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Brain gain and country's resilience: A dependency analysis exemplified by OECD countries

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Abstract

Research background: In the light of growing demand for highly skilled workers, driven by rapid changes in the labour market and business environment, the ability to attract the talented determines not only business performance, but also macroeconomic development prospects. This stimulates national governments to create positive conditions for the development and use of the human capital of migrants. One of the most important factors of brain gain can

be country stability as a sign of a comfortable environment for the realisation of intellectual potential.

Purpose of the article: The study aims to investigate the links between the factors of country's resilience and brain gain, including its partial indicators.

Methods: For a comprehensive assessment, migration indicators were used by categories of talented migrants: highly educated workers, foreign entrepreneurs, university students and start-up founders that we integrated into an integral index of intellectual migration. The data was collected for OECD countries for 2023. The authors used the methods of statistical and correlation-regression analysis, economic-mathematical modelling in the GRETL software environment.

Findings & value added: Research has shown that the components of country's resilience (especially Economic resilience and Supply chain) have a positive effect on brain gain. Considering the partial indicators of brain gain, it is found that resilience in the country of destination has the greatest influence on the migration decisions of highly educated workers and foreign entrepreneurs, i.e. migrants with a positive experience of economic activity and entrepreneurial capital, which, in turn, strengthens the resilience and competitiveness of countries. Such conclusions are important for the improvement of brain gain management programs in terms of the development of the environment for the attraction and retention of talents.

Introduction

The problem of the shortage of highly skilled workers is becoming more and more obvious in light of the rapid development of technology and the growing demand for knowledge. For example, according to the results of one of the latest studies, the World Economic Forum companies predicted that 35% of workers' skills would be disrupted in the following five years (WEF, 2023). However, according to the same report, skills gaps and the inability to attract talent are identified as key barriers to industry transformation, and overall talent is recognized as a greater limiting factor to productivity than capital availability.

Similar results in the global dimension are confirmed in another study: 77% of employers globally report difficulty finding the talent with the skills they need in 2022. This value is reaching a 17-year high (ManpowerGroup, 2022, p. 2).

The trends identified by experts in cooperation with employers confirm the urgency of the problem of the shortage of highly skilled workers, which has long been emphasized by scientists in research at both the micro- and macroeconomic levels. One of the sources of replenishment of the shortage of skilled labour is intellectual migration; therefore, the disproportions of demand and supply in the labour market are increasingly becoming the cause of a change in attitude towards talent migration, which is manifested

in the interest of employers in relevant political decisions. In the already mentioned report of the World Economic Forum, the following current position of employers is provided: "28 percent of businesses see changes to immigration laws on foreign talent as an effective tool available to governments seeking to connect talent to employment" (WEF, 2023, p. 7).

Intellectual migration as one of the cheapest sources of replenishing the shortage of skilled labour has long attracted the attention of scientists in this field. In particular, intellectual migration is analysed through such components as the migration of students, highly skilled workers (including scientists and researchers), entrepreneurs (Caviggioli *et al.,* 2020; Boucher, 2020; Chand & Tung, 2019; Gurău *et al.*, 2020; Sehoole & Jenny, 2020; Li *et al.*, 2023; Tan & Li, 2023; Bhardwaj & Sharma, 2023). This approach will be used in our research as well.

As for the results of intellectual migration, it is empirically proven that there are positive consequences for host communities and countries in the form of an increase in entrepreneurial activity at the expense of starting a business by migrant entrepreneurs (Dabić *et al*., 2020; Duan *et al*., 2021; Malerba & Ferreira, 2020; Malki *et al*., 2022), positive impact on the labour market and innovativeness of the economy (Alfano *et al*., 2022; Bloom *et al.,* 2019; Bongers *et al*., 2022; Kuzior *et al*., 2020; Ramakrishnan, 2021; Skare *et al.,* 2021), forming long-term positive economic prospects in the dynamics of economic development, strengthening the competitiveness of countries (Alshoubaki & Harris, 2021; Brieger & Gielnik, 2021; Khamidov, 2022; Laskiene *et al*., 2020). These and other positive consequences of the saturation of the labour market of the host countries with innovative, promising human capital are well-proven, which leads to corresponding changes in economic behaviour towards intellectual migrants, especially in developed countries.

Concomitantly, the numerous positive consequences of intellectual migration are still underutilized due to the insufficient development of research on the environment and the factors that attract such migrants. Explaining such reasons by the influence of the quality of life in the recipient country, including higher earnings, career prospects and other personal benefits, does not always objectively reflect migration motives. The studies of the living and working comfort (economic well-being of countries, developed social security systems, other components of well-being) in the context of its influence on migration intentions by Alvarez *et al.* (2021), d'Albis *et al.* (2019), Khalid and Urbański (2021), Gavurova *et al.* (2020) re-

veal a well-developed scientific direction, e.g. with regard to OECD countries. However, under the current conditions of increasing dangers in the habitat in many countries, the task of researching another dimension that can influence migration decisions, i.e. the resilience of countries, appears with new urgency. In our opinion, the Global Resilience Index as a special indicator developed for this purpose best reflects the resilience of countries. However, the connections between the country's resilience (inclusive its components) and intellectual migration are practically unexplored. At the same time, human capital is a crucial factor affecting the resilience of the country. The authors (Zhou & Qi, 2023) used migration big data to construct a population mobility matrix and provide an analysis of the mechanism of economic resilience from four different perspectives: innovation, industrial structure advancement, industrial structure rationalization, and economic development. Their findings suggest that human capital contributes to approximately 7% improvement in UER through innovation and economic development. The significant influence of human capital on the resilience of the country through the prism of technological and economic resilience is also proven by the example of 248 European Union regions (Cappelli *et al.*, 2021). Particularly, the results show that important interaction effects exist between technological resistance and human capital, technological resistance and the level of human capital are less effective in protecting female and elder adult workers.

