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COGNITIVE MODELING AS A METHOD TO CONTROL MIGRATION TEMPERATURE

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The research describes one of the approaches to designing a productive mechanism for migration temperature control considering it as an integral qualitative and quantitative indicator of the social and economic problems level associated with migration processes. The analysis of various approaches to studying migration processes impact on socioeconomic situation in recipient countries has been carried out. Some cognitive models have been developed basing on the questionnaire results' analysis, expert assessments, statistical data. A series of simulation experiments have been carried out using software specially developed to automate the cognitive modeling processes. In the course of our experiments, some changes in the target factor. i.e., in migration temperature, have been detected as a result from different intensity impulses impacting on individual controlling factors. Within the developed models framework, several proposals have been put forward concerning the productive mechanism for migration temperature control.

Keywords: labor migration; target factor; controlling factors; migration policy

Introduction

Current rapid increase of migration processes is stipulated by a number of reasons, such as globalization of the world economy, significant differentiation between countries and their regions in both life quality and socioconomic development, religious and political

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freedoms (or lack of) and finally, military conflicts, natural and ecological disasters and so on.

According to the data by UNO, in 2017 the number of migrants in the world reached 258 mln people and since the beginning of the XXIst century it increased by almost 50%. The researchers considered 26 mln refugees to be international migrants, 84% or 22 mln of them migrated to the countries with low or middle levels of development and life quality. Moreover, about two third of all migrants actually live in 20 countries, while 50% of the total migration flow is targeted on ten countries only.

The major number of migrants live today in the USA. Back in 2017 their population was about 49,8 mln people, or 19% from the general number of migrants in the world. Other important recipients of migration inflows are Saudi Arabia, Germany and Russian Federation. Each of these three countries has about 12 mln migrants these days. Great Britain has accepted about 9 mln migrants by now, and thus, is closing the top-five of the world leaders on immigration.

To the major donor countries of migration flows belong: India – about 17 mln people have left the country and Mexico with 13 mln people. Such countries as China, Russia, Bangladesh, Syria, Pakistan and Ukraine could also be called emigration leaders, since in these countries the number of those who left varies within the range of 6-11 mln people.

According to the forecasts by the UN IMO, by 2030 the number of migration flows will reach the threshold of 300 mln persons (Gordeev, 2017)**.** Therefore, well weighted strategies to manage migration flows and migration temperature as an integral qualitative characteristic of the migration impact on all spheres of life in both recipient and donor countries are urgently needed global-wide. Development of such strategies is impossible without in-depth scientific research traditional mathematical methods cannot cope with the tasks of such level of complexity.

The work is devoted to one of the approaches to the migration temperature prediction as an integral qualitative and quantitative indicator of the social and economic problems level associated with migration; this approach is based on the statistical data analysis, on the pilot questionnaire results, on expert assessments and finally, on the use of cognitive modeling methodology.

Background

Various aspects of migration have been studied by scientists from different countries.

Li P. (2016) analyzes qualitative-quantitative composition of Chinese migration flows in several generations starting from the 1980s. Their work emphasizes that the government and the central committee of the Chinese Communist Party pay close attention to migrant workers, and this is reflected in "New Generation of Migrant Workers" concept. The author also provides a very detailed description of this document.

Comparative analysis of intergenerational consequences from migration in terms of education results of the European Turks and their compatriots staying back in the motherland has been carried out in (Guveli et al., 2016). This study analyzes the impact of migration on various life aspects of several generations of 2,000 Turkish families, such as fertility, education, religiosity etc. The specifics of transformation and continuity in the life of migrants and their families in Europe are compared with those of their compatriots back in Turkey.

International labor market is not the mechanical totality of national markets, but rather an inter- and even supranational formation based on the demand for labor force abroad satisfied through export/import of labor force. The process of international labor market formation proceeds through the movement of people between countries and amalgamation of labor markets, though thanks to telework opportunities and growing population, joining the labor market may often take place without any physical movement as such (Patlasov, 2000).

Among the labor markets, one can distinguish the following ones: local, regional, national and common labor market (the one of the European Union, for example) and finally the international one. At present, we can distinguish five big international regional labor markets: West European, Middle Eastern, Asian, Latin American and African. In the first case, the labor market has quite strict, legal and political borders.

It would be also necessary to mention that speaking about regional markets one would always need to take into account geopolitical and economic relations between specific countries within the same region.

Regionalization of the labor force took place in Western Europe, South Western Asia and in Africa (Ushakov et al., 2017). Mobility processes are most important for the labor markets of the American continent and also for Scandinavian countries.

Other key trends in the development of today's international labor market are the following:

- international labor force market is becoming narrow because workers mostly flow from a limited number of countries;
- entry barriers at many labor force markets are only increasing;
- competition between the sellers of labor force is also increasing;
- discrimination of migrants remains to be an acute problem in the majority of countries;
- professional unions are trying to follow the national interests, thus, they inevitable resist labor emigration on their territories.

Another important factor for labor markets is foreign trade. R. Samuelson stated in this regard the following: "The way many countries use to export unemployment is based on the policy, aiming at restraining import and encouraging export" (Samuelson, 1992)**.** R. Dornbusch and S. Fisher (1997) pointed out that improvement of trade balance caused by depreciation of national currency allows "to export unemployment and to increase business in one's own country at the expense of other countries"**.**

Not only economic factors play a great role here but also political, legal, social-psychological, cultural, religious and more. Among the factors of legal influence we should probably name one of the most important ones - the absence of international legal regulation as such. Investments aimed abroad (and not only capital investments but also labor investments, for example) are often connected with conquering new markets. For example, Italian Menarini Group having bought "Berlin – Hemi AG" so that to get easier access to the markets of Central and Eastern Europe, where the Berlin firm already had 200 agencies. Relative costs of labor force and human capital overall are often the inherent investment motives of foreign businesses.

