INTERNAL MIGRATION IN POLAND: A SPATIAL INTERACTION MODEL APPROACH

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ABSTRACT: Migration is a complex phenomenon which involves the relocation of individuals between geographical locations and effects population distributions. People may change locations for a variety of reasons. Potential important factors in a migration process can be linked to economic variables (e.g GDP per capita), to labour market variables (e.g levels of employment), to environmental variables (embracing physical, economic and political aspects) and to public policy variables (as migrations incentives and migration policy). Explaining and predicting migration patterns can provide valuable insights for national and regional governments in improving their policies.

The purpose of this paper is to investigate the role played by the standard socio-economic variables as determinants of internal migration in Poland by use of the statistical framework of spatial interaction models.

Keywords: *spatial interaction models, internal migration, Poisson models, Poland's transition*

1.INTRODUCTION

This paper is concerned with the analysis of migration flows and their relations with other variables across Poland.

In contemporary Europe, population movements are gaining in importance, giving the diminishing impact of natural change on population dynamics.

There are several studies which describe migration patterns in different countries (e.g Rees and Kupiszewsky,1999, Stillwell *et al.* 1999).

The role of migration is not limited to demography, as it also affects many other areas of social life, including economy, labour relations, politics and culture.

Moreover, in a globalising world, the migratory process is becoming more and more complex and dynamic.

Individuals might be motivated to migrate between regions for different combination of reasons. Firstly, in migration modelling is important to recognise the difference between selective influences and determinants of migration. One speaks of selective influences when we refer to those characteristics of individuals that are indicative of higher or lower propensities to migrate. For example a demographic variable which has a significant influence on migration propensities is the age. By contrast, differences in migration profiles are less evident for males and females and between single, married and divorced groups.

Instead determinants of migration exemplify the factors that actually determine whether a move takes place and which destination is selected.

Seen as potentially important are the economic variables, which reveals economic prosperity, such as GDP per capita; labour market variables, such as levels of employment; environmental variables, embracing physical, economic, social and political aspects; housing market variables (such as high house price) which require careful treatment because they are complex interaction with migrations; public policy variables, which include migration incentives and migration policy. Other factors are related to lifestyle choices, including air quality, equable climate, quality of nearby educational facilities, health care access and entertainment options.

Hence, migration is a very complex phenomenon and the existing theories (built on the ground of varies disciplines) can explain only partially people movement.

We briefly focus on the economic theories which pertain to the relationship between labour market and migration.

According to the neoclassical macroeconomic theories (Lewis, 1954, Harris and Todaro 1970, Todaro,1976), migrants move from areas of low salaries level to those of high salaries level, whilst the capital flow is of opposite direction.

Hence migration is perceived as a labour market equilibration mechanism between two capitalist economies, one characterised by surplus of labour (unemployment) and the other by a surplus of capital. These flows of people and capitals would cease as soon as equilibrium is reached.

This approach is very simplistic and fails to explain the return migration. Also the neoclassic microeconomic theory (Sjaastad, 1962), which treats migration as an investment in human capital, disregards many factors, such as restrictive admission policies applied by destination countries.

Another attempt to explore the nature of migratory process is pointed out by the so-called new economic theory of migration (Stark &Bloom 1985, Stark 1991).

This theory justifies the migration process on the basis of households decision rather than individuals ones.

For family's members migration is a form of insurance for the future. It is also worth noting that this approach is able to explain why migration is continued even if equilibrium between levels of salaries at origin and destination is reached.

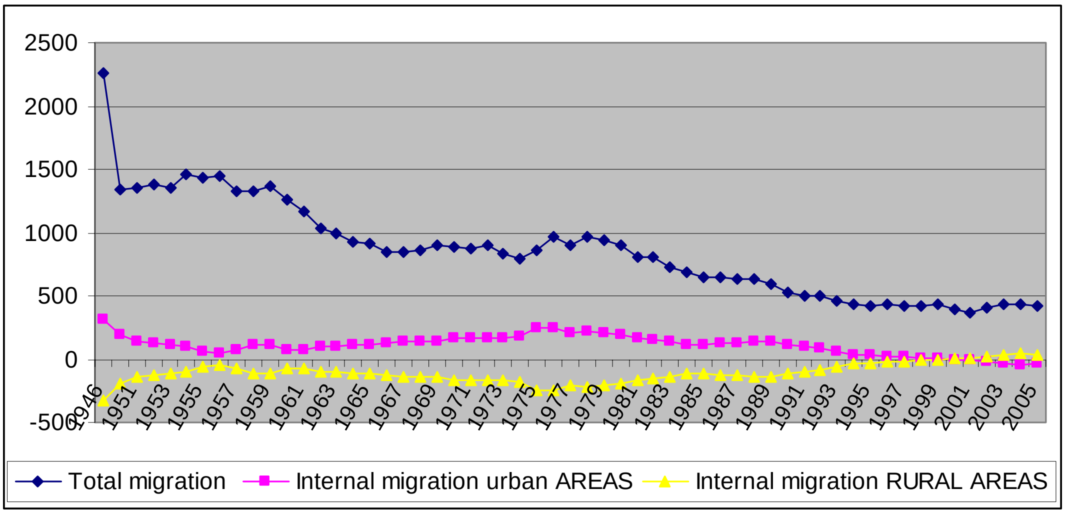
Finally, the last approach that we reviewed is the dual market theory (Piore, 1979) which is based on the key role played by the pull factors and leads to highly advanced labour market segmentation. The rationale of this theory is that immigrant workforce is more flexible production factor than the local one and they will be willing to accept less attractive jobs (i.e low paid, dirty jobs and so on).

