**Barbara Šlibar*, Dijana Oreški**, Marina Klačmer Čalopa*****

# PUSH AND PULL FACTORS IN BRAIN DRAIN AMONG UNIVERSITY STUDENTS

Received: 25. 3. 2022.
Accepted: 1. 2. 2023.
DOI https://doi.org/10.30924/mjcmi.28.1.5

Original scientific paper
UDC 314.151.3-057.875



**ABSTRACT**

**The brain drain problem has been studied in the literature as an interaction between push factors in developing countries and pull factors in wealthy countries. It is essential to measure these factors to address the problem efficiently. This study aims to improve the process of prioritizing brain drain factors among Croatian students. The study was conducted among university students from all schools of the University of Zagreb and across seven scientific fields. This research combined two methods: the neural network analysis and the analytic hierarchy process (AHP). Neural network analysis is used to identify push and pull factors that most strongly influence students' potential decision to leave a country. The AHP is used to prioritize the most critical pull and push factors according to the results of the neural network analysis. The study results indicate that pull factors are more important than push factors for students in all fields of study, except in Arts. Developing countries should strive to adopt policies to create new employment opportunities, improve the quality of life, and create a favorable business climate.**

**KEYWORDS:** *brain drain, pull factors, push factors, Analytical Hierarchical Process, neural networks*

## 1. INTRODUCTION

With the advent of globalization, spatial mobility has become a crucial factor affecting national and global economies. Brain drain is a form of population migration that refers to the outflow of highly educated individuals (experts, scientists, and intellectuals) from a country (Šverko, 2005). This form of migration harms the society in which it takes place, as highly educated people can contribute to the development of their country and improve the standard of living and economic opportunities with their knowledge and work. According to previous analyses, the countries most affected by the emigration of highly educated experts, scientists, and intellectuals are classified as moderately developed countries and underdeveloped countries (Prpić, 1989).

According to the Global Competitiveness Index

* Barbara Šlibar, Department of Organization, University of Zagreb, Faculty of Organization and Informatics Varaždin, Pavlinska 2, 42 000 Varaždin, Croatia, E-mail: bslibar@foi.unizg.hr.

** Dijana Oreški, Department of Information Systems Development, University of Zagreb, Faculty of Organization and Informatics Varaždin, Pavlinska 2, 42 000 Varaždin, Croatia, E-mail: Dijana.Oreski@foi.unizg.hr

*** Marina Klačmer Čalopa (corresponding author), Department of Economics, University of Zagreb, Faculty of Organization and Informatics Varaždin, Pavlinska 2, 42 000 Varaždin, Croatia, E-mail: marina.klacmer@foi.unizg.hr

of the World Economic Forum, which rates national competitiveness based on productivity and prosperity, the Republic of Croatia is ranked 77th out of 140 countries. One of the criteria for calculating the index includes labor market efficiency, which is associated with the sub-criterion "country's capacity to retain talent," Croatia ranks poorly at 134th place (World Economic Forum, 2016). Although Croatia improved in the following four years, human capital remains its weakest point (World Economic Forum, 2019). The spatial distribution trend of the highly educated part of the population, i.e., brain drain, is a current issue. Its global dimensions are increasingly becoming a significant problem in Croatia. The authors of this paper aim to contribute to a better understanding of this trend by examining the factors that influence the decision of current students to go abroad. The paper aims to identify factors related to the brain drain among Croatian students to prevent it. A hybrid methodology of artificial neural networks (ANNs) and analytic hierarchical process (AHP) is used. The neural network is used as the variable selection technique. Relevant push and pull factors are determined by sensitivity analysis of the neural network. Then, the AHP is applied to determine the importance of the push and pull factors that influence the decision to go abroad or stay in the home country.



This paper is structured as follows. The second section reviews relevant research papers on the given topic. The following section explains the data and research methodology. The following section presents the research results with a discussion. Finally, the last section concludes the paper with guidelines for future research.

## 2. REVIEW OF PREVIOUS STUDIES

In this section, we briefly overview related studies. Šverko (2005) conducted a study at 13 constituent schools of the University of Zagreb to investigate students' intentions to go abroad. His sample included 553 respondents, and the factors serving as reasons for going abroad were classified into push and pull factors. According to the research results, students cited the following factors as the most crucial push factors due to which they would leave their country: *Higher salary and solving the housing problem*, *Education and specialization*, *Exploring the world*, *Finding employment*, *Progress and career development*, *Better living conditions*, and *Better prospects for the future*. Šverko's study served as the basis for the development of this study (Šverko, 2005). To obtain a large sample size, 1,323 students from the University of Zagreb were included in the study, proportionally distributed across fields of study, reflecting their actual proportion in each field.

A study conducted at the end of 1998 on young researchers' professional and social status showed that 63.3% of young researchers (under 35) considered going abroad for their work (Golub, 2003). In the study, the main reasons given for the respondents' decision to go abroad were: low salary, unresolved housing issues and generally low standard of living, better conditions for scientific work and creativity abroad, the unfavorable position of science and scientists in society, better prospects for progress and affirmation in the foreign scientific community, and generally unsatisfactory social, economic and political circumstances. Mlikota and Prelas Kovačević (2013) studied the intention to go abroad among the students of the Virovitica University College. In the study, conducted on a sample of 196 respondents, the main reasons given for going abroad were: *Higher salary and solving the housing problem* (15%), *Better living conditions* (14%), *Finding employment* (13%), *Better prospects for the future* (11%), while *Dissatisfaction with the country's leadership and conservatism* were mentioned as reasons by 5% of respondents. Most students surveyed (18%) said that *Family, parents, and girlfriend/boyfriend* were the reasons for staying, while 17% said they would stay in their country because of friends and social relationships. Students cited Germany, followed by Canada, Australia, and the US, as the most desirable destinations.

Kizito et al. (2015) studied final-year medical students' intentions to leave Uganda and the factors influencing their intentions. Data were collected in 2012/2013, and 251 medical students participated. Factors influencing students to remain in Uganda after graduation were listed in order of importance as follows: incentives in the form of government scholarships (41.7%), long emigration process (36%), high costs of living abroad (33.1%), lack of family support (29.5%), racism abroad (27.3%), and satisfaction with working conditions (12.2%). The following factors were in favor of going abroad: high salary abroad (75%), further education/specialization (58%), good working conditions (53.6%), and political stability (36.6%). Notwithstanding the need for health workers in Uganda, the study showed that many respondents planned to leave their profession or migrate out of Uganda after graduation. Kaliyati (2009) examined economic and non-economic factors influencing an individual's decision to stay in or leave New Zealand. Perceptions of New Zealand's employment policies were found to be the most influential factor, and the analyses show that men are significantly more affected by this factor than women. The second most influential factor was student debt. Kazlauskienė and Rinkevičius (2006) investigated the causes of brain drain in Lithuania by

analyzing the push and pull factors influencing migrations of the highly educated Lithuanian workforce. The study was conducted on a sample of 416 highly educated Lithuanians already living abroad, and the results of the Wilcoxon test showed that pull factors had a significantly more substantial impact on the trend of brain drain. Based on their study and research papers published over about 40 years, Docquier and Rapoport (2012) examined the brain drain phenomenon and explored the determinants of the decision to move abroad. They focused on three examples of the brain drain trend: doctors in Africa, scientists in Europe, and IT experts in India. The main reason cited by European scientists for leaving the respective country was the low level of investments in science in most European countries.

