DYNAMIC ECONOMETRIC MODELS
Vol. 12 (2012) 111–122

Submitted October 25, 2012
Accepted December 20, 2012

ISSN
1234-3862

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The Analysis of Interregional Migrations in Poland in the Period 2004–2010 Using Panel Gravity Model

A b s t r a c t. The paper discusses the problem of migration in spatial and temporal perspective. The objective is to evaluate the intensity and direction of selected economic variables impact on the volume of interregional migration flows in Poland in the period 2004–2010. The analysis was performed using panel gravity model with fixed effects. The socio-economic situation and especially the level of salaries determine migration directions in Poland. Significant movements keep occurring between economically stronger regions. They indicate tendencies towards obtaining positive net migration.

K e y w o r d s: interregional migration, panel gravity model.

J E L Classification: C23, C32, J61, R11, R15

Introduction

Migrations represent an integral part underlying the functioning of societies and economies. In the times of market economy internal migrations, which occur within the territory of a given country, are of particular importance. They regulate both, the size and structure of human resources as well as job market situation and the consumption of goods and services, etc. Therefore they are of not just demographic dimension but also of economic one and have significant impact on regional development. In spite of the above, Polish population is characterized by a relatively low territorial mobility, in particular with reference

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to long distance migrations. For this reason it is of crucial importance to research conditions responsible for interregional migration flows.

In terms of relatively stable political and cultural terms, the strongest determinants of migration processes in Poland are represented by economic and social motives, among others, the tendency towards improving the living conditions and standard. Their origin is, to a great extent, influenced by socio-economic situation in a given region, owing to a significant level of regional level diversification in Poland.

Migrations represent a specific phenomenon, characterized by flows, since they occur in a territorial space. Migration flows occur between two territorial units. Therefore their conditions should be analyzed in the context of pushing and pulling factors influencing population migrations, as well as consider geographic distance. Such approach to the discussed phenomenon is possible once gravity model is applied. Questions related to gravity model implementation were discussed, among others, in the economic studies by: Tinbergen (1962), Chojnicki (1966), Anderson (1979), Grabiński et al., (1988), Sen, Smith (1995); Frankel, Stein, Wei (1995), Helliwell (1997), Egger (2002), Baltagi, Egger, Pfaffermayr (2003), Anderson, van Wincoop (2004), Roy (2004); Serlenga, Shin (2007), Faustino, Leitão (2008), LeSage, Pace (2009), Kabir, Salim (2010).

Migrations are, at the same time, characterized by long-term processes which take many years to be carried out. Their analysis in spatial perspective exclusively, e.g. covering just one year, does not allow for an overall evaluation of the occurred phenomenon. In such a situation one of the solutions is to apply an aggregated size of migration flows in relation to a given period. This approach, however, does not allow for the description of changes taking place in a given time. In such circumstances the best solution seems to use a panel model which facilitates the analysis of the studied phenomenon regarding its cross-sectional and temporal aspects. Additionally, it allows for considering individual effects with regard to territorial units covered by the study, as well as time effects referring to the years under analysis. Therefore it facilitates data heterogeneity presentation which could not be accounted for by explanatory variables in the model.

The paper discusses the proposal of an approach to be applied in modelling phenomena characterized by flows and analyzed in spatial and temporal perspective. Such standpoint is based on the construction of a panel gravity model. The purpose of the paper is to apply this approach in the estimation of both intensity and directions, regarding the impact of economic aspects illustrating socio-economic situation in the regions, on the size of interregional migration flows in Poland in the period 2004–2010[1].

[1] "A region" in the investigation is interpreted as "a voivodship" which is a unit of territorial division in Poland (NUTS 2). Interregional migrations means migration flows between voivodships.

The size of migrations, based on the previous and current permanent residence, was accepted as a dependant variable. The set of explanatory variables included indicators responsible for the size of GDP, value of investment outlays, level of earnings and unemployment rate. The role of geographical distance was also considered. Due to the fact that the intensity of internal migrations in Poland is, to a great extent, influenced by economic prosperity, the study distinguishes two time spans, i.e. 2004–2007 and 2008–2010. Such solution allowed for determining economic prosperity impact on potential reasons underlying interregional migrations.

