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Authors: Jesus Crespo Cuaresma (WU),
Mathias Moser (WU), Anna Raggl (WU)

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Authors: Jesus Crespo Cuaresma (WU), Mathias Moser (WU), Anna Raggl (WU)

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*Socio-economic Sciences and Humanities Europe
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Contribution to the Project

This study develops new econometric methods for modelling migration flows in Europe. The methods put forward will be used to improve population projections and assess future migration scenarios in the framework of the policy discussion on ageing in developed economies and its effect on welfare state sustainability.

On the Determinants of Global Bilateral Migration Flows[*]

Jesus Crespo Cuaresma[†] Mathias Moser[‡] Anna Raggl[§]

Abstract

We present a method aimed at estimating global bilateral migration flows and assessing their determinants. We employ that fact that available net migration figures for a country are (nonlinear) aggregates of migration flows from and to all other countries of the world in order to construct a statistical model that links the determinants of (unobserved) migration flows to total net migration. Using simple specifications based on the gravity model for international migration, we find that migration flows can be explained by standard gravity model variables such as GDP differences, distance or bilateral population. The usefulness of such models is exemplified by combining estimated specifications with population and GDP projections in order to assess quantitatively the expected changes in migration flows to Europe in the coming decades.

Keywords: Bilateral migration flows, gravity model, nonlinearly aggregated models.

JEL Classifications: F22, O15, J11

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[†] Corresponding author. Department of Economics, Vienna University of Economics and Business (WU); World Population Program, International Institute of Applied Systems Analysis (IIASA); Wittgenstein Centre for Demography and Global Human Capital (WIC) and Austrian Institute for Economic Research (WIFO). Address: Augasse 2-6, 1090 Vienna (Austria). Email: jcrespo@wu.ac.at.

[‡] Department of Economics, Vienna University of Economics and Business (WU). Address: Augasse 2-6, 1090 Vienna (Austria). Email: matmoser@wu.ac.at

[§] Research Institute for Human Capital and Development, Vienna University of Economics and Business (WU) and Wittgenstein Centre for Demography and Global Human Capital (WIC). Address: Augasse 2-6, 1090 Vienna (Austria). Email: araggl@wu.ac.at

1 Introduction

In 1990, there were approximately 150 million international migrants in the world, a figure that increased by more than 40% in the following two decades. Currently, about 214 million people worldwide live outside the country where they were born, a number that represents roughly 3.1% of total population (see United Nations (2011)).

The lack of availability of global databases for bilateral migration flows is an important barrier to the understanding of the causes and consequences of international migration. While the OECD's International Migration Database (OECD, 2012) provides data on bilateral immigration flows, the information is limited to migration to a relatively small group of industrialized economies. Docquier and Marfouk (2006) present a data set of bilateral migration stocks by educational attainment for over 170 countries in 1990 and 2000, which researchers have used to construct migration flows as differences between stocks at these two points in time (see for example Beine, Docquier, and Ozden (2011)). The problems involved in using differences in migration stocks as a proxy of migration flows can be important and are often acknowledged in the empirical studies performing such an approximation. Mortality and return migration distort the quality of such a variable as a measurement of migration flows and thus the assessment of the dynamics of newcomers based on the difference in the stock of migrants can lead to seriously flawed inference.

Common approaches in the empirical literature aimed at modelling bilateral migration flows and assessing their determinants are extended *gravity models*. Gravity models relate flows of goods or factors between two countries to their attractive mass and to the distance between them. Although originally introduced to model trade flows between two countries (Tinbergen, 1962), the gravity specification also provides a useful tool to model international migration flows. Ravenstein (1885, 1889), in his early assessment of the determinants of migration, states as part of his *Laws of Migration* that *"the bulk of migrants ought to travel short distances only"* and that an *"increase in the means of locomotion and a development of manufactures and commerce have led to an increase of migration"*, thereby implicitly formulating the gravity model for migration. The first empirical application of the gravity model to explain migration flows between two countries is attributed to Vanderkamp (1977), who explained the logarithm of bilateral migration flows by the distance between the countries and their bilateral size, measured by the population of the source and destination countries.

