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MODELLING AND FORECASTING IMMIGRATION PROCESSES IN THE UNITED KINGDOM USING ENDOGENOUS PULL FACTORS

ABSTRACT

This study focuses on the econometric modelling of immigration processes in the United Kingdom (UK) using endogenous pull factors. The study aims to investigate the impact of economic, social, housing and labour indicators on immigration inflows to the UK. In the article a regression model is employed, covering the period from 2000 to 2021 to estimate the relationship between the endogenous pull factors in the UK and immigration processes. The endogenous pull factors considered in this study include economic factors such as GDP per capita, the number of new businesses per year, budget spending per student and the average salary per year; social factors such as population density, level of urbanization, and crime rate; housing factors such as the number of new residential buildings built; labour factors the unemployment and the employment rates. The results of the study show that key factors like GDP per capita, unemployment rate, newly registered businesses, and government spending per student have a significant influence on immigration inflows. In contrast, it was found that crime rate, average salary and population indicators don't affect international migration to the UK as much. The findings of this article have important implications for policymakers and researchers interested in understanding the dynamics of immigration processes in the UK. By identifying the key endogenous pull factors driving immigration and using them to create forecasts such as the one in this study, policymakers can develop more effective immigration policies and better allocate resources to support immigrants and their integration into UK society.

Keywords: immigration, mathematical modelling, forecasting; migration flows, regression analysis

JEL Classification: I30, J11, J61

INTRODUCTION

Migration processes are a phenomenon that has been occurring for centuries, and their importance to the world today is undeniable. Migration occurs when individuals, families, or entire populations move from one place to another, whether within a country or across international borders. This type of movement has had a significant impact on the development of civilizations and the spread of ideas, as well as on the development of countries and the world at large.

Migration processes are believed to have been a key factor in the development of countries. They allowed the spread of ideas and cultures, which in turn made the development of cities and nations possible, as well as the growth of trade and commerce. Migration processes also allowed for the intermingling of different cultures and the exchange of goods, services, and knowledge that enabled the growth of ideas and innovations.

Immigration and emigration of the population have also had a significant impact on the development of countries. People who migrate often bring with them new ideas, skills, and perspectives that can help drive economic growth and development. Migration also helps to diversify the population of a country, which in turn can help to create a more vibrant and diverse society. In addition, migration processes can help to reduce poverty

and inequality in countries, as well as provide opportunities for individuals to escape oppressive or dangerous situations.

But migration processes also can be quite burdensome for the financial systems of countries-recipients. Governments plan by always creating a budget that accounts for all countries' expenditures. Alas, there are unpredictable circumstances that can hinder budgetary efficacy such as sudden environmental impacts and unforeseen migration waves are also a part of that category. Additional population means additional expenditures for their support which weighs down on the countries' limited budgetary resources. One prime example of such a phenomenon is the massive migration of Ukrainian refugees into European countries after Russian aggression.

All in all, migration processes are an important part of everyday life in this world that has had a significant impact on the development of civilizations, the development of countries, and the global economy both positively and negatively. Migration processes have enabled the spread of ideas, and resources, as well as the growth of trade and commerce. These processes are always complex in their nature, which makes them a perfect subject for dissection and analysis as this will allow to not only understand what exactly causes the specific migration movement, and what can help prevent it or create it, but it also helps forecast these processes for future, hence why this topic is so important.

LITERATURE REVIEW

The ability to comprehend migration processes at least partially is immensely important for several reasons. The literature that describes and analyses population immigration and emigration processes dates back all the way to the 20th century [1-2]. Authors of multiple books were analysing how migration processes were influencing the countries-recipients. A lot of people thought at the time that immigration in more developed countries could lead to an economic problem as that would create more competition in the labour market and create an additional load for the financial systems. The increase of 10% in several immigrants in the country lowered the wages of the native population by less than 1% which is negligible. The decrease in wages of immigrants themselves was more significant, around 2-4%. So, authors using a neoclassical model of labour demand concluded that empirical data did not support the concern that immigration processes could be disruptive to the labour markets in America.