In our opinion, such a gap needs to be filled, since the vulnerability of countries in terms of the functioning of economic systems, supply chains, systems of prevention and response to risks in their various manifestations, can be a significant determinant of the migration of highly skilled workers, entrepreneurs, students, i.e. all those who have higher for average intellectual potential and thus has higher possibilities of choosing the environment for its implementation. Filling such a gap is the purpose of our research.

Therefore, in order to study the relationship between intellectual migration and country's resilience, we use statistical data on the example of OECD countries for 2023. This group of countries was selected taking into account their high economic development and high barriers to realising the competitive potential of migrants (due to a higher share of highly educated workers in the labour market). The data analysis is performed using statistical approach for composite index calculations, correlation-regression analysis and economic-mathematical modelling in the GRETL software environment. This will enable to measure the impact of the resilience of the

living environment, business and work in the most objective way, because under such conditions, highly educated workers deciding on migration should consider possible risks for self-realisation.

The purpose of the article is to study the links between the factors of country's resilience and brain gain, including its partial indicators.

To achieve the goal of the research, we defined two research tasks (RT):

RT1: *to propose a methodology and define a comprehensive indicator for assessing the level of attractiveness of OECD countries for intellectual immigrants*;

RT2: *to evaluate the relationships between the attractiveness level of countries for intellectual immigrants and the components of country's resilience based on the values of the Global Resilience Index*.

The statistical basis of our research is the data on intellectual migration to OECD countries (OECD, 2023) and the resilience of countries, defined in the Global Resilience Index (FM Global, 2023).

The paper is organized as follows. The subsequent section provides a literature review considering intellectual migration, its components, consequences and connections with the components of the country's resilience. Section 3 describes the methodological basis of the authors' research. The data, empirical approach, and results of the empirical study conducted using the cases of OECD are elaborated in Section 4. Section 5 is Discussion. Lastly, concluding remarks as well as possibilities of practical implications can be found in Section 6.

Literature review

Under the conditions of economic globalisation and dynamic technological development, intellectual capital is becoming increasingly mobile. Talented professionals, researchers, entrepreneurs and students are seeking employment, research, business start-up and study opportunities abroad, making intellectual immigration an important topic for research. The issue of intellectual immigration is reflected in an increasing number of scientific works, the analysis of which allow determining the main categories of intellectual migrants (Caviggioli *et al*., 2020; Boucher, 2020; Chand & Tung, 2019; Gurău *et al*., 2020; Sehoole & Jenny, 2020): highly skilled workers

(incl. scientists and researchers), entrepreneurs (incl. developers and startup founders) and students. At the same time, scientists prove positive links between the immigration of highly skilled workers and the economic growth and competitiveness of the host country (Miguelez & Temgoua, 2020; Oliinyk *et al*., 2022; Khamidov, 2022; Laskiene *et al.,* 2020).

Highly skilled workers are an important asset for a country's economic growth, as they directly affect the production and dissemination of knowledge (Cramarenco *et al*., 2023). This is especially true for those with degrees and careers in science, technology, engineering, and mathematics (STEM) fields whose social and professional networks share important external knowledge (Miguelez & Temgoua, 2020).

Highly skilled migrants are today probably the only uncontroversial category of migrants in the political and social discourse, as they positively influence the development of the recipient country (Alshoubaki & Harris, 2021) and, at the same time, receive good wages, have high educational skills, and are easy to integrate into host society (Weinar & Klekowski von Koppenfels, 2020). At the same time, there are wage premiums for STEM workers compared to workers without higher education, and the magnitude of such a skill wage premium is higher in the destination country and increases with a positive technological change (Bongers *et al.,* 2022). The last decade has seen an increase in demand for highly skilled workers from territorial systems wishing to increase their competitiveness in the global economy. Thus, many European countries have developed a labour immigration policy based on qualifications, aimed at workers in the intellectual, scientific, technical and engineering sectors (Bolzani, 2021), which has a positive effect on the development of the knowledge-based economy (Oliinyk *et al*., 2021). In order to attract and retain such professionals, decisions are made to remove unnecessary barriers and improve conditions that will facilitate the adaptation of foreign talents in the local workplace, mastering a foreign language, ensuring sufficient income and equipment for research, and above all, comprehensive and coordinated services for foreigners (Fichtnerova *et al*., 2022).

Immigrant entrepreneurship has become a phenomenon of global interest (Dabić *et al.,* 2020; Sabary & Ključnikov, 2023a; 2023b). In this area, scientific research covers the following main directions: recognition of opportunities and business creation processes; adaptation and survival strategies; how ethnicity affects entrepreneurial strategies of immigrants; multicultural strategy and market exit strategies; internationalisation strategies and

transnational business; differences between immigrants and non-immigrants as entrepreneurs; governmental and support organisation policies (Malerba & Ferreira, 2020; Duan *et al*., 2021). Immigrants show a consistently high tendency to initiate self-employment in host countries. In the US, for example, high-skilled immigrants were found to be more likely to start new businesses than their native counterparts (Malki *et al*., 2022). At the same time, the main motives for such activity are personal experience, circumstances and values, business ideas and opportunities, purposefulness and self-efficacy, as well as the entrepreneurial ecosystem of immigrants (Duan & Sandhu, 2022). Immigrant entrepreneurship can offer host societies a win-win situation by generating income for immigrant entrepreneurs and facilitating knowledge transfer, innovation, and economic growth within the host economy (Brieger & Gielnik, 2021).

The increasing number of scientists also note the positive impact of intellectual immigration on the level of innovative development and innovative activity in the host country (Bloom *et al*., 2019; Kuzior *et al*., 2020; Bongers *et al*., 2022; Alfano *et al*., 2022; Skare *et al*., 2021; Eshetu *et al*., 2023). However, the power of influence differs in different economic sectors. It is stronger in industries with low levels of overeducation, high levels of FDIs and openness to trade, and in industries with greater ethnic diversity (Fassio *et al*., 2019). Ramakrishnan (2021) argues that immigration can stimulate innovation through the effect of population size and density, the effect of the share of migrants, the effect of skill composition and the effect of immigrant diversity.