More recent studies build upon the basic gravity model and focus on further determinants of migration flows beyond geographical distance and aggregate measures of economic mass. Vanderkamp (1977); Karemera, Oguledo, and Davis (2000); Clark, Hatton, and Williamson (2007); Pedersen, Pytlikova, and Smith (2008); Ortega and Peri (2009); Kim and Cohen (2010); Beine, Docquier, and Ozden (2011); Grogger and Hanson (2011) or Ortega and Peri (2013) are recent examples of this branch of empirical research. Data availability tends to limit these studies on the determinants of bilateral migration to cases where the recipient country is an advanced OECD economy, thus explicitly ignoring South-South migration in their analysis. Bakewell (2009) shows that, depending on how the *South* is defined, between 33% and 45% of global migration can be categorized as South-South migration. To the extent that the determinants of South-South migration may differ from those of migration flows to industrialized economies, these studies may only have limited applicability to other world regions.

In this study we propose a new method to study the empirical determinants of worldwide bilateral migration flows using net migration data, which are available for practically all countries in the world. By assuming that (log) bilateral migration flows can be described by a simple gravity model, we construct econometric specifications based on net migration, which can therefore be thought of as a nonlinear aggregation of (unobserved) bilateral flows. These, in turn, are functions of observed explanatory variables. Such a modelling strategy allows us to estimate the effects of the various determinants of bilateral migration and eventually construct estimates of bilateral migration flows as the corresponding fitted values. In addition, our approach presents a natural framework to obtain projections of bilateral migration flows that can be used to assess future trends in labour mobility and to improve existing population projection exercises.

Our work is related to recent developments in the estimation and modelling of bilateral migration flows. Abel (2013), building on Abel (2010), estimates bilateral migration flows for 195 countries based on place of birth data. This is done by deriving migration flows from sequential stock migration data in the framework of spatial interaction specifications. Although conceptually the approach in Abel (2013) shares some similarities with our method, we depart from this group of contributions by exploiting the nonlinear nature of the linkage between log bilateral migration (the variable we aim to model) and net migration (the variable we actually observe).

The paper is organized as follows. In section 2, the statistical modelling framework and the estimation strategy are presented. In order to assess the quality of the parameter estimates using our proposed method, a small-scale simulation study is also performed in this section. Section 3 presents the estimates of a representative model and section 4 provides a projection exercise where future changes in migration flows to Europe are assessed based on population and GDP projections. Finally, section 5 concludes.

2 Modelling nonlinearly aggregated bilateral migration flows

2.1 The econometric setting: From bilateral flows to net migration

Since gravity models tend to be specified in log-linear form, obtaining coefficient estimates for the model using aggregated net migration rates implies that the econometric specification used is a nonlinear function of the underlying parameters. We start by assuming that (log) bilateral migration flows can be represented by the model

$$m_{ij} = \log M_{ij} = X_{ij}\beta + u_{ij}, \tag{1}$$

where M_{ij} denotes migration from country i to country j, X_{ij} is a $1 \times k$ vector of determinants of bilateral migration, β is a $k \times 1$ vector of parameters to be estimated and u_{ij} is an error term assumed independent, identically distributed and homoskedastic with variance σ^2. Bilateral flows are not observed, but data for n countries exist on net migration (N_i), which is given by the difference of migration flows to country i from all other countries and migration out of country i to all other countries,

$$N_i = M_{i*} - M_{*i} = \sum_{j \neq i} M_{ij} - \sum_{j \neq i} M_{ji} = \sum_{j \neq i} \exp m_{ij} - \sum_{j \neq i} \exp m_{ji}. \tag{2}$$

The model for our observed data can thus be written in matrix form as

$$\mathbf{N} = \mathbf{S} \exp(\mathbf{m}) = \mathbf{S} \exp(\mathbf{X}\beta + \mathbf{u}), \tag{3}$$

where $\mathbf{N}$ is an n-dimensional column vector of net migration observations, $\mathbf{X}$ is an $n(n-1) \times k$ matrix of observations on the bilateral explanatory variables, $\mathbf{S}$ is an $n(n-1) \times n$ matrix which selects the corresponding bilateral migration flows, aggregates them for each country and creates the net migration figures and $\exp(\mathbf{u})$ denote the element-by-element exponent of vector $\mathbf{u}$. Assuming that $\mathbf{m}$ is ordered by origin country, then $\mathbf{S} = (\mathbf{I}_n \otimes \iota_{n-1}) - \mathbf{B}$, where $\mathbf{B}$ denotes a $n(n-1) \times n$ matrix formed by selected rows of the Kronecker product $(\mathbf{I}_n \otimes \iota_n)$. Denoting the selection correspondence by $(\mathbf{I}_n \otimes \iota_n) \rightarrow \mathbf{B}$, the matrix $\mathbf{B}$ is formed by the rows of $(\mathbf{I}_n \otimes \iota_n)$ which are not in the set $\{1, 2^2, ..., n^2\}$, so as to eliminate observations where origin and destination country are the same. Considering an example with three countries (A, B and C, $n = 3$), the corresponding transformation would be given by