Similar conclusions were drawn by authors of two studies where they elaborated that there wasn't a significant threat to economic prospects from immigrants in the United States [3-4]. Authors also noted that such simple empirical methodology had its' downsides. One such issue was the fact that the data that they used in their calculations completely overlooked the insight that the skills of immigrants in the labour market were, in fact, divergent in different cohorts. Additionally, the productivity of these cohorts also differs throughout time as people adapt to new environments.

Further proving this point authors of another study concluded that the effects of immigrants on the wages of the native population largely depend on human capital levels of the immigrants themselves [5]. It became clear that there was not a significant problem at that time, but the data used during modelling was simply not sufficient and sophisticated enough to conduct more elaborate experiments and analyses.

In one book [6] authors were analyzing how after the events in 1990 when the dissolution of the Soviet Union took place a serious increase in east-to-west migration flows were happening in Central, Eastern and Southeastern European countries and how it affected the growth of post-soviet countries, their private sector activities, competitiveness public finances and ultimately growth. Noticeably a significant outflow of educated and young people was happening in Southeastern countries more so than in the Baltic and Central Europe regions. Authors disclose that the EU has significantly benefited from the inflow of young and well-educated labour force, and there is sizable research that points to the benefits of receiving countries in the European Union from cross-border labour mobility. By moving abroad, migrants were able to improve their welfare and the quality of life of their relatives back home.

Meanwhile, these processes have noticeably reduced the growth and income convergence in Central, Eastern and South-eastern European countries (countries-donors) because the size of the labour market has shrunk which led to adverse effects on productivity and to making the budget structure of the country less growth-friendly. Similarly, authors of another article [7] emphasized that the net effect of innovator emigration is detrimental to domestic knowledge access and leads to slowed growth of Indian regions.

There is plenty of evidence which indicates that migration processes are of utmost importance when it comes to countries' development and prosperity. That includes both countries-donor and countries-recipients as it can be a positive thing and strenuous phenomenon. The potential and demographic structure of the migrating population plays a special role here. Some authors emphasize the importance of the intellectual capital of immigrants for the development of host countries

[8-10]. However, as acknowledged in two papers discussing the results of research conducted in India, the flow of population is a driving force for growth in selected sectors of the economy also by providing a flexible and cheap source of labour [11-12]. Many publications highlight the impact of immigrants and their behaviour on such key economic variables as prices, income, and selected microeconomic aspects of economic activity [13-16]. Not without significance for the impact of migration on the economic and social life of the country is the issue of the mental health of refugees in the new environment. Authors such as [17] or [18] recognize the challenges that displaced persons face in this respect on the way to effective acculturation, and at the same time to maintain their own values taken from their home countries, while another study directly writes about the positive correlation of the mental health of refugees with structural and cognitive social capital they represent [19]. From the point of view of the countries of origin of migrants, in addition to the often-cited socio-economic effects of such an exodus for their economy, one of the articles points to the slightly less emphasized effect of migration, which may be changes in the gender structure of the population observed especially in less developed countries [20]. As of today, many have come up with multiple ways to analyze and scrutinize these processes. Stillwell, J. suggested that the use of the Poisson regression model framework might be optimal for explanatory analysis [21]. Such a model has been used for subnational migration to explain the effects of exogenous variables.

In another study [22] authors were assessing what conditions and indicators were affecting the population migration activity in Ukraine prior to Russian aggression. The authors were determining which indicators were more prevalent and important and their reliability by use of statistical analysis. The main 30 indicators can be divided into 5 different classes: demographic stability and public health status; education coverage; labour market and employment conditions; standard of living; economic development of the country/region. The results of the study showed that these processes were affected by first and foremost demographic situation, life expectancy, public health, and the upbringing of the young generation in a family. The tendency of mortality to overgrow the birth rates has tremendously impacted demographic reproduction causing catastrophic population decline. Although, it is worth noting that such a trend is present in a lot of countries, so it is worth focusing on migration flow control first. The creation of sustainable and adequate conditions for economic growth for the well-educated part of the population can hinder their desire to migrate and thus positively impact economic and demographic markers in Ukraine.