Besides, the relationship between intellectual immigration and country resilience is not comprehensively researched, although resilience has been identified as a potential tool for solving crisis situations, especially after the start of large-scale refugee movements since 2015 (Paul & Roos, 2019). Scientists carry out research that concerns certain aspects of this issue. Thus, the article (Giannakis & Bruggeman, 2020) empirically investigates differences in regional economic sustainability and the driving forces of sustainability in the urban-rural hierarchy in the European Union. Multilevel logistic and multinomial regression models show that the resilience of NUTS-3 regions is strongly influenced by national borders; the largest effect is observed for rural areas. Concurrently, migration has the greatest positive impact on regional stability in the urban-rural hierarchy.

Under modern conditions, the resilience of the country emphasises the strengthening of the connection between humanitarian activities and eco-

nomic development, and intellectual immigration is considered an important tool for its provision for host countries (Anholt & Sinatti, 2020; Anderson *et al*., 2021; Hertel *et al.,* 2023).

The modern concept of resilience emphasises the ability of coupled socio-ecological systems to persist as they face upheaval and change, adapt to future challenges, and transform in ways that sustain the ability to function (Giannetti *et al.,* 2023; Umiński *et al.,* 2023). Resilience represents the country's adaptability, innovation, and sustainability (Lee *et al.,* 2023). A country's resilience determines its ability to withstand and adapt to a variety of threats, such as natural disasters, pandemics, economic hardship, cyberattacks, terrorist acts, etc. Scholars have supported the view that the degree of economic openness to the outside world, the type of industrial agglomeration, the behaviour of government control, and the level of technological innovation are important factors influencing the resilience of countries (Du *et al*., 2023). The resilience indicator system is composed of four dimensions: social resilience, economic resilience, infrastructure resilience, and ecological resilience (Shi *et al.,* 2023).

At the same time, population migration is one of the important factors that significantly affect the resilience of the country, particularly economic resilience (Chen *et al.,* 2023; Zapata-Barrero, 2023). Migration involves a significant life change as well as environmental changes and challenges (Qamar, 2023). The impact of migrant workers on the resilience of Gulf states is proven by drawing on two nationally representative surveys of Qatar's citizens and migrants (Ewers *et al*., 2023). Additionally, specifically highly skilled immigrants can generate positive externalities and, in some cases, can even drive long-term economic growth (Poledna *et al*., 2024), which will ensure resilience in the long term. Under crisis conditions and the conditions of a growing shortage of talent, the analysis of the relationship between intellectual immigration and the resilience of the country is an urgent scientific task, the solution of which our research is devoted to.

Research methods

For the implementation of ***RT1***, the authors selected indicators that allow comprehensive characterisation and quantitative assessment of intellectual immigration. The assessment was conducted on the example of OECD countries using the data from the 2023 report. These countries are increas-

ingly competing to attract and retain talented workers, in particular by adopting more favourable migration policies for the best and most talented migrants (OECD, 2023). The OECD's Talent Attraction Indicators are the first comprehensive tool to identify countries' strengths and weaknesses in their ability to attract and retain different types of talented migrants.

Approaches to the study of migration activity of intellectual migrants correspond to those specified in the works mentioned above (Caviggioli *et al*., 2020; Boucher, 2020; Chand & Tung, 2019; Gurău *et al*., 2020; Sehoole & Jenny, 2020).

The 2023 edition (OECD, 2023) includes 4 categories of talented migrants: highly educated workers (y_1), foreign entrepreneurs (y_2), university students (y_3), and start-up founders (y_4). These four indicators of talent attractiveness of the OECD are sufficiently detailed and, according to the methodology developed for the OECD in 2019 (Tuccio, 2019), consist of seven sub-indices, each of which represents a separate aspect of talent attractiveness, which is complemented by an overall measure of the accessibility of the country from the view of migration policy (Table 1). The seven sub-indices are based on 22 to 24 variables that provide detailed information on the main drivers of talent mobility, including both economic and intangible factors. This allows us to consider the indicators of countries' migration attractiveness as those that most comprehensively embrace the influence of various environmental factors important for migrants.

Thus, the OECD methodology as a quantitative benchmarking tool offers important information not only for potential immigrants, but also for employers and political leaders, as it allows countries to determine their place on the world map for attracting different types of talented migrants. In this regard, we used these statistical data from the 2023 report (OECD, 2023).

Given that economic studies of migration do not currently offer a comprehensive indicator for assessing the attractiveness of countries for intellectual migrants, the authors suggested using an integral method to calculate the appropriate comprehensive indicator.

Therefore, we suggest determining the level of attractiveness *(I_{im})* on the basis of an aggregate index built considering the indicators of immigration of highly educated workers, foreign entrepreneurs, university students, and start-up founders:

$$I_{im} = \frac{I_1 + \ldots\ldots + I_n}{n} \quad (1)$$

where I_{im} is index of attractiveness of the country for intellectual immigrants; $I_1, \ldots, I_n$ is partial indicators of the country's attractiveness for intellectual immigrants; n is the number of partial indicators.

To calculate partial indicators ($I_1 - I_n$), the most appropriate approach is to use the maximum value of a specific evaluation component as a benchmark, since all indicators are stimulators:

$$I_i = \frac{Q_{f_i} - Q_{min_i}}{Q_{max_i} - Q_{min_i}} \quad (2)$$

where Q_{f_i} is actual values of individual component partial indices; Q_{min_i} is minimum values of individual component partial indices; Q_{max_i} is maximum values of individual component partial indices.

Within ***RT*2**, the authors used The FM Global Resilience Index as a single comprehensive tool based on quantitative data to assess the economic resilience of countries, which provides an opportunity to understand and measure the resilience of the business environment of almost 130 countries of the world (FM Global, 2023). The calculation of this index is based on 3 sub-indices encompassing 15 indicators (Table 2).

In order to analyse the relationship between intellectual immigration and the economic stability of the country, the authors used the methods of statistical and correlation-regression analysis, economic-mathematical modelling in the GRETL (GNU Regression, Econometrics, and Time-series Library) software environment. The choice of this software product is due to the fact that GRETL is a modern and affordable econometric analysis tool that combines functionality and ease of use, including in the visualisation of the results.