$$\begin{pmatrix} \begin{array}{cccc} & A & B & C \\ AA & 1 & 0 & 0 \\ AB & 0 & 1 & 0 \\ AC & 0 & 0 & 1 \\ BA & 1 & 0 & 0 \\ BB & 0 & 1 & 0 \\ BC & 0 & 0 & 1 \\ CA & 1 & 0 & 0 \\ CB & 0 & 1 & 0 \\ CC & 0 & 0 & 1 \end{array} \end{pmatrix} \rightarrow \begin{pmatrix} \begin{array}{cccc} & A & B & C \\ AB & 0 & 1 & 0 \\ AC & 0 & 0 & 1 \\ BA & 1 & 0 & 0 \\ BC & 0 & 0 & 1 \\ CA & 1 & 0 & 0 \\ CB & 0 & 1 & 0 \end{array} \end{pmatrix}$$

While the model for the bilateral migration flows is linear in parameters, the aggregation of the flows which yields the net migration flows implies a nonlinear link between $\mathbf{N}$ and β. Therefore, we cannot estimate our model with least squares and rely on nonlinear maximum likelihood methods to estimate β. Proietti (2006) proposes an iterative algorithm which allows to estimate models specified on disaggregated data using aggregated data.[1]. The algorithm focuses on the Taylor approximation around

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[1] In a simplified setup, Proietti (2006) considers an standard linear model $y = \alpha + X\beta + \epsilon$ where α is the intercept, X is a known $N^2 \times k$ matrix of explanatory variables, y a N^2 vector of unknown responses and $\epsilon \sim N(0, \sigma^2 I)$. The vector y is not observed but a non–linear aggregation $Y = \sum_{j=1}^{N} f(y)$ is, where $f(\cdot)$ is a twice differentiable function. Y and y can be linked through an aggregation matrix $A = I_N \otimes \iota_N$, so that $Y = Af(y) = (I_N \otimes \iota_N)f(y)$.

some trial value of the vector of disaggregated variables.[2] This method can be shown to be equivalent to quasi–maximum likelihood estimation, which is the approach we take for our application.

A simple approach to the estimation of model (3) starts by ignoring the nonlinearity in the error term and estimating β based on a specification where the disturbance is defined at the level of the aggregated variable (N_i) instead of at the bilateral level,

$$\mathbf{N} = \mathbf{S}\exp(\mathbf{X}\beta) + \eta, \tag{4}$$

which allows to estimate β using nonlinear least squares or pseudo maximum likelihood methods. Assuming independence, normality and homoskedasticity for the disturbance term, the likelihood of the model can be written as

$$L(\beta, \sigma_\eta | \mathbf{N}) = \prod_{i=1}^{n} f\,(N_i | \beta, \sigma_\eta), \tag{5}$$

with the corresponding log-likelihood function

$$\ell(\beta, \sigma_\eta | \mathbf{N}) = \sum_{i=1}^{n} \ln f\,(N_i | \boldsymbol{\theta}). \tag{6}$$

Assuming normality of the errors, we can write the log-likelihood function as

$$\begin{aligned} \ell(\beta, \sigma_\eta | \mathbf{N}) &= \sum_{i=1}^{n} \ln \left[\frac{1}{\sigma_\eta \sqrt{2\pi}} \exp \frac{\eta_i^2}{2\sigma^2} \right] \\ &= -n \ln \sigma_\eta - n \ln(\sqrt{2\pi}) + \frac{\sum_{i=1}^{n} \Big(N_i - \sum_{j \neq i} \exp(X_{ij}\beta) + \sum_{j \neq i} \exp(X_{ji}\beta) \Big)^2}{2\sigma_\eta^2} = \\ &= -n \ln \sigma_\eta - n \ln(\sqrt{2\pi}) + \frac{1}{2\sigma_\eta} (\mathbf{N} - \mathbf{S}\exp(\mathbf{X}\beta)'(\mathbf{N} - \mathbf{S}\exp(\mathbf{X}\beta), \end{aligned} \tag{7}$$

which can be maximized using standard optimization methods.