Yet another study that analyzed the social and economic development of Ukraine was assessing different factors that could play into migration intensity using The Granger causality test [23]. Authors concluded that migration processes can be beneficial in the short-term for the economy, by lowering the rate of unemployment, by simply diminishing the amount of population in a country, or by influencing disposable income, remittances, aggregate food expenditures as well as consumer price index. It still can negatively impact the economy overall as the high-quality labour force is decreasing and implementing a proper effective migration control policy can help address this issue.

Author [24] was assessing social, economic, and political institutions as an explanatory factor for migration processes using gravity model which separates push as pull effects of various institutional attributes. The study shows that all factors play an important role when it comes to migration processes dissection and understanding although they vary significantly. Economic freedom has been shown to be the most influential, followed by political and social institutions. In addition, it was determined that political institutions don't pose a significant push factor compared to economic and social.

In [25-27] authors forecast the level of health care expenditure in Ukraine for 2023-2024, considering the scale of migration and the fall in the level of GDP. In [28-30] authors discover the impact of women's resistance to changing gender stereotypes, models, and inequality in migration issues.

All in all, there are more new modelling methods that can consider different factors, such as social, environmental, economic etc. Different models can use different data hence the need for model diversity. Migration is a multifaceted process that's incredibly complex in its nature. The need to understand these processes is important for both countries-recipients and countries-donors to control them and create forecasts.

AIMS AND OBJECTIVES

The purpose of writing the article is to identify the key pull factors affecting immigration processes in the UK. To realize the goal, the following tasks were set and solved:

- develop a model for predicting immigration processes (using the example of Great Britain);
- identify key parameters affecting immigration processes.

The correlation regression analysis and the visualization methods were used to write the article.

development in a country which can also impact migration. People may choose to move from less developed countries to more developed ones in search of better living standards, higher wages, and more opportunities. Budget spendings per student could potentially motivate people to acquire higher education in the UK, being an opportunity for migrants.

Labour market factors included the unemployment rate and the employment rate. The availability of jobs and better wages in another country can be a major factor in people's decision to migrate. If a person's home country has high unemployment or low wages, they may choose to move to a country with better job opportunities.

Housing factors included the number of new buildings (apartments and private houses) whose construction was completed in the current year. Housing factors can also contribute to migration, as the availability and affordability of housing can be a major consideration for people when deciding whether to move. Since prices per square meter vary vastly across the country from region to region, the same goes for policies such as rent control or subsidies as well as taxonomy, making it hard to standardize data for international migration modelling, a more comprehensive factor was chosen that would describe permanent dwellings that have been completed in the United Kingdom during a financial year and are ready for use.

