

## COGNITIVE TECHNOLOGIES FOR MODELING MIGRATION PROCESSES IN EDUCATION

**Olena Sergienko**

National Technical University Kharkiv Polytechnic Institute  
61002, 2 Kyrpychova Str., Kharkiv, Ukraine

**Maryna Mashchenko**

Simon Kuznets Kharkiv National University of Economics  
61166, 9A Nauki Ave., Kharkiv, Ukraine

**Natalia Gavkalova**

Simon Kuznets Kharkiv National University of Economics  
61166, 9A Nauki Ave., Kharkiv, Ukraine

**Natalia Chernova**

Simon Kuznets Kharkiv National University of Economics  
61166, 9A Nauki Ave., Kharkiv, Ukraine

**Yuliia Lola**

Simon Kuznets Kharkiv National University of Economics  
61166, 9A Nauki Ave., Kharkiv, Ukraine

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**Abstract.** *The cognitive model of regulating educational migration is constructed on the basis of an oriented graph-structured scheme of causal relations between system elements. This model, in contrast to others, combines factors, taking into account their interaction, leaving, and the educational conditions of foreigners, which in balance lead to educational migration. This model also determines the effects for the country, region, university, and individual migrants.*

*The cognitive model is the basis for developing a set of scenarios. Scenario modeling allows for the identification of possible variants for the development of a situation, ways and mechanisms of influencing the situation in order to achieve the desired results and avoid undesirable consequences, and the development of a set of measures to influence the situation. Each scenario is characterized by the initial data, the influence of management, and the obtained result. Thus, all possible variants of system development are considered and the optimal management strategy is chosen to achieve the desired goals.*

*Three core scenarios of development (optimistic, realistic, and pessimistic) were obtained on the basis of the cognitive model of educational migration regulation. Given these scenarios, methodological recommendations can be formulated on the regulation of educational migration in order to attract educational migrants to Ukraine from foreign countries. This will promote the interests of the social,*

*economic, political, and demographic development of the country.*

*The implementation of the proposed measures to regulate educational migration will facilitate the integration of domestic education and science into the global system, improve the quality of education and its competitiveness in international markets for educational services, increase income, and offset the negative effects of Ukraine's demographic decline.*

**Keywords:** educational migration, cognitive model, effect, scenario, modeling, educational management, educational strategy, educational services.

**Reikšminiai žodžiai:** švietimo migracija, kognityvinis modelis, efektas, scenarijus, modeliavimas, švietimo vadyba, švietimo strategija, švietimo paslaugos.

## Introduction

The current stage of civilizational development is strongly influenced by globalization trends. One of the most crucial of these trends is population migration. Among the variety of migration flows, which differ in direction, intensity, scale, and quality, attention is increasingly drawn to migration for education. This type of migration unites the movements of schoolchildren, students, graduate students, doctoral students, and trainees, and directs them towards areas of concentration such as educational institutions or training centers. It has a number of positive consequences, including economic, social, demographic, and political effects, and is considered the most desirable for the host country in both the short and long term (Arnold 2011; Browne 2017; Carnicer 2019; Kirkegaard and Nat-George 2016; Nicolai, Wales and Aiazzi 2017; Parey and Waldinger 2011; Raymer 2017; Rokita-Poskart 2016).

In Ukraine, the volume of educational migration has significantly increased over the last 10 years, which is to some extent due to the inclusion of the country in the Bologna Process in 2005. The share of foreign students in Ukraine has achieved similar figures to that of the leading countries which provide educational services, due not only to the increased inflow of educational migrants to Ukrainian higher education institutions. The difficult demographic situation in the country, together with the growing number of Ukrainians going to study abroad, requires the reassessment of the state's education and migration policies to develop an effective system for regulating educational migration flows in Ukraine (State Statistics Service of Ukraine 2021).

Despite the considerable amount of scientific research on migration processes, most scientific attention is paid to the analysis of the scale, possible consequences, and regulation of labor migration. At the same time, the problems of educational migration regulation and effective educational migration policy development in Ukraine have not been fully covered in the scientific literature. The importance of these issues determines the focus and relevance of this study.

