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## THE USE OF THE GRAVITY MODEL IN FORECASTING THE FLOWS OF EMIGRANTS IN EU COUNTRIES

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**Abstract.** Migration is a complex phenomenon with economic, social, political, cultural and human implications, and therefore, it is the locus of interest for many researchers from various fields. After 1989, migration in Romania became a social issue due to the large number of migrants searching for labour all around Europe. This paper focuses on investigating and forecasting labour migration from Romania and its geographical orientation. We analysed the gravity model, which simple and accurate, focused on the distance as a determinant of the length of the mobility and, thus, of the host country chosen by the migrant. Based on the proposed macroeconomic model, we discuss results for main destinations countries, i.e. Spain, Italy, Austria, Germany, as well as for EU as a whole.

**Keywords:** labour migration, Romania, forecast, outgoing migration, EU destination countries.

**JEL classification:** J61.

### Introduction

The international migration of workers and the policies on migration applied by the authorities are major, consistent, often multidisciplinary concerns, crowning the efforts of many researchers and practitioners from various fields: economists, sociologists, demographers and political scientists, to discuss and explain the determinants and consequences of migration. Even in its legal, organized varieties (not to mention the dramatic illegal border crossings by land or sea), migration is a costly act in economic, cultural and human terms.

### 1. Labour migration – the main component of migration in Romania after 1989

Most studies agree that migration was one of the “most ubiquitous socio-economic phenomena in Romania since the fall of communism in 1989” (IOM 2008). The extent of the

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phenomenon is highlighted by the fact that, in about 20 years, between 10 and 15% of the Romanian population have fled the country, and an even higher number is involved at present in various forms of circular migration, tempered only by the global phenomenon of the economic crisis.

To provide you with a brief overview, the migration phenomenon began abruptly immediately after the Revolution of December 1989, when, by the opening of borders, an estimated 97,000 people emigrated in one year, followed by another 170,000 people over the next three years. Basically, it's a continuation of ethnic migration: during this period, the ethnic migrations bound for Germany, Hungary and Israel underwent their final phase (Diminescu 2009: 45–62; Badulescu 2007a, 2007b; Badulescu *et al.* 2015) but there was also an increase of the Romanian ethnic component in the migratory flows.

In the years that followed, the visa restrictions and the economic difficulties and political instability did not reduce migration, but gave it a temporary and circular character, the main motivation being, at least seemingly, an economic one.

The EU accession in 2007 and the subsequent international economic crisis have not changed much of this profile; they might only have caused some structural changes in the composition of flows, destinations, education level of the migrants, etc.

Labour migration, including both temporary and circular migration, is the most noticeable component of Romanian migration in recent decades and in the whole post-communist period (IOM 2005; Andrén, Roman 2014). Here, as with other economic and demographic phenomena, the official data reflecting it, when there are any, are quite inconsistent, and often indicate values different from those provided by surveys or obtained from comparative sources – such as those on the outflows – in the Romanian records, respectively on the entries – in the records of the destination countries. Some figures are relevant: in 2005, 13% of the households had an average of 1.5 members working abroad, i.e. about 1.4 million labour migrants (CURS 2005). Moreover, a survey conducted by the Open Society Foundation – Romania, on the Romanian labour migration in 1990–2006, pointed out that more than 33% of the Romanian households had had at least one migrant at work abroad during 1990–2006 period (Sandu 2006: 8). The reports of the Department for Work Abroad (within the Ministry of Labour, Family and Equal Opportunities), of 2005 and 2006, include data on the number of employment contracts concluded through government or private agencies. According to these reports, in 2005, 42,758 employment contracts were mediated by the state institutions and, in 2006, another about 61,200, most of these contracts belonging to the agriculture and construction fields, to which a further 15,000 contracts mediated by private agencies in 2006 were added.

If the data recorded present numerous variations regarding the number of Romanians having left to work abroad, with regard to the nature of their occupations abroad the data of surveys and of the official institutions are more convergent. Thus, in 2005, the professional position of Romanian labour emigrants shows a dominance of labour employed in agriculture (food production) and constructions sector, followed by employment in households, hotel services, restaurants and similar activities and so on (CURS 2005).

## 2. The gravity model – a brief overview

In the specialized literature, there are numerous approaches and models for the study of labour migration/mobility. Many of them give an explanation either of international versus internal migration or of inter-regional migration in Europe versus the rest of the world, and its role as adjustment mechanism within the European Union (Arpaia *et al.* 2014).

Among the methods of approaching labour migration, there are: the Markov chains, the Harris-Todaro models, models of the economic influence of labour mobility within Europe, models for the researchers' mobility, models for the flexible wages' influence on the labour mobility etc.