Today we can witness that some of the globalization trends are strengthening:

- world trade and capital movements are concentrated primarily in the industrial centers of three regions: North America, Europe and Japan;
- international trade in goods and services and capital movement

increase in parallel to the growth of national economies;

- intensive development of information technologies makes communication and media truly global;
- economic globalization means additional heavy load on the environment due to constantly increasing production and consumption;
- strengthening international relations mean eroding of national sovereignty due to cross-country coordination of their economic and currency policies. New institutes and instruments are urgently needed to regulate these newer forms of international political cooperation;
- inequality between rich and poor countries has its immediate impact on the labor force movement (migration is traditionally inherent to poor people/countries).

Main Focus of the Study

Our research will start with determining the goal, identifying the object and the subject of research, and establishing methods and technologies to be used in the course of cognitive modeling. The cognitive modeling methodology was developed by R. Axelrod (1976). In contemporary Russia, development of cognitive analysis belongs to the research interests of the school affiliated to the Institute of Control Sciences of the Russian Academy of Sciences. Also, management processes in weakly structured systems using cognitive methodology have been studied by (Maksimov et al., 1999).

Currently, cognitive modeling is being developed as one of the cognitive sciences trends, and various cognitive modeling technologies are used while developing intelligent decision-supporting systems.

In cognitive modeling it is essential to take into account not only the system itself, but also its environment. Introduction of an "observer" into the meta-model allows us building a research and decision-making methodology, taking into account the object's cognition process development in the mind of the researcher. Cognitive methodology is a tool helping the expert structure knowledge while conducting a comprehensive research on various aspects of a complex open system functioning. Research objects in such a case can be as follows:

− phenomena and processes in the system itself;
− potential future ways of the system development;
− situations that need to be managed or to be adapted to them.

Cognitive modeling can significantly reduce the risk of negative impact of the human factor in decision-making.

Complex systems designed for cognitive modeling can perform the following tasks:

− object identification,
− analysis of the cognitive model cycles,
− scenario analysis,
− solution of the inverse problem,
− system implementation, observability, controllability, optimization, forecasting, connectivity and complexity problems solution,
− composition-decomposition tasks,
− analysis of stability, sensitivity, catastrophe theory, adaptability, system self-organization, decision-making.

Cognitive modeling technology is used to study problems with clear and fuzzy factors and interrelations, as it allows modeling socioeconomic systems taking into account the influence of the external environment as well as predicting situation's development, both in short and long terms (Luchko et al., 2014).

Cognitive modeling allows performing the following tasks of the qualitative level:

– to evaluate the situation overall, analyze the mutual influence of factors determining possible scenarios of the situation development;

– to identify the participants' intentions and the development of the current situation accordingly;

– to develop a strategy based on the identified development trends;

– to identify possible mechanisms for situation participants' interaction;

– to develop and justify the directions and means of situation management;

– to determine possible scenarios of situation development taking into account the consequences from decision-making and comparing them.

There are several stages in the process of cognitive modeling:

– investigation of cause-effect relationships (ways and cycles of the cognitive model);

– cognitive analysis of the model structure reflecting the mechanism of the investigated complex objects, including a simplicial (topological, q-analysis of connectivity) analysis, which allows reveal a deeper connection between blocks (simplexes) of the cognitive map not being obvious on the graph;

– analysis of the system's stability to disturbances and structural changes;

– a study of the processes' possible developments in the system by means of impulse modeling, i.e., transition from system statics to studying its dynamics.

In this regard, we need to differentiate between controlling factors and target factors, their change or stabilization being the impact goal in an open system. The influence analysis method is based on the following assumptions:

1. Strength of the controlling factor influence on the target factor depends on the path length on the graph (the number of arcs).

2. The more ways are between the target and the controlling factors, the stronger would be the influence between them.

As a result of parametrization, the abstract cognitive map becomes a cognitive model of a specific dynamic system. In the process of parametrization, the scales of the factors values and the factors interference forces are determined.

Let us consider each stage in the process of cognitive modeling in detail:

Stage 1. Identification of the most significant underlying factors.

The basic factors' selection is often based on PEST analysis being a tool for strategic analysis of the external environment. It serves to identify political, economic, social, and technological aspects affecting company's business performance. In each specific case, change can become either a threat to development, or a new strategic opportunity for future successful development.

The next step is to carry out SWOT-analysis. It means analyzing the internal environment factors -- strengths (S), weaknesses (W), and also external environment factors -- opportunities (O) and threats (T). Such an analysis makes it possible to identify the problem areas, bottlenecks, chances and hazards associated with the object under study. Based on the analysis of various combinations of strengths and weaknesses with threats and opportunities, the problem field of the investigated object is formed.

Stage 2. Cognitive model development

Cognitive modeling is realized using a cognitive map, the construction of which is called cognitive mapping. Cognitive modeling, if performed on the basis of situational analysis, allows working out alternative solutions for the identified problem areas and choosing the best way to run a business/organization.

Most often, cognitive map is a weighted oriented graph, its vertices correspond to the concepts defining the situation, and the oriented edges correspond to the causal links between them.

When developing a cognitive model in the form of a cognitive map, a part of it (a subgraph) can be constructed from the object's statistical data, another part can be based on expert and theoretical data processing.

Development of the cognitive model can be presented in the form of a cognitive map or in the form of more complex cognitive models such as: a vector parametric graph, a parametric vector functional graph, a modified functional graph.

Non-traditional cognitive models are also developed in the form of hierarchical cognitive maps being the disclosure of generalized objects (vertices) of the upper level of the cognitive map into their constituent objects, including lower-level objects and/or stimulus hierarchy.

Stage 3. Scenario study of the situation development trends around the object.