The current state of educational migration processes shows that migration policies in many countries around the world are aimed at attracting educational migrants, who represent significant capital. The study of educational migration processes allows us to identify the main purpose of educational migration policy: to attract educational migrants to Ukraine from countries near and far in the interests of the social, economic, political, and demographic development of the country. Such an educational migration policy requires interaction and coordination at several levels of regulatory influence: state (Ministry of Education, Ministry of Foreign Affairs, Ministry of Internal Affairs, State Migration Service); regional (state regional administration, and other regional public authorities); and at the level of individual universities.

The main objectives of educational migration policy are the following: to create favorable conditions for educational migrants living and learning in Ukraine; to form migration potential for the future replenishment of the number of foreign students; to improve migration policy in the direction of facilitating the conditions for entry and stay for educational migrants; and to stimulate the integration of educational migrants into the Ukrainian society and economy.

## Methodology and Data

Recently, scenario modeling and forecasting have been widely used in the development of strategies for the socio-economic development of systems. This approach most comprehensively meets the objectives of research and the prediction of the behavior of contradictory heterogeneous systems and processes. Scenario modeling, as a tool for constructing not individual development trajectories but a wide range of variants for assessing the impact of various factors, is very effective in choosing targets and system development strategies and in assessing possible risks. Let us consider in more detail the development of regulation scenarios for the migration processes of educational migration and the prerequisites for their formation and implementation.

1. To determine the set of factors and the degree of their influence on the decision of foreigners to seek education in Ukraine, a questionnaire surveying 221 foreign students from three Kharkiv universities was conducted. Based on the generalization of the survey results, a socio-economic profile of a typical foreign student in Ukraine was developed. The results showed that the educational migrant is a young representative of neighboring countries who is attracted by medical, technical, engineering, and economic specialties. The student's main purpose of arrival is to obtain the appropriate qualifications to increase their competitiveness in the labor market; they have sufficient financial support and are trying to enter universities that have a high enough ranking in different social networks.

2. By summarizing the results of previous surveys, a questionnaire was formed to determine the expert assessment of the dominant factors of educational migration at three levels: state, regional, and university. The study involved 19 practitioners who are directly involved in the regulation of educational migration. According to the results of the examination, the factors that most significantly affect educational migration at the state level are social and political security and the cost of living in the country; at the regional level, the most significant is the cost of living in the region. At the university level, such factors as the cost of education, the level of development of university infrastructure, the quality of education, and the availability of social networks of foreign students are decisive. Based on the generalization of the results of the expert assessment, these factors were classified according to the degree of influence on educational migration, and their interaction and connections were determined.

In this work, we will consider the number of foreign students arriving in a certain period ( $KSI_{KSI}$ ) as the core indicator of the effectiveness of the educational migration management system.

This indicator will be considered at the following levels: state ( $KSI_D KSI_D$ ), regional ( $KSI_R KSI_R$ ), and university ( $KSI_W KSI_W$ ). According to the defined levels, the dependence of the specified indicators is the following:

$$KSI_R = \sum_W KSI_W$$

$$KSI_D = \sum_R KSI_R = \sum_R \sum_W KSI_{RW}$$

The considered set of factors forms a set of living and studying conditions for foreign students, which in turn can be divided into three groups: social (*USUS*), financial (*UFUF*), and educational (*UOUO*). In this case, certain factors may affect the formation of several groups of conditions simultaneously (see Figure. 1).

Each group of conditions that are formed under the influence of certain factors may or may not satisfy the educational migrant. In general, however, the conditions show a reinforcing or compensating interaction.