In this paper, we present the gravity model and several results of its application, more specific the results of applying a panel model for the study of Romanian migration.

The gravity model is the simplest and most suggestive macroeconomic model of migration, being centered on the relationship between distance and the inclination to travel. The most important scientist who laid the foundations of this theory is geographer Ernst Georg Ravenstein, who, in his work "Laws of Migration" of 1885 (Ravenstein 1885), promoted the idea that migration is governed by processes of the "push-pull" type, exerting either a pushing out pressure (of the *push* type), such as: adverse economic conditions, oppressive laws, high taxes, or a pulling in pressure (of the *pull* type), such as favourable conditions in foreign locations. Ravenstein's laws emphasize that the foremost motivation for migration is economic, stating that:

1. Most people migrate only for short distances and thus generate "migration streams" to large urban centres;
2. This causes dislocation processes and population growth in the sending, respectively receiving areas;
3. The processes of absorption and dispersion are interconnected;
4. The migration chain and channels develop over time;
5. The migration channels lead the population movement especially towards commercial and industrial centres;
6. Urban residents are less prone to migration than rural population;
7. Women are less probable to migrate than men.

Briefly, the gravity model of migration shows that *the number of migration events between two regions is directly proportional to the number of inhabitants in each area and inversely proportional to the square of the distance between the sending area and the receiving area*. Its mathematical expression is reflected in the following equation:

$$M_{ij} = K \frac{P_i P_j}{D_{ij}^2},$$

where:  $M_{(ij)}$  = the number of migrants leaving from location  $i$  to location  $j$ ;  $K$  = a constant;  $P_i$  = the population of location  $i$ ;  $P_j$  = the population of location  $j$ ;  $D_{(ij)}$  = the distance between the two locations.

The above formula and the laws stated find numerous empirical confirmations in the history of human migration; the gravity model thus appears as an empirical generaliza-

tion of the large migration flows in history. However, the model cannot explain why there are considerable variations in the characteristics of migrants, or the differences in volume between migratory flows that start from similar countries. For example, on basis of this model, one could have predicted that the next big wave of migration should occur between Russia, China and India, as they fulfil the conditions laid down: they are large states with large populations (especially the last two) and relatively close geographically. However, data shows that there is no significant movement between them. Another example that contradicts the universality of the model is the preference of the 19th and 20th centuries' migrants for countries with large areas, with a low population density, such as the U.S., Australia, Canada and so on, or the consistent migration flow between Pakistan and the UK in the past 50 years. In this example, the considerable distance should have significantly reduced the result according to the model, the discrepancy with the theory confirming our assumption that the migration in question had other explanations than those provided by this model.

One way to increase the explanatory force of the model would be to enrich it with the elements discussed above, such as taking into account the transport costs, the obstacles met during the movement or cultural, historical and other kinds of factors, while accepting, however, its theoretical dilution.

### **3. Literature on using the gravity model for investigating labour migration**

Many methods used in estimating international migration are based on deterministic mathematical models or different quantitative techniques, but, contrasting with the deterministic methods, the stochastic (probabilistic) instruments for the analysis and forecasting of migration are rooted in the probability theory. Stochastic models are used more frequently than the deterministic ones because they present greater possibilities for tackling the uncertainty of migration and forecasting.

Since migration theories are too fragmented, the only option in order to obtain plausible analyses and predictions on the population flows is to use methods and models both deterministic and probabilistic, which are potentially related.

Migration is considered the neoclassical economists as the result of big disparities in economic opportunities over the world, especially in revenues. In addressing the human capital of migration, Sjaastad (1962) gives up the assumption of homogeneous labour. Depending on their skill levels, individuals calculate the value of their human capital for each region or country. Each individual assesses his/her return and costs in a different way, so that migration to a country may be useful to some people and not useful to others. Therefore, in the analysis of the structure of the migration flows one should not only pay attention to the aggregate labour market variables (such as wages and the unemployment gap), but to individuals' heterogeneity as well.

Almost all empirical studies use aggregate databases in order to find a statistically significant positive effect of income or wages in the destination country, or the wage differences between the destination countries and origin countries, as well as a negative effect of the income and wages in the migrants' decision to return to their country of origin (Martin, Radu

2012; Lang et al. 2012). Several studies further investigate factors determining individuals to make the decision to migrate, such as the lack of jobs, the migrants' qualification etc.

There is no commonly-agreed precise definition of the extremely qualified and no standardized treatment of this notion in the statistics of different countries and organizations. There are, however, two evaluations, which play an important role in virtually all definitions related to high qualifications: the first refers to qualifications obtained through studies graduation (according to this parameter, those who are graduates of higher education are regarded as very highly qualified or highly qualified), the second relates to the profession in question, the quality of high qualification being identified by the type of work that the person conducts in the country of destination.