Ette and Witte (2021) analyzed the economic and non-economic factors driving emigration in Germany. The results suggest that expected financial returns, job satisfaction, social capital, mobility capital, and employment in specific occupations are the most critical drivers of emigration. Ndiangui (2021) examined the factors that influence the out-migration of university graduates. The research found that most university graduates emigrated not only because it was not easy to find competitive and well-paid jobs in the region but because they were unaware of the availability of these jobs. Khan (2021) synthesized qualitative literature over two decades (2000–2020) to identify the causes of academic brain drain in Europe. Five critical factors were identified: (1) attractive salaries outside Europe; (2) short-term fixed contracts for early career researchers; (3) unfair hiring practices; (4) attractive migration policies, and (5) the indirect role of internationalization policies in promoting permanent mobility. Efendić (2016) studied the emigration intentions of Bosnia and Herzegovina citizens, who have a similar environment and background as Croats. His results suggest a higher intention to emigrate among young, educated, and low-income respondents.

## 3. RESEARCH OBJECTIVES AND QUESTIONS

The main objectives of this research are to identify the factors influencing the decision to go abroad among students from all constituent schools at the University of Zagreb and their weighting, as well as to weight them and determine the difference in priorities of push and pull factors depending on the field of study. In addition, the terms "importance," "weight," and "priority" are used synonymously in this paper. Moreover, this paper answers the following research questions:

*RQ1: What are the most important (push and pull) factors that influence students to go abroad?*

*RQ2: Are pull factors more important than push factors for a potential brain drain of students from all scientific fields at the University of Zagreb?*

The research objective and questions were formulated based on the study conducted by Todisco et al. (2003), who concluded that push factors are characteristic of less educated emigrants, while pull factors significantly impact highly educated emigrants.

## 4. RESEARCH METHODOLOGY



The study uses two methods to address the proposed research questions: neural networks (to answer the RQ1) and the analytic hierarchical process (to answer the RQ2).

### 4.1. Neural networks

Artificial neural networks have been successfully used for research in the technical sciences for decades. Regression techniques have been widely used in organizational science to analyze statistical relationships (Landis & Dunlap, 2000). However, in recent years, neural networks have been gaining popularity in business and social sciences (e.g., Laguna & Marti, 2002). Artificial neural networks have outperformed regression in data analysis in several fields, including the social sciences (Garson, 1998). Using neural networks offers several advantages over regression analysis: they can handle nonlinear relationships, missing data, and outliers. In addition, ANNs do not require model specification in advance or an underlying distribution of the data (Detienne et al., 2003).

A neural network analysis is performed to identify push and pull factors that most strongly influence students' potential decision to leave university. The most commonly used neural network algorithm is the backpropagation algorithm, also employed by this study. Zekić-Sušac et al. (2009) indicate that the optimal neural network consists of input, output, and hidden layers. It has been empirically demonstrated that a hidden layer is sufficient to process data regardless of complexity (Refenes et al., 1994). Neural networks function in the following way. Data enters the network through the input layer and is passed to the hidden layer. Neurons hidden in this layer receive weighted inputs and pass them to the output layer using the transfer function. The input and output sums must be calculated for each neuron (processing unit) as the information is transmitted through the network. In the output layer, an error is computed for each neuron,

which is used to increase or decrease the weighting of the connections between the neurons.

### 4.2. Analytical Hierarchical Process

The Analytic Hierarchical Process is one of the most widely used methods for multicriteria decision-making, developed by Thomas L. Saaty in the late 1970s (Daft, 1992). The hierarchical model for complex decision-making problems used in the AHP method is very similar to how people intuitively analyze complex problems and represents one of the factors contributing to the popularity of the AHP method (Sikavica et al., 2014). The AHP can be used to create a hierarchy of problems that can be used to plan decision-making scenarios. A pairwise comparison of the hierarchy elements in a top-down direction follows the described analysis. After that, it is necessary to synthesize all the comparisons and determine the weighting coefficients of all the elements in the hierarchy using an appropriate mathematical model. The sum of the weighting coefficients of the elements at each level of the hierarchy is equal to one, which thus allows the decision maker to rank all the elements of the hierarchy (in order of importance) (Begičević, 2008).



The AHP method enables sensitivity analysis, simulating the importance of criteria (sub-criteria) and observing the changes in the ranking of alternatives. This method allows the decision-maker to observe how the changes in the input affect the output data. When using the AHP method, checking the consistency of the decision maker's judgments is very important (Sikavica et al., 2014). Consistency is checked both when performing the pairwise comparison and during the process, until the final results are obtained, confirming the validity of the weights. A critical component of the AHP method is a mathematical model. It is used to calculate the priorities for each element. For pairwise comparison of elements at the same level of the hierarchical structure, decision-makers use subjective judgments. The number of comparisons is proportional to the squared number of compared elements (Begičević, 2008). The process is repeated until all alternatives have been compared at the lowest level, *n,* with the higher-level sub-criteria at the penultimate (*n*-1) level. The final values of the priorities concerning the desired goal are calculated using a mathematical model. To express the ratio of the importance of criteria that do not have unique and measurable attributes such as mass or weight, T. L. Saaty developed a scale for conducting such an assessment. It includes five levels and four intermediate values (Blenko et al., 2010).

The process of solving the decision problem using the AHP method is conducted as follows (Dawson, 1996):

- First, a hierarchical model for the decision-making problem is created, with goals at the top and alternatives at the bottom. Criteria and sub-criteria are listed at intermediate levels between the level of goals and the level of alternatives.
- (ii) The elements of the hierarchical structure are then compared pairwise at each level of the structure. The priorities the decision makers assign in their comparisons of the elements are expressed using Saaty's scale of relative importance.
- (iii) Based on the ratings of the relative importance of the elements at each level of the hierarchical structure, a mathematical model is used to calculate the weights (local priorities) of the criteria, sub-criteria, and alternatives, which are then synthesized into global priorities of the alternatives. Local priorities of an alternative are multiplied by the weight of each element at the next higher level and then summed up to get the overall priority of that alternative.
- A sensitivity analysis is conducted to determine how input data changes affect the alternatives' overall priorities.

### 4.3. Data description

The data used in the study were collected by an online survey sent to students from all 33 constituent schools of the University of Zagreb[****]. The privacy of the respondents was ensured during data collection. Their data are protected, and the analysis results are published only in aggregate form. The survey used for data collection is divided into three parts. The first part deals with students' socio-demographic characteristics. In contrast, the second and third parts ask the students to rate the importance of push and pull factors influencing their decision to go abroad on a scale from 1 to 5. Mejia et al. (1979) describe migra-

**** Faculty of Agriculture, Faculty of Architecture, Faculty of Education and Rehabilitation Sciences, Faculty of Economics and Business, Faculty of Electrical Engineering and Computing, Faculty of Chemical Engineering and Technology, Faculty of Organization and Informatics in Varaždin, Faculty of Political Science, Faculty of Transport and Traffic Sciences, Faculty of Mechanical Engineering and Naval Architecture, Faculty of Pharmacy and Biochemistry, Faculty of Humanities and Social Sciences, Faculty of Geodesy, Faculty of Geotechnical Engineering, Faculty of Civil Engineering, Faculty of Graphic Arts, Catholic Faculty of Theology, Faculty of Kinesiology, School of Medicine, Faculty of Law, Faculty of Food Technology and Biotechnology, Faculty of Science, Faculty of Mining, Geology and Petroleum Engineering, School of Dental Medicine, Faculty of Forestry, Faculty of Textile Technology, Faculty of Education, Faculty of Veterinary Medicine).