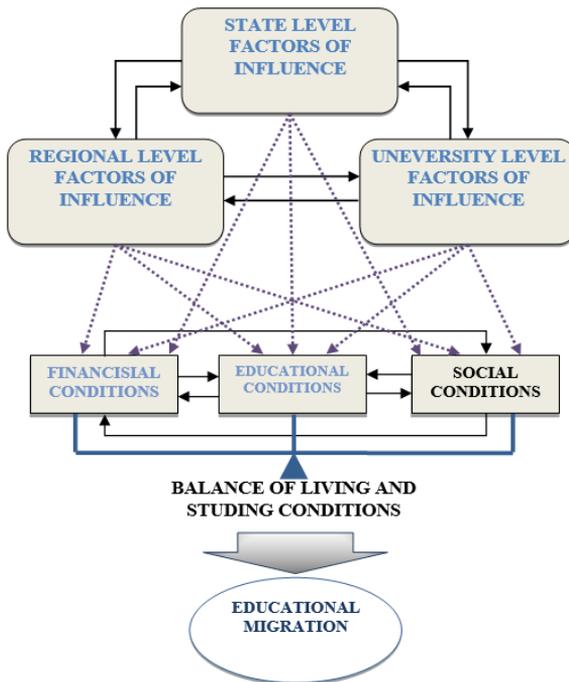


Figure. 1. Relationships between educational migration factors.

3. The set of considered factors was grouped in accordance with the impact on living and studying conditions – social, financial, and educational. Based on the generalization of the research results, a number of effects which cause the inflow of foreign students for all mentioned levels were identified. A quantitative assessment of these effects was carried out, on the basis of which the possibility of building a cognitive model of educational migration regulation was proved only at the level of an individual university.

The effects and consequences are classified into four groups:

$$SE = \{E_2, E_6, E_7, E_8, E_{10}, E_{11}, E_{12}\}$$

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*SESE* – social group;  $E_2E_2$  – the exchange of cultural values and experiences;  $E_6E_6$  – the replenishment of the working age population that possess a specialty and qualification;  $E_7E_7$  – competition for high-paying jobs between local workers and migrants;  $E_8E_8$  – social environment (the change of the national structure of the population for Ukraine);  $E_{10}E_{10}$  – prestige of the university;  $E_{11}E_{11}$  – level of development of the educational system;  $E_{12}E_{12}$  – level of development of social networks of foreign students.

$$EE = \{E_1, E_4, E_6, E_9\} EE = \{E_1, E_4, E_6, E_9\},$$

*EEEE* – economic group;  $E_1E_1$  – receipt of additional funds through the import of foreign savings;  $E_4E_4$  – increase in the number jobs;  $E_6E_6$  – the replenishment of the working age population that possess a specialty and qualification;  $E_9E_9$  – additional jobs for university workers regarding the control and regulation of foreign students' studies.

$$PE = \{E_3\} PE = \{E_3\},$$

*PEPE* – political group;  $E_3E_3$  – ethnic conflicts.

$$DE = \{E_5\} DE = \{E_5\},$$

*DEDE* – demographic group;  $E_5E_5$  – improvement of the demographic situation for Ukraine.

The considered effects can occur at the state, regional, and educational institution levels, and directly relate to the foreign student. The same effect can occur simultaneously at several levels (Figure 2).

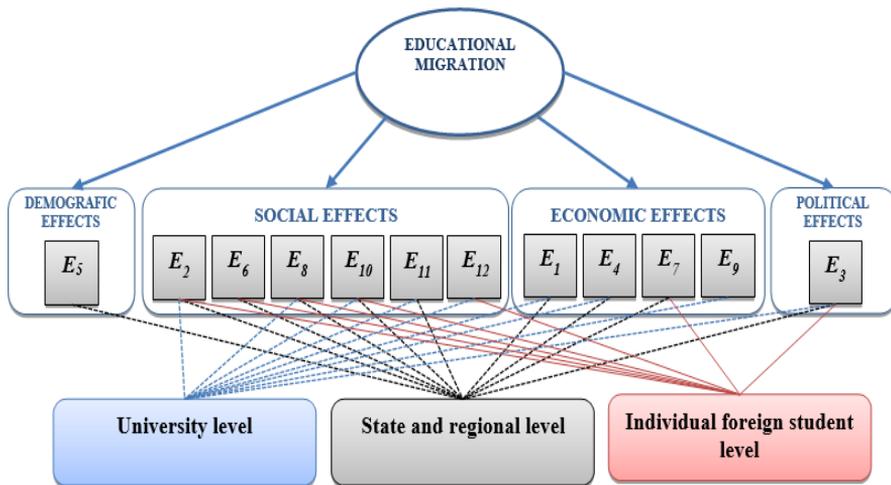


Figure 2. Distribution of effects from educational migration by level of occurrence.