Panel gravity model with fixed effects was constructed in order to measure the researched interdependencies. Both, individual and temporal, effects were analyzed. Haussman-Taylor estimator was used to estimate of the structural parameters of the model.

Three research hypotheses were put forward within the framework of the carried out objective. The first assumes that economic factors, defining regional socio-economic situation, represent the determinants of interregional migration directions in Poland. Following the second hypothesis, during economic downturn in Poland (in the period 2008–2010) the influence of analyzed factors on the level of interregional migration movements was smaller against the previous period of prosperity (2004–2007). In line with the third hypothesis it was assumed that regions featuring a relatively favourable socio-economic situation present a positive net migration.

The first part of the paper discusses the construction of panel gravity model with fixed effects. The second focuses on the analysis scope and the considered model specifications. The final part presents the results of conducted research.

1. The Construction of Panel Gravity Model

Gravity models describe relations occurring between the size of flows in relation to a given category (e.g. economic) in territorial space – from the origin region to a destination one – and explanatory variables characteristic for both regions. The influence of explanatory variables on a dependent variable is considered in the context of push factors influencing flows from origin regions and pull factors attracting migrations to destination regions. Additionally, gravity models allow for considering the role of a distance (e.g. geographical, temporal) between regional units (see Chojnicki, 1966; Grabiński et al., 1988; Sen, Smith, 1995). The dissemination of gravity models in economic studies resulted from research results published by Tinbergen, who applied gravity model in international trade studies (see Tinbergen, 1962).

The typical gravity model formula (following logarithmic linearization[2]) takes the below form (see Sen, Smith, 1996; LeSage, Pace, 2009)

[2] All variables are expressed in natural logarithms.

$$\mathbf{Y} = \beta_0 + \mathbf{X}_o\beta_o + \mathbf{X}_d\beta_d - \gamma\mathbf{d} + \boldsymbol{\varepsilon}, \tag{1}$$

where:

$\mathbf{Y}$ – vector of flow values between regions,

$\mathbf{X}_o$, $\mathbf{X}_d$ – vectors of explanatory variable values respectively for origin and destination regions,

$\mathbf{d}$ – vector representing distance between each pair of regions,

β_0 – constant,

β_o, β_d, γ –structural parameters of the model,

$\boldsymbol{\varepsilon}$ – vector of random component.

Cross-sectional (spatial) and temporal data analysis applies panel models among which fixed effects models, the so called FE models, are responsible for macroeconomic phenomena. Panel models present a major advantage over standard cross-sectional ones owing to their possibility of taking temporal changes into consideration. Additionally, distinguishing individual and time effects from the fixed ones allows for data heterogeneity description, which is not accounted for by explanatory variables (see Baltagi, 2005).

In case when the research object is represented by a migration phenomenon analyzed not only in spatial, but also temporal perspective, the authors suggest to construct a panel gravity model with fixed effects which may take the form of the formula below:

$$\mathbf{Y}_{[it]} = \boldsymbol{\alpha}_{[i]} + \boldsymbol{\alpha}_{[t]} + \mathbf{X}_{[ito]}\boldsymbol{\beta}_o + \mathbf{X}_{[itd]}\boldsymbol{\beta}_d + \mathbf{Z}\boldsymbol{\gamma} + \boldsymbol{\varepsilon}, \tag{2}$$

where:

$\mathbf{Y}_{[it]}$ – vector of flow values between regions (i=1,2,...,N, i – object's number[3], t=1,2,...,T – number of time period),

$\mathbf{X}_{[ito]}, \mathbf{X}_{[itd]}$ – matrixes of explanatory variables values respectively for origin and destination regions,

$\mathbf{Z}$ – matrix covering variables fixed in time, including distance between regions,

$\boldsymbol{\alpha}_{[i]}$ – vector of individual effects,

$\boldsymbol{\alpha}_{[t]}$ – vector of time effects,

$\boldsymbol{\beta}_o$, $\boldsymbol{\beta}_d$, $\boldsymbol{\gamma}$ – vectors of structural parameters of the model,

$\boldsymbol{\varepsilon}$ – vector of the random component.