2.2 Maximum likelihood estimation of the net migration model: Simulation results

In a first step we evaluate the method proposed using simulated data. We obtain 9900 observations of simulated log migration flows m_{ij}, which are generated by the process

$$m_{ij} = 1 + .1x_{1,ij} + 0.5x_{2,ij} - 0.5x_{3,ij} + u_{ij}, \tag{8}$$

where the observations for x_1, x_2 and x_3 are drawn from standard normal distributions. The noise term, u_{ij}, is assumed normally distributed with mean zero and variance σ_u^2. In different simulation settings we draw errors with variances which

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[2] Badinger and Crespo Cuaresma (2012) use a similar approach to estimate bilateral trade flows.

lead to signal-to-noise ratios corresponding to R^2 values which range from 0.95 to 0.7. The simulated values of m_{ij} are aggregated as in equation 1 to obtain 100 observations of simulated net migration flows N_{ij}. We use these 100 net migration observations to obtain estimates of the parameters in the model following the maximum likelihood method sketched in section 2. This exercise is repeated 1000 times for different noise-to-ratio levels. Table 1 presents the mean and root mean square error (RMSE) of the estimated coefficients for each one of the settings (which correspond to R^2 values of 0.95, 0.9, 0.85, 0.8, 0.75 and 0.7).

Table 1 – Simulation results for different levels of noise

	$R =$	0.95	0.90	0.85	0.80	0.75	0.70
$\beta_0(1.0)$	RMSE	0.082	0.121	0.156	0.215	8.922	12.748
	Mean	1.01	1.02	1.02	1.04	0.65	0.11
$\beta_1(.1)$	RMSE	0.017	0.027	0.036	0.041	0.083	0.970
	Mean	0.10	0.10	0.10	0.10	0.10	0.06
$\beta_2(-.5)$	RMSE	0.027	0.039	0.050	0.067	0.863	1.970
	Mean	-0.50	-0.50	-0.50	-0.51	-0.55	-0.63
$\beta_3(.5)$	RMSE	0.026	0.039	0.050	0.066	1.659	2.180
	Mean	0.50	0.50	0.51	0.51	0.57	0.64

The results indicate that the method works well for noise levels which correspond to an R^2 of about 0.75. Since net migration is defined as a difference of nonlinear functions of the parameters, the identification of the intercept is weak, leading to less satisfactory estimates for the constant term even for an R^2 of 0.8, while the estimates of the slope parameter present better properties throughout the simulation settings. The empirical literature on the estimation of gravity models for migration flows using (fragmentary) bilateral data tends to report high explanatory power even in parsimoniously parameterized specifications, which makes us believe that the method proposed should work acceptably well in this setting.

3 Empirical analysis: Assessing migration flow determinants

We present a simple econometric specification that should serve as an application of the model to highlight the usefulness of the approach. In particular, we construct a specification for bilateral migration flows where the respective flow depends on the distance between the two countries, the GDP per capita as well as the population of the source and destination country, as well as other geographical and cultural aspects which are summarized in a dummy variable measuring geographical contiguity, one identifying common colonial history and another one controlling for common official language, 21 world-region dummies for the destination country and 21 world-region dummies for the source country. In addition, we control for the bilateral stock of migrants already present in the destination country (measured as the share of population in the origin country) to control for network effects.

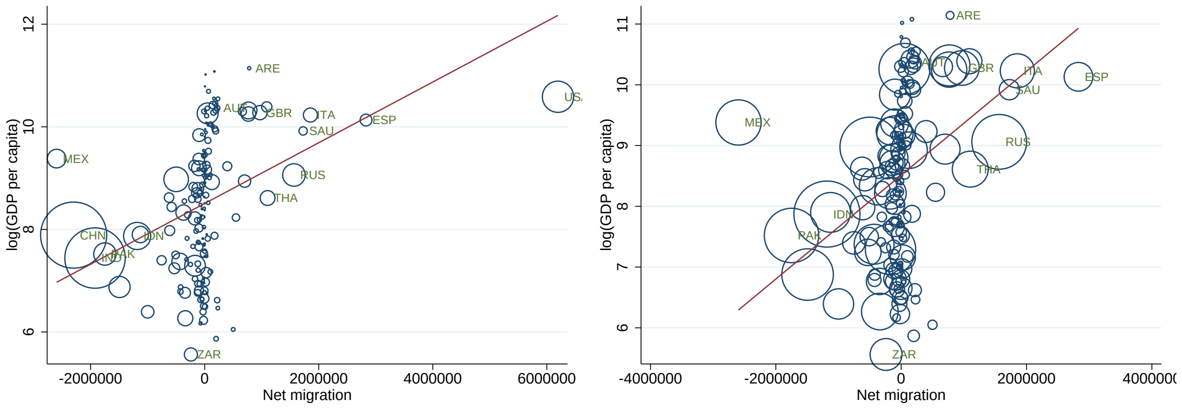

Figure 1 – Net migration flows vs. income per capita (size of the bubbles is proportional to population size). The United States, India and China are omitted in the right panel