At the macro and meso levels, the following effects occur:

$$DRE = \{E_1, E_2, E_3, E_4, E_5, E_6, E_7, E_8, E_{10}, E_{11}\}$$

$$DRE = \{E_1, E_2, E_3, E_4, E_5, E_6, E_7, E_8, E_{10}, E_{11}\}$$

At the university level,  $WE = \{E_1, E_2, E_3, E_4, E_8, E_9, E_{10}, E_{11}\}$

$$WE = \{E_1, E_2, E_3, E_4, E_8, E_9, E_{10}, E_{11}\},$$

the following individual effects occur for an individual foreign student:  $IE = \{E_2, E_3, E_6, E_7, E_8, E_{10}, E_{12}\}$

$$IE = \{E_2, E_3, E_6, E_7, E_8, E_{10}, E_{12}\}$$

4. Based on the established relationships and their assessment, a cognitive map of the model of educational migration regulation was built which, in contrast to existing approaches, combines a set of factors, taking into account the strength of their interaction. A flexible management approach leads to a predictable and balanced level of educational migration flows, indicators of which are the effects on the country, region, university, and individual student levels. The final step is to build a cognitive model in the form of an oriented graph. On the basis of the oriented graph-structured scheme of causal relations of elements of the investigated system, the cognitive model of educational migration regulation was constructed (Figure 3).

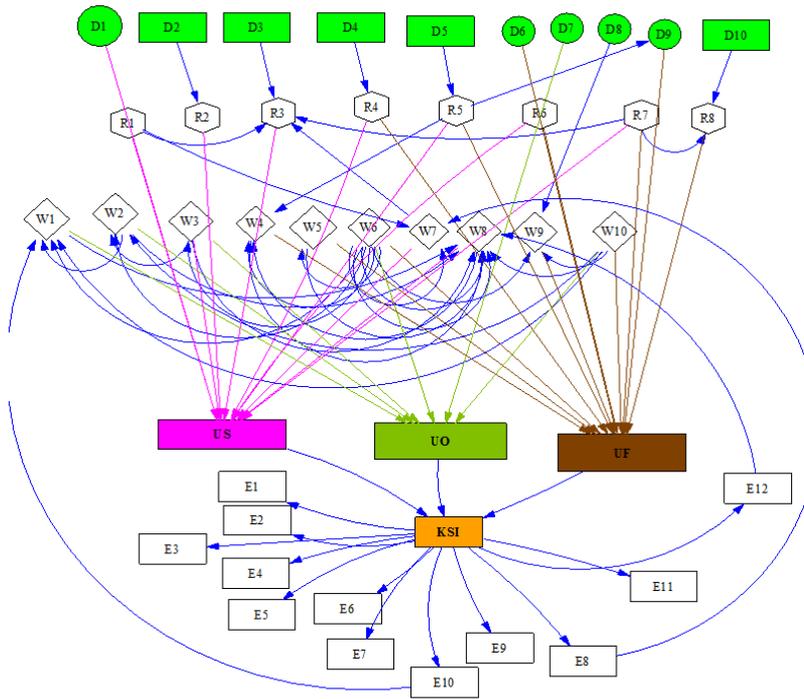


Figure 3. Cognitive map of the educational migration regulation model

Figure 3 can be explained as follows:

State level factors:  $D_1D_1$  – geographical location of the country;  $D_2D_2$  – climatic conditions, ecological situation in the country;  $D_3D_3$  – social and political safety in the country;  $D_4D_4$  – the level and availability of the health care system in the country for foreigners;  $D_5D_5$  – the level of infrastructure development in the country;  $D_6D_6$  – possibility (at the legislative level) of employment during study period;  $D_7D_7$  – the prospect of staying in the country for permanent residence;  $D_8D_8$  – accessibility and integration of the educational system in the country;  $D_9D_9$  – support for foreign students (at the state level); and  $D_{10}D_{10}$  – the cost of migration.

