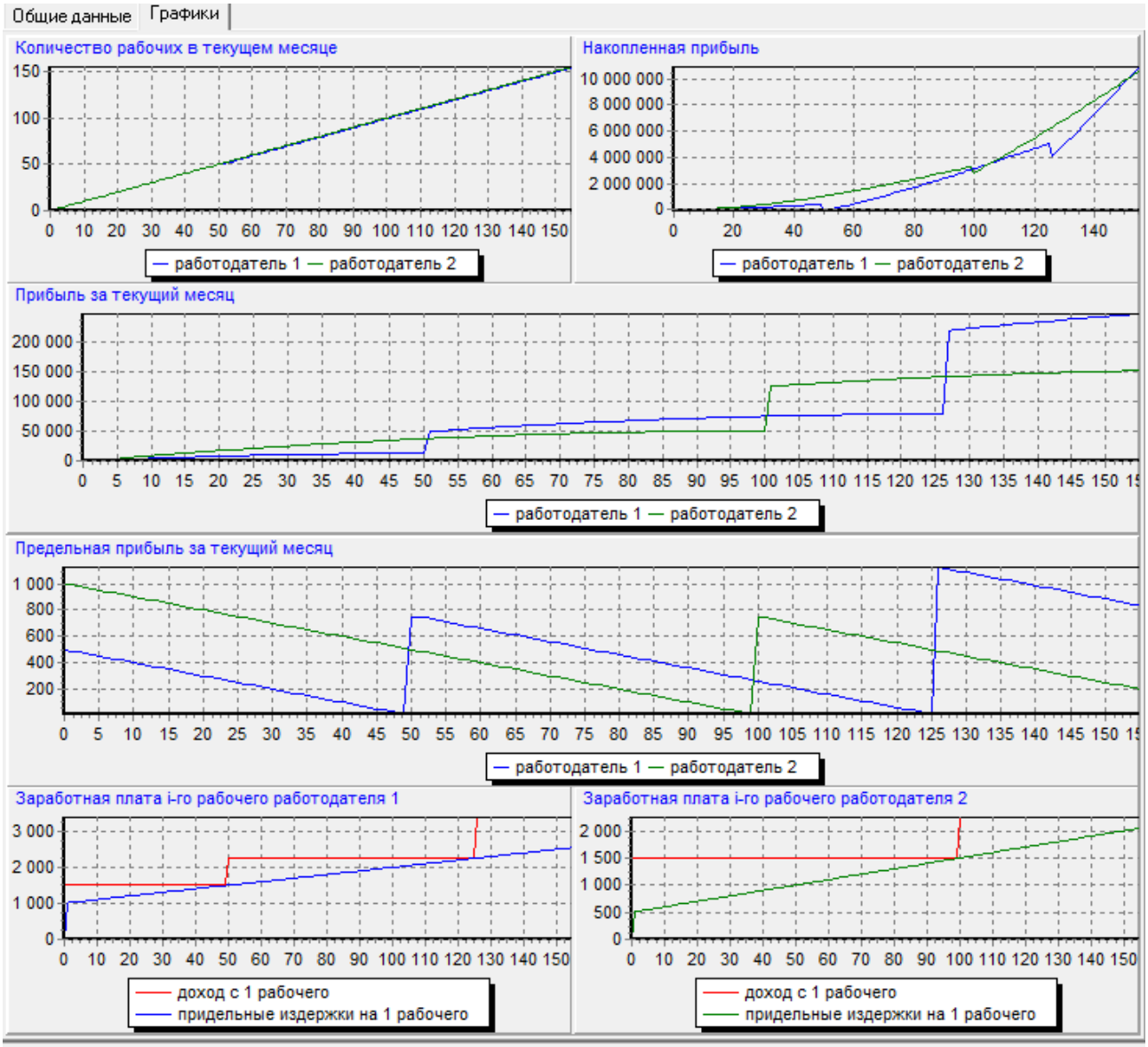

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Figure 8. The results of the model with default parameters

After hiring the expected number of new agents "workers" agent "employer" may behave in alternate ways, depending on the value of marginal profit calculated according to (3):

- If the value of marginal profit exceeds zero, "employer" hires the expected number of "workers".
- If the value of marginal profit is less or equal to zero, "employer" introduces technology, spending the number of units which is equal to the product of the new level of technology and the cost of its introduction.

The model enables us to answer the following four questions:

1. Will the profits of "western employer" with intensive economy exceed those of her "Russian" counterpart with low level of salary under expensive and high-efficiency technology?

2. Could profits of "employer" with higher costs exceed those of "employer" with lower costs under cheap and high-efficiency technology?

3. What would be the impact of expensive and low-efficiency technology on the economic development of agents "employers"?