Education and training (as well as health care) are considered as key investment in the human capital formation. These will result, at a later stage, in a better labour employment that will lead to the achievement of higher revenues by the persons concerned.

They are also considered crucial to the performance levels of national economies: a higher level of education of the workforce will lead to higher economic growth and employment.

Because economic growth in today's societies and economies is at a much higher level than in the past and is driven by innovation, investment in knowledge is seen today as more important than ever.

In the case of highly skilled migrants, the destination country receives human capital as a gift. It has achieved a "brain" gain, while the origin country has suffered a "brain exodus". It should be noted that usually we speak of a "brain gain" and "brain drain" only if the number of migrants is considerable, and if the balance between highly skilled immigrants and emigrants is highly disproportionate. Situations characterized by a relative balance are instead often referred to as "brain exchange". As a result, today it is possible to quantify, more or less correctly, the stock of migrants in a given country, and the flows within a particular period. As long as these flows cannot be measured correctly, the brain gain will remain a matter of hypothesis. Therefore, some researchers argue that as long as the emigration of the highly skilled is not permanent, it would be more appropriate to speak in neutral terms of the "brain circulation", "brain mobility" or "circulation of the elites".

Also, the migration of the highly skilled does not necessarily lead to a brain gain for the country of destination. This is possible if, for example, a migrant who is a nuclear physicist cannot find a job commensurate with his training (or in a connected profession, to adequately put to use his knowledge and skills) in the destination country and becomes a taxi driver or a waiter. In this case, there is a mismatch between the skills provided by individuals and those required by the labour market, it is what the experts call a "brain loss". The literature on migration shows that such cases are not isolated.

The scarcity of literature on professional mobility served as a motivation to undertake such analyses for several decades (Shaw 1978; Harper 1995; Parrado et al. 2007), yet it remains largely reduced as compared to the literature on geographical mobility. One reason is that it is "it is very difficult to define quantitatively and measure an occupation" (Shaw 1978: 703).

The standardization of occupational classification has been established in most developed countries, but the structure and relationships of a large number of occupational classifications are not yet identified or known.

The gravity model used in economics was developed by Tinbergen (1962) to explain trade flows, Lowry (1966) and then extended by various economic variables to represent the push and pull effects on people. Anderson (2010) and Head and Mayer (2013) provide large surveys of the literature in this domain, in order to identify many important determinants such as the network effect, the role of poverty constraints, the impact of cultural links between countries (Beine *et al.* 2014; Tubadji, Nijkamp 2015).

In the classical gravity model used to analyze migration, a flow from location  $i$  to location  $j$  is considered to be proportional to the population of the countries of origin and of destination ( $P_i$  and  $P_j$  respectively) and inversely proportional to the distance between the two locations  $f(d_{ij})$ ,  $a$  being a constant related to mobility:

$$M_{ij} = a \cdot P_i \cdot P_j \cdot f(d_{ij}). \tag{1}$$

The gravity model was extended by Molho (1986) to incorporate attraction factors, and therefore regional economic variables being considered as determinants of migration:

$$M_{ij} = a \cdot P_i \cdot P_j \cdot f(d_{ij}) \times A_i B_j, \tag{2}$$

where:  $A_i$  is the “pushing” factor in the country of origin and  $B_j$  is the “pulling” factor of the host country.

Shuming Bao *et al.* (2008) developed specific versions of the model, which were used in the approach of inter-provincial migration. This model includes provincial investment and of the control of migrant networks, and of other various controls exerted on the characteristics of the province. The logarithm of the gross rate of inter-provincial emigration ( $\log(M_{ij})$ ), calculated as the volume of emigration from province  $i$  to province  $j$  divided by the total inter-provincial migration in province  $i$ , is considered as the dependent variable:

$$\begin{aligned} \log M_{ij} = & \alpha_0 + \alpha_1 \log D_{ij} + \alpha_2 \log NETWORK + \alpha_3 \log FDI_{ji} + \alpha_4 \log FAI_{ji} + \\ & \alpha_5 (ogFDI_{ji})(\log FAI_{ji}) + \alpha_6 \log Y_{ji} + \alpha_7 \log E_i + \alpha_8 \log E_j + \alpha_9 \log U_i + \\ & \alpha_{10} \log U_j + \alpha_{11} \log MANEMP_{ji} + \alpha_{12} \log URBAN_{ji} + \\ & \alpha_{13} \log MINORITY_{ji} + \alpha_{14} \log WARM_{ji} + \varepsilon_{ij}. \end{aligned} \tag{3}$$