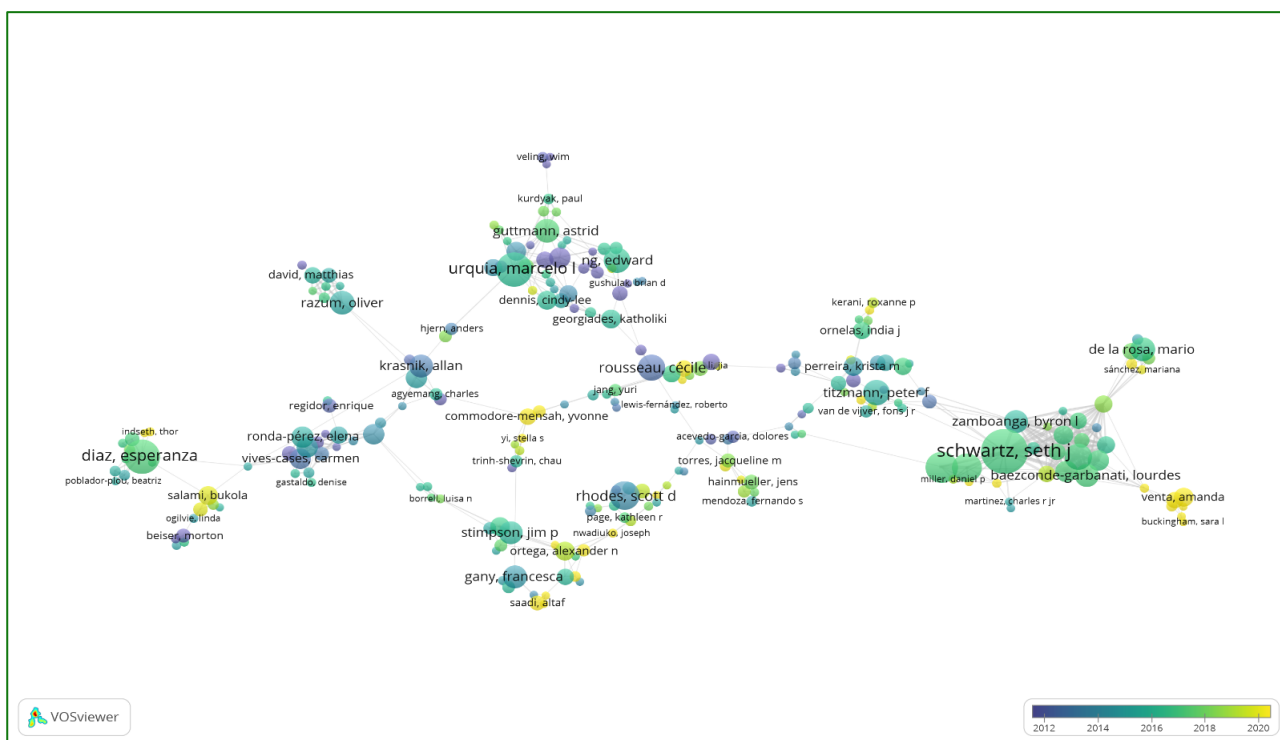


Figure 2. Visualization map of authors in PubMed publications on immigration. (Source: VOSviewer)

Social factors included population density, level of urbanization, and crime rate. People may move to urban areas in search of job opportunities, better access to education and healthcare, and a more vibrant cultural scene. On the other hand, people may also leave urban areas due to the high cost of living, traffic congestion, pollution, and lack of green spaces. Population density can also impact migration. High population density can lead to overcrowding, higher competition for resources, and more crime. As a result, people may choose to move to areas with lower population density in search of a higher quality of life and lower crime rates. Crime rate is another factor that can influence migration. High crime rates can make people feel unsafe and insecure in their homes and communities. In such cases, people may choose to move to areas with lower crime rates. Conversely, low crime rates can attract people to areas that are perceived as safer and more secure. The data used for modelling was taken for the past 21 years from 2000 to 2021 (Table 1).

Table 1. Values of economic, social, housing and labour factors used for modelling. Notes: *Endogenous variable:* immigrants – long-term international migration numbers (in thousands/non-EU migrants). *Exogenous variables:* gdp_per_capita – in USD; unemp_rate – the total percentage of unemployed people in the labour market aged 16 and over; new_build – permanent residential dwellings completed in total in the United Kingdom at the end of the calendar year; pop_density – population density illustrated by people per sq. km of land area; urb_pop – per cent of urban population to total population; emp_rate – per cent of UK population that is employed aged 16 and over; exp_per_stud – per cent of GDP per capita spent on student education; new_buss – number of new limited liability corporations (or its equivalent) registered in the calendar year; crime – the number of crimes for 1000 people in England & Wales, Scotland and Northern Ireland cumulatively; avg_income – mean household disposable income value adjusted for inflation. (Source: World Bank, UK.GOV, Office of National Statistics)