4. Do agents "employers" have the need to introduce cheap and low-efficiency technology?

We simulate processes by altering the following parameters of agents "Employers": the cost of one level of technology and the percentage growth in productivity after introduction of technology. Parameters giving us the answers to the above questions are presented on the graphs: marginal profit in the current month and profits in the current month. The values of parameters for "western employers" are drawn with blue lines and those of "Russian employer" – with green lines.

Each subsequently hired worker costs employers 10 units more. This assumption simulates the growth of marginal cost, occurring due to the fact that workers function in limited space.

1. To study the first question, we set the cost of technology twice larger than the default value, and the growth of productivity – equal to 50%. The resulting graphs are presented on Fig.9:

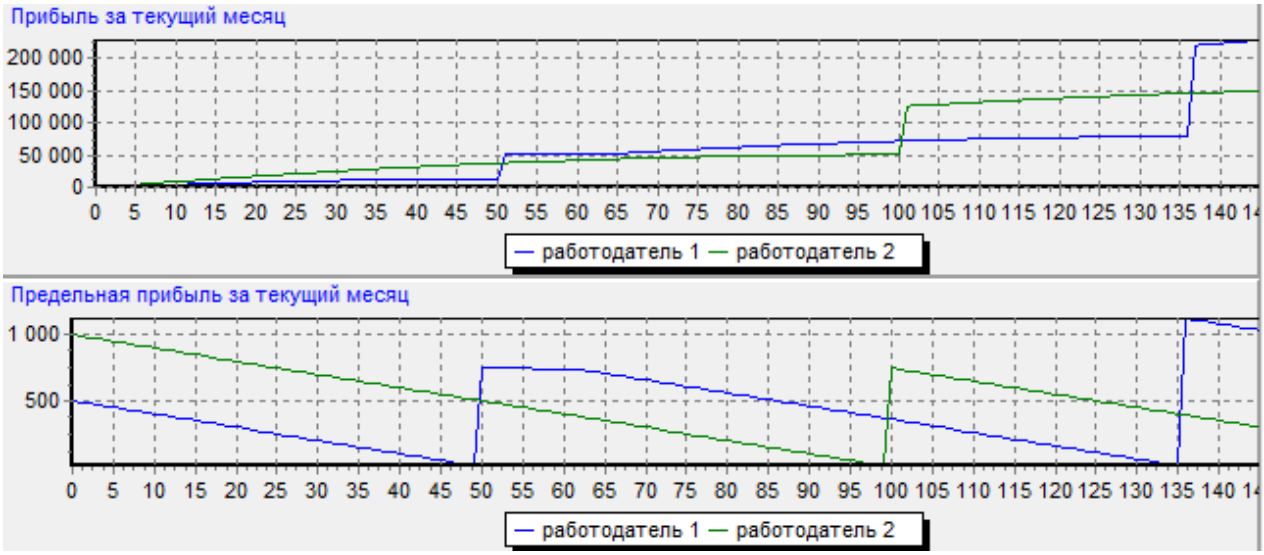

Figure 9. Introduction of high-efficiency and expensive innovation

"Western employer" introduces innovation at the 50th iteration of the model. Blue line, which demonstrates the first employer on the lower graph ("marginal profit in current month") increases from 0 to 750 units at the 50th iteration. In this moment monthly profits of the first employer exceed those of the second employer, since the position of the line without dots is higher than that of the line with dots at the 50th iteration of the upper graph ("profits in the current month"). The realization of the model with such parameters reveals that due to earlier introduction of innovation "western employer" receives larger profits than "Russian employer".

2. To answer to the second question it is necessary to keep the default value of the productivity growth and set the cost of the technology equal to ½ of this value (Fig.10).