In order to assess potential parameter heterogeneity with respect to the level of development of the source and destination countries, we interact the variables described above with two dummies representing migration flows from the *South* or from the *North*. Furthermore, dummy variables indicating the direction of the migration flows, i.e. from North to North, North to South, South to North and South to South, are also used in interactions with selected covariates, so as to evaluate potential parameter heterogeneity depending on the direction of migration flows. According to the World Bank's classification of income groups, we classify a country as belonging to the South if it belongs to income group *Low income* or *Lower middle income* and as belonging to the North if it is part of the *High income* or *Higher middle income* groups.[3]

Net migration flows as well as the GDP and population data are sourced from the World Bank's World Development Indicators. Net migration is evaluated at the period 2000-2005 and measures the difference between the total number of immigrants and the number of emigrants. As such, it represents the net total of immigrants of a given country over this period. The net migration estimates are based on a number of national sources. In cases where no official source of net migration is available, it is calculated by the difference between total population growth and natural increase in a country for a given period.[4] GDP and population are measured in the year 2000. Data on common official language, common borders, colonial history and bilateral distance corresponding to a country pair are obtained from the CEPII Gravity Dataset (Head, Mayer, and Ries, 2010). Bilateral migration stocks for the year 2000 are obtained from the World Bank's Global Bilateral Migration Database (Özden, Parsons, Schiff, and Walmsley, 2011). Dummy variables representing world regions are based on the United Nations Statistics Division's geographical sub-regions classification. The dataset contains information for a cross-section of 172 countries.

The relationship between net migration flows, GDP per capita and population at the

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[3] A complete list of countries and the corresponding income groups is provided in the Appendix.

[4] Notice that the "quality" of each data point is thus not necessarily the same. Exploiting the existing information on the quality of observations to develop a weighting scheme that can be embedded in the estimation method is a potentially fruitful avenue of further research which is outside the scope of this contribution.

country level is displayed in Figure 1. The scatterplots link net migration to income per capita, the size of the bubbles in the figures is proportional to the population of each country. The red line represents the estimated least square slope. Figure 1 shows that the absolute values of net migration flows tend to be higher for countries that are larger in terms of population. Countries with relatively high GDP per capita are associated with positive net migration flows, indicating that income acts as a pull factor for migration. The left panel in Figure 1 includes all countries used in the analysis, whilein the right panel the United States, China and India are omitted, in order to show that the findings are not driven solely by these countries.

Table 2 shows the estimates of the different specifications described above, obtained using the nonlinear maximum likelihood estimation method sketched in section 2. The results in column (1) of Table 2 suggest that the core variables of the gravity model (per capita GDP of destination and source countries, the populations of both countries, the distance between the countries as well as colonial relationships, common language and contiguity) are important determinants of global bilateral migration flows. The estimated coefficients support the predictions of the standard gravity model and in addition provide new quantitative insights to the determinants of bilateral migration flows. A higher per capita GDP in the destination country attracts migrants and thus increases the bilateral flows, whereas better economic conditions in the source country, measured by the GDP per capita, reduces migration flows. Geographical contiguity increases the flow between countries on average by approximately 115% while migration flows between pairs of countries having a common colonial history tend to be more than the double of those without colonial links, keeping all other variables constant. A common official language between two countries, assumed to reduce the cost of migration, increases migration flows by roughly 35%, given all other characteristics. The positive relation between migration stocks and bilateral flows provides evidence for network effects. Existing networks and communities in the destination country facilitate migration as they support a potential migrant by the provision of information regarding legal matters, infrastructure or employment opportunities. Additionally, many countries explicitly support family reunifications in their immigration laws, an effect that is also captured by this variable.