In the model  $D_{ij}$  denotes the distance by rail (in km) between the capitals of provinces  $i$  and  $j$ ;  $NETWORK$  denotes the rate of past migration flows between the two provinces;  $FDI_{ji}$ ,  $FAI_{ji}$  and  $Y_{ji}$  denote, respectively, the ratio between respectively the size of foreign direct investment per capita, the real domestic investment in fixed assets per capita, and real income per capita for the province  $j$  and for the province  $i$ ;  $E$  and  $U$  denotes the relative level of education respectively of unemployment rate in the two provinces  $i$  and  $j$ ;  $MANEMP_{ji}$  is the ratio between the share of employment in the manufacturing sector in province  $j$  and the share of employment in the manufacturing sector in province  $i$ ;  $URBAN_{ji}$  and  $MINORITY_{ji}$  are the ratio between, respectively, the share of urban population respec-

tively of minority population in the two provinces;  $WARM_{ji}$  is the ratio between the annual average temperature in the capital city of the two provinces;  $\varepsilon_{ij}$  = the error term.

Cseres-Gergely (2004) proposes an analysis of internal migration in Hungary during the period 1994–2002. In his approach, the author starts from the basic gravity model:

$$m_{ij} = g \frac{P_i^{\beta'} \cdot P_j^{\beta''}}{d_{ij}^\gamma}, \tag{4}$$

where:  $m_{ij}$  is the flow of migrants from region/country  $i$  to region/country  $j$ ;  $P_i$  and  $P_j$  are “the size of the migration flows”;  $d_{ij}$  the distance between region/country  $i$  and region/country  $j$ .

Although Newton’s theory restricted the parameters  $\beta' = \beta'' = 1$ , in terms of migration they can be assumed to be different from unity.

By logarithming this relation, we obtain the following linearized equation (Lowry extended it by adding economic variables as generalizations of  $P_i$  and  $P_j$ ):

$$\ln m_{ij} = \alpha + \beta' \ln P_i + \beta'' \ln P_j - \gamma \ln d_{ij}. \tag{5}$$

Although venerable, in the present juncture, when the data at micro-level are very detailed, this model is considered as outdated by many researchers. However, it is still used in cases where such data are not available. Because migration data are available at global scale, the gravity model seems to be a natural candidate.

Over time, different versions of the original gravity model were developed, in order to better describe the evolution of the economic phenomenon considered.

The introduction of the chain notion in the variant of the random utility model by McFadden (1973), where the decisive factor for those who live in location  $i$  to choose a place to live in location  $j$ , with  $j = 1, J$  possibilities, was based on the expected utility of living in a particular place over a period of time (see Schultz 1977). The utility deriving from such a movement can be written as  $U_{ij}^n(Y_j, A_j, C_{i,j}, \mu_j^n)$ , where  $Y_j$  means income in location  $j$ ,  $A_j$  are amenities in  $j$ ,  $C_{j,i}$  are the costs of moving from location  $i$  to and  $\mu_j^n$  is the individual random earning.  $P_{ij}$ , the probability of moving from region  $j$  to region  $i$  is:

$$P_{ij} = \Pr[U_{ij} = \max(U_{i1}, U_{i2}, \dots, U_{ij})]. \tag{6}$$

McFadden’s result shows that if  $U_{ij}$  is linear in the logarithms of arguments and the logarithm of the original stochastic perturbation is independent and identical to the Weibull distribution, then the probability of moving from one place to another is given by the relation:

$$P_{ij} = \frac{\exp(U_{ij})}{\sum_{k=1}^J \exp(U_{ik})} = \frac{\exp(\alpha_1 \ln A_j + \alpha_2 \ln Y_j + \alpha_{31} \ln C_{ij})}{\sum_{k=1}^J \exp(\alpha_1 \ln A_k + \alpha_2 \ln Y_k + \alpha_{31} \ln C_{ik})}. \tag{7}$$

The probability of moving from  $i$  to  $j$ , as compared to that of staying in  $i$ , a linear function depending on the differences between local characteristics:

$$\ln \left( \frac{P_{ij}}{P_{ii}} \right) = \alpha_1 (\ln A_i - \ln A_j) + \alpha_2 (\ln Y_i - \ln Y_j) + \alpha_3 C_{ij}. \tag{8}$$

To estimate the proposed model, the author used data on inter-county migration because: i) there are no individual survey-level data that could be used to reliably estimate migration, ii) there are studies on wages and employment at the county level, therefore, the estimation of stimulation variables can be accurate in this case, iii) although the data on flows between NUTS 3 micro-regions are collected by the respective authority, such data are not disclosed to the public for confidentiality reasons.