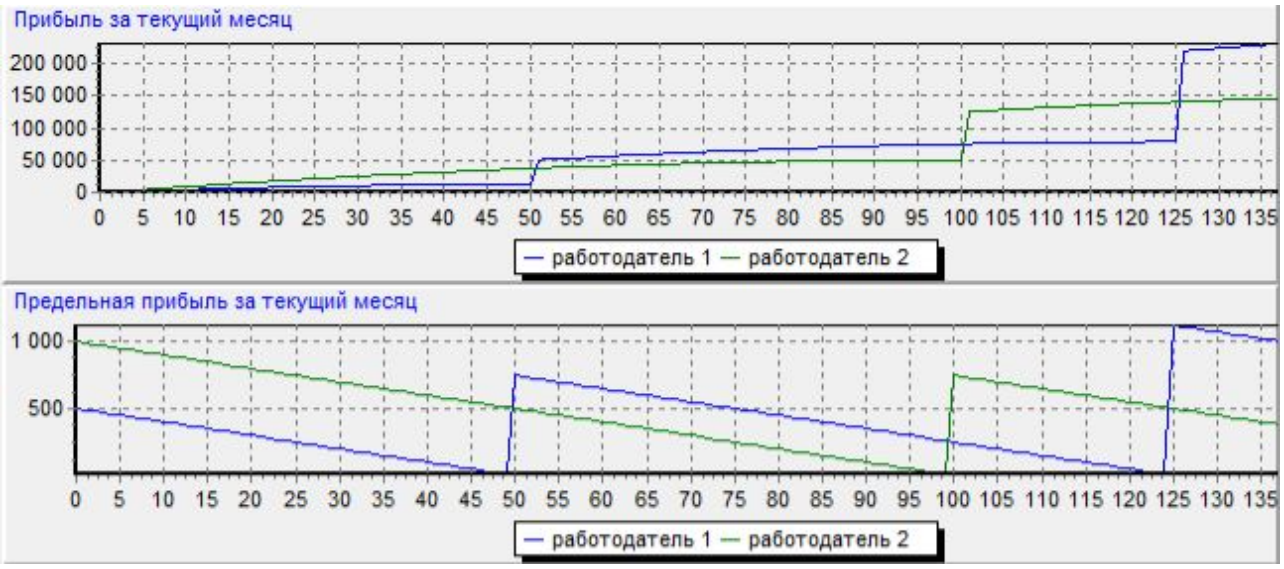

Figure 10. Introduction of high-efficiency and cheap innovation

Introduction of innovation in this scenario is more intense for "western employer", since there is no debt to prevent increase in the number of workers. Similarly to the first case, the profits of "western employer" exceed those of "Russian employer" (125th iteration in the graph "Profits in the current month" in Fig.10).

3. If the cost of technology is set similarly to the first case, and the value of growth – equal to 10%, the following situation is observed (Fig. 11).

At the 50th iteration of the model, introduction of innovation by "western employer" (blue line of the graph "Marginal profit in current month") increases marginal profit by the value which does not even exceed the starting value of marginal profit (zero iteration of the blue line of the same graph). Negligible fluctuations of marginal profit of "western employer" occur under subsequent improvements of technology. These improvements do not reach starting values, since they are restricted by the weakness and expensiveness of innovation. Consequently,

the profits of "western employer" do not exceed those of "Russian employer" (the blue line is always below the green line on the graph "Profits in current month"). Therefore, not all improvements of technology are economically efficient, and it is necessary to analyze the cost and efficiency of innovation.

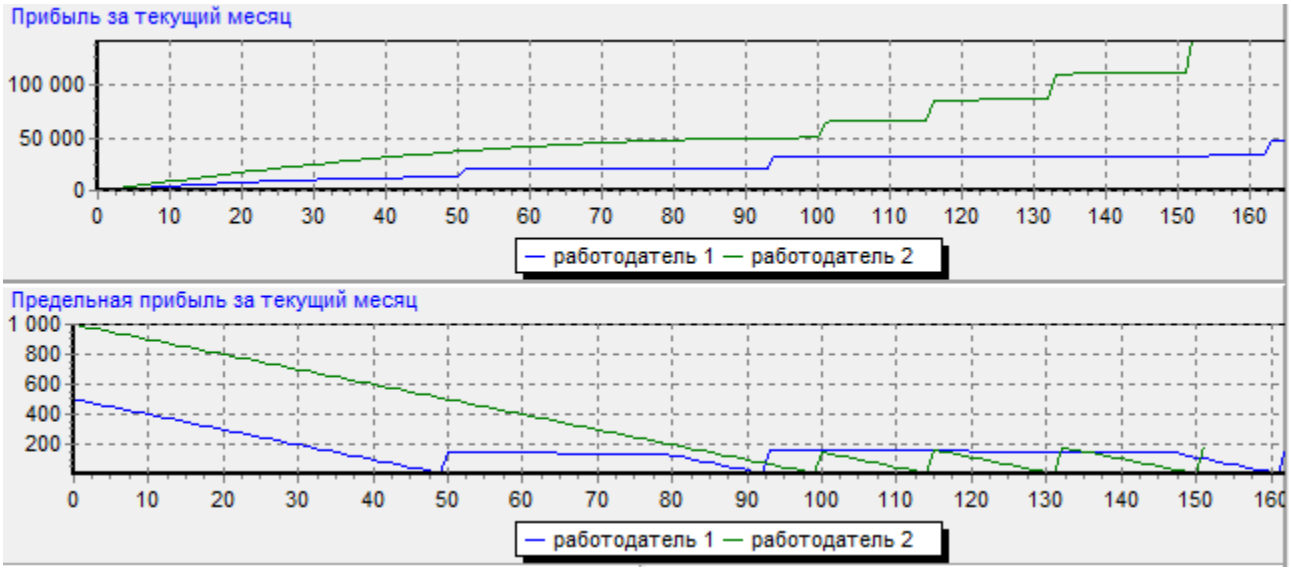

Figure 11. Introduction of low-efficiency and expensive innovation

4. Finally, let us examine introduction of low-efficiency (productivity growth is 10%) and cheap (similar to the second case) innovation (Fig. 12).

