

# **Behavioral model of interaction between economic agents and the institutional environment**

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# *The Purpose of the Study*

- Human behavior and decision-making in situations of economic choice have recently been increasingly described with the help of interdisciplinary models that synthesize the economy's achievements with the results of other sciences.
- Appealing to the socio-psychological characteristics of agents traditionally studied by psychologists makes it possible to obtain new results in solving problems in analyzing the interaction between economic agents and public institutions.
- This paper proposes a model of the system “the mentality of economic agents – public institutions”.

# *Agent as a Socio-Economic System*

## **7 dominants**

The history of a person's life, his own experience of interacting with other people

7. Archive

Orientation of a person to the experience of other people, behavioral patterns transplanted from the outside world

Artifacts of the material world that provide vital needs

6. Benchmarking

5. Infrastructure

Selection, perception and processing of information

Formal and informal attitudes that affect the life of an agent

4. Knowledge

3. Rules and Regulations

Features of human interaction with other people and artifacts, features of the communication language

Life philosophy / View of life

2. Culture

1. Worldview

# Agent as a Socio-Economic System

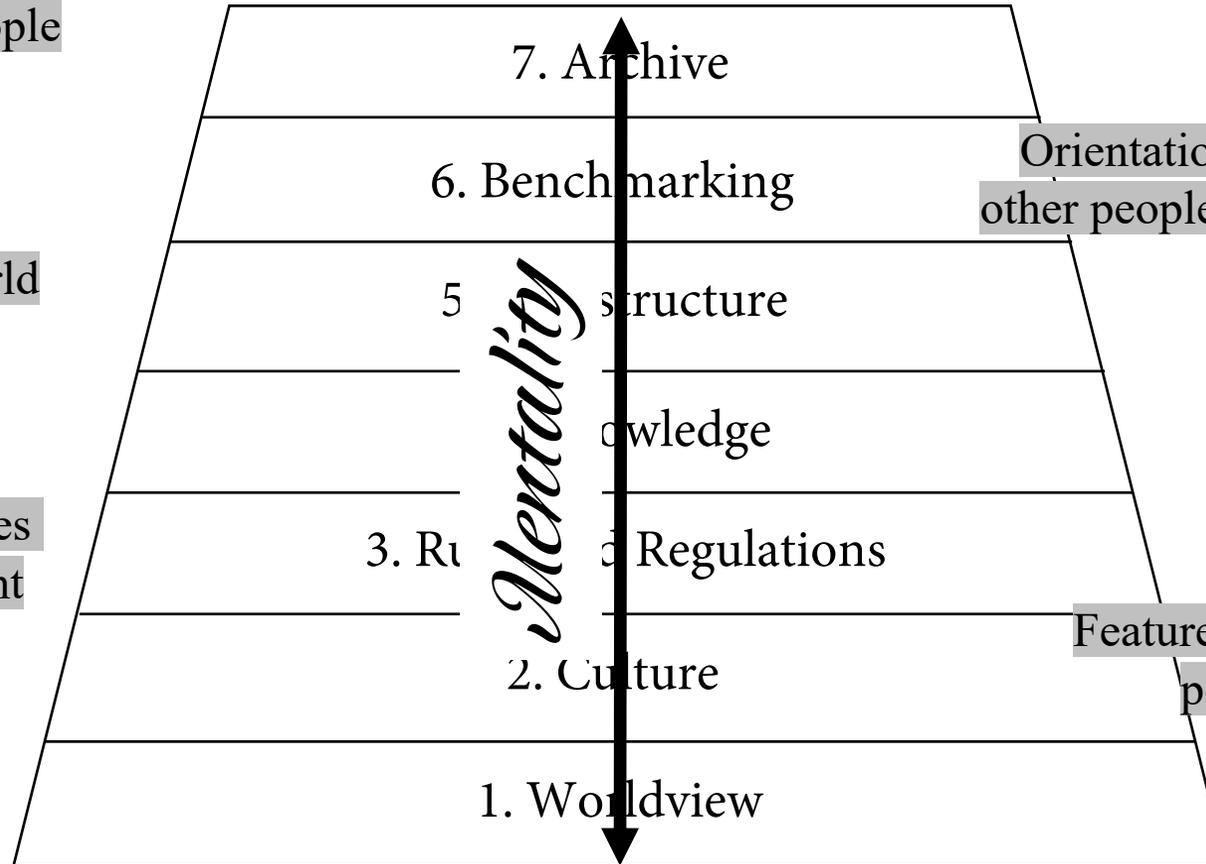
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# *Institutional Structure of Society*