Year	Immigrants	Gdp_per_capita	Unemp_rate	New_build	Pop_density	Urb_pop	Emp_rate	Exp_per_stud	New_buss	Crime	AVG_income
2000	359.4	28290.97	5.45	176850	243.43	78.65	58.47	12.73	346720	271.4	30341
2001	372.1	27886.80	5.08	174090	244.37	78.75	58.66	13.27	350230	271.8	32733
2002	385.9	30079.66	5.18	181960	245.40	79.05	58.68	14.41	357320	285.4	33635
2003	426.8	34479.39	5.01	190490	246.55	79.34	58.90	16.30	367870	277.4	34037
2004	518.1	40390.79	4.75	203500	247.96	79.63	59.04	15.88	392540	272	35461
2005	496.5	42131.70	4.84	205740	249.66	79.92	59.31	17.01	392670	268	36621
2006	529.0	44536.62	5.42	208970	251.51	80.20	59.34	19.73	403860	264.6	37397
2007	526.7	50435.37	5.33	223590	253.47	80.48	59.23	20.91	452135	240.3	38670
2008	530.3	47429.94	5.71	187320	255.47	80.76	59.23	21.34	362322	233.1	36420
2009	519.3	38821.18	7.61	157140	257.41	81.03	57.84	22.24	364131	216.4	37689
2010	546.8	39693.19	7.89	135980	259.44	81.30	57.49	24.33	400867	206.1	36240
2011	524.7	42150.70	8.10	140720	261.48	81.57	57.32	24.67	453898	198.7	35421
2012	452.1	42485.59	7.99	141610	263.30	81.84	57.56	24.04	492754	180.3	34735
2013	471.9	43449.09	7.54	135590	265.07	82.10	57.90	23.15	522439	179.4	36153
2014	570.1	47447.59	6.14	145120	267.03	82.37	58.85	23.58	585672	178	36875
2015	557.9	45071.07	5.38	172010	269.15	82.63	59.42	24.98	611478	181.6	38078
2016	520.8	41146.08	4.89	171810	271.20	82.89	59.91	24.17	663616	182.5	37956
2017	593.1	40621.33	4.38	193690	273.05	83.14	60.19	25.42	632517	192.3	37330
2018	525.8	43306.31	4.08	199110	274.71	83.40	60.56	25.22	664974	199.5	37724
2019	578.4	42747.08	3.83	214160	276.26	83.65	60.86	25.03	684874	201.6	39218
2020	471.3	40318.56	4.55	169260	277.27	83.90	59.99	25.14	774854	182.1	38994
2021	689.1	46510.28	3.70	159819	279.66	84.15	59.65	25.34	784834	197.7	39328

RESULTS

During the modelling stage of research, multiple models have been built to isolate the most representative one. To choose the best variables that could influence the migration process first a multicollinearity test was performed to understand which variables could correlate with each other and thus hinder the overall results of the model. During the test, the most correlation was observed between 12 pairs (Table 2). Most of which contained the following variables: population density, urban population, employment/unemployment rate, crime rate and average income.

Table 2. Most correlated pairs.

Pair	Correlation
Employment rate / Unemployment rate	-0.904
Average income / GDP per capita	0.781
Urban population / Population density	0.998
Expenditure per student / Population density	0.907
New business / Population density	0.942
Crime / Population density	-0.880
Average income / Population density	0.745
Expenditure per student / Urban Population	0.923
New business / Urban Population	0.932
Crime / Urban Population	-0.884
Average income / Urban Population	0.776
Crime / Expenditure per student	-0.921

These data indicate that there is a strong indirect correlation between the employment rate and the unemployment rate (-0.904), crime and population density (-0.880), crime and urban population (-0.884), crime and expenditure per student (-0.921). There is also a strong direct correlation between urban population and population density (0.998), expenditure per student and population density (0.907), new business and population density (0.942), and expenditure per student and urban population (0.923).

In addition to the pairwise correlation coefficient, the variance inflation factor (VIF) was also used to determine the relationship between variables. This statistical concept provides to detect multicollinearity between independent variables in a multiple regression model. Most of the independent variables are closely intertwined with each other and other variables in the model, which would explain the correlation. Additionally, the major statistical insignificance of some of them made the process of variable elimination easier. As a labour indicator, an unemployment rate was chosen instead of the employment rate as it's more precise at representing the labour market of the country.

The final model was built using 3 variables (GDP per capita, unemployment rate, and government expenditure per student) that could affect migration flows in the UK (Table 3).

Table 3. The coefficients of the final regression model.