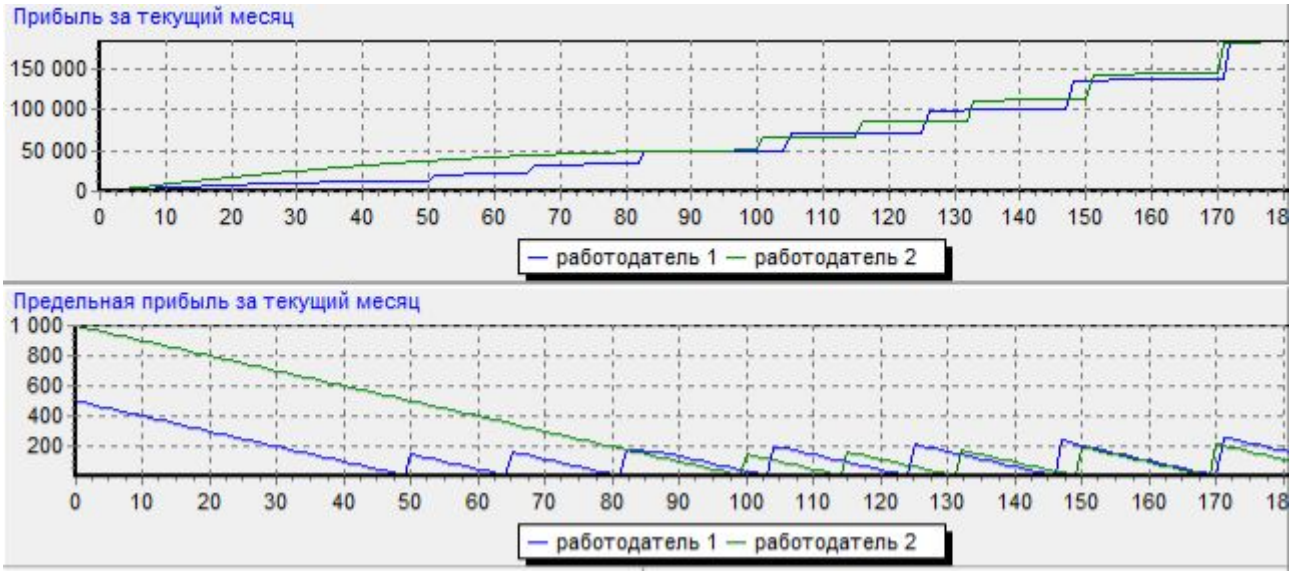

Figure12. Introduction of low-efficiency and cheap innovation

In the current example intensity of innovation in agents "employer" become similar after a certain number of iterations. Consequently, profits also do not considerably differ from each other. In this way we have two agents "employer" with different costs but similar profits. This implies that they are competitive even under the condition that one employer is more technologically developed, and another – uses large amounts of workforce.

The simulations in the model demonstrate that under equal starting conditions (the same technology) at first larger profits are noted at employers on "Russian" territory, but later the profits of employers on "western" territory begins to exceed the "Russian" level with accelerating rate. This confirms the hypothesis that larger salary level is an independent determinant of innovation-oriented economy.

Note that the results of simulations that support the hypothesis are based on large efficiency of introduced technology, which allows to increase marginal profit till the value facilitating economic growth of the enterprise. Simulations with the use of low-efficient technologies demonstrated that under expensive cost the technologies do not correspond to the task of stimulating efficient production. Inexpensive and "weak" technologies lead to similar profits by the two types of employers. Simulation

of the model with enhanced capacity to introduce technology and low level of salaries (e.g., in China) showed that such economic strategy is as efficient as usual use of innovations under high salaries.

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A Review of Socio-Economic Agent-based Models

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On the 5th of August, 2009 American economists Doyne Farmer and Duncan Foley published an article «The economy needs agent-based modeling», where they criticize world leaders for ruling economy practically without moving from the dead point. The authors suggest a better way to help financial policy, and propose agent-based modeling for fast development of computer models [1].

What is the concept of agent-based modeling? Special types of agents, endowed with properties, methods and propensity to interact, are created to study a certain phenomenon. All processes occur in iterations, in discrete time intervals and are not determined. Autonomous computer becomes a major tool for demonstrating graphic and symbolic models to users. For example, graphic three dimensional models of cities may be created in geo informational system and be opened to public through the service “Google Earth”.

