







# Agent Model for Evaluating Efficiency of Regional Human Resource Management

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**Abstract.** In this paper we study influence of regional programs on the population resettlement in the Russian Federation at the example of the Belgorod region, where the Program of regional human resource development is being implemented. We divide population into clusters, grouped by a place of residence, age, education and employment; events of the Program are aimed at different clusters. We present the agent-based model of regional human resource dynamics. The model reflects sex-age structure, composition of households and spatial distribution of population; production; educational and administrative institutions in the region providing realization of the Program. To simulate social activity of the population in the agent-based model we need information about their reaction on the Program events. Within the survey we collect and process information about satisfaction with financial situation, desire to change job or region of residence of respondents in different clusters. Simulation on the basis of the agent-based model would show how these factors affect individual decisions and, consequently, size and structure of the regional human resource.

**Keywords:** Regional human resource · Spatial development · Migration · Agent-based modeling · Survey · Questionnaire

## 1 Introduction

Managing the regional human resource is an urgent task in sustainable socio-economic development of the country, since market mechanisms for regulating structure of the working population do not provide the required balance with socio-economic dynamics of the regions. Improvement of the resettlement system, distribution of productive forces and communication systems at the federal, regional and local levels is planned within the Strategy of spatial development of the Russian Federation [1, 4]. In turn, the Strategy should be taken into account within strategies of socio-economic development of the regions [3].

The aim of our research is to study influence of control actions (events of the Strategy) on the population resettlement in the Russian Federation. Particularly, in this paper we would accent at assessing impact of the regional human resource

development program (using the example of the Belgorod region), and this methodology would further be adjusted to the general strategy at the federal level.

## 2 Research Methodology

In our study we have chosen agent-based modeling as a main method combining it with sociological surveys and statistical data analysis. The concept of agent-based modeling was proposed in the 1990s [8] and since then has been widely implemented in the analysis of economic, financial, social and environmental processes [7, 9, 11, 15]. There has been proposed a set of tools for simulation of population resettlement and urban planning using agent-based modeling [5, 6, 10, 14].

Application of agent-based approach allows to analyze influence of macro-level administrative decisions on the behavior of micro-level objects. The agent approach has already been used by our team to assess the effectiveness of social policy. In the study of 2008–2010, the impact of the activities of the federal target program “Russian language” on the dynamics of Russian language skills in Russia and abroad was evaluated [13]. Within this research the population (considered as set of agents) is grouped in clusters according to their social and demographic characteristics. For each cluster we set distribution of proficiency in Russian language. Language dynamics is characterized by indicators of the Program that show efficiency of the events. Modeling was performed for the Russian Federation and the CIS countries.

Methodology for research of regional human resource dynamics includes the following steps:

1. Reconstructing current territorial and demographic structure of population, administrative and economic system of the region in the agent-based computer model on the basis of statistical data.
2. Simulating dynamics of the system through decision-making procedures and behavior of agents that are affected by actions of the regional administration.
3. Conducting a series of experiments, statistical processing and analysis of the results.

In this article the issues of modeling dynamics of the system, connected with individual decisions of residents and impact of the events of the regional Program for the human resource development are discussed. At this stage, an urgent task is to collect and process information about the parameters of social activity of various categories of the population, including their satisfaction with the financial situation, desire to change job or region of residence, which affect their exposure to the Program events and, as a result, influence on the size and structure of the human resource of the region. To achieve this goal a series of sociological surveys are conducted.

## 3 Management of the Regional Human Resource

Human resource in the qualitative aspect is determined by demographic and migration processes, its quantitative character depends on the educational system in general and the professional retraining programs in particular. Administrative influence on

demographic processes is indirect; the key channels are social security system: maternity transfers, transfers for low-income families with children, maternity capital. Immigration can be regulated legislatively by quoting the number of migrants and execution of the established requirements [12]. The educational system is regulated by setting the number of budgetary educational places and their distribution by groups of specialties. There are also educational orders from large enterprises, which provide targeted training of specialists for the industry.

In this study we have chosen the Belgorod region, since there the development strategy is currently being implemented, which is aimed, among other socio-economic tasks, at developing the regional human resource [3]. The Program of human resource development in the Belgorod region includes the following tasks: coordinating structure of the labor force and the needs of the labor market in the region; strengthening the relationship of educational institutions and the regional enterprises; support of business; social infrastructure development; designing a system of information support for the regional human resource management. Participants of the Program are regional administration, enterprises and organizations of the region, educational institutions for training and retraining of personnel at all levels and the population of the region.