The theories outlined above, explaining the purely economic mechanisms of migration, recognize the importance of disparities in labour market.

Poland, distinguishes herself by considerable disparities between the situation both in regional and local labour markets. On the other hand, however, the literature on spatial mobility in this country, suggests that the extent of internal migration is relatively low compared with other western European countries. In comparing the intensity of internal migration across countries, one should keep in mind a fundamental problem, that is the European countries differ substantially with respect to the size in density of population of territorial units.

Most studies concerning the Polish labour market focus on relevant analysis at the voivodeship level. This is probably due to the greater availability and better quality of data at aggregate level. It is noticeable that the analysis of migration is affected by the Modifiable Areal Unit Problem (MAUP) and the decision about which geography to use is often made for the researcher because data are usually available for a limited set of zones (Wrigley *et al.*,1996).
Migration intensity level in Poland has fluctuated considerably in the last decades.
In particular, the fall of communism, the crucial transformation of socio-economic and political situation in Poland, involved huge changes in the population movements.
We can look at profound changes in internal migration through the analysis of the change in the proportion of flow in four main directions: rural-urban, rural-rural, urban-rural and urban-urban.
In the period 1984–1994 the Polish migration system has been characterised by diminishing role of rural to urban flows whereas the reverse flows show an increasing magnitude (Fig. 1) (Kupiszewski M, 1998). People mainly migrate away from regions which are relatively less developed to those offering much better working and living conditions.

Fig.1 Internal migration in Poland 1946-2005



Source: our own elaboration of Gus Data (Polka Statystyca Publiczna – Polish Official Statistics).

Features of regional labour markets which may exert an impact on the intensity of migration are basically the unemployment rate, wages, sector employment structure.
Previous research studies suggest that the internal migration in Poland is weakly related to the situation on the labour markets. However these conclusions have been drawn on the basis of regression model results (see Firdmuc 2003, Mainardi 2004, Huber 2003).
There is evidence that incorrect statistical specification of the regression model may lead to cast doubt on the nature of migration’s equilibrating role in spatial labour markets.

The present analysis employs a spatial interaction approach to relate flows of migrants between Polish voivodeships to a some potentially important explanatory variables.
The paper is organized as follows. Section 2 is devoted to describe the spatial interaction models employed and the overall goodness of fit statistics adopted in order to draw conclusions regarding models performance and to assess if the differences in the actual and predicted migrants flows are statistically significant. In the section 3 a background discussion of data used is presented. Section 4 deals with the interpretation of the parameters model and the errors in predictions. Finally the section 5 contains some concluding remarks and hints at directions for further research.

2. THEORETICAL BACKGROUND: STATISTICAL FORMULATIONS

Gravity models, based on the analysis with Newtonian physics, have been widely applied in the migration literature (Greenwood, 1997), even if they have been criticized for their lack of economic and behavioural foundations.
As known, one of the weakness of these early approaches was the inability to ensure that the sum of all the flows predicted in the origin-destination matrix is equal to the flows observed in the system. Moreover, gravity models, have received heavy criticism in term of underlying theory. Wilson (1967,1970), who avoids the term "gravity" and uses instead the term "spatial interaction models", moved away from the rigidity of Newton models by introducing the so-called *balancing factors* to ensure internal consistency within the models and providing the statistical mechanics entropy formulation. By the Wilson's entropy approach these models have been recast in a probabilistic form. Applications of spatial interaction models to migration can broadly be divided into three categories. In fact various aspects of determinants of migration patterns has been obtained from doubly, unconstrained and singly constrained models.
The latter has been employed to examine the relative roles of origin and destination characteristics in determining migration patterns.
Summing up, spatial interaction models can be used in projection or in an exploratory modes: they allow to predict migration flows at some future time or in a different spatial system or to draw conclusion about interaction behaviour from a comparison of parameters estimates (i.e to predict these flows when changes in the origins and/or destination occur).
Migration flows might be best understood when both characteristic of origin region and destination region are taken into account.
Hence, in this study, in order to separate the influence of possible variables for the origin region i that may act as "push" factors for migration and those one that may attract migrants in the destination region j ("pull factors") we adopted two kind of gravity models: an *attraction-constrained model* (sometimes known as destination-constrained) and a *production–constrained model* (sometimes known as origin-constrained) respectively.
Fotheringham and O'Kelly (1989) argued there are a number of technical advantages in choosing these constrained models. One of them are the more accurate produced results compared to those obtained via unconstrained models.
A general spatial interaction model can be formulated as follows:

$$Y_{ij} = \mu_{ij} + \varepsilon_{ij} \qquad (2.1)$$

where flows can be viewed as observations on random variables Y_{ij} with mean value μ_{ij} and ε_{ij} the residual error term relating to a pair of locations.
Looking for a characterization of μ_{ij} that reflects destination effect and distance frictional effect, the general *production–constrained model* can be written in this way

$$Y_{ij} = \alpha_i e^{v(x_j^{(d)};\theta)+\gamma d_{ij}} + \varepsilon_{ij} \qquad (2.2)$$

where $v(x_j^{(d)};\theta)$ is usually a linear function of the vector of destination characteristics (destination attractiveness); θ is a vector of associated parameters; the notation d_{ij} is used to represent the distance between *i* and *j*; γ is a distance deterrence effect; α is the balancing factor to ensure the origin constraint on predicted flows.
By contrast, in an *attraction-constrained model* the sum of flows that arrive in a region is imposed to equal the observed value. Then the model becomes:

$$Y_{ij} = \beta_j e^{u(x_i^{(o)};\phi)+\gamma d_{ij}} + \varepsilon_{ij} \qquad 2.3$$