Agent-based models are often united in a similar way. In particular, it is possible to create a model in NetLogo and link it with other models through network application. The link of such model with users may be organized through email, video conferences and communications tools, offered by such services as Skype. Similar realistic agent-based models may be created in other three dimensional software and graphic packages, such as Quadstone Paramics and 3D Studio Max. In this case graphic modeling is used as background for modeling traffic, but the tools are primarily aimed at a single user. Most output of these three dimensional models is based on animation. Virtual worlds with a large number of users are created on the basis of agent-based models and enable the precise study of social behavior. In their essence virtual worlds are inclined to public visualization. This is important since visualization becomes a major and most effective tool of linking the output of agent-based model and the researcher. Some researchers believe that when models are visualized, they become more transparent (Batty, 2007), since visualization of key

processes enables clear and fast description of the model (Kornhauser et al., 2009). A combination of so called graphic and symbolic models in virtual environment allows the creators of the models and the users actually observe step-by-step work of the model in reality and assess its effectiveness. In particular, agent-based models which forecast human behavior allow understanding the preciseness of simulation on personal experience.

1. Let us consider one of virtual worlds, related to the concept of agent-based modeling – international project "Second Life". This is not only one of the most powerful visual and virtual worlds with understandable language of scenarios, which allows creating objects as copies of actual buildings. The project is also the most successful socio-visual environment in the Internet. As of 2008, there were 14 million registered users in Second Life with over 400 thousand users a week (Linden 2008). Modeling only a few kilometers of space in 2003, when it originally appeared, currently, the project encompasses over 10 thousand square kilometers. Initiated by Linden Lab, the world of "Second Life" was created in full unity with its users. For example, citizens of Earth spend altogether 23 thousand hours a day for creating various objects (from clothes to houses), and in this way demonstrate a wonderful example of collective creation of a code (Howe 2008). Users create digital geography in its pure way. Rivers, valleys, mountains, villages and cities, occupying more and more space, were gradually created by millions of users. Each part of digital world of "Second Life" remains editable. Users can freely enter "Second Life", exchange messages, and if anyone wants to start "construction", s/he will have to register and buy land. Players spend on average $350,000 a day which makes $130 million a year. Virtual worlds become widely used as a medium for social interaction and work related to education. Many companies, organizations and academic institutions (e.g., IBM, Sony-Ericsson, Oxford University) bought land in "Second Life". Construction of facades, virtual campuses and head-quarters where representative agents (the personnel of these organizations) can do business or research, is believed to promote

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science (Hackathorn, 2006). "Second Life" is a rich environment for teaching, learning and links. "Second Life" is an interface where many socio-economic models are implemented.

Virtual world "Second Life" may be considered a three dimensional game with real economic rules. However, this virtual world is not applicable for solving certain local tasks. Creation of high quality models aimed at emulating real world is a burning issue in many fields. Only a few models are available for free download and acquaintance, but some implemented models are outlined in electronic sources. This enables us learn the directions of the work of our colleagues.

2. Let us examine the experience of European colleagues in creating "An area-wide model for the Euro area" [2]. The key words of the model are: European currency union, macroeconometric modeling of Euro zone. The implemented model is a quarterly model for macroeconomic estimations in Euro zone. The model considers Euro zone as a unified economy. Agents are firms that produce goods, consumers and workers. In fact, this is supply and demand model, with introduction of an additional agent – "worker". The model considers long term equilibrium according to neoclassical theory since in the short term dynamics is mostly oriented at demand. In the long term the demand corresponds to the solution to the problem of firms' profit maximization. Short term differences in the volume of production and unemployment influence prices, salaries and the dynamics of costs. The current version of the model is similar to the previous ones in interface and general concept. Yet, the equations for financial variables are being constantly perfected. In other words, experts change mathematical apparatus and behavior of a particular agent, but the final user does not need to adapt to a new version of the model, since the principle of model work remains the same. The quality of estimates within the model has increased due to improvements in calibration, which are based on detailed local data on unemployment, producers and consumer demand. The model may be emulated to

test various hypotheses about fiscal and monetary policy and agents' expectations. The model is employed for forecasting tasks of all-European scale.