The GRETL software product was used to build heat maps to visualise correlations between indicators of intellectual migration and economic stability. Each element of this matrix reflects the correlation coefficient between pairs of variables. A strong positive correlation is shown in red; strong negative correlation in blue; no correlation or weak correlation is displayed in white. Thus, such a visualisation helps to quickly identify and display the dependencies between different variables and the degree of their strength.

Further processing of data on the relationship between the complex indicator of attractiveness of countries for intellectual migrants and the components of country's resilience was carried out on the basis of correlation-regression analysis with the justification of the economic-mathematical

model and the traditional procedure of checking the adequacy of the model using GRETL software.

The relationships between the components of the brain gain and country's resilience were verified using GRETL software with a calculation of Pearson correlation coefficient. T-test also called as Student's T-test was used as statistical significance test of Pearson correlation coefficient.

The relationships between the dependent and independent variables are described by the authors based on an economic-mathematical model:

$$y = f(x_1, x_2, ..., x_n, u) \quad (3)$$

where y is dependent variable (index of attractiveness of the country for intellectual immigrants, calculated according to formula 1); x_1, x_2, …, x_n are independent variables — the values of sub-indices from The FM Global Resilience Index: Economic Resilience (x_1), Risk quality (x_2), and Supply chain (x_3); u is random component — contains that part of the movement y that is not explained by the variables x_1, x_2, …, x_n.

Results

The relationship between brain gain and economic stability was analysed by the authors on the example of 37 OECD countries; the initial data are shown in Table 3. For the convenience of further processing of the data during ***RT2*** execution, indicators are marked as y_i — dependent, and x_i — independent variables. Scores on a scale 0-1.0 are used to calculate y_i; and scores on a scale 0-100 to calculate x_i.

The statistical parameters of the indicators calculated in Table 3 characterise various aspects of the data distribution and provide important information for the analysis of this distribution. For most measures, the standard deviation is small, indicating that the data has relatively little spread. The negative asymmetry of most indicators states that the distribution of the data is skewed to the left, i.e. that there are rather low values than high ones within the data. The indicators variation coefficients are not high and are found in a fairly narrow range (0.14-0.20), which allows considering this group of countries sufficiently homogeneous in terms of the manifestations of migration and stability selected for analysis.

To study the relationships between the components of the migration of highly skilled workers and country's resilience, we built correlation matrices (Figure 1–4). In the construction of the matrices, only the indicators of the countries for which the corresponding values were given in the reports are taken into account. Therefore, the number of countries in Figure 1–2 is 37, for Figure 3 — 36, and only 24 OECD countries report data on start-up founders from among migrants, which is reflected in the determination of correlations in Figure 4.

The obtained results allow asserting a direct connection between the selected indicators. However, the closeness of this relationship varies depending on the category of intellectual immigrants (Figure 1–4).

The immigration of highly skilled workers (Figure 1) has a close relationship with both the overall value of the Global Resilience Index and all its sub-indices, because the calculated values of the correlation coefficients exceed 0.6 and are statistically significant.

Among all the analysed categories of immigrants, the migration of entrepreneurs has the closest ties with ensuring the country's resilience (Figure 2) as the correlation coefficient with The FM Global Resilience Index is 0.9. Such a strong close relationship is due to the innovativeness of foreign entrepreneurs, their ability to take risks (Rustiarini *et al*., 2023) and implement social responsibility (Zhou & Huang, 2022; Oliinyk *et al*., 2023), which increases the level of country's resilience and readiness for new risks, challenges and shocks. In particular, innovation can include the development and implementation of new production methods, more efficient use of resources and solving environmental problems. The creation of new jobs increases resilience in the face of economic difficulties and ensures the reduction of social risks. Thus, the findings suggest that immigrants act rather as "job creators" than "job takers" and play outsized roles in high-growth entrepreneurship (Azoulay *et al*., 2022).

Student immigration (Figure 3) also has a fairly strong relationship with economic resilience in general, and supply chains resilience in particular (correlation coefficient values of 0.8, respectively). International students contribute to a diversity of cultures, languages, perspectives, and personal experiences (Schachner *et al*., 2019). The economic impact is also considerable, as international students form the country's workforce, being employed after graduation abroad. In general, the impact of foreign students on The FM Global Resilience Index is more positive in countries that effectively use their potential and promote integration into all areas of society,

because a passive policy on student immigration can lead to catastrophic consequences for national competitiveness in terms of innovation and development, which are driven by the talented (Mishchuk *et al.*, 2019).

This close relationship between a country's attractiveness for international students and the "supply chain" sub-index is explained by the fact that this category of intellectual migrants makes a significant contribution to the economy through the costs of education, accommodation, food, transport, entertainment and sports. This has a positive effect on the support of the business environment and the activities of business entities that manufacture goods and provide services that students use in their daily lives. Thus, an increase in the number of foreign students increases the consumer demand of the recipient country.

The immigration of start-up developers (Figure 4) has the smallest, but quite significant connections with the creation of a more stable and ready-to-change country (the value of the correlation coefficients exceeds 0.5). Start-up developers usually work on innovative ideas and technologies, which increases a country's technological readiness and ability to cope with change. This category of immigrants ensures the creation of new jobs, which affects the improvement of the employment level of the population and the economic resilience of the country in general.

In the meantime, the analysed indicators of intellectual immigration are partial, as they assess the attractiveness of OECD countries for certain types of immigrants. Therefore, in accordance with the determined goal of the study, there is a need to define an integral indicator that would be comprehensive and unite all four categories of intellectual immigrants.

There is currently no method for calculating such an indicator, because the existing studies concern either a separate category of intellectual migrants, e.g. International students (INSEAD, 2022) take into account only partial manifestations of intellectual migration and are calculated on the basis of expert surveys, such as the "Brain gain" indicator in The Global Talent Competitiveness Index (INSEAD, 2022), or evaluate individual areas of migration policy, or "Labour Market Flexibility" sub-index in the Hays Global Skills Index (Hays, 2020).