Variables	Coefficients	Standard Error	t Stat	P-value
Intercept	174.928008	73.07878	2.393691	0.0278
gdp_per_capita	0.006014	0.002159	2.785459	0.0122
unemp_rate	- 14.232203	6.788531	-2.096507	0.0504
exp_per_stud	7.798610	2.994629	2.604199	0.0179

According to the results of the modelling process, almost all chosen variables are statistically significant as all the p-values were less than 0.05 (Prob. Likelihood ratio for unemp_rate in Redundant Variable Test = 0.0284 less than 0.05). The model itself can be considered adequate as Prob(F-statistic) = 0.000018 less than 0.05 and the coefficient of determination is approximately equal to 0.7 (Adj. R2 = 0.695). During the analysis of potential autocorrelation in a model a Durbin-Watson statistical test was used showing results of 2.169, indicating there is no autocorrelation of first order present in the model. To check heteroskedasticity in a model a White statistical test was used. The results show that a corresponding p-value of the test statistic is 0.1966 which means that we fail to reject the null hypothesis of homoscedasticity presence in this model. This points to the fact that there is not sufficient evidence to say that heteroscedasticity is present in the final regression model. All the concludes that the final regression model is adequate and reliable (Formula 1):

$$Immigration = 174.928 + 0.006 * (GDP\ per\ capita) - 14.232 * (Unemp.\ rate) + 7.799 * (Exp.\ per\ student) + \epsilon \quad (1)$$

From the results in the final model, we can determine, using the elasticity coefficient, that the more influential factors are the GDP per capita, government expenditure per student and unemployment rate (Table 4).

Table 4. Elasticity coefficients for independent variables.

Variables	Elasticity coefficients
GDP per capita	0.4844
Government's expenditure per student	0.3275
unemployment rate	-0.1566

With the help of this model, we can forecast immigrant numbers in the UK by using projected numbers of variables used. According to the results of the calculation in the close future, the number of immigrants should subside and diminish slightly (Table 5).

Table 5. Immigrant numbers forecast until 2025.

Year	immigrants	gdp_per_capita	unemp_rate	exp_per_stud
2022	601.58	46510.4	3.66	25.52
2023	606.69	47046.14	3.62	25.69
2024	611.89	47581.87	3.58	25.87
2025	621.35	48117.61	3.24	26.05

We can compare these results to the forecast made in a report by Office for National Statistics (ONS) in the UK back in 2020. As we can see both immigration projections show an estimated downward trend in 2022 and the numbers themselves are quite close. According to the report made by the Office of National Statistics in 2022 about long-term international migration, the number of immigrants recorded in 2022 was 704 000 [32]. This additional inflow of immigrants can be partially explained by Ukrainian refugees, who fled their home country due to the war in Ukraine caused by Russian aggression (Table 6).

Table 6. Forecast comparison to Office for National Statistics (ONS) migration projections.

Year	Forecast (1000s)	ONS estimates (1000s)
2022	601.58	602.00
2023	606.69	589.00
2024	611.89	576.00
2025	621.35	563.00

As this model was not built for forecasting forced migrations and factors used in this in this model are not meant to take into account these processes, we can conclude that overall migration estimates of the model are really close to the ones presented by ONS in 2022 and show close future values with the ONS forecast, which means this model can be used to describe overall immigration flow into the country have a practical use.

DISCUSSION

To sum up, everything said above, the United Kingdom is a country with a diverse population that has been shaped by immigration over many years. Immigration has contributed to the UK's economic growth and cultural diversity, but it has also raised concerns about its impact on public services, wages, and social cohesion. The United Kingdom, like many other countries, has a complex immigration system that is designed to regulate the entry and residence of foreign nationals. Being a developed country with a lot of opportunities for possible migrants, immigration has been a hotly debated issue in the UK for many years, with different viewpoints on the benefits and drawbacks. Analyzing immigration processes is crucial for the UK and other countries as well to understand the economic, social, and legal impacts of immigration.