Regional level factors:  $R_1R_1$  – the foreigner’s proficiency in a local regional language;  $R_2R_2$  – ecological situation in the region;  $R_3R_3$  – social safety in the region;  $R_4R_4$  – the level and availability of the health care system in the region for foreigners;  $R_5R_5$  – the level of infra-

structure development in the region;  $R_6R_6$  – additional conditions and benefits in the region for foreign students;  $R_7R_7$  – the level of corruption of law enforcement agencies in the region;  $R_8R_8$  – the cost of living in the region; and  $R_9R_9$  – the possibility of employment during study period;

University level factors:  $W_1W_1$  – the prestige of the institution;  $W_2W_2$  – quality of education;  $W_3W_3$  – language of study;  $W_4W_4$  – availability of admission conditions for foreign students;  $W_5W_5$  – development of university infrastructure;  $W_6W_6$  – additional benefits provided by the educational institution;  $W_7W_7$  – social environment;  $W_8W_8$  – social networks;  $W_9W_9$  – cost of education; and  $W_{10}W_{10}$  – the level of corruption in the educational institution.

5. The cognitive model is the basis for developing the set of scenarios. Scenario modeling will allow us to: identify possible variants for the development of the situation and ways and mechanisms of influencing the situation in order to achieve the desired results; avoid undesirable consequences; and develop a set of measures to influence the situation. Each scenario is characterized by the initial data, the influence of management, and the obtained result. Thus, all possible variants of international migration system development are considered, and the optimal management strategy is chosen to achieve the desired goals.

## Results and Analysis

Several groups of factors were identified to build scenarios based on the developed model. Factors-constants affect educational migration, but do not participate in the regulation of educational migration processes. They are: geographical location of the country, climatic and ecological conditions, social environment, cost of migration, and the foreigner's proficiency in a local regional language.

Conditionally constant factors have their own quantitative estimates, but do not relate to the direct regulation of educational migration processes. They are: social and political safety in the country, the level and accessibility of the health care system in the country, the level of infrastructure development in the country, the availability and integration of the education system in the country, and the cost of living in the country.

Other factors were quantified or qualitatively assessed. Membership functions were built for them to determine scenarios for the development of educational migration processes in Ukraine.

It is suggested in this study to model educational migration regulation scenarios in two directions: self-development and direct tasks. The situation of self-development is characterized by the absence of any regulatory influences, so the conditions for the formation of the foreign student contingent will be formed by factors that are not regulated at the macro level, nor at the meso level, nor at the university level.

Thus, the pessimistic scenario is formed as a combination of the lowest values for fac-

tors-stimulators and the highest values for factors-destimulators. A realistic scenario is formed as a combination of average values of factors of different levels, or as a combination of the highest values for factors-stimulators and the lowest values for factors-destimulators. An optimistic scenario is formed as a combination of the highest values for factors-stimulators and the lowest values for factors-destimulators. A fragment of the simulation parameter values is presented in Table 1.

To implement the scenarios, the values of the influencing factors remain at the level of the basic values. These factors are normalized and substituted for the system of functional dependencies of the fuzzy cognitive model. Then, integrated estimates of the conditions of educational migration processes are calculated.

The results of scenario modeling with the selected vector of managerial influences are presented in Table 2. Based on the obtained results, the following conclusions can be drawn. The selected threshold of significance of influencing factors showed that the most influential factors are social and educational ones. Therefore, appropriate managerial influences should be aimed at improving the educational and social conditions. Therefore, the results of experiments for these two groups of conditions will differ from the results obtained in predicting the self-development of the system.

*Table 1. Fragment of parameter values for educational migration modeling scenarios.*

Factors		Significance	Factor values for different scenarios				
			Optimistic	Realistic 1	Realistic 2	Realistic 3	Pessimistic
$R_6$	Additional conditions and benefits in the region for foreigners learning	0.034	67–100	34–66	34–66	0–33	0–33
$W_3$	Language	0.075	3–5	2	3–5	1	1
$W_4$	Availability of admission conditions for foreign students	0.184	67–100	34–66	67–100	34–66	0–33
$W_8$	Social networks	0.055	67–100	34–66	67–100	0–33	0–33
$W_0$	The level of corruption in the university	0.026	0–1.5	1.5–3.5	3.5–5	0–1.5	3.5–5

When comparing the results of the two groups of scenarios, greater effectiveness of the second group is clearly observed. This is because they provide the development of a set of managerial decisions on the most significant factors and conditions of formation of the contingent of foreign students and allow the effectiveness of these decisions to be evaluated.