**TABLE 1.** THE PROPORTION OF STUDENTS IN EACH FIELD OF STUDY AT THE UNIVERSITY OF ZAGREB AND THE PROPORTION OF STUDENTS IN EACH FIELD OF STUDY IN THE SELECTED SAMPLE

| Field of study | Total number at the University (%) (Source: Divjak et al., 2014) | Sample (%) |
|---|---|---|
| Natural Sciences | 6.48 | 9.75 |
| Technical Sciences | 23.80 | 28.34 |
| Biomedicine and Health | 7.09 | 12.47 |
| Biotechnical Sciences | 5.55 | 7.86 |
| Social Sciences | 43.98 | 32.43 |
| Humanities | 11.52 | 7.11 |
| Academies of the Arts | 1.58 | 2.04 |



tion as the result of the interaction of several factors: political, economic, historical, cultural, and educational. The authors classify these factors as push or pull factors. Push factors operate in the country of origin, while pull factors are found in the destination country. The interaction of both sets of factors leads to migration. Push factors observed in this study include *Higher salary and solving the housing problem*, *Better living conditions*, *Finding employment*, *Better prospects for the future*, *Exploring the world*, *Progress, and career development*, *Better working conditions*, *Foreign language acquisition, Education and specialization*, *Dissatisfaction with the country's leadership and conservatism*. Pull factors include *Family, parents, girlfriend/boyfriend*, *Friends and social relationships*, *Love for the home country*, *Personal reasons*, *Solving the housing problem*, *High commuting and accommodation costs abroad*, *Relationships with colleagues and co-workers*, and *Cultural activities*.

The analysis of this study is based on a sample of 1,323 students. The students are evenly distributed across the fields of study: the proportion of students in each field in this sample is equal to that of students in each field at the University of Zagreb. Table 1 shows the actual proportion of students in each field of study at the University of Zagreb and the proportion of students in each field of study in the selected sample.

Since all variables, except the first six (scientific field at the University of Zagreb, year of study, respondent's gender, respondent's perception of their own socioeconomic status, preferred destination, assessment of the likelihood to goabroad), are factors that were ranked according to their importance on a Likert scale from 1 to 5 (see Table 2), only the values and distribution of likelihood to go of the first six variables are described more detail: Scientific field at the University of Zagreb – social sciences (32.43%), tech-

**TABLE 2.** Descriptive analysis of responses collected using Likert-type questions

| Variable | Mean | Median | Mode |
|---|---|---|---|
| Higher salary and solving the housing problem | 4.22 | 4 | 5 |
| Better living conditions | 4.28 | 5 | 5 |
| Finding employment | 4.35 | 5 | 5 |
| Better prospects for the future | 4.44 | 5 | 5 |
| Exploring the world | 4.03 | 4 | 5 |
| Progress and career development | 4.29 | 5 | 5 |
| Better working conditions | 4.29 | 5 | 5 |
| Foreign language acquisition | 3.93 | 4 | 5 |
| Education and specialization | 4.05 | 4 | 5 |
| Dissatisfaction with the country's leadership and conservatism | 3.88 | 4 | 5 |
| Family, parents, girlfriend/boyfriend | 4 | 4 | 5 |
| Friends and social relationships | 3.51 | 4 | 4 |
| Love for the home country | 2.51 | 2 | 1 |
| Personal reasons | 3.07 | 3 | 3 |
| Resolved housing issue | 3.15 | 3 | 3 |
| High commuting and housing costs abroad | 3 | 3 | 3 |
| Relationships with colleagues and co-workers | 2.82 | 3 | 3 |
| Cultural activities | 2.64 | 3 | 3 |

nical sciences (28.34%), biomedicine (12.47%), biotechnology (7.86%), natural sciences (9.75%), arts (2.04%), humanities (7.11%); Year of study – 1st year (20.41%), 2nd year (15.80%), 3rd year (23.81%), 4th year (18.21%), 5th year (20.64%), 6th year (1.13%); Respondent's gender – male (42.78%), female (57.22%); Respondent's perception of their own socioeconomic status – poor (4.40%), lower middle class (49.28%), upper middle class (44.50%), upper class (1.82%); Preferred destination – USA (9.65%), Canada (8.1%), Australia (9.57%), Germany (17.88%), France (3.29%), Italy (2.98%), Austria (8.08%), group including Sweden, the Netherlands, Norway, Finland (23.2%), Ireland (9.33%), Switzerland (7.92%); Rating the probability of going abroad – very low (8.87%), low (20.47%), medium (33.81%), high (27.52%), and very high (9.33%).



First, descriptive statistics of the collected data were made to become familiar with the data and identify the characteristics of the sample. First, an overview of the students' assessment of the likelihood of going abroad by their current year of study is presented. Figure 1 shows the assessment of the likelihood of students from all faculties at the University of Zagreb going abroad in relation to their current year of study. There are minor differences in the willingness to leave the country between students of different years of study. The figure shows the distribution of responses for each year of studies. Most students chose "medium" when assessing the likelihood of leaving their country. Thus, first-year and senior students intend to leave their country to the same extent. The sixth year of study is an exception, as only three faculties of the University offer six-year study programs: the School of Medicine, the Faculty of Veterinary Medicine, and the School of Dental Medicine (see Figure 1). Considering that there are no differences between academic years, the further analysis focused on students from all years of study, although previous studies focused mainly on the final academic years.

Figure 2 shows the distribution of students' ratings of their intention and willingness to leave the country concerning the field of study. Arts students express the most substantial willingness to leave the country (more than 25% of the respondents from the field of Arts expressed a strong desire to go abroad). In contrast, science students' willingness to go abroad is the lowest (more than 40% of students expressed a very weak or weak desire to leave the country). These results should be interpreted cautiously, as the proportion of these study programmes in the sample and the general population is small.

## 5. RESEARCH RESULTS

Of the original 18 push and pull factors, eight were selected by neural networks: four pull and four push factors that students considered most important. One of the drawbacks of the AHP method is the large number of necessary pairwise comparisons required for more complex problems (Belton, 1986; Salo & Hämäläinen, 1997; Sikavica et al., 2014). The complexity of the problem would increase if all the original pull and push factors were included. By using neural networks, i.e., selecting only the factors that students considered most important, the original problem was simplified. In ad-