[3] In case of panel gravity models, which analyze interregional migration flows, a pair of regions represents an object (unit). For n analyzed regions n^2 objects are included in the study, i.e. pairs of regions between which migrations are observed.

2. Modelling of Interregional Migrations in Poland

The purpose of the study is to identify both the intensity and direction of the selected economic categories' influence, which to some extent serve as an illustration of socio-economic situation, on interregional migration movements in Poland in the years 2004–2010.

Within the analyzed period of time two sub-periods were distinguished. The first refers to the years 2004–2007, right after Polish accession to the European Union structures, representing the period of Polish economy prosperity. These years were characterized by the significant intensity of domestic migrations. The second time span covers the years 2008–2010 and is analyzed in the context of global financial and economic crisis also experienced by Polish economy. This period featured economic downturn and lower intensity, as well as stability, in migration flows within the country borders.

Panel gravity model with fixed effects, represented by the formula (2), was applied for the description of spatial-temporal migration aspects. The size of migration flows between regions was adopted as the dependant variable[4]. On the other hand, the selected economic indicators were accepted as explanatory variables, i.e. GDP per capita, the size of investment per resident, average monthly salary before tax and the registered unemployment rate.

Separate models were constructed for both time periods. Due to the strong statistical correlation of explanatory variables[5] the panel gravity models were performed separately for every analyzed economic variable[6]. Additionally, in case of each model the impact of geographical distance on the size of migration movements was examined[7]. Table 1 presents variables included in the study.

The model assumes the possibility of individual effects occurrence for each analyzed pair of regions, as well as time effects for particular years[8]. Three model specifications were considered and represented by formulas (3–5), i.e. panel gravity model FE:

- with both individual and time effects (formula 3),
- with individual effects only (formula 4),
- with time effects only (formula 5).

[4] The analyzed migration flows require their origin region *i* and their destination region *j* to be specified. Each pair of regions is included in the panel twice to model the size of migration flows in both directions. The study does not cover internal regional migration flows.

[5] Distinguishing two periods of time did not influence, to a large extent, the decrease of statistical correlation level between explanatory variables.

[6] It has to be considered that the regressions obtained represent gross regressions and apart from the effect of explanatory variables adopted in the model they also reflect impacts of variables correlated with them.

[7] Geographical distance between regional (voivodship) centroids was analyzed.

[8] In case of the analyzed panel data a pair of regions represents a unit (240 pairs of regions), between which migration flows occur, while the time span is one year (2004, 2005,...,2010).

Table 1. Variables included in the analysis of interregional migrations

Variable	Definition	Accepted measure unit
Migrations	Size of interregional migration flows (permanent residence) according to previous and current residence address	person
GDP	Gross Domestic Product *per capita*	1000 PLN per person
Investments	Investment outlays in enterprises per resident	1000 PLN per person
Salaries	Average gross monthly salary in national economy	100 PLN
Unemployment	Registered unemployment rate	%
Distance	Geographical distance (distance between regional centroids)	km

The estimation stage, during panel gravity models application, is a problematic one. While analyzing the effect of distance on the size of migrations it has to be considered that this variable is fixed in time. The presence of such variable, or a set of variables fixed in time, excludes the ordinary estimation of FE model parameters with individual effects due to the occurring collinearity. The solution to the problem is the application of Hausman-Taylor estimator since it allows for estimations of all model parameters (see Hausman, Taylor, 1981).