## 7 groups of institutions

Strategic planning institutions

Statistical institutions

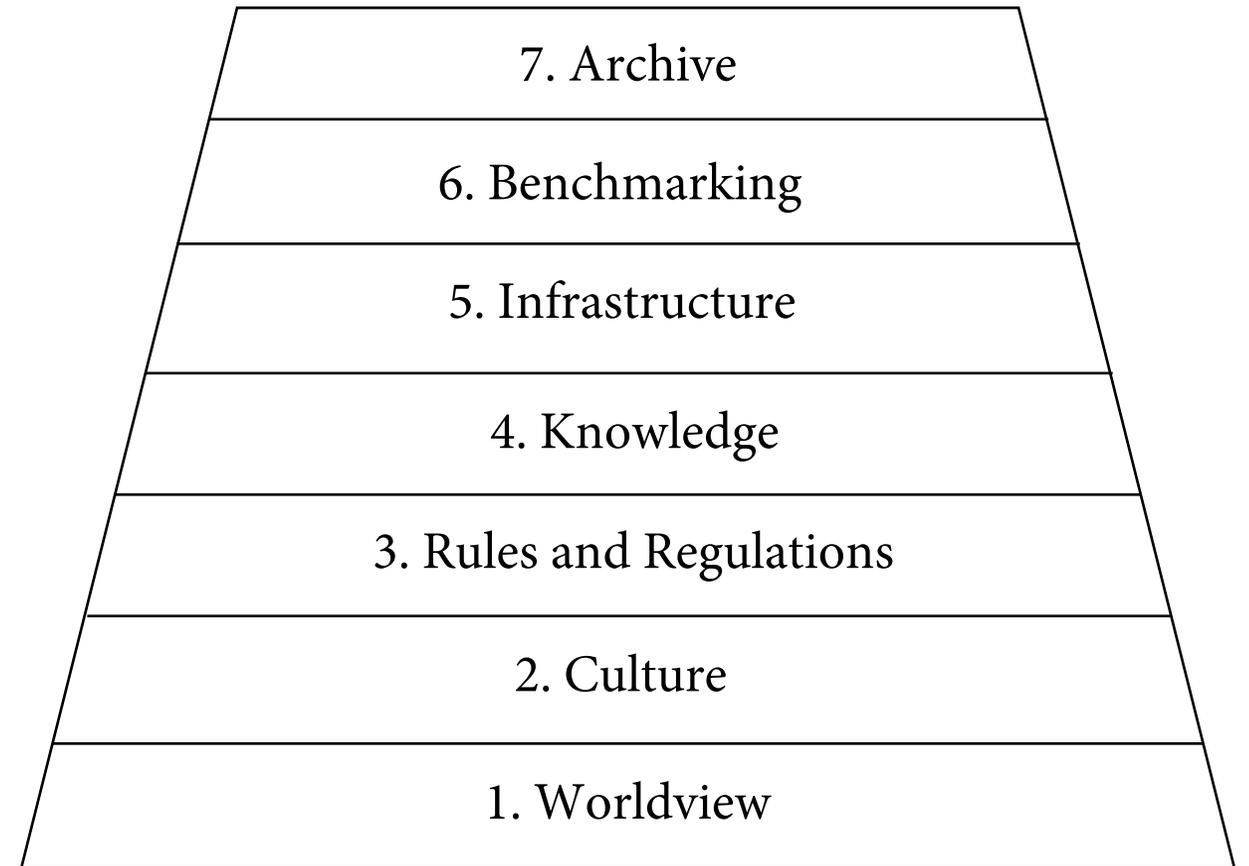
Property rights institutions

Education

Regulatory and sanctioning institutions and  
political party institutions

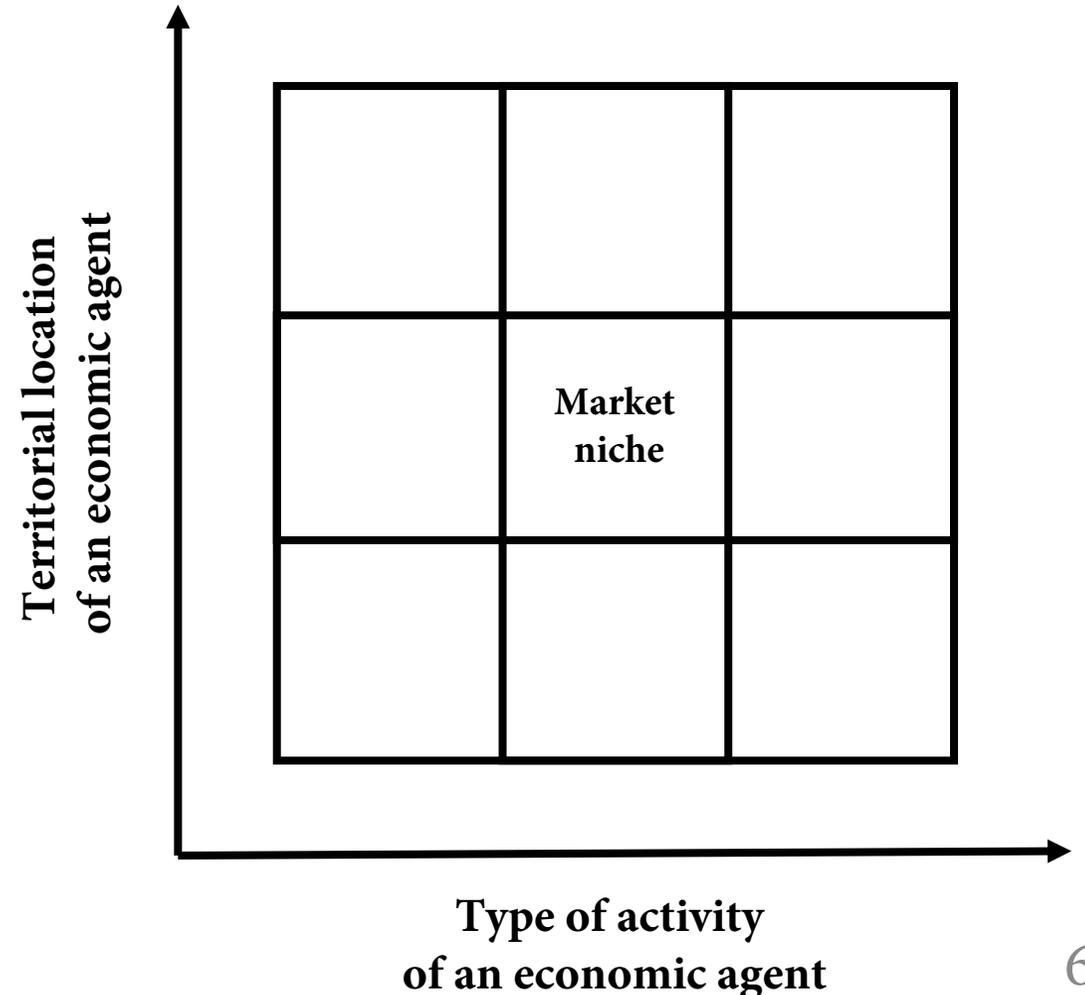
Socio-cultural institutions

Institutions of communication  
and institutions of religion