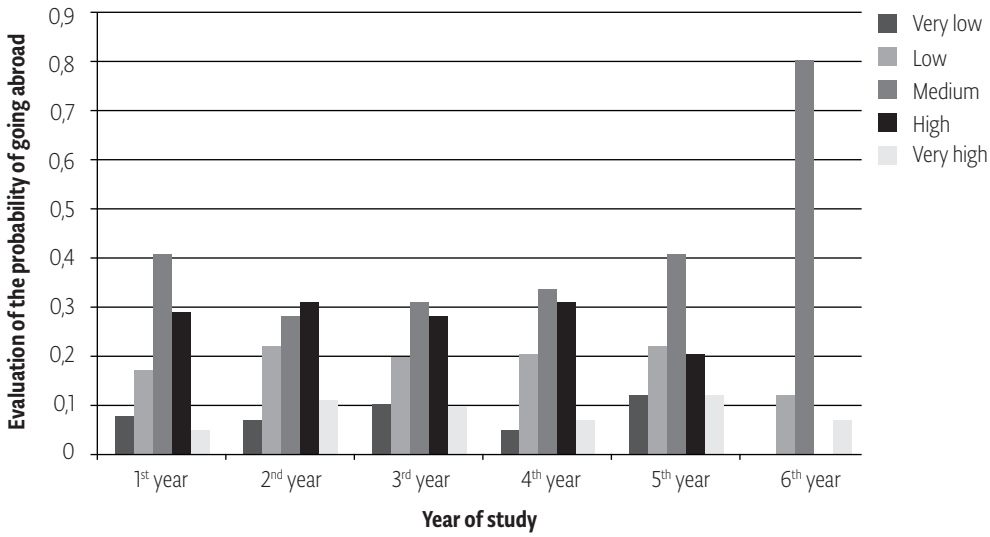


**FIGURE 1.** Evaluation of the probability of going abroad concerning the year of studies

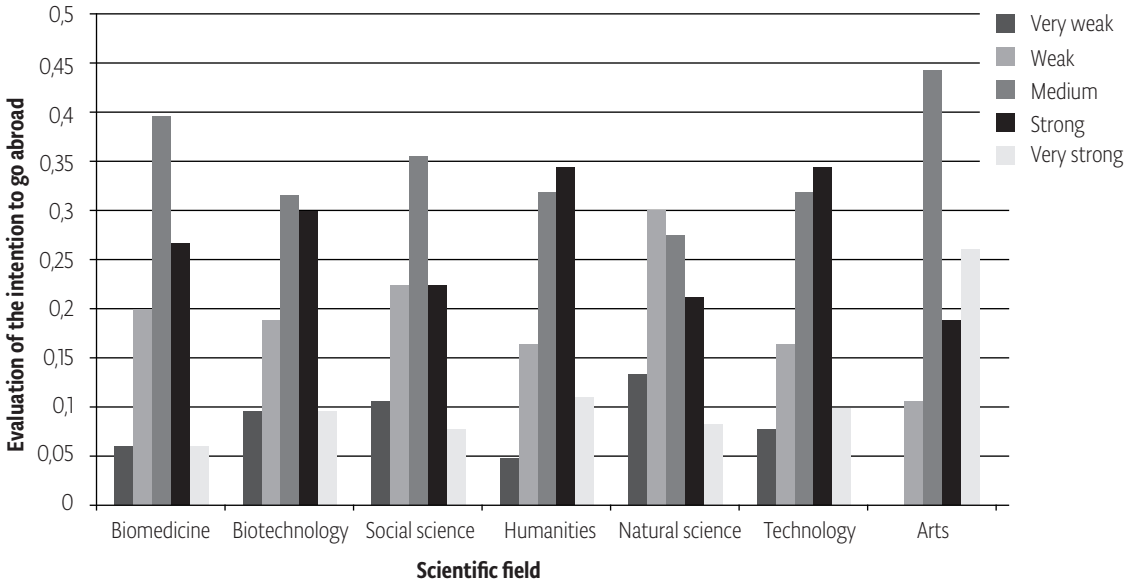


**FIGURE 2.** Evaluation of the intention to go abroad concerning the field of study

dition to selecting essential factors, neural networks were used to determine the degree of association between push and pull factors and students' intention to go abroad.

The neural network is constructed in three layers. The first layer, or input layer, consists of the neurons representing an independent variable. The last layer, the output layer, consists of neurons, each representing an output variable. Independent variables in the neural network model consisted of 23 variables: 18 push and pull factors variables and five socio-demographic variables. The dependent variable was the probability of going abroad. One layer was located between the input and output layers, called the hidden layer. Determining the number of nodes in the hidden layer is an important parameter to define. A more significant number of hidden neurons can lead to overfitting, whereas a small number can lead to underfitting. (Detienne et al., 2003). There is no test to determine the optimal number of nodes to put in a hidden layer, so the trial-and-error method is necessary (Detienne et al., 2003). The arithmetic mean of the input and output neurons is one approach to determining the number of hidden neurons. (Detienne et al., 2003). Thus, in our study, 12 hidden neurons were used, i.e., (23+1)/2. Then, the activation function hyperbolic tangent was applied.

Neural network modeling involves determining how specific input data affect output data. For this purpose, a sensitivity analysis was performed. Sensitivity analysis provides information on how much the output changes when the input changes for one. Moreover, sensitivity analysis contributes to the explainability of neural networks. Therefore, sensitivity analysis was performed on the neural network model with the aim of variable selection. From the total number of push factors, neutral networks filtered out the four most important ones, which were further analyzed: *Better living conditions*, *Finding employment*, *Better prospects for the future,* and *Dissatisfaction with the country's leadership and conservatism*.

The following pull factors were selected for further analysis: *Family, parents, girlfriend/boyfriend*, *Friends and social relationships*, *High commuting and accommodation costs abroad*, and *Love for the home country* (see Table 3).

### 5.1. Problem structuring

The ratio of the relative importance of push and pull factors was evaluated by surveying experts in each field of study. The experts were students selected according to the faculty who submitted the most responses in a given area and students in the year of study that provided the most extensive responses. (Topolko et al., 2012).

The following sections describe decision-making models for seven fields of study at the University of Zagreb (Biomedicine, Biotechnology, Social sciences, Humanities, Natural sciences, Technology, and Arts). Local priorities/importance/weightings of criteria were calculated using the Expert Choice software and

**TABLE 3. The main impact of the independent variables on the dependent variable, "Evaluation of the probability of going abroad"**

| *Main impact* | |
|---|---|
| 0.074 | Field |
| 0.029 | Preferred country |
| 0.022 | Perception of socioeconomic status |
| 0.004 | Year of studies |
| 0.012 | Family |
| 0.004 | Better prospects |
| 0.005 | Finding employment |
| 0.009 | Better living conditions |
| 0.001 | Higher salary |
| 0.003 | Exploring the world |
| 0.011 | Friends |
| 0.003 | Foreign language acquisition |
| 0.004 | Conservativism |
| 0 | Resolved housing issue |
| 0.003 | Low for the home country |
| 0.001 | Relationships with colleagues |
| 0.002 | Personal reasons |
| 0.008 | High commuting costs |
| 0.002 | Education and specialization |
| 0.006 | Gender of respondent |
| 0.001 | Cultural activities |
| 0.001 | Progress |
| 0.003 | Better working conditions |



the Microsoft Excel 2010 software. A complete calculation process is provided for a single field, i.e., Biomedical Sciences. As for other fields, only the results are presented and discussed in the paper.

### 5.2. Comparison of the Priority Values of the factors concerning the scientific field

Following Chen's (2006) study, this study compared pull and push factors according to their local and global weight. The local weight (priority) is obtained from the evaluation concerning a single criterion, i.e., the weight of sub-criteria obtained by pairwise comparison. In contrast, the global weight (priority) is obtained from multiplication by the weight of criteria, i.e., the weight of sub-criteria obtained by multiplying the weight of sub-criteria with the weight of the criteria (Chen, 2006). In this paper, the local and global weights regarding students' fields of study are further discussed.