To attain the objectives of our research, we suggest using a complex indicator of migration attractiveness of countries calculated by means of formulas (1–2). The actual, maximum and minimum values of the indicators are revealed in Table 3.

The calculation of partial indicators and the integral index of the attractiveness of OECD countries for intellectual immigrants is shown in Table 4.

As Table 4 shows, among all OECD countries, only for Switzerland the value of the integral index exceeds 0.9. Therefore, it can be argued that this country is the most attractive for all types of intellectual migrants. The second place in the formed rating is occupied by Norway (I_{im} = 0.8885), the third is Canada (I_{im} = 0.8860). The following OECD countries are also extremely interesting for studying and employment of potential migrants, these are United States (I_{im} = 0.8696), Sweden (I_{im} = 0.8220), the United Kingdom (I_{im} = 0.7926), Australia (I_{im} = 0.7890) та Luxembourg (I_{im} = 0.7776).

At the same time, the value of the integral index for Turkey, Mexico, Costa Rica and Colombia barely exceeds 0. It can be stated that it is in these countries that highly skilled workers are least inclined to look for work, entrepreneurs from other countries to start their own business, and foreign students to study. In general, the obtained data indicate that an immigration system aimed at using the potential of highly skilled immigrants to improve their own labour market works better because it takes into account domestic demand in the labour market, the interests of employers in the selection and hiring of workers from abroad. This makes it possible to achieve other economic advantages in the development of the country; as it is to see from the list of OECD countries that attract most migrants, they are not only more attractive in the sense of migration, but also have higher indicators of country's resilience (Table 3). Thus, the long-term two-way connections between intellectual migration and country's resilience are evident.

At the same time, verification of such dependence on the basis of existing data can be carried out by applying economic and mathematical modelling. The goal is to detail the relationship and determine the impact of a country's economic resilience on its attractiveness for intellectual immigrants. The calculation will be carried out using GRETL.

The calculated integral index of attractiveness of the OECD country for intellectual immigrants (I_{im}) was used as the dependent variable (Table 4). The independent variables are the values of such sub-indices as The FM Global Resilience Index: Economic (x_1), Risk quality (x_2), and Supply chain (x_3).

An economic and mathematical model (3) was obtained as a result of the calculations:

$$I_{im} = -0.840 + 0.00773*x_1 + 0.00356*x_2 + 0.00752*x_3 \quad (3)$$
$$(0.139) \quad (0.00223) \quad (0.00171) \quad (0.00236)$$

n = 37, R-squared = 0.774, (standard errors in parentheses)

Indicators confirming the statistical significance and adequacy of this three-factor model are given in Table 5.

The obtained results of monitoring the adequacy of the economic and mathematical model according to the main statistical indicators allow stating that the built three-factor economic and mathematical model is suitable for practical use. Therefore, the country's economic resilience in key areas is an important condition for attracting and retaining intellectual immigrants. In particular, intellectual immigrants choose countries with a high level of economic development, where there are opportunities for highly paid and highly skilled work. An economically resilient country can provide them with such opportunities that encourage them to move. Besides, economically resilient countries often have highly developed scientific, educational and innovation sectors, where intellectual immigrants can fulfil their potential by working on cutting-edge projects and joining research and entrepreneurial communities.

Discussion

The results of this research are supported by the conclusions of other researchers obtained in directions close to the resilience of countries. Thus, highly skilled workers are a source of productivity growth, innovation and scientific research (Glennon, 2023; Artyukhov *et al*., 2023), and help develop the potential and increase the country's ability to adapt to new challenges and changes, to be resistant to various types of risks. Concomitantly, the revealed relationship between the immigration of highly skilled workers and the economic resilience of the country may depend on many variables. To explain the mechanism of forming connections, similarly to our approach, one can use, e.g., the findings of Borjas (2019) stating that important factors for the successful employment of immigrants are the composition of immigrants' skills, the speed of assimilation, the consequences of the distribution of the labour market, etc. Active immigration of highly qualified workers contributes to the development of information and

communication networks, modern infrastructure and digital technologies, which increases the country's resilience to technological challenges.

In the light of the investigation of migrants' entrepreneurs' activity links with the country resilience, our results are aligned with the previous findings. Particularly, other scientists proved that immigrant entrepreneurship has a significant impact on the socio-economic development of the country and sustainability in all its manifestations; so, understanding the entrepreneurial motivation of immigrants is crucial for the development of migration policy in this field (Duan *et al*., 2023; Sabary *et al*., 2023a, 2023b). Foreign founders play a key role in efforts to attract international attention to newly created entrepreneurial structures, thus playing a key role in facilitating the internationalisation efforts of new ventures, especially by matching existing resources with international operations of new ventures (Drechsler *et al*., 2019).

As for the migration of students, this has a positive effect on the development of cultural diversity, increases tolerance and mutual understanding between different population groups, which, in turn, strengthens social stability. Besides, foreign students, thanks to their knowledge and skills, enrich the educational and scientific potential of the country, participate in scientific research and innovative projects, which ensures technological resilience (Uctu & Al-Silefanee, 2023).

The explanation of differences in the attractiveness levels of the OECD countries for intellectual migrants may lie in demand factors in national labor markets, mechanisms of selection of intellectual immigrants, gender aspects of employment, etc. Thus, immigrant workers with tertiary education in Canada are much more likely to be overeducated than their US counterparts, and the gap between immigrants and natives in levels of over-education is significantly higher in Canada than in the United States (Lu & Hou, 2020), and in Australia it is skilled immigrant women who are the source of skills for the Australian economy (Carangio *et al*., 2021).

Conclusions

Based on the research findings, we can state that the OECD countries create a favourable environment for attracting intellectual migrants. Even the fact of monitoring the processes of intellectual migration according to the newly developed methodology and dividing immigrants into 4 groups is al-

ready a sign of how important the migration of talents as a resource of economic development is for a group of highly developed countries. Modern studies of intellectual migration are a well-developed and popular area of economic science; and the factors that attract migrants are well described mainly from the perspective of influence of material components of personal well-being. At the same time, a certain omission is insufficient attention to the study of factors that comprehensively characterise the resilience of countries as an environment for the formation of migration intentions.