3. Let us look a popular agent-based mode created for regional forecasting – a quarterly model for Belgium [3], which is employed since May 2007. The quarterly model for Belgium constructed at the National Bank of Belgium provides a quantitative impact to the processes of analysis and policy forecasting in the framework of micro level infrastructure. The model also simulates money flows in the country. Optimization problems of households and firms are restrained by various regulations. The important characteristics of the model are market prices, flexible markups and incomplete transfers, quality control in production, time dependent wage, various costs of regulation similar to Regulation council in the Federal Reserves System of the US. Money demand depends on the use of modern financial and bank technologies, and smoothness of the whole system of payments circulation. The model demonstrates that money demand decreases after implementation of electronic transfers of securities from one owner to another. Most equations in the mathematical part of the model, taken separately, have good statistical properties. Diagnostic simulations provide for adequate reaction of agents on exogenous shocks. Modeling may be implemented under alternate formation of expectations about money circulation not only for Belgium but also for other Euro zone countries. The key words are: econometric modeling; market assessment; multinomial costs of regulation.

4. The work "Population ageing and intertemporal consumption: representative agent versus social planner" [4] was published in Australia in 2006. The implemented model considers the ways of optimal behavior of consumers when ageing is taken into account. Elder people are regarded to have more demands owing to additional expenditure on health care. These differences lead to the concept of "equivalent number of people". An emphasis is put on the difference between environment with representative agents and environment in which decisions are made by social planner. The exact conditions for consumption growth are set the same for

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representative agents and for social planner. The equivalency is established only if people are regarded as corresponding unique units of analysis in the decisions of social planer. There are alternative assumptions which consider agents as corresponding aggregated groups of people and specific patterns of optimal consumption are chosen for each group. Quantitative examples track the ratio of monitored factors to a range of parameters. Differences are considered potentially important. The choice of corresponding consumers – actual physical persons or "equivalent people" – is not arbitrary since it provides for potentially inconsistent assessments. The choice has consequences for policies aimed at optimal management of savings levels, such as pension policy and budget balancing policy. The results in the models with social planners and agent-based models incorporating ageing and relation between age and needs were very similar. The authors think that integration of such "ageing" module adds credibility to existing agent-based models with market economy. The key words are social planner, representative agents, intertemporal planning, population ageing.

5. Employing agent-based models becomes popular not only in the US and Europe. Let us analyze the model "The effects of education subsidies on human capital accumulation: a numerical analysis of macroeconomy in China" [5], created in Japan in 2010.

The model analyzed the impact of education subsidies on regional economic growth and the differences between two Chinese provinces by imitating their economy in 6 overlapping generations, where people decide on the length of their education. To effectively spend budgetary source on preparation of specialists within "government order" the model introduces the mechanism of targeted education subsidies only for those specialists who reach good results in their study. The research analyzes long-term growth, i.e. sustainability of regional economy based on current subsidies in education; as well as human capital accumulation in view of economic growth with consideration of increase in education subsidies. The results of

simulations demonstrate that since larger volume of public subsidies in education inclines individuals to invest in human capital, both regions increase their growth rates. Due to large difference in productivity between the regions, the gap in growth increases proportionately with the raise in education subsidies rate. The key words are overlapping generations, human capital, educational subsidies, economic growth.

6. The work "Assessing the impact of the 2004 Olympic Games on the Greek economy: A small macroeconometric model " [6] was published in Greece in June 2008.

The model analyzes the impact of the 2004 Olympic games in Athens for the Greek economy. The results of the model demonstrate that Olympiad becomes an event capable to successfully stimulate the economy of host city by creating a number of advantages that exceed the costs for preparation. According to the modern literature in the field, the effects of influence are rather strong at the preparation stage and during the Olympic year. However, the long-tern economic effect is regarded to be rather modest. Obviously, the results of the simulations contradict current economic situation in Greece. Olympic objects are not fully demanded after the end of the games. The reason largely lies in economic crisis. While sports grounds were supposed to be lent for exhibitions, concerts and other events, it did not happen. Such mistakes are inevitable when the model does not account for external factors that are often excluded in order to concentrating on a particular problem. The key words are macroeconometric model, forecasting, large sport events, Greece.

7. Agent-based model "How's Life? Combining Individual and National Variables to Explain Subjective Well-Being" [7] was published in Canada in March 2003.

The work attempts to explain international tendencies and differences in subjective well-being relative to the last 5 years of the 20th century. This is implemented in several stages. The main novelty of the model with respect to earlier studies of subjective well-being is employment of large international samples of

individual agents for calibration. This enables simultaneously define well-being determinants at the individual and at the social levels. The approach is particularly useful in determining direct and indirect links between social capital and well-being. Human agents are endowed with various potential demands, which depend of social status, age and locality. All factors are conventionally divided into individual and national well-beings. The results show the reasons for offering the central role to subjective measures of well-being, link between social capital, education and well-being. The key words are subjective well-being, social capital, international comparisons.

8. "Competition as a Test of Hypotheses: Simulation of Knowledge-generating Market Processes" [8]. The key words are Hayek's concept, competition, knowledge, innovations, control of mergers, concentration, modeling, evolutionary economics.