Based on the evaluations of the experts in the field of Biomedicine, it is concluded that pull factors are more important than push factors. In the case of local ranking, the most critical factors include *Better living conditions* from the group of push factors and *Family, parents, girlfriend/boyfriend* from the pull factors group. The least important factors in the local rankings include *Love for the home country* and *Dissatisfaction with the country's leadership and conservatism*. In the global rankings, the most critical factors include *Family, parents, girlfriend/boyfriend, Friends and social relationships*. The lowest priority was assigned to *Dissatisfaction with the country's leadership and conservatism* and *Love for the home country*.

5.3. Development of the Hierarchical Model and pairwise comparisons

The process of determining local priorities (weights) of pull and push factors is presented for Biomedicine. The AHP method decomposes the decision-making problem into a hierarchical model. The hierarchical model is identical for all scientific fields and consists of the objective (determination of local priorities/weights of pull and push factors), the criteria (two groups of factors), and the sub-criteria (eight individual criteria - four from each group of criteria) (see Figure 3).

After developing the hierarchical model using the AHP method, the next step was to perform a pairwise comparison. First, the sub-criteria were compared concerning their parent criterion, and then the criteria were compared regarding the desired goal. For each scientific field, three pairwise comparisons were performed by selected experts.

First, the expert evaluated the ratio of the relative importance of the sub-criteria concerning the push factors criterion, which calculated the local weights of the sub-criteria within the push factors group (Table 4). Then, the ratio of the relative importance of the sub-criteria concerning the pull factors criterion was assessed (Table 4). Thus, the local weights of the sub-criteria within the group of pull factors were calculated. Finally, the expert compared pairwise criteria groups, i.e., whether pull or push factors are generally more critical (see Table 4). The comparison was conducted with the Expert Choice software, using Saaty's 1–9 scale.

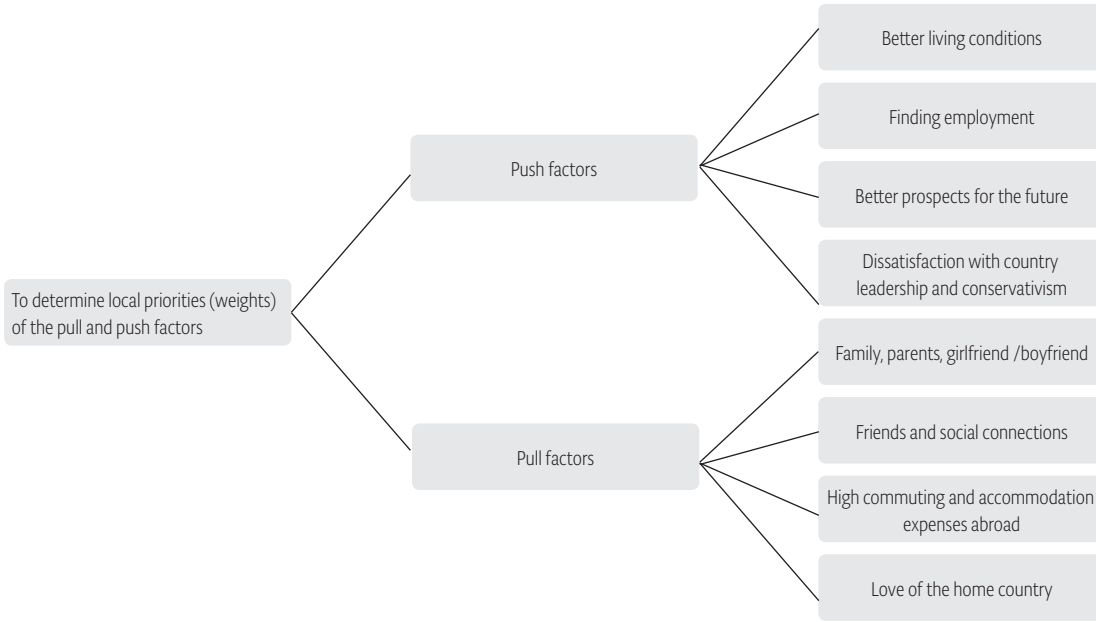


**FIGURE 3.** The hierarchical model applied to all scientific FIELDS



**TABLE 4.** Pairwise comparisons for the field of Biomedicine

| ***Pairwise comparison of sub-criteria concerning the Push factors criterion*** | Better living conditions | Finding employment | Better prospects for the future | Dissatisfaction with the country's leadership and conservatism |
|---|---|---|---|---|
| Better living conditions | | 5 | 2 | 7 |
| Finding employment | | | 4 | 5 |
| Better prospects for the future | | | | 9 |
| Dissatisfaction with the country's leadership and conservatism | | | | |
| ***Pairwise comparison of sub-criteria concerning the Pull factors criterion*** | Family, parents, girlfriend/ boyfriend | Friends and social relationships | High commuting and accommodation expenses abroad | Love for the home country |
| Family, parents, girlfriend/boyfriend | | 1 | 9 | 9 |
| Friends and social relationships | | | 7 | 9 |
| High commuting and accommodation costs abroad | | | | 4 |
| Love for the home country | | | | |
| ***Pairwise comparison of criteria regarding the goal*** | Push factors | Pull factors | | |
| Push factors | | 3 | | |
| Pull factors | | | | |

Verification that experts were consistent in their assessments is done by calculating the consistency ratio (CR) for all pairwise comparisons. Estimates are acceptably consistent if the person giving them is up to 10% inconsistent (Sikavica et al., 2014). Since the consistency ratios for all pairwise comparisons of the experts were below 10%, no corrections were necessary (see Table 5).

**TABLE 5.** Consistency ratio (CR) values of expert judgment in all scientific fields

| | Biomedicine | Biotechnology | Social sciences | Humanities | Natural sciences | Technology | Arts |
|---|---|---|---|---|---|---|---|
| CR of pairwise comparison of sub-criteria concerning the Push factors criterion | 0.08 | 0.07 | 0.08 | 0.09 | 0.09 | 0.06 | 0.02 |
| CR of pairwise comparison of sub-criteria concerning the Pull factors criterion | 0.08 | 0.08 | 0.08 | 0.04 | 0.08 | 0.09 | 0.07 |
| CR of pairwise comparison of criteria regarding the goal | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |



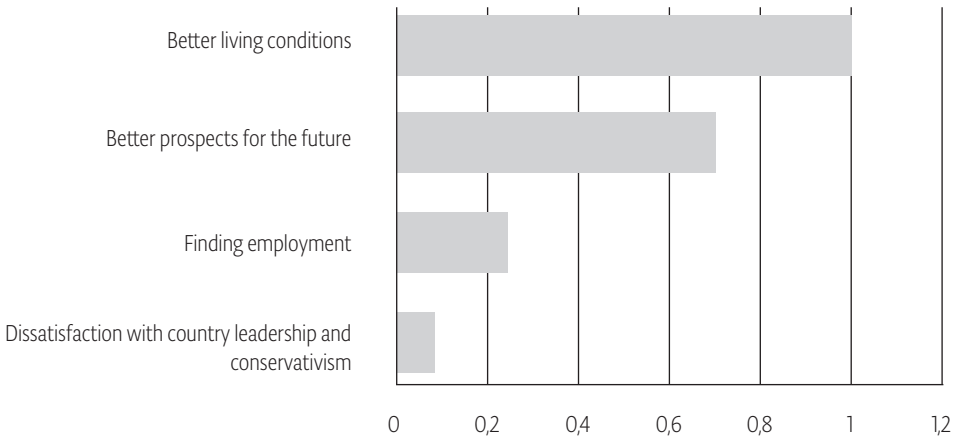


**FIGURE 4.** Comparison of the sub-criteria of the push factors criterion for the field of Biomedicine

The local weights of the sub-criteria within the push factors group for the field of Biomedicine were calculated based on the pairwise comparison of the sub-criteria concerning the push factors criterion done by experts from the field of Biomedicine. Comparing the sub-criteria of the push factors criterion reveals that the most critical sub-criterion is *Better living conditions*. The sub-criterion, *Better prospects for the future,* is in second place, followed by the sub-criteria, *Finding employment* and *Dissatisfaction with the country's leadership and conservatism,* as seen in Figure 4.