In Hungary there are 20 counties (NUTS 2), with an average population of about 500,000 inhabitants (except Budapest, a city with a population of about 2 million people with atypical concentration and a high level of economic activity). The data analysed were national official statistical data and specific databases providing annual data for the period 1990–2002 regarding the settings, which can be aggregated at county level. Studies on wages carried out by the National Centre for Labour provided annual data on wages in firms with less than 11 employees since 1994, and quarterly data since 1993 for the employment of at least 80,000 people. Each variable was logarithmic, which excluded the possibility of zero migration from one region to another. To avoid this inconvenience, Poisson regressions were used to estimate the migration flows.

The explanatory variables are the following: gravitational variables (population and distance), variables related to the labour market, to the related housing market, as well as other indicators on the given county amenities.

On the basis of the evidence and methods presented in Köllö (2004) and Nagy (2004), the author calculated an additional set of variables related to conditions in the labour market, the level of education, potential experience (assumed from education), the local unemployment rate.

Also, a regional price index was introduced in the analysis of migration. Local amenities were represented by various factors, including the number of physicians per capita, of pediatricians, the number of tourists visiting the county (equivalent to a “commodity”), the number of criminal offences and suicides.

On basis of the available data, the author used in the study of inter-county migration in Hungary a regression in a rather general form:

$$\ln M_{ijt} = \beta_0 \ln M_{ijt} + \beta_1 \ln A_{it} + \gamma_1 A_{jt} + \beta_2 \ln Y_{it} + \gamma_2 Y_{jt} + \beta_3 \ln C_{ijt} + g_t + f_{ij} + \varepsilon_{ijt}, \quad (9)$$

where, in addition to the variables already mentioned,  $g_t$  appears as a time effect variable, and  $f_{ij}$  for specific effects.

#### 4. Study on Romanian emigration's evolution by using the gravity model

For study the emigration in Romania an adaptable regression model based on the popular gravity model of migration was used, as available data provided by EUROSTAT (2016), TEMPO-Online (2016), World DataBank (2016), the Organisation for Economic Co-Operation and Development, the French Centre d'Etudes Prospectives et d'Informations Internationales (CEPII Research and Expertise on the World Economy 2011), are not comprehensive with regard to all exogenous variables in the gravity model. Therefore, we made an analysis of Romanian migration flows only to certain EU countries and at EU-27 level for the period 1995–2014.



The exogenous variables considered are: the GDP of each country  $i$  considered; the employment rate in industry for each country  $i$ ; the unemployment rate for each country  $i$ ; the volume of the *Foreign direct investment* (FDI) in each country  $i$ ; the distance between Romania and the destinations of Romanian emigrants was calculated from the cities' longitude and latitude using the great circle formula (Mayer, Zignago 2011).

The model of the Romanian emigration to **Spain** is presented in Table 1.

The degree of dependence of the endogenous variable on all independent variables, which is of 86.19%, indicates that the latter have a significant impact on the size of the Romanian migration to Spain. We used the *variable Student*  $t_{v,\alpha}$ , retrieved from the *Student* distribution table. For a significance level of 5%, its value is 1.725.

The analysis of the values calculated for each of the estimators determined indicates that for all,  $t\text{-Statistic} > 1.725$ , so they are significantly different from zero. The probabilities of each estimator indicate that they are acceptable for the model considered.

The value of Durbin Watson statistic is 2.94, which indicates that there is no autocorrelation of errors.

The  $F$  test shows a value of 2.44, inferior to the  $F$  distribution (Fisher-Snedecor) corresponding to the 8 degrees of freedom (10.70) and the significance threshold of 5%. Therefore, the model is valid for use in the prognosis.

Table 1

Dependent Variable: EMIGRSPAIN				
Method: Least Squares				
Sample: 1995 2014				
Included observations: 20				
EMIGRSPAIN=C(1)+C(2)*GDPSP+C(3)*GDPRO+C(4)*RSSP+C(5)*RSRO+C(6)*EMPINDSP/EMPINDRO)+C(7)*(FDIRO/FDISP)+C(8)*DISTANCE				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1787623.	571124.4	3.130006	0.0087
C(2)	2.972444	1.469810	2.022332	0.0660
C(3)	-0.388797	0.215702	-1.802472	0.0966
C(4)	-8852.752	3183.593	-2.780743	0.0166
C(5)	54831.72	25617.79	2.140376	0.0536
C(6)	360349.6	180491.6	1.996489	0.0691
C(7)	-1691.968	837.2175	-2.020942	0.0662
C(8)	-55953.32	24326.22	-2.300124	0.0402
R-squared	0.861960	Mean dependent var		48799.85
Adjusted R-squared	0.781437	S.D. dependent var		51565.89
S.E. of regression	24107.41	Akaike info criterion		23.30760
Sum squared resid	6.97E+09	Schwarz criterion		23.70589
Log likelihood	-225.0760	Hannan-Quinn criter.		23.38535
F-statistic	10.70451	Durbin-Watson stat		2.940060
Prob(F-statistic)	0.000252			

For **Italy**, the actual data on the number of Romanian emigrants are available in several studies such as Alexandru (2011), or Mara (2012). In Table 2 there are presented the results of using the gravity model to study the Romanian migration.