For this stage implementation a mathematical representation of the cognitive model is used. Clear mathematical models are used if all the factors are quantitatively measured and their interaction can be written in formulas. An example is the "predator-prey" ecosystem; its "struggle for existence" cognitive map consists of two vertices and four edges and is described by the Lotka-Volterra model reflecting the oscillatory process: the number of predators and preys varies in a cycle.

Fuzzy mathematical models are constructed in that case when a real mechanism of factors interaction is not known, and it can be described as follows: "with a significant increase in the factor A, the factor B decreases insignificantly," i.e., a relation of the form "if the value of the factor k increases by X_k percent, then the value of the factor m decreases by X_m percent" and it is expressed by the formula (1):

$$X_m(t+1) = W_{m,k} \cdot X_k(t), \qquad (1)$$

where X is an object state set, W is a set of weights (expert estimates).

If there are several arcs in one vertex, their interactions are summed up:

$$X_m(t+1) = \sum_k W_{m,k} \cdot X_k(t) \qquad (2)$$

Evaluation of the received deductions reliability is considered as the consonance value according to the formula:

$$C_m(t) = \frac{\left|z_m^+(t) + z_m^-(t)\right|}{\left|z_m^+(t)\right| + \left|z_m^-(t)\right|}, \quad (3)$$

where $z_m^+(t) = \max_k \left(W_{m,k} \cdot X_k(t)\right)$, a $z_m^-(t) = \max_k \left(-W_{m,k} \cdot X_k(t)\right)$.

The consonance value means confidence in the deduction, correspondence of the expected and received information, and the more it is, the better. Maximum confidence equal to 1 is achieved if there are no factors acting in different directions; the minimum is 0, when there are some stimuli approximately equal in strength and oppositely directed. Such a method can be applied also when several arcs enter into one vertex using the formula (4) to calculate the consonance:

$$C_m(t) = \frac{\left|\sum_k W_{m,k} \cdot X_k(t)\right|}{\sum_k \left|W_{m,k} \cdot X_k(t)\right|}, \quad (4)$$

where the summation symbol corresponds to the total positive and total negative impacts.

As it has been mentioned above, the cognitive map can be viewed as a model for representing expert knowledge or statistical data, constructed as a directed graph (F, W), where F is the set of situation factors, and W is the set of cause-effect relations between them.

Formalization of the cognitive model is carried out in the form of a tuple Φ = (G, X, F), where G = <V, E> is a directed graph; X is a set of vertices parameters V; X: V → R, R is a set of real numbers; F = F (X, E) = F (x_i, x_j, e_{ij}) is the arc transformation functional that assigns the w_{ij} weighting coefficient to each arc.

Under the preferred future vertex or target factor of the graph under investigation we understand some future state of the object. The remaining vertices correspond to controlling factors. The arcs connecting the controlling factors to the vertex of the state have a thickness and a symbol corresponding to the influence force and direction. The arcs connecting the control factors to each other show similarity and difference of these factors’ influence on the control object.

At the initial stage, a model in the form of a cognitive map is developed with the involvement of experts and expert assessments. The obtained image of the object does not only reflect objective laws and patterns, but also represents the belief system, experience and intuition of developers. Cognitive maps are created and modified as a result of the researcher’s active interaction with the environment.

On a fuzzy cognitive map, the influence forces between factors are determined as the experts' confidence in their availability. Any factor can have a direct and opposite meaning. Expert assessments represent the degree of confidence in the increment of factors. Zero is interpreted as an "impossible" increment, and 1 is as a "reliable" increment. Degrees of confidence constitute an ordered set of linguistic assurances Z^p={"impossible", "weakly possible", etc.}. The confidence scale is represented as aφ map: $Z^p \rightarrow [0, 1]$to a segment of the numerical axis.

The conflict between positive and negative evaluations is determined with the help of the cognitive consonance indicator.

c_{ij}, consonance is a measure of difference between positive and negative influences. The more it is, the clearer is the character of influence.

Let the strategy be characterized by a pair of variables (s_{ij}, c_{ij}). v(s_{ij}, c_{ij}) evaluation function must satisfy the following requirements:

1. If c_ij = 0, then v (s_ij, c_ij) = 0 for any s_ij.
2. If $c_{ij} > 0$, then v(s_{ij}, c_{ij}) increases monotonically with respect to both variables.
3. If $c_{ij} < 0$, then v(s_{ij}, c_{ij}) decreases monotonically with respect to both variables.

To assess the degree of various factors' mutual influence, the expert method is usually used. The experts have a questionnaire with the situation description enumerating the basic factors and the relationships between them and are asked to provide individual self-assessment as experts in the corresponding sphere in scores ranging from 0 to 10 and to assess the level of the basic factors' mutual influence in the range from 0 to 1. It should be noted that each expert is supposed to work independently and anonymously.

Further, the median is calculated as the arithmetic average value between the average expert estimates for the factors' influence level, the confidence area is the range of values between the minimum and maximum estimates from the set of examined results.

When the data from the experts are collected, the received estimates are processed. While ranking the objects, the opinions' consistency measure of a group of experts is used - the dispersion coefficient of concordance (the agreement coefficient).

We consider | r_{is} |results matrix of m objects ranked by a group of d experts s=1, … , d, i=1, … , m, where r_{is} is the rank assigned by the s-expert to the i-th object.