Experts in the field of Natural sciences have expressed the same attitude as experts in the field of Biomedicine, indicating that pull factors are more important than push factors. According to the local ranking (Figure 5), the most critical factors include *Better living conditions* in the push factors group and *Family, parents, girlfriend/boyfriend* in the pull factors group. The least important factors in the local rankings for the field of Biomedicine include *Love for the home country* and *Dissatisfaction with the country's leadership and conservatism*. The local rankings suggest that the most and least important factors are identical for the Biomedicine and Natural sciences fields. Similarly, according to the global rankings, the most important factors in the field of Natural sciences are also found in the field of Biomedicine. The factors with the lowest global priority (Figure 6) for the field of Natural sciences are similarly *Dissatisfaction with the country's leadership and conservatism* and *Finding employment*.

An analysis of the experts' ratings for the field of Biotechnology suggests that pull factors are more im-

portant than push factors. According to the local ranking (Figure 5), the following factors have the highest priority: *Family, parents, girlfriend/boyfriend,* and *Finding employment*, and the factors with the lowest priority include *High commuting and housing costs abroad* and *Love for the home country*. Based on the global rankings, the most critical factors are identical for all the fields observed so far. The factors with the lowest global priority for Biotechnology include *Better prospects for the future* and *Dissatisfaction with the country's leadership and conservatism*.

In the field of Social sciences, as in all the scientific fields examined so far, pull factors are more important than push factors. As in the case of Biomedicine, the highest priority factors according to the local rankings are: *Family, parents, girlfriend/boyfriend,* and *Finding employment*. The lowest priority factors in the local rankings include *Better living conditions* and *Love for the home country*. Based on the global rankings, the most critical factors are identical for all the fields observed so far. Among the global rankings, factors with the lowest priority are *Better living conditions* and *Better prospects for the future*.

Based on the assessments of the experts in the field of Humanities and the local weighting of the criteria, pull factors are more important than push factors. Based on local rankings, the most critical factors include *Friends and social relationships* from the pull factors group and *Better prospects for the future* from the push factors group. The least important factors in the local rankings include *Finding employment* and *Love for the home country*. In the global rankings (Figure 6), the ranking of the most important factors has changed, with *Family, parents, girlfriend/boyfriend* being ranked second, while *Friends and social relationships* ranked first. The lowest priority in the global rankings is assigned to *Finding employment* and *Better living conditions*.

An analysis of the ratings of experts in the field of Technology shows that pull factors are more important than push factors. According to the local ranking, factors with the highest priority include *Family, parents, girlfriend/boyfriend,* and *Better prospects for the future*. In contrast, factors with the lowest priority include *High commuting and accommodation costs abroad* and *Better living conditions*. It is noticeable that the essential factors in the global rankings are identical in all scientific fields except for the Humanities. The factors with the lowest global priority in Biotechnology include *Better living conditions* and *Dissatisfaction with the country's leadership and conservatism*.

From the evaluations provided by the experts in the field of Arts, it appears that the push factors are more important than the pull factors based on their local weighting. Only in the Arts field are push factors more important than pull factors. Based on local rankings (Figure 5), the most critical factors include *Family, parents, girlfriend/boyfriend*, and *Better living conditions*. The least important factors in the local rankings include *Love for the home country* and *Dissatisfaction with the country's leadership and conservatism*. In the global rankings (Figure 6), the ranking of the most important factors has changed, with factors *Better living conditions* and *Finding employment* hav-