The impact of events on each resident depends on their socio-economic characteristics and personal preferences. The significance of these factors differs among various categories of the population; therefore, it is necessary to divide the population into homogeneous groups – clusters (Table 1).

**Table 1.** Grouping characteristics of the population clusters.

Feature	1	2	3	4	5	6	7	8	...	17	18	19	20	21
Schoolchildren	+	+												
Students			+											
Employees					+		+			+		+		
Unemployed						+		+			+		+	
Self-employed				+										
Pensioners														+
Age under 35 years					+	+				+	+			
Age over 35 years							+	+				+	+	
Unqualified					+	+	+	+						
Qualified										+	+	+	+	
Town	+				+	+	+	+						
Village		+								+	+	+	+	

Clustering agents in the corresponding feature space is based on the assumption that for agents, who are closed in this space, Program events should be similar, and for agents represented by distant points - different. The criteria for grouping are: place of residence (city, village); age (up to 35 years, over 35 years); education (schoolchild, student, qualified worker or unqualified worker); employment (working, unemployed,

self-employed). Population clusters formed on the basis of the described criteria are presented in Table 1.

Events of the Program of the regional human resource development are aimed at different clusters of the population, and for each group the events have different economic and social efficiency. Program events and indicators of their effectiveness are presented in Table 2.

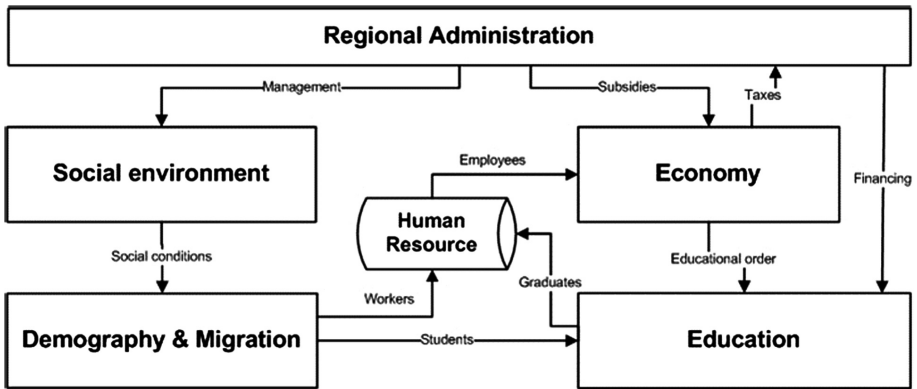
**Table 2.** Events of the Program of the regional human resource development.

Sphere of the event	Event	Efficiency indicator of the event	Target cluster
Education	Increasing number of specialties in educational institutions in the region	Number and average USE grade of the target groups of specialties students	1, 2
	Increasing number of target educational quota from regional enterprises		
	Assigning students to the enterprises of the region at the time of study	Number of graduates employed at enterprises of the region	3
Economy	Creation of workplaces in towns and villages of the region	Percentage of unemployed in the region	6, 8, 10, 11, 14, 16, 18, 20
		Outflow of residents from the region	
	Subsidies for regional business	Number of self-employed in the region	4
Number of new jobs in commercial organizations			
Social sphere	Providing housing for young professionals	Outflow of young specialists from the region	5, 13
	Increasing the number of kindergartens, clubs, sections		5, 9, 13, 17
	Regional pension benefits	Outflow of experienced specialists from the region	7, 11, 15, 19

#### 4 Agent Model of Human Resource Dynamics

The impact of the Program events on the decisions of residents and the changes resulting from these decisions in the size and structure of the regional human resource are studied on the basis of the agent-based model of regional human resource dynamics. The model includes a number of interrelated modules: “Demography and Migration”, “Education”, “Economy”, “Social environment” and “Regional Administration”, each of those reflects significant factors affecting quantitative and qualitative composition of the labor force (Fig. 1). The geography of the model is set of territorial

units corresponding to the districts of the region; regional center and other towns are set separately [12].



**Fig. 1.** Structure of the agent-based model of the regional human resource dynamics.

The module “Demography and Migration” generates agents representing population of the region, their grouping by households, resettlement by towns and districts. During modeling time agents get older, marry, divorce, die; they also migrate from the CIS countries (within the set quotes) and move to other regions.

Organizations of various economic sectors are created in the module “Economy”. We set volume of production output and number of workplaces on the basis of statistical data [2]. Agents are assigned to workplaces in accordance with their qualifications; workable unemployed agents are assigned to the employment centers.