The rank sums for each row are calculated. The result is a vector with components:

$$r_{is} = \sum_{s=1}^{d} r_{is}, \; i = 1, \dots, m. \qquad (5)$$

r_{is} values are considered as the values of a random variable and a variance estimate is found, and its error is determined in accordance with the criterion of the mean square minimum by the formula:

$$D = \frac{1}{m-1} \sum_{i}^{m} (r_i - \underline{r})^2, \qquad (6)$$

where $\underline{r}$ is the estimate of the mathematical expectation (average rank) equal to

$$\underline{r} = \frac{1}{m} \sum_{i}^{m} r_i^2. \qquad (7)$$

The dispersion coefficient of concordance is defined as the ratio of the variance estimate to the maximum value of this estimate:

$$W = \frac{D}{D_{max}} . \qquad (8)$$

The coefficient of concordance varies from zero to one, since $0 \le D \le D_{max}$, the maximum value of the variance is: $D_{max} = \frac{d^2(m^3-m)}{12(m-1)}$. Let us introduce the notation: S =

$\sum_i^m (\sum_s^d r_{is} - \underline{r})^2$, and record the variance estimate in the form of $D = \frac{1}{m-1} S$. The transformations will give the final expression for the coefficient of concordance being:

$$W = \frac{12}{d^2(m^3 - m)} S. \tag{9}$$

The formula defines the coefficient of concordance for the case of the related ranks absence. When W = 0, consistency of the o various experts evaluations is absent, and when W = 1, there is a complete consensus in experts' opinions. When the concordance coefficients are extreme, the following recommendations can be given. If W = 0, then, in order to obtain reliable estimates, it is necessary to update the initial data on the events or to change the composition of the expert group. When W = 1, evaluations cannot always be considered objective, since it may turn out that all the members of the expert group agreed to adhere to the same views.

It is necessary to have the determined value of W greater than the specified value. Usually it is assumed that W=0,5, i.e., when W>0,5, experts' conclusions are coordinated to a greater extent. They agree on the evaluation of events. When W<0,5 the estimates cannot be considered sufficiently consistent.

If there are related ranks, the coefficient of concordance is calculated by the formula:

$$W = \frac{12\, S}{d^2(m^3 - m) - d \sum_s^d T_s}, \tag{10}$$

where $TT_s = \sum_k^{H_s} (h_k^3 - h_k)$. T_s is the indicator of connected ranks in the s-th ranking, H_s is the number of equal ranks groups in the s-th ranking, h_k is the number of equal ranks in the k-th group of related ranks in the ranking by the s-th expert. If there are no matching ranks, then H_s=0, h_k=0 and, consequently T_s=0.

The coefficient of concordance is a random variable. The significance of W can be estimated by the Pearson criterion.

$$\chi^2 = 12\, S / \left[dm(m+1) - \frac{1}{m-1} \sum_s^d T_s \right]. \tag{11}$$

Cognitive models are implemented using cognitive maps, being, as a rule, a weighted directed graph which makes it possible to automate the processes of cognitive modeling. When implemented in a computer program with the help of a cognitive model, a simulation experiment can be carried out and it makes it possible not only to predict the object's behavior, but also to see the prospects for object management process development, to formulate a set of recommendations for top management of an organization with the aim to mprove the effectiveness of management decisions.

Therefore, cognitive maps are both a means of situation structuring and formalizing, and a means of its analysis.

Let us consider the process of perturbations propagation on the cognitive model graph, parameters of those $x_i(t)$, t= 1, ..., n depend on time.

If at *t*–1 moment a $p_j \in P$ pulse arrived at the vertex, then the system transition from the state *t*–1 to *t* was carried out according to the rule:

$$x_i(t) = x_i(t-1) + \sum_{j=1}^{k-1} f(x_i, x_j, e_{ij}) p_j(t-1).$$

When the perturbation enters one of the vertices of the graph, then it updates, to a greater or lesser extent, the whole system of indicators.

For example, if the amount of communication between the two controlling factors is 0,5 and the value of one controlling factor increases by 10%, then the value of the other controlling factor will increase by 5%.

It should be noted that for a comprehensive analysis of modeling results, it is necessary to conduct a series of simulation experiments with a built model but without automation tools this work is very labour intensive.

The subject area cognitive structure obtained in the form of a directed graph as a result of the simulation experiment is transformed into a cognitive model, i.e., a functional graph. The simulation experiment reproduces the course of this process with the help of software. In simple terms an interactive cognitive map can be developed by means of an electronic simulator.

Cognitive map can also be a cause-effect network reflecting some area of knowledge through nodes and arcs of the semantic network. Among them, it is possible to identify a map-path (route) as a set of successive steps in connection between the concepts and a map-view as a simultaneous representation of the spatial arrangement of objects.

A series of control options obtained in the course of the simulation experiment makes it possible to identify the most significant controlling factor being most sensitive to the change in another controlling factor.

Thus, simulation experiments make it possible to not only predict the object behavior but also see the prospects for the object management process development, to form a set of scientifically grounded recommendations for decision-makers, to develop effective management strategies.

Migration is a complex phenomenon representing a set of interrelated processes of different origins being influenced by many different factors, both objective and subjective ones. The factors of objective nature are, for example, changes in the number and ethnic composition of population due to migration, the level of unemployment in a country or a recipient region etc.

These are expressed as specific numerical values. Assessment of subjective factors including, in particular, the level of social tension in a society and as one consequence, local population attitude to migrants can be carried out using expert methods. Migration temperature as an integral qualitative and quantitative characteristic of social and economic tension level in a society must take into account both objective and subjective factors.

The most dramatic development of the migration situation may take place due to uncontrolled migration. A persuasive example in this regard is separation of Kosova from Serbia after the civil war. Such an outcome was the result of the processes that lasted for many decades, gradually contributing to an increase in migration temperature through changes in the number and ethnic composition of the region's population. The basis for determining the most significantly influencing factors on the migration temperature would be the statistical data characterizing the situation in Kosovo from 1931 to 2007, which first led to the civil war and then to proclamation of independence (see Tab.1 for details).