The dependence of Romanian migration on all independent variables is of 76.05%, which indicates that other exogenous variables are needed. This can be explained by the fact that the model should include other exogenous variables, possibly qualitative ones (e.g. family reunification, return to the place of origin, etc.), which are not available in the official statistics.

The calculated values indicates that only for some of the estimators  $t_{calc} > 1.725$ , the others presenting values of less than 1.725, but the vast majority of more than 1. The Durbin-Watson statistic shows the value 2.66, which indicates there is no autocorrelation of errors.

For **Austria**, it was possible to apply the gravity model in order to study Romanian emigration with a large number of exogenous variables. The analysis of the results presented in Table 3 shows that the explaining of Romanian emigration by means of the 7 exogenous variables is achieved in a proportion of 98% and the Durbin-Watson statistic (2.31) reveals that there is no autocorrelation of errors.

The *t-Student* statistic calculated for each estimator (except the seventh estimators) is much greater than the tabular value  $t = 1.725$ , which indicates that they are significantly different from zero.

Table 2

Dependent Variable: EMIGRITALY				
Method: Least Squares				
Sample: 1995 2014				
Included observations: 19 after adjustments				
EMIGRITALY=C(1)+C(2)*GDPRO+C(3)*GDPIT+C(4)*RSRO(-1)+C(5)*RSIT(-1)+C(6)*(INDIT/INDRO)+C(7)*(FDIRO/FDIIT)+C(8)*DISTINCE				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1895044.	955788.1	1.982703	0.0729
C(2)	-0.578814	0.284646	-2.033453	0.0669
C(3)	3.825179	1.441993	2.652703	0.0225
C(4)	33127.73	25289.00	1.309966	0.2169
C(5)	-30221.82	9886.174	-3.056978	0.0109
C(6)	18565.00	310055.1	0.059876	0.9533
C(7)	-499.6557	1499.883	-0.333130	0.7453
C(8)	-211076.7	153150.7	-1.378229	0.1955
R-squared	0.760521	Mean dependent var		64994.47
Adjusted R-squared	0.608125	S.D. dependent var		66489.37
S.E. of regression	41622.32	Akaike info criterion		24.40622
Sum squared resid	1.91E+10	Schwarz criterion		24.80388
Log likelihood	-223.8591	Hannan-Quinn criter.		24.47352
F-statistic	4.990423	Durbin-Watson stat		2.666324
Prob(F-statistic)	0.009250			

Table 3

Dependent Variable: EMIGRAUSTRIA				
Method: Least Squares				
Sample: 1995 2013				
Included observations: 18 after adjustments				
EMIGRAUSTRIA =C(1)+C(2)*GDPAUT+C(3)*GDPRO+C(4)*RSAUT+C(5)*RSRO(-1)+C(6)*(INDAUT/INDRO)(-1)+C(7)*(FDIRO/FDIAUT)(-1)+C(8)*DISTANCE				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-131149.1	17220.54	-7.615853	0.0000
C(2)	0.042282	0.022177	1.906564	0.0857
C(3)	-0.049752	0.020171	-2.466505	0.0333
C(4)	-1141.416	509.0095	-2.242425	0.0488
C(5)	940.7682	464.4897	2.025380	0.0703
C(6)	12621.92	3985.705	3.166796	0.0100
C(7)	162.5646	111.4776	1.458272	0.1754
C(8)	-7682.701	1252.710	-6.132863	0.0001
R-squared	0.986691	Mean dependent var		6411.444
Adjusted R-squared	0.977374	S.D. dependent var		4378.068
S.E. of regression	658.5413	Akaike info criterion		16.11903
Sum squared resid	4336767	Schwarz criterion		16.51475
Log likelihood	-137.0713	Hannan-Quinn criter.		16.17360
F-statistic	105.9085	Durbin-Watson stat		2.313933
Prob(F-statistic)	0.000000			

Romanian migration flows to **Germany** were more consistent in the early part of the last decade of the last century. The application of the gravity model for the proposed study, using the same variables as for the other countries, led to a high determination coefficient: 0.98, *t-Student* statistic values greater than the table values (1.725) for most estimators (Table 4) and the Durbin-Watson statistic (2.36) reveals that there is no autocorrelation of errors.