where $u(x_i^{(o)};\phi)$ is a linear function of the vector origin characteristics $x_i^{(o)}$, involving a vector of parameters ϕ, which measures the origin propulsiveness.
In this study, we made extensive use of the exposition of Bailey and Gatrell (1996).
From a statistical point of view, fitting the these kind of spatial interaction models to the observed data, is a question of estimating the unknown parameters.
So, in our research, we have to estimate the effect of pull factors on migration decision process in a *production-constrained* spatial interaction model and that of push factors in an *attraction-constrained* model.
For the calibration procedure, as the flows have an integer nature, an appropriate approach is to view them as observations of random variables following independent Poisson distributions (Flowerdew and Aitkin,1982).
The assumption that Y_{ij} follow a Poisson distribution could lead to some problems.
Firstly, flows are not strictly independent and additionally the underlying hypothesis may not take into a proper account the degree of variation exhibited by many real data sets.
Notwithstanding, the assumption that Y_{ij} are independent Poisson random variables ensures that the maximum likelihood parameters estimates have some desirable properties. They automatically satisfy the required constraints, without being applied a posteriori, and overcome some limitations of estimating parameters by the ordinary log-linear regression model (see Fotheringham and Williams 1983 and Fotheringham and O' Kelly,1989).
Then the log likelihood for the *production constrained spatial interaction model* takes the form of equation 2.4

$$l = \sum_{i=1}^{m}\sum_{j=1}^{n}\left(Y_{ij}\left(\log\alpha_i + v(x_j{}^d;\theta) + \gamma d_{ij}\right) - \alpha_i e^{v\left(x_j^d;\theta\right)+\gamma d_{ij}}\right)$$

2.4

The obvious alternative to log-likelihood function specified for a production-constrained model is that one referred to *an attraction-constrained model*. Hence, in this case, the log-likelihood function is given by:

$$l = \sum_{i=1}^{m}\sum_{j=1}^{n}\left(Y_{ij}\left(\log b_j + u(x_i{}^{o};\phi)\right) + \gamma d_{ij}\right) - b_j e^{u\left(x_i^0;\phi\right)+\gamma d_{ij}}) \qquad 2.5$$

In both cases, the calibration of these models can be achieved through the Generalised Linear Models (GLM) framework, with Poisson error structure and logarithmic link function.

In our study, the parameters values are obtained via maximum likelihood estimation, using an iterative algorithm (Stillwelll,1991) implemented with an hoc R routine.

The standard errors of maximum likelihood parameter estimates are obtained by the square root of diagonals of ($-H^{-1}$), where H is a n*n matrix of second derivatives and n the number of parameters in the models.

A review of spatial interaction models literature, suggests that it is possible to draw proper conclusions regarding model performance examining the values of goodness-of-fit measures.

Black (1991) criticized the use of correlation methods to evaluate flow model fit. The basic question regarding the use of this index in this context is due to two additional parameters involved: an implicit intercept value and a regression coefficient which might alters the estimated flows. Keeping in mind this caution in the use of correlation coefficient for evaluating the accuracy of spatial interaction model, we employed at this purpose a combination of two statistics: the Standardised Root Mean Square Error (SRME) and the Information Gain (Fotheringham and Knudnes,1986,1987).

The first statistics is calculated as follows:

$$SRME = \frac{\left\{\sum_i\sum_j\left(Y_{ij} - \hat{Y}_{ij}\right)^2 /(m*n)\right\}^{\frac{1}{2}}}{\left(\sum_i\sum_j Y_{ij} /(m*n)\right)} \qquad 2.6$$

where Y_{ij} is the observed number of people moving from region *i* to region; $\hat{Y}_{ij}$ are the estimated interactions between *i* and *j* and *m* and *n* are the number of origin and destination zones, respectively.

The SRME statistic has a lower limit of zero, indicating perfectly accurate predictions and an upper limit variable, depending on the distributions of $Y_{ij}{}^{'}s$, although, in practice, it is often 1.

Instead, the Information Gain statistics is defined as

$$I = \sum_i\sum_j p_{ij}\ln\left(p_{ij} / q_{ij}\right) \qquad 2.7$$

where $p_{ij} = Y_{ij} / \sum_i\sum_j Y_{ij}$ and $q_{ij} = \hat{Y}_{ij} / \sum_i\sum_j \hat{Y}_{ij}$.

This goodness-of-fit statistic measures the difference between two probability distributions. It has minimum at zero, indicating a completely accurate set of predictions; the value of I increases with differences between the observed and predicted migration flows distributions.

Moreover a simple index of dissimilarity has been also applied to calculate the percentage of migrants in the observed migration matrix who are placed in the wrong cells of the estimated migration matrix.

The index of dissimilarity employed in this study is given by:

$$G = \frac{50}{T} \sum_i \sum_j \left| \hat{Y}_{ij} - Y_{ij} \right| \qquad 2.8$$

It is worth noting that a value of zero of G indicates a perfect fit while 100 represents a situation of maximum possible difference between two distributions.

So the attempt at interpretation of model parameters should be tempered by the degree of correspondence between the predicted and observed migration flows matrix evaluated by means of outlined indexes.

3.DATA DESCRIPTION

The internal migration flows, obtained from Polish Official Statistics (Polka Statystyca Publiczna), are set out in Table.1 This origin-destination table provides internal migration data at the regional (voivodeship) level (the rows representing the origin regions and the columns the destination regions).