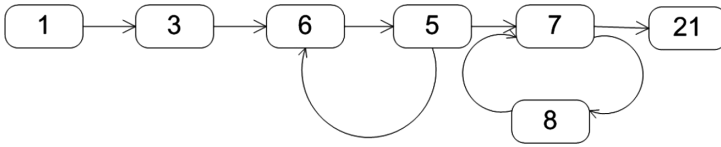
Education system in the model consists of educational institutions of various levels: school, secondary vocational and higher education. For each institution a list of educational places is formed, and agents of the corresponding age are assigned to them. Some details on this issue are presented in [12].

Social environment in the model includes housing, public transport, kindergartens and other parameters that affect quality of life in the region.

Regional administration implements events of the Program for regional human resource development.

The agent state diagram reflects its transition between states corresponding to different clusters. The state diagram of a city resident agent, shown in Fig. 2, corresponds to maturation, education, employment, retirement. Reverse transitions between clusters 4 and 10, 7 and 14 correspond to temporary loss or change of job.

Behavior of agents in the model is determined in education, employment and migration. In the educational sphere agents choose level and specialty of professional education. After graduating agent chooses to be an employee or a businessman and a sector of economy for his future job. Agents can change region of their residence; migration is directly related to education if agent is an entrant, or with employment, if he is a graduate or a qualified employee.

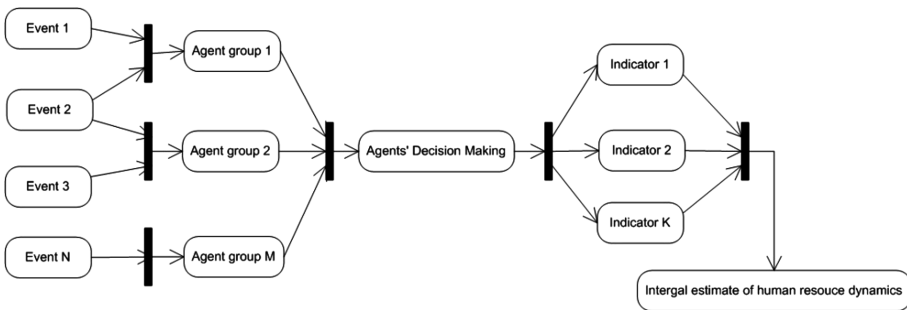


**Fig. 2.** State diagram of a city resident agent.

Dynamics of the model is determined by the impact of the Program’s events on the regional human resource. To reflect influence of events on key indicators we use the following algorithm:

1. For a given event type, number of agent clusters connected with the event is calculated, the property of the agent that is changing after the event, and percentage of agents that are affected by an event of a given type are selected.
2. Depending on the administrative level of the event, the following steps are carried out for all, some or one locality in the region:
  - 2.1. Find the total number of agents in clusters, connected with the event, residing in this locality;
  - 2.2. Calculate the number of agents affected by the event;
  - 2.3. Change the specified property for the calculated number of agents.
3. Modeling of individual decision making by agents.
4. Recalculation of indicators of the Program.

The state and transition diagram reflects the process of assessing impact of the events on the target indicators for each agent group (Fig. 3).



**Fig. 3.** Implementation of the Program events in the model.

Initially, the model consistently handles transitions to evaluate effect of the held events to change the values of target indicators in each agent group. Parameters of the transitions are probability characteristics of sensitivity of a particular agent group for various events, obtained on the basis of sociological surveys and statistical analysis. Further the agents make individual decisions with parameters changed under the

influence of events. According to the results of the simulation, the values of the target indicators and the integral estimate of the regional human resource are formed.

The input of the model receives statistical information on the economic structures of the region, demographic and migration processes [2], plan of events of the Program of regional human resource development [3], and also assessment of the importance of factors influencing personal decisions, obtained through sociological surveys.

## 5 The Survey: Organization and Results

To obtain information about the parameters of social activity of the population and their simulation in the agent-based model of the regional human resource dynamics, a sociological survey was conducted in the Belgorod region. The purpose of the survey was to determine and assess factors influencing the decision to change the region of residence (Table 3).

**Table 3.** Factors influencing the choice of region of residence.

Group number	Type of factors in the group	Example of factors in the group
1	Economic factors	Personal income, average income per member of a household, living wage in the region
2	Personal factors	Presence of relatives in the region, personal assessment of the region
3	Infrastructure	Development of the public transport system, availability of medical services, outlets, kindergartens and schools
4	Ecology	Climate, proximity of industrial areas

Two questionnaires were prepared for the survey: the first for employable adult residents, the second for students and schoolchildren. The questionnaires include the following sections:

Section 1. Affiliation of a resident to a social group (cluster): gender, age, place of residence (city/village), level of education, specialty, employment (employee/self-employed/unemployed).