At the last stage, the choice of the most effective decisions for regulation of the conditions of formation of a contingent of foreign students is carried out. The strength and direction of decisions and ways to prevent their negative consequences are also determined. This paper also proposes a simulation approach to the implementation of this task. The block of estimation of scenario modeling results is presented in Figure 4.

The number of foreign students, as the main result of the constructed cognitive model, is an important criterion for increasing the prestige of higher education, which is reflected in various rating systems, both domestic and international. One such ratings is the ranking of world universities, QS, which is calculated on the basis of 6 criteria (QS World University Rankings 2012).

To build a model, let us denote  $R_t$  as the value of the rating for a particular educational institution in a certain period, and  $K_i$  as the value of the criteria. The appropriate QS rank can be calculated by the formula of arithmetic weighted average:

$$R_t = \sum_{i=1}^6 \alpha_i K_i$$

where  $\alpha_i$  represents the criterion level of significance.

Table 2. Results of scenario modeling.

	Periods					
	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20
Pessimistic scenario						
Social conditions	1.14	1.20	1.29	1.39	1.49	1.61
Educational conditions	0.35	0.36	0.39	0.42	0.45	0.49
Financial conditions	0.20	0.22	0.23	0.25	0.27	0.29
Number of foreign students	2,244	2,271	2,296	2,322	2,348	2,374
Realistic scenario						
Social conditions	2.74	2.77	2.80	2.83	2.87	2.90
Educational conditions	0.46	0.46	0.47	0.47	0.50	0.54

Financial conditions	1.60	1.62	1.64	1.66	1.67	1.69
Number of foreign students	2,493	2,524	2,552	2,580	2,609	2,638
Optimistic scenario						
Social conditions	2.78	2.81	2.83	2.92	3.01	3.11
Educational conditions	1.30	1.31	1.32	1.36	1.41	1.45
Financial conditions	1.64	1.66	1.67	1.73	1.78	1.84
Number of foreign students	2,715	2,740	2,762	2,850	2,941	3,035

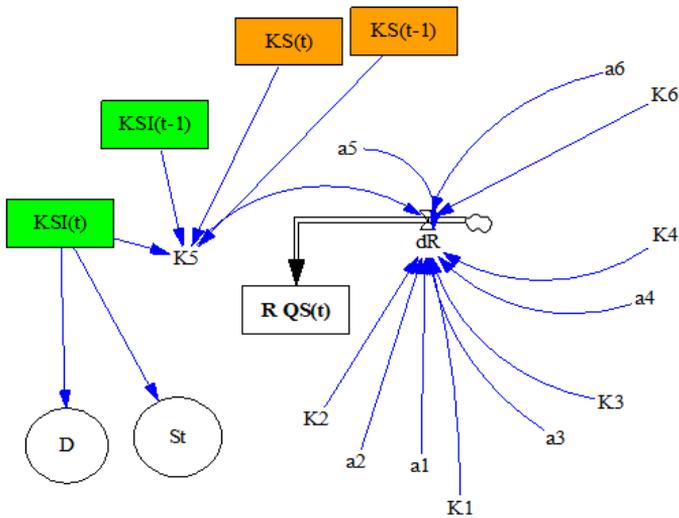


Figure 4. Block of estimation of scenario modeling results.

We will consider the increase in the rating for a certain period (one year) as an assessment of the managerial effectiveness of educational migration processes at the level of the educational institution:

$$dR_t = R_t - R_{t-1} = \sum_{i=1}^6 \alpha_i (K_{i,t} - K_{i,t-1})$$

In this study, we examine the impact on rating growth (Table 3) of the following criteria: the share of foreign students, and reputation among employers. The first is formed from the contingent

of foreign students, and the second is an assessment of the quality of training and acquired competencies of foreign students who graduate and receive a diploma.