Table 1 Internal migration flows 2004

Region of origin (voivodeships)	**Region of destination (voivodeships)**																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total**
Lódzkie (1)	0	2632	303	851	154	81	244	71	816	258	109	453	216	297	149	284	6918
Mazowieckie (2)	1430	0	601	636	1321	334	667	731	514	430	143	450	108	711	1122	809	10007
Malopolskie (3)	160	1003	0	2022	193	868	489	64	174	148	75	301	118	107	85	178	5985
Slaskie (4)	951	1746	3074	0	446	533	799	180	686	521	285	1032	993	447	410	489	12592
Lubelskie (5)	222	4643	545	506	0	620	196	116	255	262	86	324	96	159	151	350	8531
Podkarpackie (6)	128	1177	1807	566	583	0	379	45	129	121	61	306	85	70	77	139	5673
Swietokrzyskie (7)	289	1941	1026	804	265	432	0	36	123	84	38	230	107	64	49	167	5655
Podlaskie (8)	81	1960	101	112	113	43	19	0	102	94	25	126	9	108	718	280	3891
Wielkopolskie (9)	577	980	205	408	81	72	62	62	0	766	729	976	148	865	146	482	6559
Zachodniopomorskie (10)	296	1077	182	308	151	93	84	64	1295	0	710	346	64	572	180	974	6396
Lubuskie (11)	88	411	147	214	74	50	41	31	1154	564	0	798	67	134	79	106	3958
Dolnoslaskie (12)	388	1058	529	793	184	200	148	94	1405	484	983	0	879	177	168	337	7827
Opolskie (13)	185	331	248	920	66	92	57	25	219	96	71	984	0	71	21	58	3444
Kujawsko-Pomorskie (14)	302	1333	174	320	91	42	49	53	1353	449	96	217	50	0	422	1335	6286
Warminsko-Mazurskie (15)	162	1985	126	293	131	70	57	710	272	190	71	178	35	589	0	1560	6429
Pomorskie (16)	180	1056	172	256	127	70	49	101	515	839	106	216	48	821	676	0	5232
Total	5439	23333	9240	9009	3980	3600	3340	2383	9012	5306	3588	6937	3023	5192	4453	7548	105383

Source: Polka Statystyca Publiczna – Polish Official Statistics.

For each pair of regions we know how many people migrated from one region to the other during 2004 (most recent data). According to these migration flows, in 2004 there were 105,383 persons who migrated across Poland.

Data are first explored by the FlowMapper routine of W.Tobler, which contains options for diverse forms of movement depiction.

Moves presented in Table 1 show an evident outflow from Slaskie, Mazowieckie, Lubelskie and Dolnoslaskie regions and a dynamic inflow to Mazowieckie, Malopolskie, Wielkopolskie, Slaskie and Pomorskie voivodeships (see also Fig. 2 and Fig. 3).

As migration is one of the potential ways that regions might adjust to economic changes, it is worth noting what are the voivodeships with good labour market conditions. Existing data, drawn from Polish Official Statistics (Polka Statystyca Publiczna), indicate that the group of voivodeships with the lowest disparities in labour market performance includes the Kujawsko-Pomorskie, Lubelskie, Warmińsko-Mazurskie and Łódzkie voivodeships; whereas the highest disparities occur in the Świętokrzyskie, Mazowieckie and Pomorskie voivodeships. One of the basic indicator of the labour market, the unemployment rate, is particularly high in Dolnoslaskie, Zachodniopomorskie, Lubuskie voivodeships (see Table 2).

Actually, the unemployment rate, compared to other economic variables, is homogeneous throughout Poland (Table 2). One possible explanation could be linked to the agricultural regional disparities in this country. The highest and persistent unemployment rate in the east and west of Poland may be ascribed to the dissimilarities of the labour market during the transition process. This important change is due to the transition to a market economy. In fact workers have been expelled by the old industrial and agricultural firms, under the government control, and not yet reabsorbed in the new economic sectors. This important factor creates an hidden employment in the oriental regions, where the important rule of the old agricultural firms caused a modest contribution to the country economy (Crescenzi, 2004).

The explanatory variables used in the fitted models are presented in Table 2. The main conclusion that can be drawn in analysing the inflow and outflow of above indicated voivodeships reveals the diminishing intensity of the long distance migration flows in favour of short-distance ones. The only exception is represented by Mazowieckie region, including the capital Warszawa, which constitutes a developed area of good business and job opportunities.