If we consider the total number of Romanian emigrants to countries of the European Union, then the application of the model results in the following estimators (see Table 5).

The influence of the exogenous variables is in a proportion of 89.67%, at a confidence level of 5% (Table 5).

The calculated values of the *variable Student*  $t_{v,\alpha}$ , for almost all estimators are higher than 1.725, indicating that the model estimators are significantly different than zero.

The Durbin-Watson statistic shows a value of 2.84, and therefore there is no autocorrelation of errors.

The *F* test shows a value of 17.36, inferior to the *F* distribution (Fisher-Snedecor) corresponding to the 7 degrees of freedom and the significance threshold of 5% ( $F_{tab} = 2.51$ ). Therefore, the law of the evolution of migrants is stable over time, and the model, with all its drawbacks, can be used to achieve the forecast.

Panel data models consist in estimating regression equations that use series which are simultaneously time series and cross-sectional data.

Table 4

Dependent Variable: EMIGRGERMANY  
 Method: Least Squares  
 Sample: 1995 2014  
 Included observations: 18 after adjustments  
 $EMIGRGERMANY = C(1) + C(2) * GDPGERM + C(3) * GDPRO + C(4) * RSGERM(-2) + C(5) * RSRO + C(6) * (INDG/INDR) + C(7) * (FDIR/FDIG) + C(8) * DISTANCE$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-519772.2	269590.5	-1.928006	0.0827
C(2)	0.317185	0.055574	5.707416	0.0002
C(3)	-0.982996	0.435408	-2.257645	0.0476
C(4)	-6408.598	3748.713	-1.709546	0.1181
C(5)	16337.52	6851.697	2.384449	0.0383
C(6)	132935.2	57645.46	2.306083	0.0438
C(7)	-168.7857	72.64995	-2.323273	0.0425
C(8)	-11678.94	49648.32	-0.235233	0.8188
R-squared	0.983165	Mean dependent var		54699.00
Adjusted R-squared	0.971381	S.D. dependent var		50792.06
S.E. of regression	8592.575	Akaike info criterion		21.25629
Sum squared resid	7.38E+08	Schwarz criterion		21.65201
Log likelihood	-183.3066	Hannan-Quinn criter.		21.31085
F-statistic	83.43004	Durbin-Watson stat		2.364041
Prob(F-statistic)	0.000000			

Table 5

Dependent Variable: EMIGRUE  
 Method: Least Squares  
 Date: 11/03/16 Time: 21:17  
 Sample (adjusted): 1996 2014  
 Included observations: 19 after adjustments  
 $EMIGRUE = C(1) + C(2) * GDPRO(-1) + C(3) * GDPUE + C(4) * (INDUE/INDRO) + C(5) * RSRO + C(6) * RSUE + C(7) * FDIRO$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-430222.3	338209.9	-1.272057	0.2275
C(2)	-2.891119	1.415521	-2.042442	0.0637
C(3)	0.085065	0.030274	2.809853	0.0158
C(4)	907825.7	402697.0	2.254364	0.0437
C(5)	116733.3	42656.23	2.736605	0.0180
C(6)	-36173.73	19053.69	-1.898515	0.0819
C(7)	-18.36486	9.817239	-1.870674	0.0860
R-squared	0.896713	Mean dependent var		201074.8
Adjusted R-squared	0.845070	S.D. dependent var		138193.0
S.E. of regression	54394.41	Akaike info criterion		24.92322
Sum squared resid	3.55E+10	Schwarz criterion		25.27117
Log likelihood	-229.7706	Hannan-Quinn criter.		24.98211
F-statistic	17.36355	Durbin-Watson stat		2.846277
Prob(F-statistic)	0.000028			

With this type of model, we can determine the coefficient expressing the impact of a macroeconomic variable on the performance of a group of other indicators.

Panel data models allow:

- summarizing by a single coefficient the impact of a variable on a group of time-series dependent variables;
- estimating specific coefficients (constants or coefficients of independent variables) for each time-series considered as a dependent variable – fixed effects;
- grouping dependent variables in categories and estimating the impact of the category the dependent variable is part of on its evolution.

The impact of macroeconomic indicators on the evolution of the number of Romanian emigrants to the EU-27 was also estimated by means of the *panel data methodology using the Eviews program*, and resulted in a sample of 100 observations (Table 6).