With the increase in dangers of various content and influence in today's world, the concept of resilience becomes one of the key ones, and in the migration decisions of highly educated workers, students, entrepreneurs with their higher competitiveness and aspirations to realise their own potential, the country's resilience can be an important motivation for decision-making. Taking this assumption as the basis of our research, we evaluated the connections of intellectual migration (on the basis of its complex indicator, as well as in the section of four groups of intellectual migrants) with the components of the resilience of countries.

The substantiated integrated index of migration attractiveness of the countries, formed on the basis of indicators of immigration of highly educated workers, foreign entrepreneurs, university students, and start-up founders, was offered for the first time. Its advantage is the possibility of a comprehensive assessment of the migration attractiveness of a country specifically for intellectual migrants, and on this basis — the ranking of countries, the possibility of studying best practices, regulation of migration flows and development of effective migration policies for each country. In addition, the application of the developed methodological principles for calculating the integral index of the country's attractiveness for intellectual immigrants will allow determining "bottlenecks" and directions of priority changes in the field of global movement of certain categories of intellectual immigrants; determine priority areas and develop management solutions with the aim of improving the migration policy for certain groups of intellectual immigrants.

Such possibilities of practical application of the developed index make it a valuable applied tool, missing so far in scientific studies about the migration of the talented. The advantages of using the integrated index of the country's migration attractiveness for intellectual migrants become even more obvious if this tool is used in conjunction with the study of the impact of resilience factors. Our analysis proves that partial components of resili-

ent countries have an important influence on the formation of immigration flows, the most important ones being economic resilience and supply chain resilience. Such results can be used to improve the institutional environment of a resilient country, which will be useful both to increase the perception of safety, comfort and reliability of living in the country by the local population, and will serve as a factor for attracting the talented with corresponding long-term economic benefits.

Developing a new methodological approach and appropriate tool for evaluating the links between country resilience and brain gain, authors dealt with some limitations in this research. First of all, using as a statistical basis for brain gain measurement the approach of OECD in intellectual migrants' classification, it was found that only data for 2023 are available for the aim of holistic investigation. Previous similar OECD research for 2019 is not appropriate for comparisons. Since 2019 the global crises such as the Covid-19 pandemic, the war in Ukraine and military conflicts in other countries have significantly affected the picture of intellectual migration in the world, including OECD countries. Therefore, the 4-years gap in data collecting is not appropriate for dynamic analysis, like panel model use, considering that the study is aimed at defining current peculiarities of intellectual migration linked with countries' resilience. Besides, the report on country attractiveness in 2019 does not contain the data on startup founders, so, the results will be incomparable due to this reason too. Thus, only 2023 data are available to consider the interdependencies in intellectual migration and country resilience.

Our future research will be focused in deepening the approach to understand the links between intellectual migration as a source for country development and constituents of the institutional surroundings attracting the talents, including the efforts to maintain the resilience of the country. Particularly, the most valuable data could be achieved using the special surveys of existing and potential intellectual migrants. In this regard, one of the most important directions is the investigation of pull-factors affecting the migration of R&D personnel. It is aligned with our findings on the most obvious links between resilience of countries and migration of the highly-skilled workers and, therefore, this requires further investigation using the sociological surveys.

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Annex

Table 1. Determinants of talent attractiveness

Policies and practices for admission	Quality of opportunities		Income and tax		Future prospects
	Family environment	Skills environment		Inclusiveness	Quality of life

Source: compiled on the basis of Tuccio (2019).

Table 2. Components for calculation the 2023 FM Global Resilience Index

The Global Resilience Index (x)		
Economic (x_1)	**Risk quality (x_2)**	**Supply chain (x_3)**
Productivity	Seismic risk exposure	Infrastructure quality
Political risk	Climate risk exposure	Control of corruption
Energy intensity	Cyber risk quality	Corporate governance
Urbanisation rate	Fire risk quality	Supply chain visibility
Health expenditure	Climate risk quality	Supply chain timeliness

Source: compiled using the data of FM Global (2023).

Table 3. Value of indicators of brain gain and resilience and their numerical characteristics in OECD countries in 2023

Country	**Highly Educated Workers**	**Entrepreneurs**	**University Students**	**Start-up founders**	**The FM Global Resilience Index**	**Economic**	**Risk Quality**	**Supply chain**
	y_1	**y_2**	**y_3**	**y_4**	**x**	**x_1**	**x_2**	**x_3**
Australia	0.62	0.53	0.55	0.47	87.4	72.30	91.90	80.60
Austria	0.49	0.51	0.47	0.43	93.3	75.80	93.10	89.40
Belgium	0.54	0.5	0.46	*	93.2	71.20	99.40	88.30
Canada	0.57	0.6	0.53	0.57	85.7	63.30	89.90	85.70
Chile	0.42	0.44	0.4	0.33	60.9	53.70	51.10	68.40
Colombia	0.37	0.3	0.27	*	47.9	41.40	47.60	53.70
Costa Rica	0.32	0.34	*	*	54.2	54.1	55.60	51.10
Czech Republic	0.48	0.42	0.4	*	83.7	65.4	96.60	75.00
Germany	0.55	0.53	0.56	0.45	96.8	79.7	97.60	90.40
Denmark	0.57	0.55	0.49	0.44	100	83.3	96.40	95.00
Spain	0.5	0.5	0.48	0.44	87.9	64.60	99.90	82.10
Estonia	0.5	0.49	0.41	0.38	77.2	65.3	84.70	69.80
Finland	0.55	0.54	0.48	0.45	93.6	70.9	94.50	92.90
France	0.54	0.5	0.48	0.52	89.7	68.6	95.30	85.90