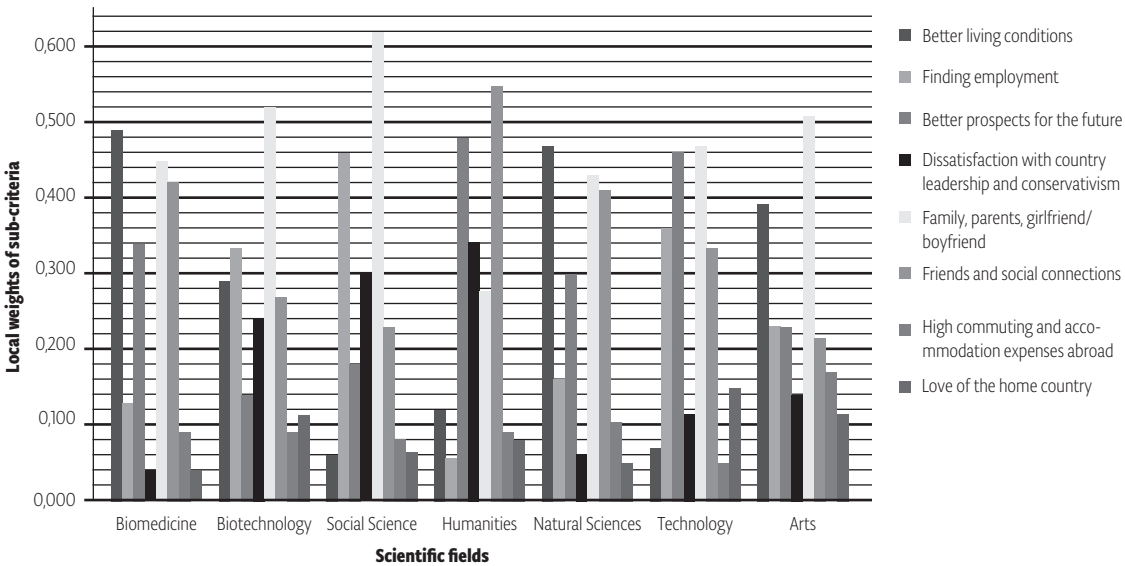


**FIGURE 5.** Local weights of pull and push factors

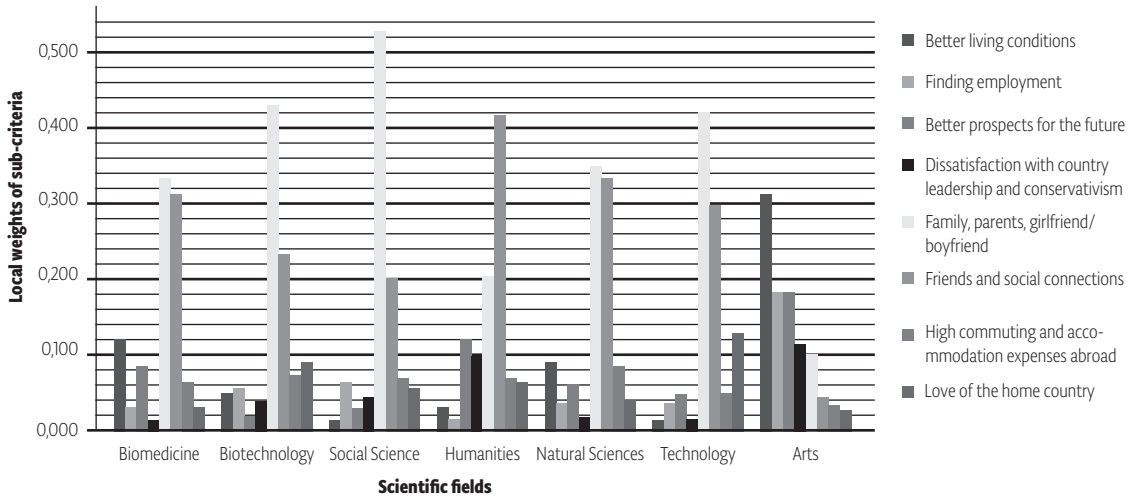




**FIGURE 6.** Global weights of pull and push factors

ing the most significant weight in this scientific field. The lowest priority in the global ranking is *Love for the home country* and *High commuting and accommodation costs* abroad.

The results of the AHP modeling reveal that the pull factors are more important than the push factors in influencing potential brain drain in all scientific fields at the University of Zagreb, except for the field of Arts.

Figure 5 shows the local weights of the push and pull factors for all scientific fields to which the respondents' study programs belong. The pull factor *Family, parents, girlfriend/boyfriend* ranks first in four out of seven scientific fields at the University of Zagreb, second out of 7 fields, and fourth in only one scientific field. The factor with the lowest local priority in all fields is the push factor, *Love for the home country*. The rankings of the other pull and push factors vary from field to field.

Figure 6 shows the global weights of the push and pull factors concerning the scientific field to which the respondents' study programs belong. The figure suggests significant differences in the level of priority assigned to the factors compared to their local weights. It is important to note that the weight of the group to which a particular factor belongs is also considered when calculating the factors' overall weight (priority).

It is noticeable that the priority of the factors from the pull factors group increased significantly when the local weights of the pull and push factors groups were taken into account, meaning that the respondents consider pull factors more important. The pull factor *Family, parents, girlfriend/boyfriend* still has the highest priority (it ranks first in 5 out of 7 scientific fields at the University of Zagreb, second in 1 out of 7 scientific fields, and fourth in 1 out of 7 scientific fields). The factor with the lowest local priority across all fields is no longer the push factor *Love for the home country*. The factors with the lowest local priority belong to the push factors group, for example, *Better living conditions*, *Finding employment*, *Better prospects for the future*, and *Dissatisfaction with the country's leadership and conservatism*.

## 6. DISCUSSION AND CONCLUSION

A number of factors contribute to the migration of the highly educated. The results of this study indicate that brain drain will continue to increase among students from the University of Zagreb. Consequently, the question remains as to how the brain drain will affect our society, especially from an economic perspective, and what its equally important social, i.e., the demographic impact, will remain an open question. A comparison with previous studies leads to the following conclusions. According to the literature review, this is the most extensive study conducted in Croatia. It included 1,323 students from the University of Zagreb (the proportion of students in each field in this sample is equal to that of students in each field at the University of Zagreb). Although the overall probability of leaving the country is approximately the same as in Šverko's (2005) study, the respondents in our study indicated a high probability of leaving the country, while in Šverko's (2005) study, the highest proportion of respondents indicated a low probability of leaving the country. Therefore, the intention of the highly educated to leave the country has become more robust.

The main push factors in Šverko's (2005) study

were a higher salary and solving the housing problem, education, and specialization, exploring the world, and finding employment, while in Golub's (2003) study, they included a low salary, an unresolved housing issue and a generally low standard of living, better working conditions abroad, better prospects for progress and affirmation in the foreign scientific community, generally unsatisfactory social, economic and political circumstances, family reasons and a desire to change the way of life. In the 2013 study, Mlikota and Prelas Kovačević found that a higher salary, solving the housing problem, finding employment, better prospects for the future, dissatisfaction with the country's leadership and conservatism were the most significant push factors, while they considered family, friends, and love for the home country the most significant pull factors (Mlikota & Prelas Kovačević, 2013). In addition, a study conducted by Kizito et al. (2015) identified a higher salary abroad, further education, good working conditions, and political stability as the most significant reasons for leaving the country, while incentives in the form of government scholarships, a long emigration process, high costs of living abroad, and a lack of family support as reasons for staying. The results can be interpreted in the context of this study, as the family is the most critical factor among students in all fields, except for the Humanities, where friends and social relationships are the most critical factors.

Contemporary international migrations indicate a movement of the highly educated workforce (Castles, 2016). In some countries, such as Croatia, migrations may intensify the problem of brain drain. The analysis of push and pull factors in this study leads to the conclusion that pull factors have a greater weight in the migration of the highly educated workforce.

Implementing effective policies to address brain drain entails understanding the factors driving migration flows. Therefore, the findings of this study can potentially be helpful at the institutional and national levels. It is not enough to identify the causes of brain drain; effective solutions to the problem must also be identified. Applying these findings to the national level could be of interest to competent authorities so they can take timely action and respond to the brain drain. Like other developing countries, Croatia is seeking policy measures to stop the brain drain, not only by creating new jobs but also by improving the quality of life and creating a favorable business climate.

From the viewpoint of the country of origin, brain drain has negative consequences since the educated workforce leaves and the efforts invested in their education are lost. However, the phenomenon also has certain benefits: financial and non-financial flows from the country of origin to the destination country. More extensive economic indicators are needed to draw concrete conclusions about brain drain's benefits and negative consequences. The results of this study can be used to guide the development of evidence-based policy, and they can be combined with studies that collect and analyze economic data.