Table 1 - Kosovo population and ethnic composition in the selected years

Population / years	1931	1961	1971	1981	1991*
Population of Kosova, thousand people	552,0	964,0	1242,0	1588,0	2000,0
Albanians, thousand people	331,2	647,8	915,4	1230,7	1800
Serbs, thousand people	180	227,5	228,5	209,6	160
Other nationalities, thousand people	40,9	88,7	98,1	147,7	40

*Here are the estimated data due to the boycott of the 1991 census by Kosovo Albanians

In particular, during this period, the proportion of Albanians in the region population increased from 60% to 90%, which contributed to aggravation of interethnic conflicts in the province and the outflow of non-Albanian population. 92 197 Serbs and 20 424 Montenegrins left the province only from 1961 to the 1980, and they were replaced by Albanians from Montenegro, Macedonia and South Serbia. It should be noted that these processes proceeded against the background of constantly growing economic problems, the main one was unemployment.

For example, in 1990, unemployment in the province (the main causes of which were rapid demographic growth of the Albanian community and the lack of new jobs) reached almost 50% of the employable population. By 1997, even before the start of full-scale military operations, the local unemployment already affected 65% of the employable population or about 860 thousand people. At the same time, rapid population growth in Kosova was up to 30 thousand people per year, while the level of production was steadily falling. Unemployment among the young people was especially highly, thus, it is no surprise that many of them, forced by such circumstances, became involved in illegal armed groups and various other shadow activities.

Since the migration temperature depends on many different control factors, only some of them are identified in this study, the ones revealed during the analysis of the statistical data, the results of our pilot sociological research and expert assessments (see Table 4).

Expert assessments methods are widely used in forecasting and long-term planning, especially when there is lack of reliable statistical data on the problem investigated, when there are several potentially possible solutions and when it is necessary to choose the most preferable one.

Heads of the Omsk region migration services and professors of Omsk universities studying migration processes were involved as experts in our pilot study (7 experts in total). The average group self-assessment of experts was 8,72 on the ten-point scale. Obviously, it would be necessary to expand the expert group up to at least 10-15 people to conduct a more extensive study.

At the next stage of the study, a cognitive model of the migration temperature level was developed, reflecting the interrelationships of controlling factors and the degree of their mutual influence and their influence on the target factor (Fig. 1).

Table 2 - The main controlling factors reflecting the features of the migration process in Kosovo on the eve of its separation from Serbia and affecting the target factor level i.e. the migration temperature
(Source: made by co-authors)

Letter code	**Factors types**	**Methods of measurement**	**Measuring units**
Target factor			
А	Migration temperature	Semantic Differential	Points
Controlling factors			
Б	The share of a certain nationality migrants in a region's population or in a recipient country	Expert assessments	Points
В	High birth rates among migrants	Expert assessments	Points
Г	Migrants' inflows	Expert assessments	Points
Д	Native population outflow from the regions of migrants' compact residence	Expert assessments	Points
Е	Sociocultural contradictions between migrants and the rest of population	Expert assessments	Points
Ж	Difference in the traditions of migrants and native population	Expert assessments	Points
З	Difference in the religious views of migrants and native population	Expert assessments	Points
И	Difference in communication and languages between migrants and native population	Expert assessments	Points
К	Level of socialization and assimilation of migrants	Expert assessments	Points
Л	Level of unemployment among migrants, especially young ones	Expert assessments	Points
М	Migration policy effectiveness	Expert assessments	Points
Н	Level of education among migrants	Expert assessments	Points
О	Level of the host country language knowledge by migrants	Expert assessments	Points

Basing on the constructed cognitive model, a matrix of controlling factors' influences on the migration temperature level was created. Further, basing on the use of a matrix of influences and capabilities, as the purpose was to automate the processes of cognitive modeling, a series of simulation experiments was conducted. Gradually varying the impulses' magnitude affecting certain controlling factors, we have received the impulses indicators changes influencing the target factor -- migration temperature and the other factors as well.

Table 3 - The main controlling factors, reflecting the attitude of the local population towards migrants and affecting the target factor level i.e. the migration temperature
(Source: made by co-authors)

No	Factors types	Methods of measurement	Measuring unit
Target factor			
А	Migration temperature	Semantic Differential	Points
Controlling factors			
Б	Migrants do unskilled low wage jobs, local citizens do not want to do	Expert assessments	Points
В	Migrants contribute to the development of certain sectors of the economy: trade, construction, agriculture, etc.	Expert assessments	Points
Г	In conditions of the birth rate decline, the children of migrants replenish the number of children	Expert assessments	Points
Д	Migrants contribute to increase employable population proportion of the country regarding the number of dependents	Expert assessments	Points
Е	Low level of education among majority of migrants	Expert assessments	Points
Ж	Migrants bring traditional cultural and moral values to society	Expert assessments	Points
З	Migrants exacerbate competition in the labor market increasing unemployment	Expert assessments	Points
И	Migrants take out the earnings from the country	Expert assessments	Points
К	Migrants raise the crime rate	Expert assessments	Points
Л	Interethnic conflicts arise in migrants communities	Expert assessments	Points
М	Migrantsspreadinfectiousdiseases	Expert assessments	Points
Н	The migrants inflow increases housing prices	Expert assessments	Points
О	Low level of socialization and perception of the cultural and national traditions of the host country by migrants	Expert assessments	Points
П	Migrants change the national composition of the host country population	Expert assessments	Points

When the impulses affecting factors of the B and J groups increase by 20% and the impulses affecting factor L increase by 10%, the value of the target factor A (migration temperature) increases by almost 23% (Fig. 2).

Within the framework of this model, a productive migration policy helps reducing the migration temperature, otherwise, inefficient control actions focused on migration processes can increase the values of the controlling factor.

Under the influence of negative impulses (-10%) on the controlling factors of the groups D, J and M respectively, migration temperature decreases by 22% (Fig. 3).

At the next stage of the study, the factors reflecting the attitude of local residents to migrants were considered as controlling factors.

The study of migration temperature is based on the questionnaire results analysis carried out by (Bokova & Likhmanov, 2015). Our pilot sociological study and expert assessments in particular have helped us the main controlling factors (Tab. 3).