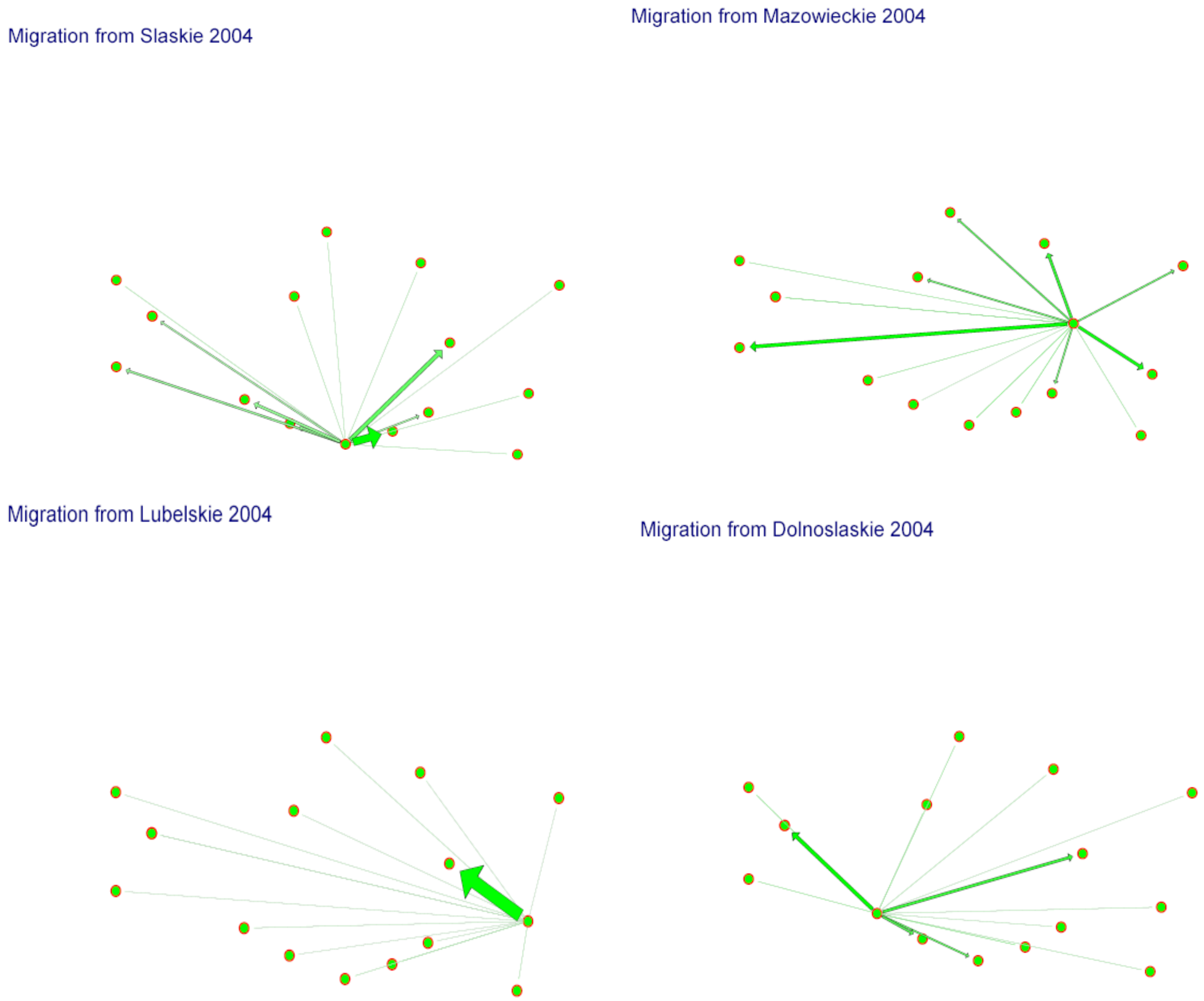


Fig. 2 Main outflow from Polish regions displayed by Flowmapper routine

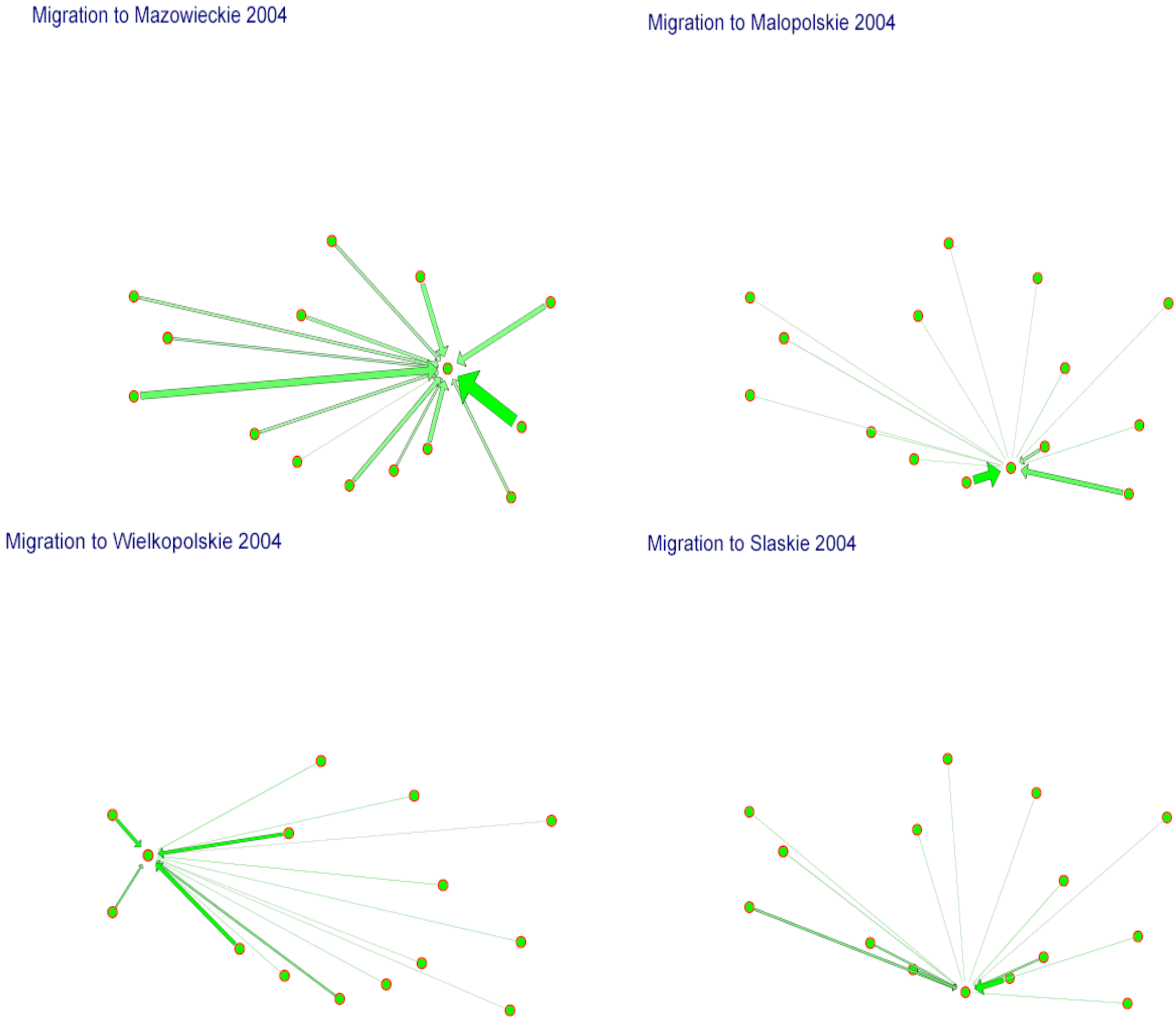