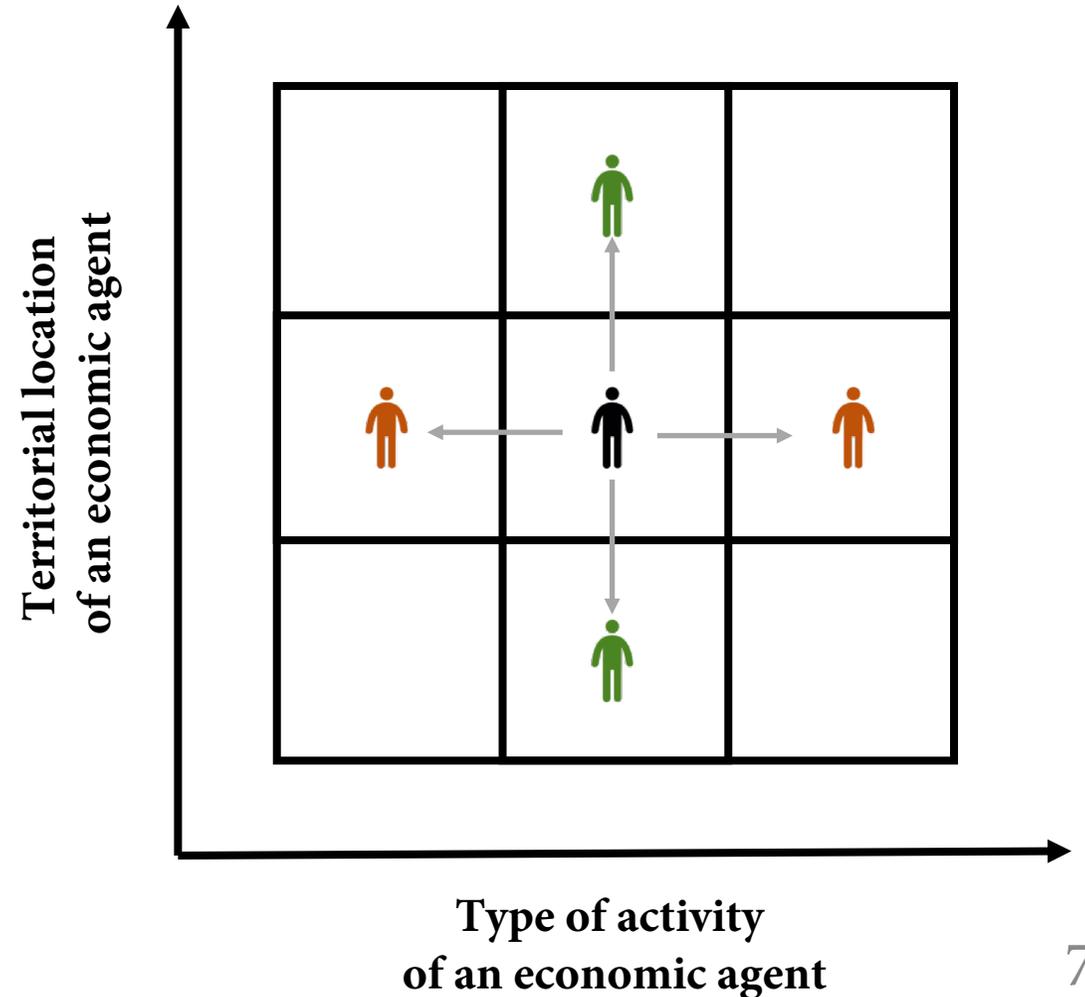
# *Model Space (Virtual World)*

- An area on the plane is covered by a grid.
- The nodes of the grid contain cells, peculiar niches for agents to conduct economic activities.
- Each cell thus has two coordinates on the plane.
- The initial distribution of agents in the cells of the virtual world is set randomly, with one agent per cell.