Taking into account the factors affecting the level of migration temperature revealed during the study (Table 5), a cognitive model has been developed (Fig. 4).

Similarly, an influence matrix has been developed and a series of simulation experiments have been carried out. Varying incrementally on a percentage base the value of impulses affecting certain controlling factors, it became possible to get the values of impulses influencing other factors and the target factor i.e. the migration temperature.

In particular, if the impulses affecting the categories “Interethnic conflicts arise in migrants communities” and “Low level of socialization and perception of cultural and national traditions of the host country by migrants” increase by 20%, this leads to the increase of the impact on A target factor by 46% (Fig. 5).

Solutions and Recommendations

Simulation experiments results from using the abovementioned models make it possible to conclude that the interrelated factors having the most significant effect on migration temperature include the following ones:

−a constant but weakly controlled inflow of migrants;

−a large share of a particular nationality migrants communities in the population structure of a recipient country/region;

−low level of socialization and assimilation of migrants.

From all of the above, our recommendations on control and regulation over the migration temperature would be as follows:

1. World experience has shown that migrants inflows’ control through the measures associated with stricter legislation (longer prison terms and larger fines for illegal migration) and with construction of almost insurmountable barriers along the borders (like the border wall between the US and Mexico) happens to be both inhumane and ineffective. The most expedient measures are direct foreign investments aimed at workplaces’ creation in foreign affiliates of transnational companies and in their subcontractors. Such measures can generally reduce the motivation for moving abroad in search of work when it comes to potential migrants from economically challenged countries. For example, the innovative impulse from transnational companies in Argentina, Brazil, Hong Kong, Mexico and South Korea led to a decrease in the labor force migration propensity in these countries.

2. Another promising direction in regulation of the migration inflows is remote employment system development based on the use of the advanced Internet technologies. This includes distance work, freelancing, video conferencing etc.

3. In some cases, provision of humanitarian assistance also helps reducing the migration flow intensity and preventing the formation of new migration flows. Syria would be probably a well-fit example in this regard.

4. Closed nature of migrants' communities, strict occupational division within national diasporas, active influence of mass media and social networks in native languages together increase the risks of non-assimilation into the local cultural and linguistic environment. These factors also make migrants adaptation a much more difficult mission, and in extreme situations may lead to the emergence of new ethnic criminal structures and various extremist organizations.

5. In referring to the above issues, it is necessary to develop a system of measures aimed to settling the migrants of certain nationality in various regions, as well as to teach them the language, the basics of the local sociocultural traditions and also orient them regarding what occupations are currently in demand locally..

6. Many countries, such as Czech Republic, for example, put forward certain requirements for migrants so that to ensure qualitative composition of migration flows: education level, qualifications, professional experience. In addition, many countries having a complex demographic structure tend to encourage the representatives of their titular nation to emigrate from other countries (Kazakhstan, Germany etc.).

Conclusion

Globalwide, in various countries and regions, migration temperature depends on different controlling factors, and the degree of their influence can also vary in a fairly wide range. However, development of cognitive models for each specific situation based on the statistical data analysis, questionnaire results, expert assessments and simulation experiments make it possible not only to reveal the factors determining the migration temperature level and the complex system of direct and indirect interrelations between them but also to predict the degree of their changes' influence on the target factor. Thus, the simulation experiments data provide an opportunity to identify the greatest "pain points" of the system, and if we influence them properly, it will reduce the migration temperature most effectively and, as a consequence, it will reduce the risks of socioeconomic crisis in society. In other words, these data can serve as the basis for designing and improving the mechanisms of migration temperature control.

References:

Bokova, N.A., Likhmanov, O.V. (2015). *Questioning of residents of the Volgograd region on the attitude towards migration*. Retrieved on April 10, 2018, from: http://sci-article.ru/stat.php?i=1438071792

Dornbusch, R. & Fisher, S. (1997). *Macroeconomics*. Moscow: MGU, INFRA-M.

Gordeev, V. (2017). *The number of migrants in the world has increased from the beginning of the century by almost 50%.* Retrieved on May 30, 2018 from: RL: https://www.rbc.ru/politics/19/12/2017/5a38670d9a7947cbce6346bb.

Guveli, A. et al. (2016). *Educational Attainment. Intergenerational Consequences of Migration*. Palgrave Macmillan, London.

Li, P. (2016). Social Attitudes, Behaviors, and the Significance of Social Governance Among New-Generation Migrant Workers. In: Li, P. (ed.). *Great Changes and Social Governance in Contemporary China*. *China Insights*. Springer, Berlin, Heidelberg.

Luchko, O. N., Maevsky, D. P. & Marenko, V. A. (2014). *Cognitive modeling as a decision support tool*. Omsk: Omsk State Institute of Service. Publisher: SB RAS.

Luchko, O.N. & Patlasov O.Yu., Mukhametdinova S. Kh. (2017). Instrumentation of cognitive modeling in the analysis of vector educational migration. *Bulletin of the Novosibirsk State Pedagogical University*, 7(6) 225-241.

Maksimov, V.I., Kornoushenko, E. K. & Kachaev, S. V. (1999). Cognitive techniques for support and adoption of managerial decisions. *Technologies of Information Society 98*. Moscow: IPU RAN.

Patlasov, O. Yu. (2000). *Marketing-labor market management*. Tomsk: Publishing House of Tomsk State University.

Samuelson, P. (1992). *Economy*. Moscow: Algon.

Ushakov, D., Elokhova, I. & Kozonogova, E. 2017. Post industrialization prospects in the dynamics of socioeconomic transformations: Cluster approach . *International Journal of Ecological Economics and Statistics*, 38(2).