Table 6

Dependent Variable: LOG(EMIGRUE)				
Method: Pooled Least Squares				
Sample: 1995 2014				
Total panel observations: 100				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(GDPRO)	-1.327311	0.146855	-9.038228	0.0000
LOG(INDRO)	-2.722180	1.371101	-1.985396	0.0657
LOG(RSRO)	2.575669	0.579232	4.446699	0.0005
LOG(FDIRO)	-0.129272	0.096142	-1.344594	0.1987
C	-18.33028	5.189450	-3.532220	0.0030
R-squared	0.953992	Mean dependent var		11.79941
Adjusted R-squared	0.941723	S.D. dependent var		1.000810
S.E. of regression	0.241602	Akaike info criterion		0.209264
Sum squared resid	0.875569	Schwarz criterion		0.458197
Log likelihood	2.907361	Hannan-Quinn criter.		0.257858
F-statistic	77.75744	Durbin-Watson stat		2.336419

The analysis of the model estimators' values indicates that, with the growth of the Romanian GDP, the employment rate in industry, and of the foreign direct investment, the number of emigrants has declined. The rise of unemployment by 1 percent leads to an increase in the number of emigrants by 2.57 persons.

To conclude, the use of this model to estimate the number of Romanian emigrants is econometrically significant. These estimates, however, can be improved if longer and more detailed data series would be available.

Panel data models can be used to increase the number of observations for a global analysis of the studied phenomenon and to make a comparative analysis of the results obtained on the endogenous variable.

## Conclusions

For the study of migration, using the gravity model for estimating the number of (Romanian) emigrants can generate interesting results.

Some studies highlight the fact that individuals calculate the value of their human capital for each region or country and each individual assesses his/her return and costs in different manners, so that migration to a country may be useful to some people and not useful to others. Therefore, when analysing the migration flows, one should not only pay attention to the aggregate labour market variables (such as wages and the unemployment gap), but to individuals' heterogeneity as well.

Other empirical studies use aggregate databases in order to find a statistically significant positive effect of income in the host country, or the wage differences between the destination countries and origin countries, as well as a negative effect of the wages in the migrants' decision to return back home. Thus, it has been demonstrated that individuals are attracted to areas with jobs deficit, but also issues such as professional status and education are considered as major factors affecting the overall impact of migration.

For the study of emigration in Romania we used a simplified gravity model, due to the limited access or incomplete statistical data provided by the EUROSTAT (2016), TEMPO-Online (2016), World DataBank (2016), OECD.Stat (2016), the French Centre d'Etudes Prospectives et d'Informations Internationales (CEPII Research and Expertise on the World Economy 2011), which are not comprehensive with regard to all exogenous variables in the gravity model. Therefore, we made an analysis of Romanian migration flows only to certain EU countries and at EU-27 level for the period 1995–2014.

In the model, there were considered as exogenous variables the followings: the GDP of the destination country, the employment rate in industry and the unemployment rate also in the destination countries, the volume of the *Foreign direct investment* (FDI) in each destination country  $i$ , and the distance between Romania and analysed destination countries for Romanian emigrants, which was calculated using the great circle formula (Mayer, Zignago 2011).

In the description of Romanian emigration to Spain, the degree of dependence of 86.19%, indicates a significant impact on the size of the Romanian migration to Spain.

For Italy, the results indicate a dependence of Romanian migration of 76.05%, which indicates the need for the use of other exogenous variables. This can be explained by the fact that the model should include other exogenous variables, possibly qualitative ones (e.g. family reunification, return to the place of origin, etc.), which are not available in the official statistics.

For Austria, it was possible to apply the gravity model in order to study Romanian emigration with a large number of exogenous variables. The analysis of the results shows that the explaining of Romanian emigration by means of the 7 exogenous variables is achieved in a proportion of 98.66% and the Durbin-Watson statistic reveals that there is no autocorrelation of errors.

Romanian migration flows to Germany were more consistent in the early part of the last decade of the last century. The application of the gravity model for the proposed study, using the same variables as for the other countries, led to a high determination coefficient: 0.98, *t-Student* statistic values greater than the table values for most estimators (Table 4) and the Durbin-Watson statistic (2.36) reveals that there is no autocorrelation of errors

Panel data models consist in estimating regression equations using series which are simultaneously time series and cross-sectional data.

With this type of model, we can determine the coefficient expressing the impact of a macroeconomic variable on the performance of a group of other indicators.

The impact of macroeconomic indicators on the evolution of the number of Romanian emigrants to European Union was also estimated by means of the *panel data methodology using the Eviews program*.

The analysis indicates that, with the growth of the Romanian GDP, the employment rate in industry, and of the foreign direct investment, the number of emigrants has declined. The rise of unemployment by 1 percent generate a growth of 2.57 emigrants.

Several ways to improve the estimation would include further analysis, using more data, especially longer data series, more detailed information on the number of Romanian emigrants, introducing other exogenous variables, introducing more qualitative variables and reconsidering some of them etc.

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