Section 2. Significance (from 0 to 100) of each factor affecting the choice of region of residence (Table 3).

Section 3. Attitude towards changing region of residence (neutral/preference of native region/preference of another region or country).

Section 4. Evaluation of the impact of the Program for regional human resource development events on personal preferences and intentions in employment and migration.

At the first stage of the survey, 150 students of different ages living in towns and villages of the Belgorod region were interviewed. Results of the survey were processed by the following algorithm:

Step 1. Split the respondents into clusters in accordance with their answers to the Section 1 of the questionnaire. Representatives of three clusters were among the respondents: cluster 1 – schoolchildren living in the towns; cluster 2 – schoolchildren living in rural areas; cluster 3 – students. The number of representatives of each cluster among the respondents is presented in Table 4.

**Table 4.** Survey results in the Belgorod region.

Cluster		1	2	3
Number of representatives		45	40	65
Position, %	leave	69	50	61.5
	neutral	20.7	40	15.4
	stay	10.3	10	23.1
Significance of the factor groups, %	1	0.33	0.29	0.3
	2	0.2	0.26	0.23
	3	0.2	0.22	0.21
	4	0.27	0.23	0.27
Influence of the events, %	E	55	70	67
	H	14	5	65
Intention, %		79	65	54

Step 2. Calculate significance of each group of factors (Table 3) within clusters, based on the data from the Section 2 of the questionnaire.

$$\alpha_{ij}^* = \frac{\alpha_{ij}}{\sum_{i=1}^4 \alpha_{ij}} \tag{1}$$

$$\alpha_i^* = \frac{\sum_{j=1}^m \alpha_{ij}^*}{m} \tag{2}$$

where  $\alpha_{ij}$  - significance of a factor group  $i$ ,  $i = \overline{1, 4}$  for the resident  $j$ ,  $j = \overline{1, \dots}$ ;  $\alpha_{ij}^*$  - normalized individual significance of a factor group  $i$ ;  $\alpha_i^*$  - averaged significance of a factor group  $i$  within the cluster.

Results of calculations for each cluster are presented in Table 4.

Step 3. Calculation of percentage distribution of residents’ attitudes towards the choice of region of residence in each cluster.

Step 4. Evaluation of the influence of the Program events on decisions of representatives in various clusters. For students, events related to education (group E) were considered - creation of additional educational places, making relations with the regional enterprises; and improvement of living conditions (group H) - provision of housing for young professionals. Table 4 shows the percentage of respondents who were interested in implementing events of each group.

Step 5. Calculation of percentage of respondents with a firm intention to move to other regions in selected clusters. For clusters 1 and 2, percentage of respondents who



were ready to move to another region for education was calculated. For cluster 3, percentage of respondents who did not want to return to their region after graduation was determined (Table 4).

According to the results of the survey, the following conclusions can be drawn:

1. In general, more than half of the respondents see their future outside the region and plan to leave for education and employment.
2. A large part of the respondents is interested in establishing communication with the regional enterprises and subsequent employment. Provision of housing in the region is not a serious incentive for the majority (more than 80%) of the respondents.
3. Respondents with a neutral position tend to stay in their native region the older they become: in clusters 1 and 2 (average age 15 years), this indicator is about 10%, in cluster 3 (average age 23 years) - already 23%.

For the Program of regional human resource development the target groups are residents with a neutral position. In favorable conditions, they would highly likely continue to live and work in the region.

## 6 Perspectives of the Study

Currently, a series of surveys are continuing among other categories of the population: employed, self-employed and unemployed. Analysis of data in these categories would make it possible to assess impact of economic and socially-oriented events of the Program of regional human resource development on the decisions of residents in employment and relocation to other regions. In total, it is planned to interview at least 500 respondents of different ages, gender and employment.

Obtained results would be loaded into the agent model of regional human resource dynamics, in particular, the calculated values would reflect attitudes and intentions in the agent groups corresponding to the clusters of respondents, and assess their liability to the Program's events. Within experimental studies on the agent-based model estimates of the impact of the Program events on decisions of residents would be obtained, resulting in the forecast of human resource dynamics in the Belgorod region.

Perspective direction of our research is conducting a series of surveys in various federal districts, which would allow to take into account influence of economic factors, social environment and climatic conditions on the attitudes of residents. The collected data would be integrated into the model of the Russian Federation spatial development and used to analyze effectiveness of measures of the Strategy of spatial development of the country.

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