Four separate models, referring to a selected explanatory variable[9], were defined for each model specification and two analyzed time periods. In case of one explanatory variable and fixed in time distance between regions, panel gravity model represented by formula (2), depending on selected effects, is reduced to the following form:

$$\mathbf{Y}_{[it]} = \boldsymbol{\alpha}_{[i]} + \boldsymbol{\alpha}_{[t]} + \beta_0 \mathbf{X}_{[ito]} + \beta_d \mathbf{X}_{[itd]} + \gamma \mathbf{d} + \boldsymbol{\varepsilon}, \tag{3}$$

$$\mathbf{Y}_{[it]} = \boldsymbol{\alpha}_{[i]} + \beta_0 \mathbf{X}_{[ito]} + \beta_d \mathbf{X}_{[itd]} + \gamma \mathbf{d} + \boldsymbol{\varepsilon}, \tag{4}$$

$$\mathbf{Y}_{[it]} = \boldsymbol{\alpha}_{[t]} + \beta_0 \mathbf{X}_{[ito]} + \beta_d \mathbf{X}_{[itd]} + \gamma \mathbf{d} + \boldsymbol{\varepsilon}, \tag{5}$$

where:

$\mathbf{Y}_{[it]}$ – vector of flow values between regions (i=1,2,...,N, i – object's number, t=1,2,...,T – number of time period),

$\mathbf{X}_{[ito]}, \mathbf{X}_{[itd]}$ – vectors of explanatory variable values respectively for origin and destination regions,

$\boldsymbol{\alpha}_{[i]}$, $\boldsymbol{\alpha}_{[t]}$ – vectors of individual and time effects,

$\mathbf{d}$ – vector representing distance between each pair of regions,

β_o, β_d, γ –structural parameters of the model,

[9] Finally 24 models were estimated, 12 for each analyzed period of time. Adequate tests confirmed statistical significance of individual effects or periodical effects in case of each specification.

$\boldsymbol{\varepsilon}$ – vector of the random component.

Prior to the estimation of subsequent FE panel gravity model the specifications' significance, both jointly and separately, was analyzed for individual and time effects. The obtained test statistics indicated statistical significance of effects for all three specifications. Having performed the estimation of the model specifications the statistical significance of the models' parameters were performed. The economic verification of the models with regard to interpretability of the obtained estimates was done as well.

Statistical insignificance of parameter estimations for the majority of accepted explanatory variables, or no possibility for correct interpretation of the analyzed economic phenomena impact, were characteristic for model specification with joint individual and time effects, as well as the specification with individual effects. Therefore, considering individual effects provided an opportunity for capturing spatial heterogeneity but, at the same time, did not allow for impact measurement of the analyzed potential determinants on migration phenomenon[10]. It was only the choice of the final model specification, including time effects, which allowed for obtaining substantively interpretable parameter estimates for the selected explanatory variables. Therefore the following part of the paper presents 8 models, out of 24 analyzed specifications, four in each subperiod.

3. Determinants for Interregional Migrations in Poland in the Period 2004–2010

Table 2 shows the results of estimation of panel gravity models with time effects for four explanatory variables.

Negative estimates of the distance parameter and its statistical significance for all models indicate the decreasing trends in migration intensity, proportionally to geographical distance increase between regions. This confirms unceasing timeliness of gravity model concept which assumes that geographical distance[11] represents one of the basic factors determining the size of migration flows. In case of the remaining explanatory variables, i.e. GDP, Investments, Salaries and Unemployment, for origin regions and destination ones parameters β_1 and β_2 proved to be statistically significant at 5% level of significance. Therefore it may be agreed that all accepted variables describe, to some extent, the determinants of interregional migration flows in Poland.

[10] It presents an interesting situation and may result from strong correlation of individual effects with the analyzed explanatory variables. Such correlation probably resulted in the occurrence of parameters insignificance for selected variables and changes in values or the sign of the obtained estimates of the parameters.

[11] Distance measure between regions in the gravity model of migration flows reflects costs of moving the place of residence.

Table 2. The results of estimation of panel gravity models in the period 2004–2007