Fig. 3 *Main inflow in Polish regions displayed by Flowmapper routine*

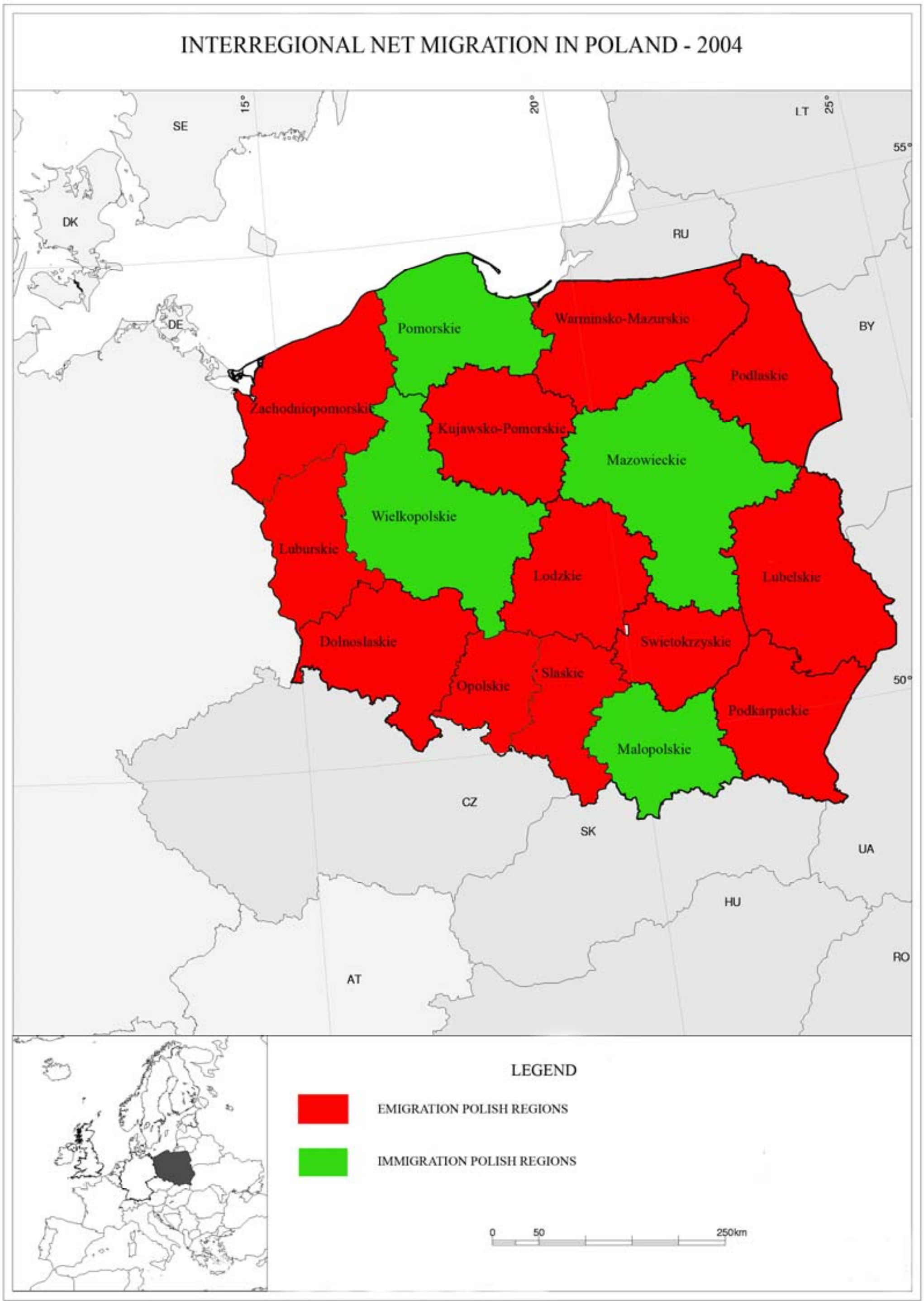
Table 2 Explanatory variables for the 16 voivodeships, Poland [a]