## REFERENCES


1. Belton, V. (1986). A comparison of the analytic hierarchy process and a simple multi-attribute value function. *The European Journal of Operational Research*, 26(1), 7-21.
2. Begičević, N. (2008). *Multicriteria decision making models for strategic planning of e-learning implementation*. Ph.D. Thesis. Faculty of Organisation and Informatics, University of Zagreb.
3. Blenko, M., Mankins, M.C., & Rogers, P. (2010). *Decide and Deliver: Five Steps to Breakthrough Performance in Your Organization*. Boston, Mass: Harvard Business Review Press.
4. Castles, S. (2016). Understanding global migration: A social transformation perspective. In *An anthology of migration and social transformation* (pp. 19-41). Springer, Cham.
5. Chen, C.-F. (2006). Applying the Analytical Hierarchy Process (AHP) Approach to Convention Site Selection. *Journal of Travel Research,* 45(2). 167–174. DOI: 10.1177/0047287506291593.
6. Daft, R.L. (1992). *Organization Theory and Design*. West Publishing Company.
7. Dawson, S. (1996). *Analysing Organisations*. Macmillan International Higher Education.
8. Detienne, K. B., Detienne, D. H., & Joshi, S. A. (2003). Neural networks as statistical tools for business researchers. *Organizational Research Methods*, 6(2), 236-265.
9. Divjak, B., Ivanda, Ž., & Pavlek, I. (2014). *Izvješće o radu Sveučilišta u Zagrebu u akademskoj godini 2011./2012.* Zagreb: Sveučilišna tiskara d.o.o. Available at: http://www.unizg.hr/fileadmin/rektorat/O_Sveucilistu/Tijela_sluzbe/Rektorat/Izvjesca_uprave/Izvjesce_uprave_11.-12..pdf.
10. Docquier, F., & Rapoport, H. (2012). Globalization, Brain Drain, and Development. *Journal of Economic Literature,* 50(3), 681–730. DOI: 10.1257/jel.50.3.681.
11. Efendic, A. (2016). Emigration intentions in a post-conflict environment: evidence from Bosnia and Herzegovina. *Post-Communist Economies*, 28(3), 335-352.
12. Ette, A., & Witte, N. (2021). Brain drain or brain circulation? Economic and non-economic factors driving the international migration of German citizens. In *The Global Lives of German Migrants* (pp. 65-83). Springer, Cham.
13. Garson, G. D. (1998). *Neural networks: An introductory guide for social scientists*. London: Sage.
14. Golub, B. (2003). Zašto odlazimo? (Why Are We Leaving?) *Društvena istraživanja : časopis za opća društvena pitanja (Journal for General Social Issues),* 12(1-2 (63-64)), 115–140.
15. Kaliyati, W.Q. (2009). *Staying or leaving New Zealand after you graduate?–reflecting on brain drain and brain circulation issues facing graduates*. PhD Thesis. Lincoln University.
16. Kazlauskienė, A., & Rinkevičius, L. (2006). Lithuanian "brain drain" causes: Push and pull factors. *Engineering economics,* 46(1), 27–37.
17. Khan, J. (2021). European academic brain drain: A meta-synthesis. *European Journal of Education*, 56(2), 265-278.
18. Kizito, S., Mukunya, D., Nakitende, J., et al. (2015). Career intentions of final year medical students in Uganda after graduating: the burden of brain drain. *BMC Medical Education* 15(1), 122. DOI: 10.1186/s12909-015-0396-0.
19. Laguna, M., & Marti, M. (2002). Neural network prediction in a system for optimizing simulations. *IIE Transactions*, 34:3, 273-282.
20. Landis, R. S., & Dunlap, W. P. (2000). Moderated multiple regression tests are criterion specific.
21. *Organizational Research Methods*, 3(3), 254-266.
22. Mejia, A., Pizurki, H., Royston, E., et al. (1979). Physician and Nurse Migration: Analysis and Policy Implications, Report on a WHO Study. *World Health Organization*. Available at: https://apps.who.int/iris/handle/10665/37260 (accessed December 22, 2020).
23. Mlikota, D., & Prelas Kovačević, A. (2013). Veličina potencijalnog „odljeva mozgova "studenata Visoke škole za menadžment u turizmu i informatici u Virovitici. *Praktični menadžment: stručni* časopis *za teoriju i praksu menadžmenta,* 4(2), 32-42.
24. Ndiangui, P. (2021). From brain drain to brain gain: the battle against talent drain. *Journal of Culture and Values in Education*, 4(1), 34-48.
25. Prpić, K. (1989). *Odliv mozgova: tok i* činioci *vanjskih migracija znanstvenika*. IDIS, Zagreb.
26. Refenes, A.N., Zapranis, A., & Francis, G. (1994). Stock performance modeling using neural networks: a comparative study with regression models. *Neural networks,* 7(2), 375–388.
27. Salo, A. A., & Hämäläinen, R. P. (1997). On the measurement of preferences in the analytic hierarchy process. *Journal of Multi-Criteria Decision Analysis*, 6(6), 309-319
28. Sikavica, P., Hunjak, T., Begičević Ređep, N., et al. (2014). *Poslovno odlučivanje*. Zagreb: Školska knjiga.
29. Šverko, I. (2005). Studentske namjere odlaska u inozemstvo: veličina potencijalnog 'odljeva mozgova' i njegove odrednice u 1995., 1997. i 2004. godini (Students' Intentions to Leave Croatia: The Extent of Potential "Brain Drain" and Its Determinants in 1995, 1997 and 2004). *Društve-*

*na istraživanja : časopis za opća društvena pitanja (Journal for General Social Issues)*, 14 (6 (80)), 1149–1174.

30. Todisco, E., Brandi, M.C., & Tattolo, G. (2003). *Skilled migration: a theoretical framework and the case of foreign researchers in Italy*. Department of Languages, Flinders University. Available at: https://dspace.flinders.edu.au/xmlui/handle/2328/175 (accessed December 22, 2020).
31. Topolko, K., Oreški, D., & Horvat, J. (2012). Multicriteria Modeling of Postgraduate Students Bank Selection. *Proceedings of the 23rd Central European Conference on Information and Intelligent Systems*: 219.
32. World Economic Forum (2016). *The Global Competitiveness Report 2015 - 2016*. Available at: http://wef.ch/1KCKoGw (accessed December 22, 2020).
33. World Economic Forum (2019). *The Global Competitiveness Report 2019*. Available at: https://www.weforum.org/reports/how-to-end-a-decade-of-lost-productivity-growth/ (accessed October 25, 2021).
34. Zekić-Sušac, M., Frajman-Jakšić, A., & Drvenkar, N. (2009). Neuronske mreže i stabla odlučivanja za predviđanje uspješnosti studiranja. (Neuron Networks and Trees of Decision-making for Prediction of Eficiency in Studies). *Ekonomski vjesnik : Review of Contemporary Entrepreneurship, Business, and Economic Issues*, XXII(2), 314–327.

# ČIMBENICI PRIVLAČENJA I PRIVLAČENJA ZA STUDENTSKI "ODLJEV MOZGOVA"

**SAŽETAK**

**Problem „odljeva mozgova“ u znanstvenoj se literaturi proučava u okvirima interakcije između čimbenika odvraćanja u okruženju zemalja u razvoju i privlačnih faktora bogatih zemalja. Mjerenje tih čimbenika važno je u svrhu efikasnog rješavanja navedenog problema. Ovo istraživanje nastoji poboljšati proces postavljanja čimbenika „odljeva mozgova“ među hrvatskim studentima. U istraživanju su sudjelovali studenti sa svih sastavnica Sveučilišta u Zagrebu, raspoređeni u sedam znanstvenih područja. Istraživanje je provedeno kombiniranjem dviju metoda: neuronskih mreža i analitičkog hijerarhijskog procesa (AHP). Analiza neuronske mreže korištena je za identifikaciju čimbenika odvraćanja i privlačenja, koji najviše utječu na potencijalnu odluku studenata da napuste zemlju. Metoda AHP korištena je za određivanje prioriteta najvažnijih čimbenika odvraćanja i privlačenja, a prema prethodnim rezultatima analize neuronske mreže. Rezultati istraživanja pokazuju da su čimbenici privlačenja važniji za studente od čimbenika odvraćanja u svim područjima studiranja, osim u umjetničkom. Zemlje u razvoju trebale bi nastojati kreirati politike usmjerene prema otvaranju novih radnih mjesta, ali i poboljšati kvalitetu života te stvoriti pozitivnu gospodarsku klimu u zemlji.**

**KLJUČNE RIJEČI:** *odljev mozgova, čimbenici odvraćanja, čimbenici privlačenja, analitički hijerarhijski proces, neuronske mreže*