GDP			Investments		
Parameters	Estimates	p-value	Parameters	Estimates	p-value
α_{2004}	1.385	0.02	α_{2004}	12.646	0.0
α_{2005}	1.165	0.04	α_{2005}	12.388	0.0
α_{2006}	0.948	0.1	α_{2006}	12.140	0.0
α_{2007}	0.596	0.3	α_{2007}	11.686	0.0
β_1	1.286	0.0	β_1	0.695	0.0
β_2	2.598	0.0	β_2	1.444	0.0
γ	-1.413	0.0	γ	-1.445	0.0
R^2 Coefficient		68%	R^2 Coefficient		66%
Salaries			Unemployment		
Parameters	Estimates	p-value	Parameters	Estimates	p-value
α_{2004}	-47.015	0.0	α_{2004}	18.695	0.0
α_{2005}	-47.306	0.0	α_{2005}	18.584	0.0
α_{2006}	-47.633	0.0	α_{2006}	18.393	0.0
α_{2007}	-48.239	0.0	α_{2007}	18.043	0.0
β_1	2.845	0.0	β_1	-0.375	0.0
β_2	5.058	0.0	β_2	-1.106	0.0
γ	-1.500	0.0	γ	-1.564	0.0
R^2 Coefficient		72%	R^2 Coefficient		48%

Regarding the first three explanatory variables (GDP, Investments and Salaries) positive estimates of β_1 and β_2 parameters were obtained, however in case of Unemployment the respective values were negative. This means that higher GDP, Investments and Salaries level and lower Unemployment level act as a pull factors to the destination region, but also a push ones from the origin region. This observation provides grounds for concluding that the population from regions characterized by better socio-economic situation presents higher territorial mobility than residents of poorer regions. Therefore it is highly likely that the most intensive migration flows occur between more developed regions. On the other hand, an unfavourable level of these determinants functions as the factor which slows migrations down. Weak position of a given region is translated, to a great extent, into lowering local community living standards (including worse financial stability) and plays the crucial role in their migration potential reduction.

The results of parameter estimations, referring to panel gravity models with time effects for the period 2008–2010 for four explanatory variables, are illustrated in Table 3.

Table 3. The results of estimation for panel gravity models in the period 2008–2010

GDP			Investments		
Parameters	Estimates	p-value	Parameters	Estimates	p-value
α_{2008}	0.395	0.6	α_{2008}	11.377	0.0
α_{2009}	0.217	0.8	α_{2009}	11.569	0.0
α_{2010}	0.251	0.7	α_{2010}	11.604	0.0
β_1	1.250	0.0	β_1	0.565	0.0
β_2	2.512	0.0	β_2	1.204	0.0
γ	-1.387	0.0	γ	-1.404	0.0
R^2 Coefficient		69%	R^2 Coefficient		59%

Salaries			Unemployment		
Parameters	Estimates	p-value	Parameters	Estimates	p-value
α_{2008}	-49.789	0.0	α_{2008}	18.412	0.0
α_{2009}	-50.160	0.0	α_{2009}	18.897	0.0
α_{2010}	-50.455	0.0	α_{2010}	18.984	0.0
β_1	2.875	0.0	β_1	-0.596	0.0
β_2	5.098	0.0	β_2	-1.429	0.0
γ	-1.494	0.0	γ	-1.482	0.0
R^2 Coefficient		71%	R^2 Coefficient		55%

Models referring to the period 2008–2010 include all explanatory variables which are statistically significant, while the same signs of parameter estimates allow for identical interpretation of their influence directions as in the period 2004–2007. In this period it was also confirmed that migration intensity keeps decreasing along with increasing distance between regions, proved by γ parameter with negative sign. Additionally, the statistical significance of parameters for the accepted economic variables allows for the first hypothesis verification that socio-economic situation in Poland, which to some extent is represented by the adopted economic indicators, presents an important determinant of domestic interregional migration directions.

It should also be observed that the impact intensity of adopted explanatory variables on migration phenomenon is diversified. Variables can be arranged according to their impact on interregional movements. The size of explanatory

variable impact intensity results from the total (in absolute terms) value of estimates of the parameters (see tab. 4). The higher the total value the more intense migratory movements should be expected as the result of changes in the level of explanatory variables. The highest values of the parameter estimates regarding structural models, in case of both analyzed periods of time, referred to Salaries and then subsequently to GDP. The sequence of variables by the significance level did not present radical changes in relation to economic prosperity transformations. However, in times of crisis the impact intensity of all variables (except Distance) was reduced. Most probably also other factors, not covered by the study, did play major role in the discussed period of time.