Table 3. Continued

Country	Highly Educated Workers	Entrepreneurs	University Students	Start-up founders	The FM Global Resilience Index	Economic	Risk Quality	Supply chain
	y_1	y_2	y_3	y_4	x	x_1	x_2	x_3
United Kingdom	0.59	0.54	0.55	0.49	91.9	72.00	89.00	92.30
Greece	0.4	0.37	0.31	*	63.1	53.3	70.50	59.90
Hungary	0.5	0.43	0.4	*	73	59.40	86.40	64.60
Ireland	0.57	0.54	0.41	0.48	87.6	94.10	70.50	78.60
Israel	0.41	0.35	0.26	0.31	72.9	54.60	76.70	74.90
Italy	0.44	0.46	0.47	0.39	76.7	64.70	78.00	74.00
Japan	0.5	0.48	0.52	0.36	80.6	71.60	60.80	88.60
Korea	0.5	0.51	0.51	0.4	78.2	62.10	75.30	81.10
Lithuania	0.48	0.45	0.45	0.45	75.2	64.60	84.00	66.70
Luxembourg	0.59	0.55	0.49	*	97.3	100.00	93.50	78.10
Latvia	0.44	0.4	0.36	0.36	67.6	61.60	82.60	54.30
Mexico	0.36	0.29	0.27	*	50.5	42.50	57.00	51.50
Netherlands	0.57	0.53	0.48	0.47	90	76.30	79.50	91.60
Norway	0.61	0.58	0.55	*	92.7	74.90	96.00	86.80
New Zealand	0.64	0.57	0.49	0.44	87.3	73.10	74.50	91.80
Poland	0.44	0.42	0.43	0.41	80.3	59.80	100.00	70.10
Portugal	0.57	0.51	0.51	0.48	79.1	60.80	89.60	74.10
Slovak Republic	0.5	0.45	0.43	*	68.9	56.80	90.30	55.30
Slovenia	0.53	0.47	0.42	*	67.7	61.50	62.50	68.40
Switzerland	0.62	0.6	0.53	*	96.3	94.20	81.90	88.90
Sweden	0.62	0.61	0.51	0.47	93.8	75.50	93.90	90.00
Turkey	0.33	0.29	0.3	*	60.8	41.10	77.30	60.00
United States	0.58	0.54	0.6	0.54	93.3	82.60	92.60	84.30
Mean	0.51	0.48	0.45	0.44	80.4	67.21	82.60	76.60
Median	0.50	0.50	0.475	0.445	83.7	65.3	86.40	78.60
Minimum	0.32	0.29	0.26	0.31	47.9	41.1	47.60	51.10
Maximum	0.64	0.61	0.60	0.57	100.00	100.00	100.0	95.00
Std. Dev.	0.085	0.087	0.087	0.063	14.018	13.602	14.655	13.408
Coefficient of variation	0.1679	0.1820	0.1933	0.1445	0.1743	0.2024	0.1774	0.1750
Skewness	-0.5365	-0.6864	-0.7241	-0.1032	-0.6967	0.2778	-0.8643	-0.4881
Ex. kurtosis	-0.5565	-0.3057	-0.1753	-0.2683	-0.4608	0.1790	-0.2636	-0.9832
5% perc.	0.3290	0.2900	0.2685	0.3150	50.24	41.37	50.75	51.46
95% perc.	0.6220	0.6010	0.5660	0.5625	97.57	94.78	99.91	93.11
IQ range	0.1300	0.1150	0.1075	0.0850	22.05	15.60	19.30	21.20

Note: * data are unavailable.

Source: authors' calculations based on OECD (2023) and FM Global (2023) data.

Table 4. Calculation of the integrated attractiveness index of OECD countries for intellectual immigrants in 2023

Country	I_1	I_2	I_3	I_4	I_{im}
Australia	0.9375	0.7500	0.8529	0.6154	0.7890
Austria	0.5313	0.6875	0.6176	0.4615	0.5745
Belgium	0.6875	0.6563	0.5882	*	0.6440
Canada	0.7813	0.9688	0.7941	1.0000	0.8860
Chile	0.3125	0.4688	0.4118	0.0769	0.3175
Colombia	0.1563	0.0313	0.0294	*	0.0723
Costa Rica	0.0000	0.1563	*	*	0.0781
Czech Republic	0.5000	0.4063	0.4118	*	0.4393
Germany	0.7188	0.7500	0.8824	0.5385	0.7224
Denmark	0.7813	0.8125	0.6765	0.5000	0.6926
Spain	0.5625	0.6563	0.6471	0.5000	0.5915
Estonia	0.5625	0.6250	0.4412	0.2692	0.4745
Finland	0.7188	0.7813	0.6471	0.5385	0.6714
France	0.6875	0.6563	0.6471	0.8077	0.6996
United Kingdom	0.8438	0.7813	0.8529	0.6923	0.7926
Greece	0.2500	0.2500	0.1471	*	0.2157
Hungary	0.5625	0.4375	0.4118	*	0.4706
Ireland	0.7813	0.7813	0.4412	0.6538	0.6644
Israel	0.2813	0.1875	0.0000	0.0000	0.1172
Italy	0.3750	0.5313	0.6176	0.3077	0.4579
Japan	0.5625	0.5938	0.7647	0.1923	0.5283
Korea	0.5625	0.6875	0.7353	0.3462	0.5829
Lithuania	0.5000	0.5000	0.5588	0.5385	0.5243
Luxembourg	0.8438	0.8125	0.6765	*	0.7776
Latvia	0.3750	0.3438	0.2941	0.1923	0.3013
Mexico	0.1250	0.0000	0.0294	*	0.0515
Netherlands	0.7813	0.7500	0.6471	0.6154	0.6984
Norway	0.9063	0.9063	0.8529	*	0.8885
New Zealand	1.0000	0.8750	0.6765	0.5000	0.7629
Poland	0.3750	0.4063	0.5000	0.3846	0.4165
Portugal	0.7813	0.6875	0.7353	0.6538	0.7145
Slovak Republic	0.5625	0.5000	0.5000	*	0.5208
Slovenia	0.6563	0.5625	0.4706	*	0.5631
Switzerland	0.9375	0.9688	0.7941	*	0.9001
Sweden	0.9375	1.0000	0.7353	0.6154	0.8220
Turkey	0.0313	0.0000	0.1176	*	0.0496
United States	0.8125	0.7813	1.0000	0.8846	0.8696