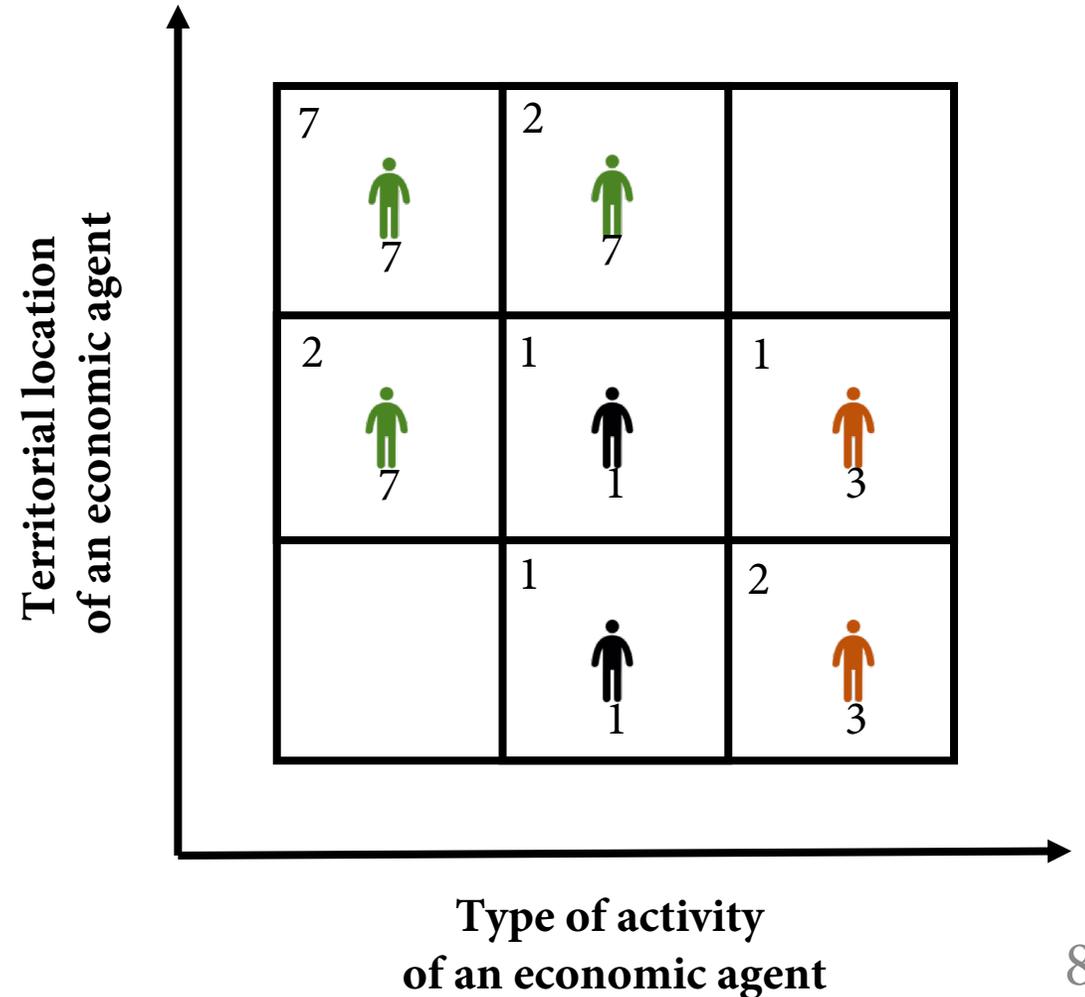
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# *Economic agents and their basic characteristics in the model (1)*

- Economic agents have a mentality, which is determined by the dominant.
- Activities in different market niches are regulated by different groups of public institutions.
- At the same time, depending on the position in a particular cell, the mentality of the agent will either be supported by the corresponding group of regulatory institutions, or resist it.



# *Economic agents and their basic characteristics in the model (2)*

- Each time step the agent achieves certain economic results of activity in the occupied market niche (*result*).
- **These results depend on the following factors:**
  - (*productivity*) is set exogenously in the model (by default, from 1 to 30 units).
  - (*individuality*) determined randomly in the range from 0.5 to 2.
  - (*experience\_coefficient*) in the presence of 10-19 units of experience → increase in labor productivity equal to 10%, 20-29 units of experience → 20%, over 30 units of experience → 30%. Each time step of work in the same niche, the agent receives 1 unit. experience.
  - (*environment\_coefficient*) conditions of the agent's activity.