Another criterion – the reputation of employers – also significantly affects the rating. The level of significance of this criterion is 0.1 (10%). At its numerical calculation, we take into account the following: according to the results of the statistical survey of graduate students for 2010–2020, the following data were obtained. On average, 50% of graduates were employed this year in prestigious companies and organizations that positively assess the knowledge and abilities of graduates. However, such statistics are different for foreign students. According to the survey, 2% of foreign graduates plan to work in Ukraine after graduation, 17% plan to work and continue their studies, and the rest plan to return home. Thus, of the total number of well-educated foreign graduates, only 20% will receive positive feedback from employers.

Of the remainder of the graduates, 25–30% achieve a prestigious job during the next year, the rest work for themselves, work in small businesses, work in private enterprises, start their own business, or do not get a job at all during the current and subsequent year.

**Table 3. The results of modeling dependencies between QS rank growth and the share of foreign students.**

	Periods					
	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20
Pessimistic scenario						
Number of foreign students	2,244	2,271	2,296	2,322	2,348	2,374
Share of foreign students, %	16.03	16.22	16.40	16.59	16.77	16.96
Increase in the share of foreign students, %	0.65	0.19	0.18	0.18	0.18	0.19
Rating increase, units	0.07	0.02	0.02	0.02	0.02	0.02
Realistic scenario						
Number of foreign students	2,493	2,523	2,551	2,580	2,609	2,638
Share of foreign students, %	17.81	18.03	18.23	18.43	18.63	18.84
Increase in the share of foreign students, %	0.65	0.22	0.20	0.20	0.20	0.21
Rating increase, units	0.07	0.02	0.02	0.02	0.02	0.02
Optimistic scenario						
Number of foreign students	2,715	2,740	2,762	2,850	2,941	3,035
Share of foreign students, %	19.40	19.57	19.73	20.36	21.01	21.68
Increase in the share of foreign students, %	0.65	0.17	0.15	0.63	0.65	0.67
Rating increase, units	0.07	0.02	0.02	0.06	0.07	0.07

As for foreign students, we also believe that 25–30% of the remainder achieve a prestigious job in their home country. The overall increase in the QS rating, depending on changes in the reputation of employers and the share of foreign students in different scenarios, is presented in Table 4.

**Table 4. Overall increase in the QS rating depending on changes in the reputation of employers and the share of foreign students in different scenarios.**

Scenario	Period					
	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20
Pessimistic	0.16	0.20	0.21	0.22	0.23	0.24
Realistic	0.24	0.28	0.29	0.30	0.31	0.32
Optimistic	0.31	0.35	0.35	0.41	0.44	0.47

## Conclusions

Thus, three core scenarios of development (optimistic, realistic, and pessimistic) were obtained on the basis of the cognitive model of educational migration regulation and the set of quantitative and qualitative indicators. Given these scenarios, methodological recommendations can be formulated on the regulation of educational migration in order to attract educational migrants to Ukraine from foreign countries. This will promote the interests of the social, economic, political, and demographic development of the country.

Improving the system of state regulation of international educational migration on the basis of the developed scenarios involves the establishment of basic targets to ensure regulatory influence at all levels – state, regional, and university. Targets are determined primarily in: the updated regulatory framework for the education of foreign students; the improvement of the system of accounting for educational migration processes; and the improvement of organizational and informational support for the regulation of educational migration.

Implementation of the proposed measures to regulate educational migration will facilitate the integration of domestic education and science into the global system, improve the quality of education and its competitiveness in international markets for educational services, increase income, and offset the negative effects of Ukraine's demographic decline.

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## Kognityvinės migracijos procesų modeliavimo technologijos švietime

Olena Sergienko, Maryna Mashchenko, Natalia Gavkalova, Natalia Chernova

**Anotacija.** Kognityvinis švietimo migracijos reguliavimo modelis konstruojamas remiantis grafine-struktūrine sistemos elementų priežastinių ryšių schema. Autorių pateiktas modelis, priešingai nei iki tol sukurti modeliai, sujungia veiksnius atsižvelgdamas į jų sąveiką, išvykimo galimybes, užsieniečių išsilavinimo sąlygas, kurios subalansuotai lemia išsilavinimo migraciją, taip pat poveikį šaliai, regionui, universitetui ir individualiems migrantų lygiams.