Table 4. The difference and the total value of parameter estimates regarding the origin and destination regions

Economic variable	Difference in values of parameter estimates (β_2-β_1)		Total value of parameter estimates $\lvert(\beta_2+\beta_1)\rvert$	
	Period 1	Period 2	Period 1	Period 2
GDP	1.311723	1.262386	3.885185	3.762408
Investments	0.749878	0.639443	2.140044	1.768789
Salaries	2.213778	2.2235	7.902992	7.97324
Unemployment	-0.73106	-0.833313	1.48135	2.024317

Therefore, the obtained results allow for concluding that in recent years higher salaries represented the strongest factor stimulating Polish population to change their place of residence. This observation is of high probability since higher salary frequently constitutes not only the most important objective for a potential migrant, but just in itself allows for saving financial means indispensable for covering costs of moving to another place. The collected results suggest that the level of salaries is the most important determinant of interregional migration flows, which proves the crucial role of job market in exerting impact on migrations in Poland.

Further analysis of the total value parameter estimates indicates that the second in line variable, influencing migration level most intensely, is GDP per capita. The impact of investment outlays against unemployment rate is stronger in the first period, while in the second it is changed and a reverse situation occurs.

In accordance with the second research hypothesis economic factors, in the period of prosperity, have a stronger influence on migratory movements than in times of economic downturn. The power of these factors' impact on migrations went up regarding values related to job market, i.e. the level of gross average monthly salary and the registered unemployment rate. However, in the period 2008–2010 the intensity of regional GDP per capita and the impact of investment outlays were reduced. This fact does not allow for an unequivocal verification of the second hypothesis. The results obtained suggest the need for more

research covering other factors impact to be carried out, especially these referring to economic development and job market.

Interesting conclusions can also be drawn from the interpretation of the value of the parameters regarding push and pull factors, i.e. the difference in value of β_2 and β_1 (see tab. 4). Owing to the fact that population migrations between regions are two-directional, positive parameter estimates for both origin and destination regions point to the migratory movements occurring simultaneously in both directions. The final balance of population flows is determined by the sign of the designated difference. Positive difference indicates higher population movement towards regions featuring favourable values of explanatory variables. In case of interregional migration flows the positive difference illustrates the tendency towards obtaining positive net migration by regions enjoying favourable socio-economic situation. On the other hand, negative difference underlies tendencies towards more intense population outflow from regions showing less attractive values of explanatory variables. This allows for the third hypothesis verification following which the regions featuring the highest socio-economic development present the tendency for positive internal net migration.

Conclusions

The purpose of the paper was to analyze the selected economic variables' impact on interregional migratory movements in Poland in the period 2004–2010. Panel gravity model with time effects for the assessment of potential determinants' impact intensity and direction was applied. The conducted research indicates the usefulness of such approach in interregional migration phenomenon modelling in Poland.

The results obtained in the investigation allowed for the first research hypothesis adoption according to which socio-economic situation illustrated, to some extent, by values of economic indicators represents an important determinant defining interregional migration directions in Poland. The analysis of the underlying variables impact intensity in two analyzed periods of time did not allow for unequivocal verification of the second hypothesis which suggests a relatively higher influence of the discussed economic factors in the period of prosperity. It was only in case of GDP and Unemployment that slightly higher values of parameter estimates were observed in the period of prosperity.

However, it was noticed that the level of salaries represent the most important determinant of interregional population migration flows, which confirms the significant role of job market in relation to migrations. The obtained results also emphasized different, in time, nature of impact exerted by factors responsible for economic development, as well as these related to job market.

The conducted analysis also provided grounds for the third research hypothesis verification stating that in regions characterized by the highest level of socio-economic development there is a tendency towards positive migration flow

balance. This is definitely one of the factors responsible for the divergence in the development of Polish regions.

The presented approach does not cover all options possible in relation to the phenomenon of migrations. Among the problems still left open for consideration the following should be mentioned: an in-depth analysis of internal migration determinants in times of crises, analysis of factors influencing interregional migrations and also spatial relations which may occur in case of migrations, all of them to be studied using panel gravity model with spatial effects.

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