# *Economic agents and their basic characteristics in the model (3)*

Conditions of the agent's activity	Combination of boolean variables				
	1	2	3	4	5
The institution operating in the niche occupied by the agent supports his mentality	-	-	+	+	+
At least one of the adjacent niches is occupied by some agent	-	+	-	+	+
In adjacent niches, there are institutions that support the mentality of the agent	-	-	-	-	+
<b>The final value of the <i>environment_coefficient</i></b>	<b>0.8</b>	<b>0.9</b>	<b>0.9</b>	<b>1.0</b>	<b>1.1</b>

$$\sum_{t=1}^n \text{result} = \text{productivity} \cdot \text{individuality} \cdot \text{experience\_coefficient}_t \cdot \text{environment\_coefficient}_t,$$

where  $n$  – the number of steps of the model,  $t$  – ,  $t = 1, \dots n$ .

## *Economic agents and their basic characteristics in the model (4)*

- The satisfaction of the agent with functioning in the occupied market niche is reflected by the parameter *satisfaction*, the initial value of which is set randomly in the range from 0.5 to 1.5.
- If all conditions listed in the table are fulfilled (the vector of boolean variables contains only "+" values), the value of parameter *satisfaction* increases by 0.1 each time step. If at least one of these conditions is not met, the value of parameter *satisfaction* each time step is decreased by 0.1.

# *Mechanisms for finding balance in the system*

- 1. A direct change in the institution (*change-institution*) regulating the activity in the market niche occupied by the agent, and a change of the market niche and/or territorial location to exit from the institution's influence (*change-place*).
- 2. Satisfying a need in society (*change-place-for-lonely*) and the agent's search for an institutional environment that matches his mentality (*change-place-near-the-same-institution*).
- 3. Finding a reference group (*find-new-group*) and changing the agent's mentality (*change-mentality*).
- 4. Removal (retirement) of an agent from the virtual world (*die*).
- 5. Checking the current status of agents and public institutions, redefining the total economic results of the agent.

## *Changing the institution and occupying a new market niche by an agent*

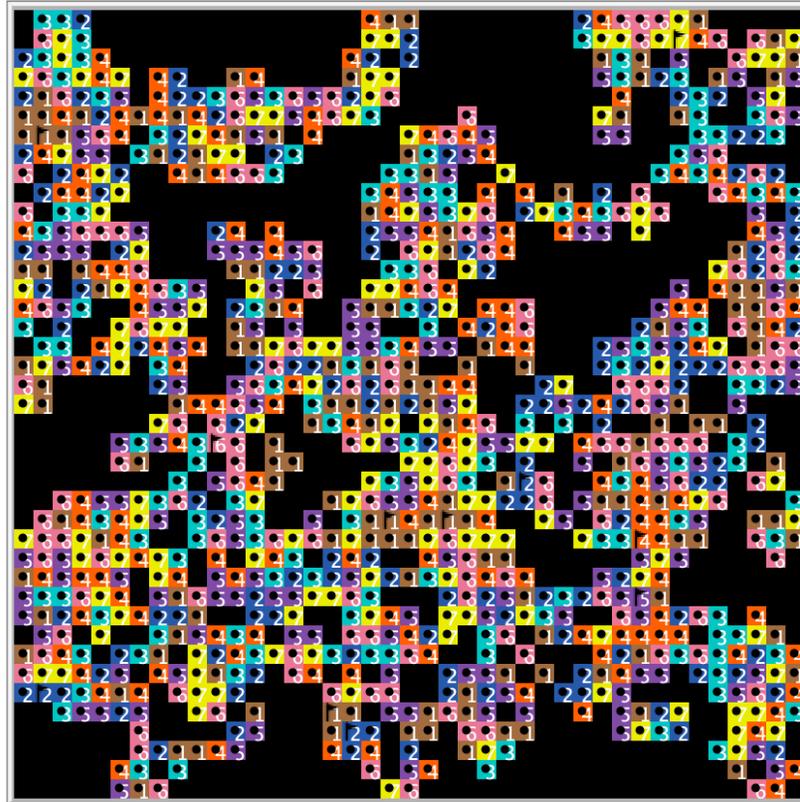
- The cost of changing the institution (*change\_price*) depends on the nature of the agent's environment and on the price of occupying this niche (*buy\_price*), which, in turn, does not depend on the agent and the number of the time step, is constant and is randomly set on the set of niches in the range from 50 to 250 units.
- If activity in adjacent market niches is regulated by the same institution, then the cost of changing the institution in this market niche is equal to  $buy\_price \cdot k$ , where the coefficient  $k$  takes the value 1.25 for one adjacent niche, 1.5 – for two adjacent niches, 1.75 – for three adjacent niches and 2 – for four adjacent niches from the agent's environment regulated by the same institution.
- Thus, the cost of replacing an institution is higher, the more widespread this institution is in the agent's environment.