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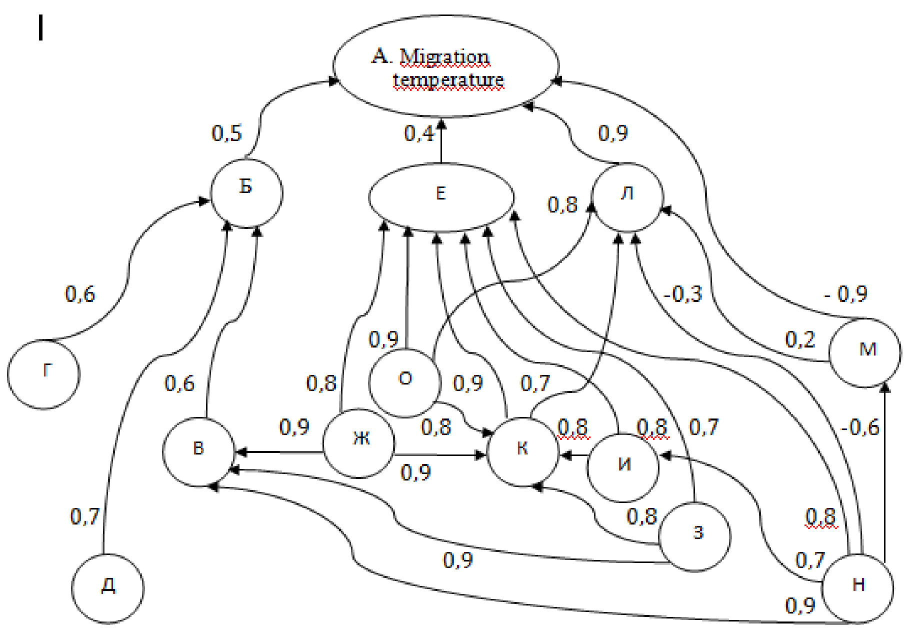

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Figure 1 - Cognitive model of migration temperature (Model 1)
(Source: made by co-authors)

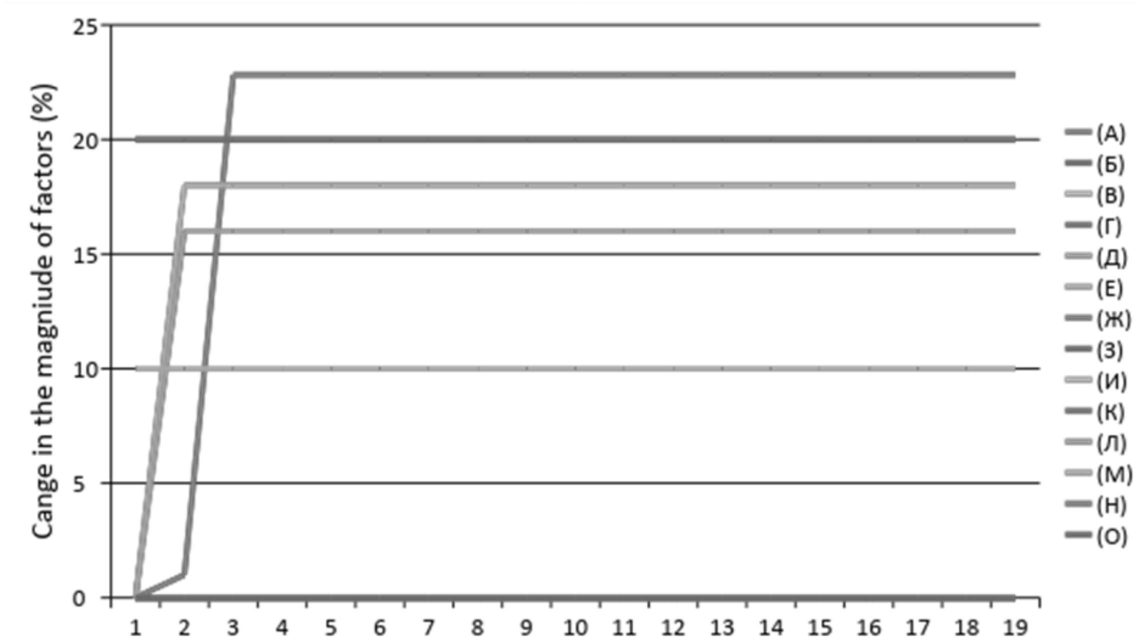

Figure 2 - Visualization of the simulation experiment results (Model 2)
(Source: made by co-authors)

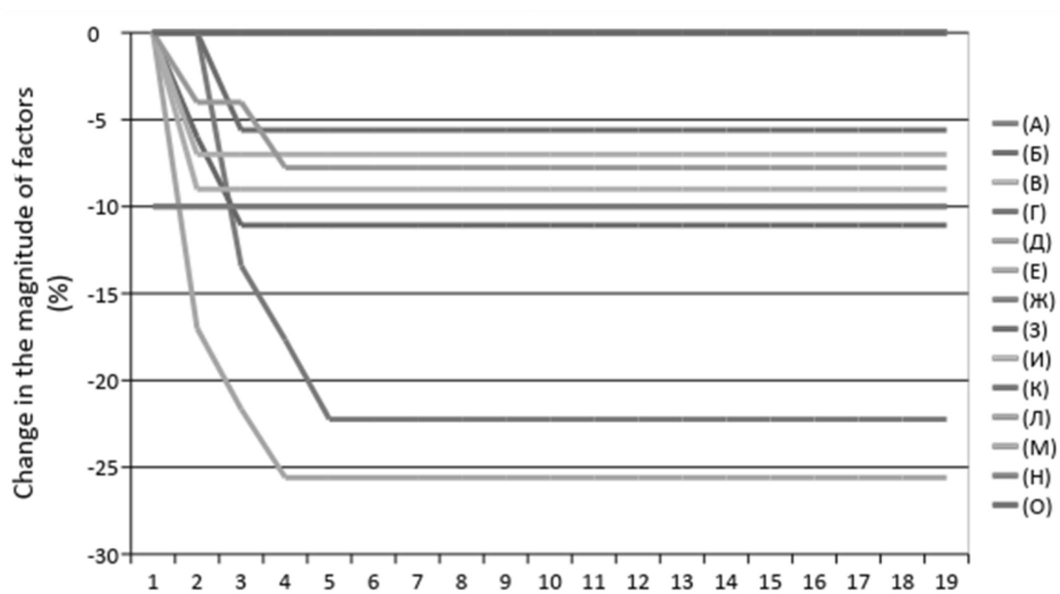

Figure 3 - Visualization of the simulation experiment results (Model 1)
(Source: made by co-authors)