The major purpose of the work is to create a model based on Hayek's learning mechanism, which consists of experiments on mutual learning and sets the speed of knowledge accumulation for agents. Hayek's idea of evolutionary competition of generated knowledge regards market competition as parallel processes of "trials and errors" in conducting experiments. In the course of these processes competing firms create and test new hypotheses on the best ways of satisfying agents' demands at the market.

At the microlevel of this multilevel imitational model firms create new hypotheses by mutation. These hypotheses meet at the macrolevel (at the market) where the best forms are determined. All firms start imitating the best one. The model simulates 100 periods, which consist of innovation and imitation phases. Decentralization is assumed to have a key impact for implementing the process of knowledge generation, since larger number of independent innovative firms leads to larger number of experiments. The model allows studying how the growth rate of knowledge accumulation is influenced by company concentration, firm decentralization and obstacles for imitation. The results demonstrate that the number

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of firms is positively correlated with the speed for knowledge accumulation. This offers a new argument for critical assessment of the policy of merging in competition.

9. Social forecasting is regarded one of the most important problems in Europe. The work "Modelling the participation decision and duration of sporting activity in Scotland" [9] was published in Scotland in November 2009.

Motivating to do active physical exercise which has a favorable impact on health is an integral part of health care policy in Scotland. Researchers in Scotland generally recommend moderate physical activity of 30 minutes a day at least 5 times a week. There are also individual recommendations dealing with motivation, intensity, duration and repetition of exercise. Understanding differences of each decision helps to develop methods of influencing people to follow recommended policy. The data received from Scottish medical centers enabled calibrating the model of combined decision making process. When such approach is applied, the model behaves in a flexible way in all statistical associations which may exist among different components of decisions. In this way the model simulates relations between individuals who decide to participate in sport events. The model reconstructs the duration of chosen activity for those who decided to participate. The model incorporates various instruments of control, such as demographic factors (e.g., age and gender), economic factors (e.g., education and income), life style (e.g., smoking, alcohol, healthy food, medical history). The model is employed for comparing the impact of measures aimed to increase strength, fight obesity and improve health, as well as reconstructs social groups according to general interests. The key words are sport, samples, participation, duration.

10. "Regionalization, public spending and growth: a stylized model dealing with 'predatory states'" [10], published in France in June 2007.

The study develops a model analyzing the impact of regionalization on economic activity. It could be applied for the regulation of the activity of society,

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provision of integrity and sustainability of national economy, increase in economy's survival rate relative to external aggression at the scale of the state. The model is not linked to a certain country and demonstrates that geographic separation of powers in a society may have an impact on the rate of economic growth depending on the choice of government: primary advantages for weak levels and limitation of decentralization (decrease of regional size) in danger of underestimation of public expenditure at the local level. The key words are interbudgetary relations, special economy, public finance and corruption.

11. "Exploring Agent-Based Methods for Analysis of Payment Systems: A Crisis Model for StarLOgo" [11].

The purpose of the work is to create a real time gross settlement (RTGS) payment system (RTGS). Banks are the agents of the model. The model is implemented in StarLogo (Fig.1). Agents exchange payment orders and act according to a set of simple rules. The model includes the key elements of real life (e.g., Central bank which is the supplier of cash, and a simplified monetary market). The results of the imitational model with synthesized data BI-REL (Italian RTGS) forecast macroscopic effects of destructive events on the flow in interbank payments. 3 separate hypothetical phases emerge in our reduced system after a destructive event:

1) shell liquidity effect and excessive expectations of liquidity by participants;

2) spurious increase of monetary market along with increase in payment arrears;

3) sharp decrease of obligation default.

Scenarios when the Central bank may act as a liquidity supplier appear in the model.