Voivodeships	Socio-economic variables						
	Population	GDP per capita100=national average 1995	GDP per capita100=national average 2004	*Performance* 1995-2004	GDP per capita	Unemployment rate	Rate of detectability of delinquents
Lódzkie	2587702	91.0	92.1	1.1	10049.1	18.8	45.3
Mazowieckie	5145997	127.9	151.5	23.6	16523.2	14.6	46.2
Malopolskie	3260201	87.7	85.5	-2.2	9324.2	17.3	52.6
Slaskie	4700771	118.8	112.4	-6.4	12260.2	19.3	49.1
Lubelskie	2185156	78.2	69.4	-8.9	7568.1	16.7	64.8
Podkarpackie	2097975	76.3	69.8	-6.5	7616.7	16.6	71.9
Swietokrzyskie	1288693	78.6	77.4	-1.2	8443	20.6	67.4
Podlaskie	1202425	77.2	74.7	-2.5	8147.5	15.6	66.6
Wielkopolskie	3365283	98.4	107.5	9.2	11727.9	18.2	62.6
Zachodniopomorskie	1694865	103.1	93.0	-10.0	10149.2	23.8	50.4
Lubuskie	1009168	98.1	89.5	-8.6	9764.9	23.2	68.2
Dolnoslaskie	2893055	105.1	101.9	-3.2	11112.5	24.9	32.7
Opolskie	1051531	97.8	86.0	-11.8	9377.8	17.8	69.4
Kujawsko-Pomorskie	2068258	99.8	89.4	-10.4	9756.2	22.1	58.0
Warminsko-Mazurskie	1428714	80.2	77.6	-2.5	8468.7	22.3	66.4
Pomorskie	2194041	101.6	97.7	-3.9	10658.5	20.2	55.5

[a] *Umployement rate, rate of detectability of delinquents are percentages*
Source: our own elaboration of Gus data (Polka Statystyca Publiczna – Polish Official Statistics).

As confirmed by the net migration figures (Table 3), the area of capital (Mazowieckie) gained 13,326 people through migration, whereas Lubelskie region lost 4,551 individuals during 2004.
Mazowieckie has the highest immigration rate (0.45), followed by Lubuskie (0.36) and Pomorskie (0.34). The five highest emigration rates concerned Warminsko-Mazurskie (0.45), Swietokrzyskie (0.44), Lubuskie (0.39), Lubelskie (0.39), Zachodniopomorskie (0.38) regions (see Table 3).
Fig. 4 displays the immigration and emigration Polish regions

Fig. 4 Interregional net migration in Poland - 2004



In addition, a social variable, the rate of detectability of delinquents is also incorporated in our specified models in order to evaluate how this social security parameter is involved in the migration decision process.
It is important to remark that the rate of detectability of delinquents is the relation of the number of detected crimes in a given year to the total number of crimes ascertained in a given year, plus the number of crimes recorded in commenced proceedings and discontinued in previous years due to undetected delinquents.

Table 3 Arrivals, departures, immigration and emigration rates for the 16 voivodeships

Voivodeships	Population	Arrivals	Departures	Net migration	Immigration rate (%)	Emigration rate (%)
Lódzkie	2587702	5439	6918	-1479	0.21	0.27
Mazowieckie	5145997	23333	10007	13326	0.45	0.19
Malopolskie	3260201	9240	5985	3255	0.28	0.18
Slaskie	4700771	9009	12592	-3583	0.19	0.27
Lubelskie	2185156	3980	8531	-4551	0.18	0.39
Podkarpackie	2097975	3600	5673	-2073	0.17	0.27
Swietokrzyskie	1288693	3340	5655	-2315	0.26	0.44
Podlaskie	1202425	2383	3891	-1508	0.20	0.32
Wielkopolskie	3365283	9012	6559	2453	0.27	0.19
Zachodniopomorskie	1694865	5306	6396	-1090	0.31	0.38
Lubuskie	1009168	3588	3958	-370	0.36	0.39
Dolnoslaskie	2893055	6937	7827	-890	0.24	0.27
Opolskie	1051531	3023	3444	-421	0.29	0.33
KujawskoPomorskie	2068258	5192	6286	-1094	0.25	0.30
WarminskoMazurskie	1428714	4453	6429	-1976	0.31	0.45
Pomorskie	2194041	7548	5232	2316	0.34	0.24

Source: our elaboration of Gus Data (Polka Statystyca Publiczna – Polish Official Statistics).

4. EMPIRICAL RESULTS

In this research two spatial interaction models were specified.
Ideally such a models would include variables that somehow effect migrant process. Firstly, we estimate parameters of a *production-constrained* spatial interaction model, in order to select variables that determine the relative attraction of destinations. Moreover, in order to investigate the role played of the same explanatory variable in the sending regions (i.e as push factors) we also estimated an *attraction-constrained* model. In our migration models the unemployment rate in the region of destination is used as a proxy for tightness of local labour market. We also expect that regions that provide many job opportunities attract more labour migrants.
Another explanatory variable we added to our model is GDP per capita as we supposed that it could play an important role in explaining internal migration.
In other words, we are interested in the following question: “are migrants more likely to move from deprived areas to well-to-do zones?”. This issue is supported

by some statistics on net migration which highlight that rich regions are gaining population while the poor regions are loosing population.

The standard demographic population and distance variable were also included.

We considered in both models the population size among regressors in order to detect how differently the population affects migration in the origin and destination regions. The distance variable has been computed between centroids of the origin and destination zones.

Table 3 and Table 5 summarise the coefficients for the *production-constrained* model and *attraction-constrained* model respectively.

It is worth noting that all variables are expressed in logarithmics. The signs of both models are as may be expected for all the covariates according to the main economic migration theories. As known, in spatial interaction models population (of both origin and destination regions) is expected to affect positively migration. Our findings reveals that the population size has a stronger effect when it acts as "push" factor: so the more one region is inhabited, the higher will be the probability that more people decide to migrate. We find that population coefficient is less than one in Model 1 and much greater in Model 2.

With regards the other so-called *gravity variable*, that is the distance, in spatial interaction models the aggregate flows of migrants should decrease with distance between two regions.