# Software implementation of the model on the Netlogo platform

setup    go

number 1000

productivity 30



satisfied\_by\_institution?  
148

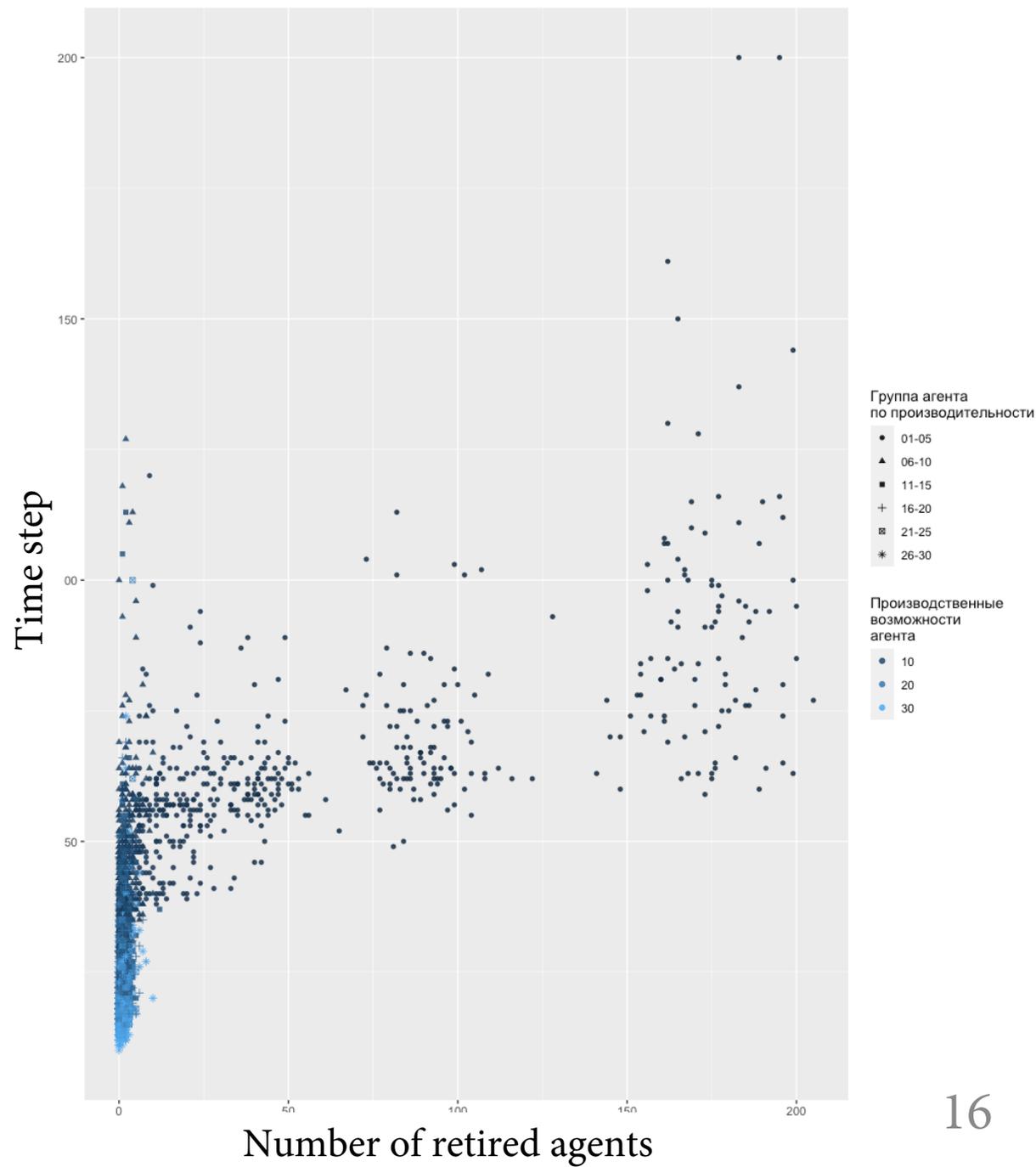
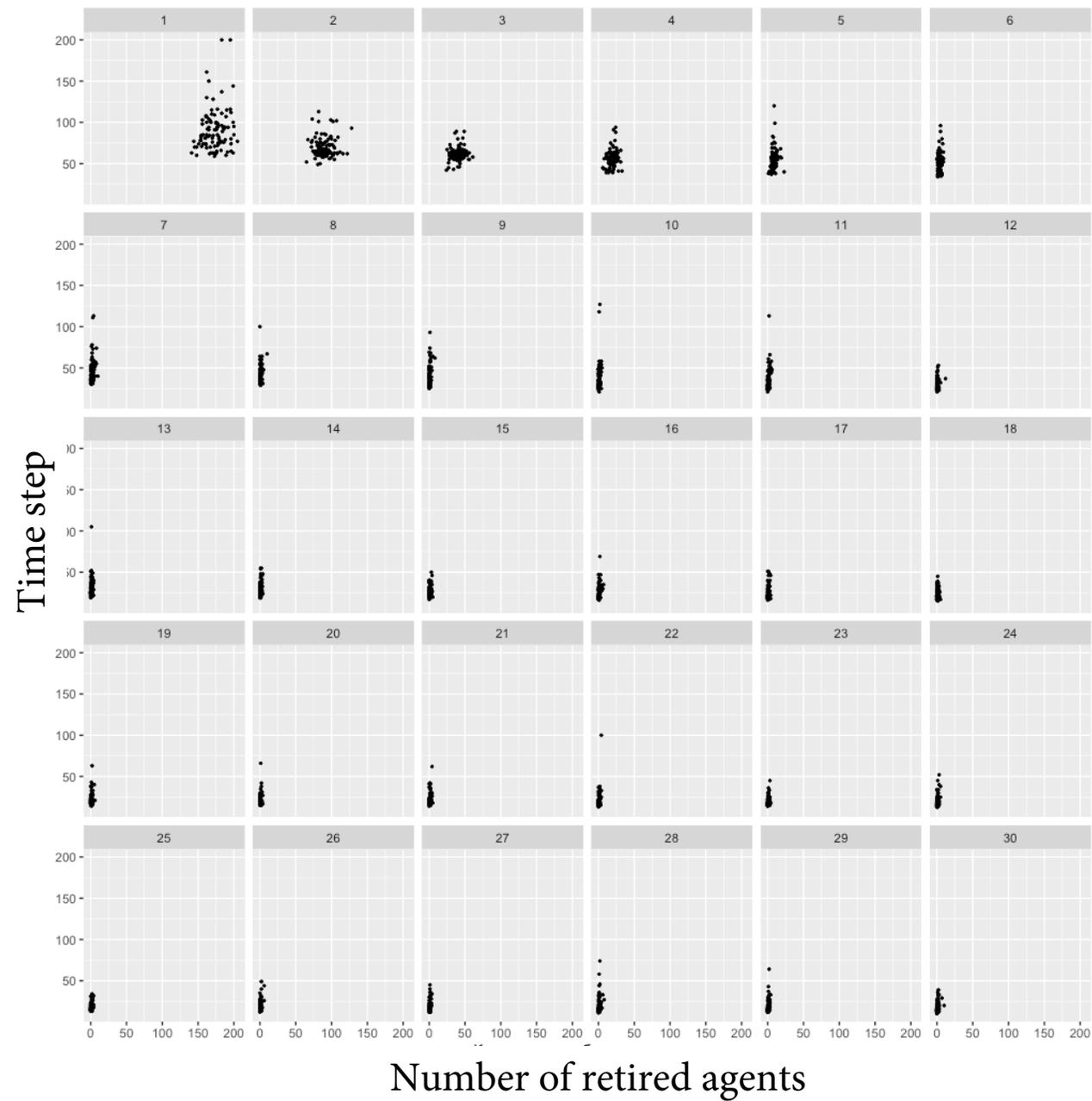
not\_lonely?  
997