In this article, a regression model was built to analyze what key factors could contribute to the immigration flows of the UK as well as to make predictions of future migrant numbers to make according to financial decisions on the governmental level. Multiple articles have been reviewed, which helped to narrow the focus down to 4 main categories: economic (GDP per capita, number of new businesses registered at the end of calendar year, average income), social (population density, urbanization level, government's expenditure per student, crime rate), labour (unemployment rate, employment rate) and housing factors (new residential dwellings built).

The final model used 3 factors that help describe the immigration process in the UK. The results of the model point to the fact that immigrants are largely influenced by the economic development level of the country and by the possible opportunities in the labour market as well as the possibilities of acquiring higher education. Factors such as urbanization level, average income and a crime rate that could directly influence immigrants' comfort and living conditions don't play a significant role when choosing the UK as a migration destination. It should be noted though that a model in this article is built to analyze international immigration processes and not interregional ones. There is a plethora of literature pointing out that factors, which didn't make it to the final model, can be and have been successfully used to model migration processes, just in different scenarios, where indicators like crime rate and population density could influence which region would an immigrant choose to move into, but not significant enough to change the country of choice.

CONCLUSIONS

The forecasts made using the model in this article show the same trend as other reputable sources such as the Office for National Statistics with the preciseness that is comparable to the real result of the immigrant numbers in reports. Nonetheless, such a model does not consider hard-to-predict migration processes such as migrations forced by natural disasters or political conflicts, which could explain the variance between forecast results and real numbers. It should be noted that while the model presented in this article describes immigration processes in the UK by 82%, the intercept has high significance, which indicates that if all variables were to be dismissed, there are other processes that create immigration flows

in the UK, possibly exogenous, as this article focuses on the influence of endogenous factors only, the ones, that the country has some level of control.

In summary, analysing immigration processes is essential for any country to understand the impacts of immigration on the economy, social systems, and legal framework. Precise forecasts using such models can enable countries to make informed decisions on immigration policies that balance their economic and social interests and comply with their legal obligations, not to mention help prevent possible epidemiologic occurrences, which is especially important today.

ADDITIONAL INFORMATION

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МОДЕЛЮВАННЯ ТА ПРОГНОЗУВАННЯ ІМІГРАЦІЙНИХ ПРОЦЕСІВ У СПОЛУЧЕНОМУ КОРОЛІВСТВІ З ВИКОРИСТАННЯМ ЕНДОГЕННИХ ФАКТОРІВ (PULL FACTORS)

Дослідження сфокусоване на економетричному моделюванні імміграційних процесів у Сполученому Королівстві (Великобританії) з використанням ендогенних факторів. Стаття спрямована на вивчення впливу економічних, соціальних, житлових та інших показників на приплив іммігрантів до Великобританії. У статті використана регресійна модель, яка охоплює період із 2000 по 2021 р., для оцінки взаємозв'язків між ендогенними факторами у Великій Британії та імміграційними процесами. До ендогенних факторів (pull factors), які розглянуті в дослідженні, входять такі економічні індикатори, як: ВВП на душу населення, кількість новостворених підприємств на рік, бюджетні витрати на одного студента, середня зарплата на рік; соціальні індикатори, такі як: щільність населення, рівень урбанізації, рівень злочинності; житлові фактори, зокрема кількість новобудов; трудові фактори, зокрема безробіття та рівень зайнятості. Результати дослідження показують, що такі ключові фактори, як ВВП на душу населення, рівень безробіття, нові зареєстровані підприємства та державні витрати на одного студента, мають значний вплив на приплив іммігрантів. Навпаки, рівень злочинності, середня зарплата та показники щільності населення недостатньо впливають на міграцію іноземців до Великобританії. Висновки дослідження мають важливе значення для політиків і дослідників, зацікавлених у розумінні динаміки імміграційних процесів Великобританії. Використовуючи ключові ендогенні pull factors для створення довгострокових прогнозів, політики можуть розробити більш ефективну імміграційну політику та краще розподілити ресурси для підтримки іммігрантів і їх інтеграції в британське суспільство.

Ключові слова: імміграція, математичне моделювання, прогнозування, міграційні потоки, регресійний аналіз

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