In our empirical analysis the physical distance, used as a proxy to take into account costs related directly or indirectly to distance, seems to discourage only slightly the migration process. However a considerable number of studies argue that physical distance does not consider other important costs, such as time of moving, information costs and psychological costs. Results for the attraction constrained model also shows the same distance elasticity estimate.

The evidence for a labour market influence on migration flows is substantial. The estimated coefficients for the unemployment rate and per capita GDP emphasise this aspect. The coefficients signs for both models considered confirm that migrants prefer to move in voivodeships with low unemployment rate and high per capita GDP. In particular this latter covariate seems to play a more important role as *"pulling factor"* rather than "*pushing one*". Furthermore the higher coefficients of the per capita GDP with respect to unemployment rates both in the sending and destination regions indicate that the former has a stronger influence as economic determinant of internal migration flows.

Another aspect that we can highlight is the effect of unemployment rates which appear to be more significant in the destination region (as a pull factor), than in sending regions, i.e migrants are willing to move to regions with lower employment rates.

Table 3 Production-Constrained Model Coefficients (Model 1)

	Value	Std.Error	t value	p value
LOG POP	0.736	0.14203	5.185	0.000
LOG GDP	7.460	0.17836	41.828	0.000
LOG UNEMP	-4.860	0.04856	-100.102	0.000
LOG DELIQ	-4.754	0.04817	-98.695	0.000
LOG DIST	-0.002	0.00002	-123.615	0.000

Table 4 Overall goodness-of-fit for the Production-Constrained model (Model 1)

Index of dissimilarity	G=23.23
Standardized Mean Square Root Error	SMRE=0.82
Information gain	IG=0.18

Table 5 Attraction-Constrained Model Coefficients (Model 2)

	Value	Std.Error	t value	p-value
LOG POP	7.778	0.13923	55.865	0.000
LOG GDP	-5.9654	0.18000	-32.373	0.000
LOG UNEMP	0.620	0.05886	10.534	0.000
LOG DELIQ.	-1.100	0.04890	-22.498	0.000
LOG DIST	-0.002	0.00002	-122.952	0.000

Table 6 Overall goodness-of-fit for the Attraction-Constrained model (Model 2)

Index of dissimilarity	G=34.64
Standardised Mean Square Root Error	SMRE=1.27
Information gain	IG=0.46

Moreover, although this study focuses on the economic determinants of migration, there are several aspects that may affect the decision to migrate.
So, in addition to the economic factors, we also consider a social indicator as covariate, linked to the public security: the rate of detectability of delinquents, defined in Section 2, in order to better explain people mobility.
Our findings, seem to show that migration was negatively related to percentage of detected crimes at the origin as well at the destination (Andrienko&Guriev, 2004). The corresponding coefficient of the fitted *production-constrained model* (Model 1) is particularly high: as expected, people are discouraged to move towards regions characterised by warning level of crime.
It is worth noticing, however, that also the calibration of the *attraction-constrained model* leads to a negative sign for this coefficient and this is in some sense counter-intuitive. One possible explanation for that could be the collinearity of this variable with the others involved in the models.
As previously reported, the model performance can be assessed by examining three indicators of how well the predicted flows correspond to the observed ones.
The overall goodness-of-fit measures calculated indicate a better ability of *production-constrained model* to replicate the observed migration flows(see Table 4 and Table 6) respect to the *attraction-constrained model.*
The lower values of the information gain statistic, of the SMRE statistic and of the index of dissimilarity support the superiority of Model 1 (*production constrained model)* in replicating Polish internal migration flows.

5.CONCLUDING REMARKS

In this paper, two singly constrained spatial interaction models were fitted and compared with respect to their performance on a set of observations on Polish internal migration flows.
Pull factors which affect the internal migration flows are determined in a *production-constrained* spatial interaction model whereas push factors are investigated through an *attraction constrained* model.
As argued by economic theories, internal migration is clearly influenced by some economic factors. Generally speaking regions with favourable labour market conditions attract more migrants. Our research establishes the leading role of GDP per capita over the unemployment rate. As expected, we find that regions with a large unemployment rate generate more migrants.
Moreover a social covariate, the rate of detectability of delinquents, is also incorporated in both models in order to assess if better living conditions, in terms of social security, might have an impact on the migration process.
The high negative value of the estimated coefficient in the *attraction-constrained* model seems to suggest that migrants are discouraged to move in regions characterized by an elevated number of detected crimes. By contrast we found an unsatisfactory coefficient, with a counter-intuitive sign, for this variable as push factor. Accordingly, it seems plausible that the propulsiveness of origin regions (i.e the ability of an origin zone to generate flows) is mainly related to their economic activity. The signs of the so-called gravity variables (distance and population) validate the thesis that migration is positively related to the population in the origin and destination, and negatively related to the distance between the two places.

In particular, the impact of distance deterrence effect does not appear considerable.
The overall goodness-of-fit statistics employed reveals a better correspondence between the migration flows patterns estimated from the production-constrained spatial interaction model and observed migration flows patterns.
Finally, we make some remarks on our research and we draw some lines of future research. It is possible to identify a number of issues to be developed that deserve further investigation.
Note the interactions between migration, socio-economic factors may be of course more complex than represented in the models, as they are a simplification of the real world. Moreover we are tied to a very limited number of explanatory variables. Hence, the prediction and explanation of migration flows should therefore be based on a larger spectrum of them.
This study could be also improved by considering spatial structure effects of phenomenon as the estimated coefficients could exhibit reliable patterns over the space. So future work will deals with assessment of spatial variations in flows by applying origin and destination specific spatial interaction models.

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