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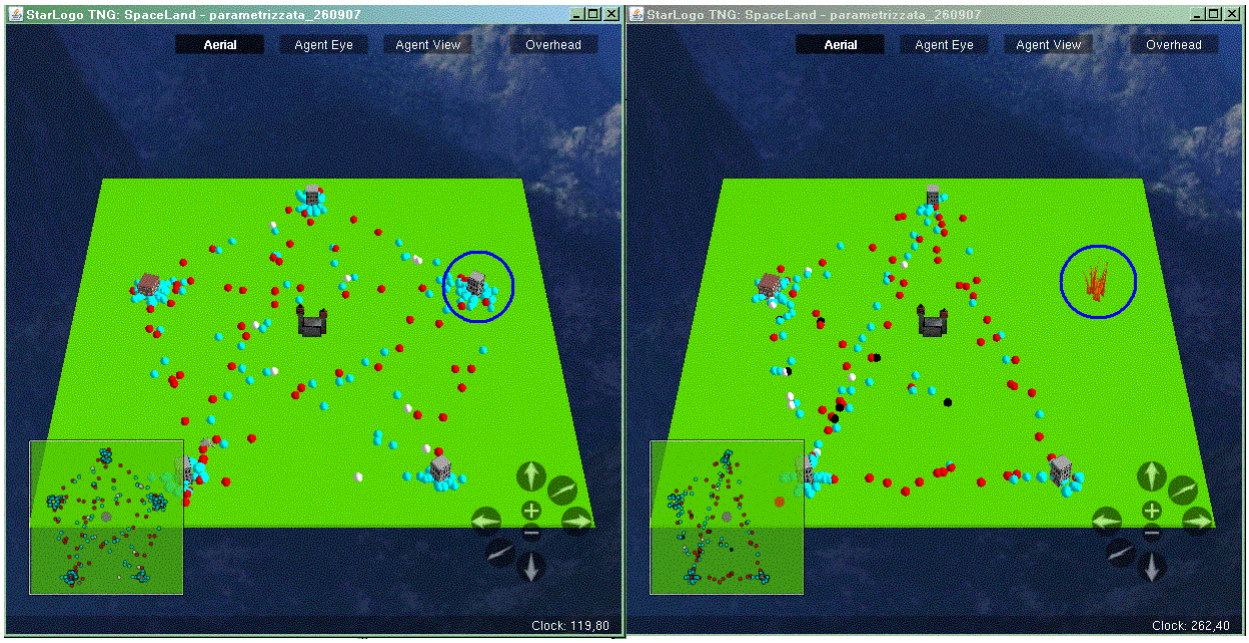

Figure 1. Modeled world before and after a critical event, which hit the circled agent and deprived the agent of the money flow (left: one second before; right: 140 seconds after).

The key words are agent-based modeling, payment systems, RTGS, liquidity, modeling crisis. The research is related to current events in modeling RTGS and aims at creating the knowledge and algorithmic beliefs on major rules of behavior of participating banks. The work implements miniature agent frameworks, which albeit not exhaustive, include all major elements of the real world. Owing to small scale and restrictions the model is implemented in StarLogo. The model needs to be perceived as a study of potential agent-based method, founded on the analysis of payment systems. The novelty of the model, if compared to previous agent-based exercises, is an introduction of monetary market, which becomes fundamental in the after-crisis evolution of the system under restricted participant activity.

12. Modeling Peter's principle.

Italian scientists offered a way to fight the pattern known as Peter's principle [12]. According to the principle any worker rises to the level of his/her incompetence in the hierarchical system. The logical explanation of Peter's principle

is the following. Leaders of a typical hierarchical organization promote those workers who demonstrate themselves in the best way at their current positions. Sooner or later the worker reaches a position with responsibilities s/he can not cope. The reason lies in the fact that success of worker at a certain position does not imply that s/he has enough personal and professional qualities to fulfill more complicated tasks.

The impact of Peter's principle is a gradual spread of incompetence to all the levels of organization. The authors analyzed other ways of promoting workers to leading posts and compared final effectiveness of the functioning of an organization. The alternatives are: gradual promotion of the most successful workers; the least successful workers; random assignment of workers to leading positions. According to the conclusions of the authors all methods produce better results than the existing practice of promotion. The scientists decided to model the principle employing agent-based modeling and software NetLogo. What is the logics of the model? A company is presented as a 6-level hierarchical structure (Fig.2) [13]. There is a certain number of workers with certain competence and work experience at each level of the structure. The following can happen to the agent at each step of the model:

1. If competence of an agent falls lower than a certain critical value or if his/her age reaches pension age, agent is fired. A vacancy appears when agent is fired and a vacant position is colored in yellow.
2. When position is vacant, it is filled according to one of the three strategies. Namely, the best, the worst or random worker from the previous level is promoted to the position.
3. When there is a vacancy at the lowest level, a new worker is hired from outside. The age and competence of the worker lie in a certain given range.

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Figure 2. Modeling hyerarhical ladder in NetLogo.

2 hypotheses of inheriting competence were studied in promoting a worker to a new level:

- common – worker inherits competence s/he had at the previous level, with a certain noise;
- Peter's principle – competence of worker at the new level does not depend on the competence at the previous level.

The following results were obtained by the researchers in the course of modeling [13]:

- If Peter's principle is true, it is necessary to promote the worst workers to maximize the total level of competence of all workers.

- If common hypothesis is true (competence is inherited), it is necessary to promote the best workers.
- The best strategy for both hypotheses is random promotion of workers, which does not account for competence or considers a random combination of "the best" and "the worst" principles.

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