satisfied\_by\_neighbors?  
11

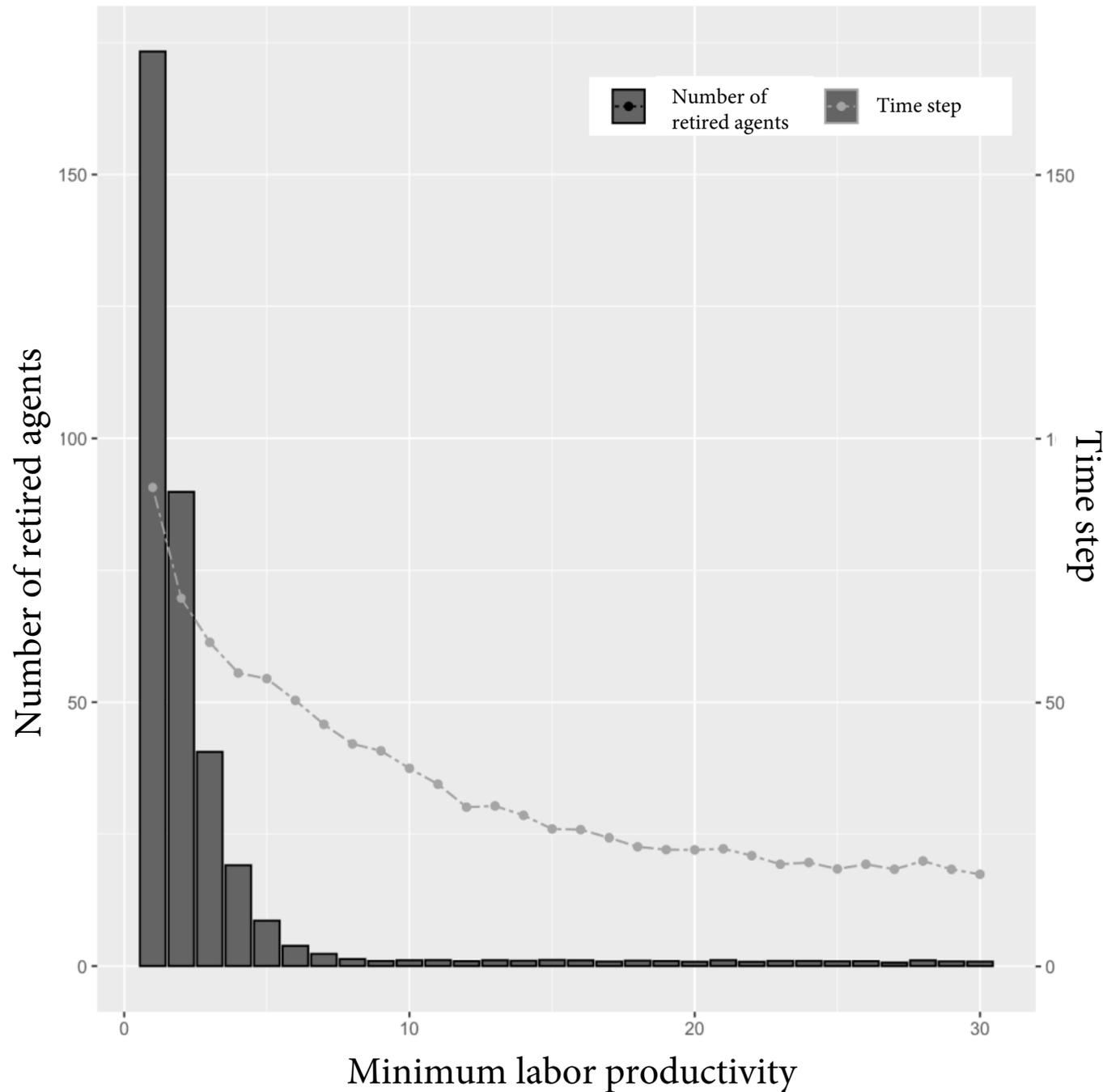
agents\_dead  
0

# *Experiment Results (1)*

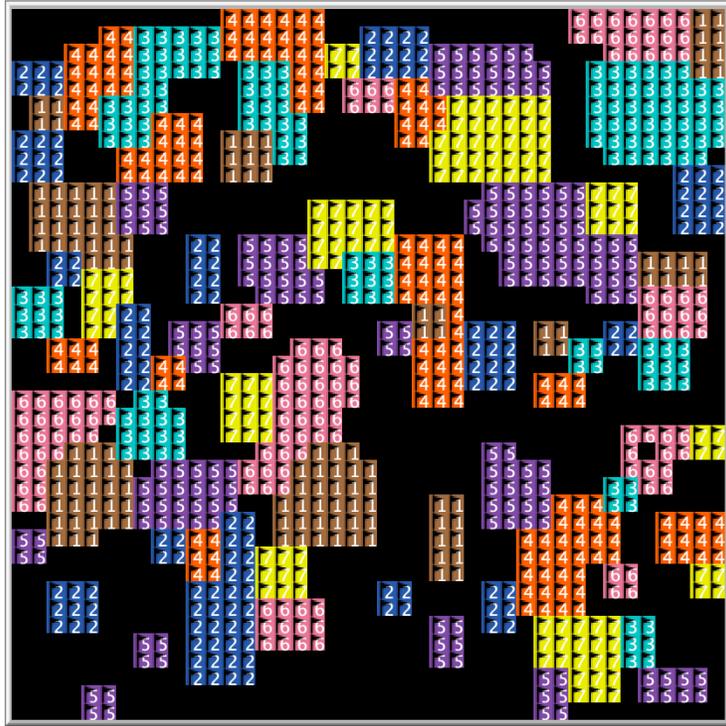
- In order to simulate the process of achieving equilibrium in the system “mentality of economic agents - public institutions”, the following conditions for simulations were established.
- The number of simulations is 100, the number of agents in the virtual world is 1000, the basic production capabilities of agents vary from 1 to 30, the change step is 1.
- The bundle **NetLogo + R** was used to analyze the simulation results.



# Experiment Results (3)



- With an increase in the minimum labor productivity of agents, the average time for the system to reach an equilibrium state decreases from 90 to 17 time cycles, i.e. about 5 times.
- As well as the average number of agents who drop out from the system decreases from 173 (with a minimum labor productivity of 1) to 1 (with a minimum labor productivity of 9 to 30).



## *Conclusion*

- The more developed, wealthy and attentive to traditions a society is, the faster the balance in the system comes, and the fewer agents drop out of the system.
- Upon completion of the simulation, economic agents are assembled into “institutional blocks”.
- Agents “vote with their mentality” for certain groups of public institutions.
- The virtual world was created with a lot of assumptions, but by introducing an additional number of conditions, we tried to achieve realism.

# *Selected References*

1. Kleiner, G., Rybachuk, M., & Ushakov, D. (2021). The mentality of economic agents and institutional change: In search of an equilibrium model. *Terra Economicus*, 19(4), 6-20. (In Russian)
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4. Kleiner, G. B., Rybachuk, M. A., & Ushakov, D. V. (2018). Psychological factors of economic behavior: a systemic view. *Terra Economicus*, 16(1), 20-36. (In Russian)

## Special Issue "Modeling and Simulation of Social-Behavioral Phenomena"

- **Goal:** This Special Issue of Mathematics aims to highlight and explore some of the more recent theoretical and practical advances in computer modeling and simulation of social-behavioral phenomena toward efficient decision processes. Each submitted paper will be rigorously evaluated following the revision process generally applied in the Mathematics journal. This process will be based on assessing the originality, significance, technical soundness, clarity of exposition, and relevance of the submitted paper to the theme of the Special Issue.
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