Scenarijų rinkinio kūrimo pagrindas yra kognityvinis modelis. Scenarijų modeliavimas, siekiant norimų rezultatų, leidžia nustatyti galimus situacijos raidos variantus, būdus, situacijos įtakos mechanizmus, išvengti nepageidaujamų pasekmių, parengti priemonių kompleksą situacijai paveikti. Kiekvienas scenarijus apibūdinamas pradiniais duomenimis, valdymo įtaka, gautu rezultatu. Taigi, apsvarstomi visi galimi sistemos kūrimo variantai ir parenkama optimali valdymo strategija norimiems tikslams pasiekti.

Remiantis kognityviniu švietimo migracijos reguliavimo modeliu, gauti trys pagrindiniai raidos scenarijai (optimistinis, realistinis ir pesimistinis). Atsižvelgiant į šiuos scenarijus ir siekiant į Ukrainą pritraukti švietimo migrantus iš artimesnių ir tolimų užsienio šalių, galima suformuluoti metodines rekomendacijas dėl švietimo migracijos reguliavimo. Švietimo migracijos procesai turėtų skatinti socialinį, ekonominį, politinį ir demografinį šalies vystymąsi. Siūlomų švietimo migracijos reguliavimo priemonių įgyvendinimas palengvins šalies švietimo ir mokslo integraciją į pasaulinę sistemą, pagerins švietimo kokybę ir konkurencingumą tarptautinėse švietimo paslaugų rinkose, padidins pajamas ir kompensuos neigiamus Ukrainos demografinio nuosmukio padarinius.

Olena Sergienko – Doctor of Science in Economics, professor at the Department of Entrepreneurship, Trade, and Logistics at the National Technical University “Kharkiv Polytechnic Institute”, Kharkiv, Ukraine.

E-mail: serhelenka@gmail.com

Olena Sergienko – ekonomikos mokslų daktarė, Nacionalinio technikos universiteto Charkivo politechnikos instituto Verslumo, prekybos ir logistikos katedros profesorė, Charkivas, Ukraina.

E. paštas: serhelenka@gmail.com

Maryna Mashchenko – Doctor of Science in Economics, associate professor and head of the Department of Economic Theory and Economic Policy at Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine.

E-mail: mmashchenko@ukr.net

Maryna Mashchenko – ekonomikos mokslų daktarė, docentė, Simono Kuznetso Charkivo nacionalinio ekonomikos universiteto Ekonomikos teorijos ir ekonominės politikos katedros vedėja, Charkivas, Ukraina.

E. paštas: mmashchenko@ukr.net

Natalia Gavkalova – Doctor of Science in Economics, professor and head of the Department of Public Administration and Regional Economics at Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine.

E-mail: gavkalova@gmail.com

Natalia Gavkalova – ekonomikos mokslų daktarė, profesorė, Simono Kuznetso Charkivo nacionalinio ekonomikos universiteto Viešojo administravimo ir regioninės ekonomikos katedros vedėja, Charkivas, Ukraina.

E. paštas: gavkalova@gmail.com

Natalia Chernova – PhD, associate professor at the Department of Economic Cybernetics and System Analysis at Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine.

E-mail: natacherchum@gmail.com

Natalia Chernova – mokslų daktarė, Simono Kuznetso Charkivo nacionalinio ekonomikos universiteto Ekonominės kibernetikos ir sistemų analizės katedros docentė, Charkivas, Ukraina.

E. paštas: natacherchum@gmail.com

Yuliia Lola – Doctor of Science in Economics, associate professor at the Department of Public Administration and Regional Economics at Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine.

E-mail: yuliia.lola@hneu.net

Julija Lola – ekonomikos mokslų daktarė, Simono Kuznetso Charkivo nacionalinio ekonomikos universiteto Viešojo administravimo ir regionų ekonomikos katedros docentė, Charkivas, Ukraina.

E. paštas: yuliia.lola@hneu.net