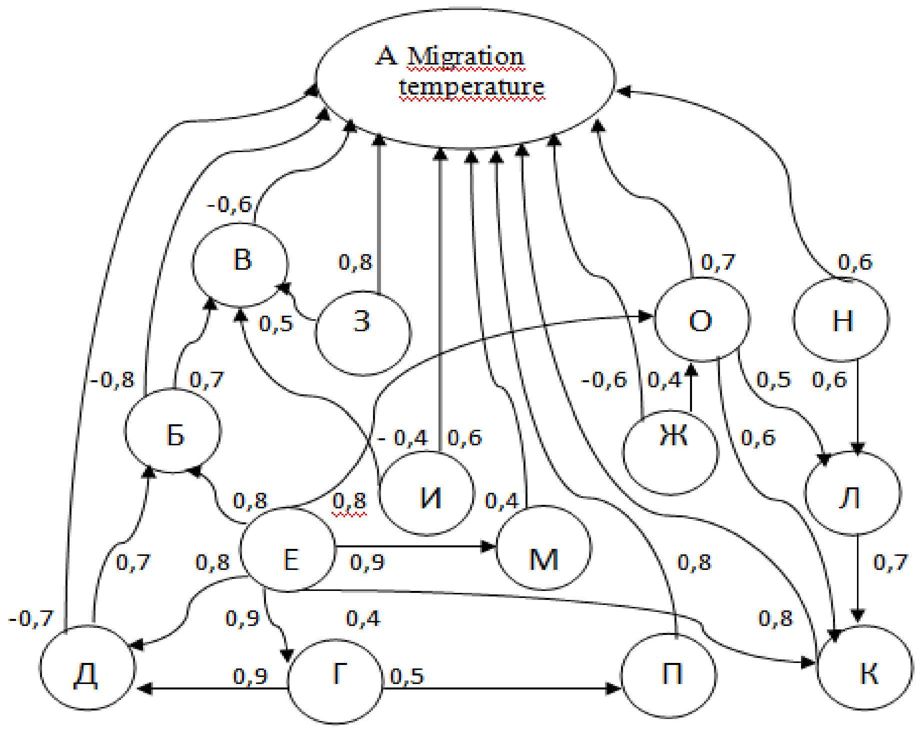

Figure 4 - Cognitive model of migration temperature (Model 2)
(Source: made by co-authors)

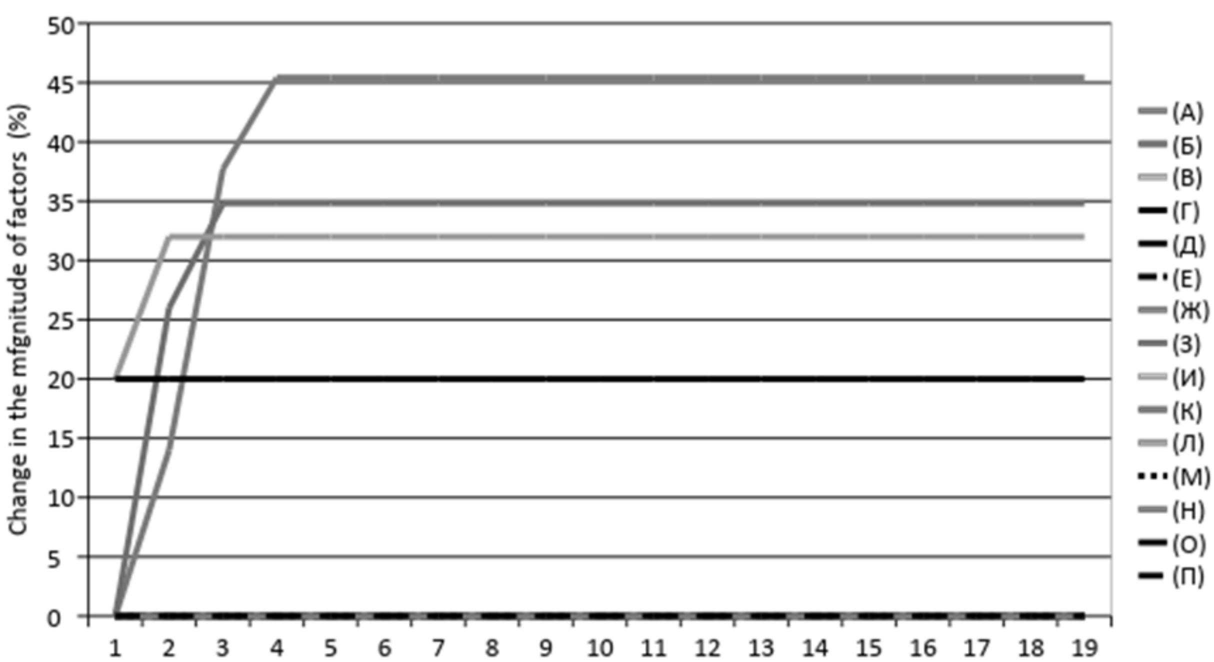

Figure 5 - Visualization of the simulation experiment result (Model 2)
(Source: made by co-authors)