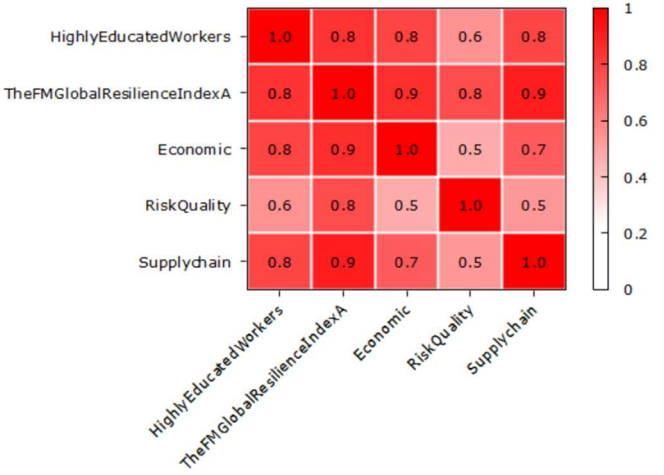
Note: * data is unavailable.

Table 5. The results of monitoring the adequacy of the economic and mathematical model according to the main statistical indicators

	Coefficient	Std. Error	t-ratio	p-value
const	−0.840	0.138746	−6.054	<0.0001***
Economic (x_1)	0.00773	0.00223065	3.466	0.0015***
Risk Quality (x_2)	0.00356	0.00171291	2.081	0.0453**
Supply chain (x_3)	0.00752	0.00236016	3.185	0.0032***
Mean dependent var		0.549805	S.D. dependent var	0.253766
Sum squared resid		0.524318	S.E. of regression	0.126049
R-squared		0.773836	Adjusted R-squared	0.753275
F (3, 33)		37.63717	P-value (F)	9.26e-11
Log-likelihood		26.24590	Akaike criterion	−44.49180
Schwarz criterion		−38.04813	Hannan-Quinn	−42.22011
White's test for heteroskedasticity - Null hypothesis: heteroskedasticity not present Test statistic: LM = 8.01669 with p-value = P(Chi-square (9) > 8.01669) = 0.532465				

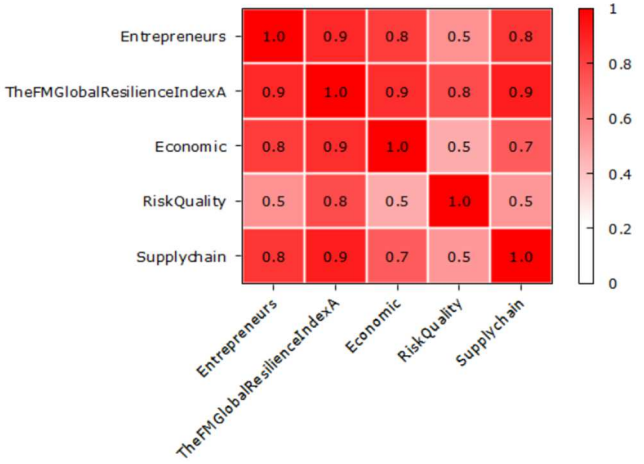
Notes: ***, **, * showing significance at 1%, 5%, and 10% probability levels, respectively.

Figure 1. Correlation coefficients of interdependence between the highly educated workers and country's resilience on the example of OECD countries in 2023



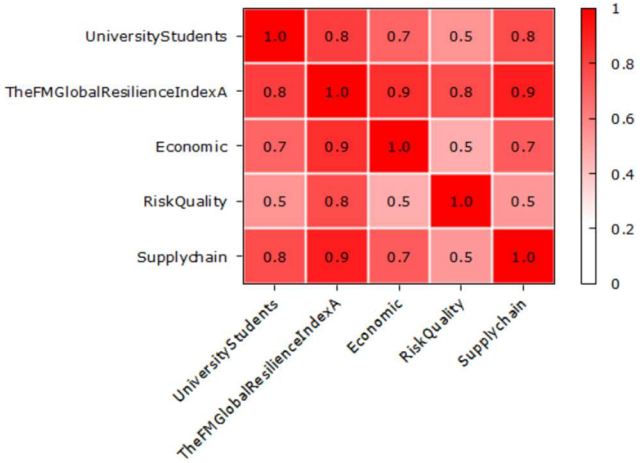
Note: *5% critical value (two-tailed) = 0.3246 for n = 37*

Figure 2. Correlation coefficients of interdependence between the immigration of entrepreneurs and country's resilience on the example of OECD countries in 2023



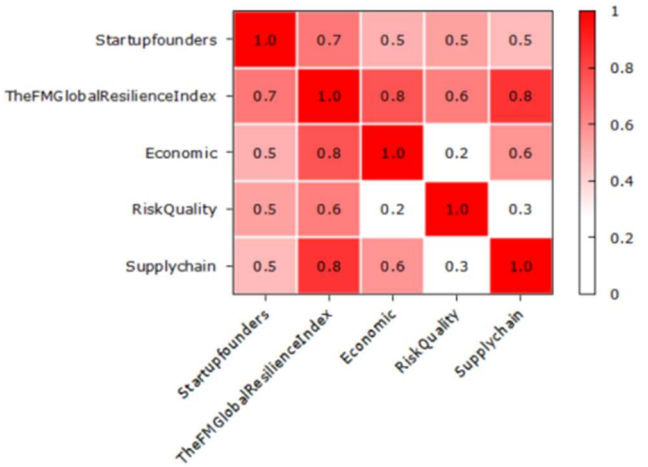
Note: *5% critical value (two-tailed) = 0.3246 for n = 37*

Figure 3. Correlation coefficients of interdependence between immigration of university students and country's resilience on the example of OECD countries in 2023



Note: *5% critical value (two-tailed) = 0.3291 for n = 36*

Figure 4. Correlation coefficients of interdependence between immigration of start-up founders and country's resilience on the example of OECD countries in 2023



Note: 5% critical value (two-tailed) = 0.4044 for n = 24