In Column (2) in Table 2 the effects of the covariates are allowed to vary depending on the income level of the source country. Low income countries are denoted as countries in the South and high income countries are referred to as countries in the North. The geographical location of the countries is disregarded in this definition. The results show that geographical distance appears to be a larger barrier when the origin country belongs to a low income group and that network effects are significant only for migration flows originating in developing countries. Column (3) shows the results of the estimation of a more flexible specification in terms of parameter heterogeneity. In this model, some covariates are interacted with dummy variables indicating the direction of migration flows. We find that GDP per capita in the destination country has the highest effect for migration flows within the group of developing countries. While for flows to the north and within the group of northern countries a higher GDP per capita in the destination country attracts more migrants, this is not the case for flows from high to low income countries. Higher GDP per capita in the source country decreases out-migration in most cases, although for mi-

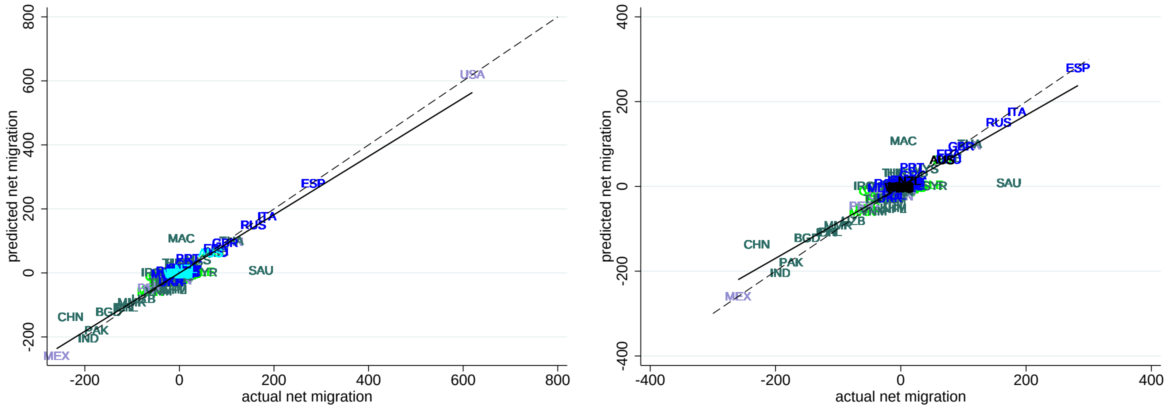

Figure 2 – Actual vs. predicted net migration flows (in 10.000s), full sample (left panel) and full sample excluding United States (right panel)

gration between countries in the North this result can not be validated. A common colonial history of two countries multiplies migration flows by roughly three within the group of high income countries and for South-North migration flows. We gain further insights about the effect of the migration stock in the destination country when interactions with direction dummies are used. The effects of the existing stock of migrants found in Columns (1) and (2) seem to be mainly driven by the relevance of this variable for flows from developing to developed countries. Although a significant effect is also found for North-North migration, its magnitude is comparably small.

As a cross-validation check, we compute the net migration flows implied by our model estimates for 2000-2005 and compare them to the actual data. Figure 2 plots actual versus estimated net migration rates for each country. The left panel of Figure 2 shows net migration flows for all countries and the right panel excludes the United States, as immigration to the United States is significantly higher than to any other country. Comparing the least squares fit (solid line) to the 45-degree line (dotted line) shows that the net migration figures implied by our model estimates are very much in line with actual net migration flow data. The slope parameter estimate of the line is not significantly different from unity and estimated with an extremely high degree of precision.

4 Projecting migration flows to Europe: An illustration

The elasticities provided by the estimates obtained can be used to obtain projections of migration flows using assumptions on global population and income dynamics. As an illustration of this type of analysis, we carry out a simple migration projection exercise for the period 2010-2050, where we concentrate on the migration trends to Europe.

We combine the parameter estimates presented in Table 2 with population and GDP projections for most countries of the world which have been recently developed in the framework of the 5th Assessment Report of the Intergovernmental Panel

Table 2 – Maximum Likelihood estimation results

	(1)		(2)		(3)	
ln(distance)	-0.7271***	[0.0765]				
× Origin North			-0.3809***	[0.0520]		
× Origin South			-0.6495***	[0.0465]		
× North-North					-0.5469***	[0.0916]
× North-South					-0.2397**	[0.1150]
× South-North					-0.7564***	[0.0883]
× South-South					-0.6625***	[0.0950]
ln(GDP pc destination)	0.4335***	[0.0922]				
× Origin North			1.5736***	[0.2583]		
× Origin South			0.6241***	[0.0718]		
× North-North					0.7552***	[0.1653]
× North-South					-1.6009***	[0.2442]
× South-North					0.4820**	[0.2014]
× South-South					1.7540***	[0.3417]
ln(GDP pc × Origin)	-0.3332***	[0.0399]				
× Origin North			0.6749***	[0.1166]		
× Origin South			-0.0414	[0.0771]		
× North-North					1.1179***	[0.1427]
× North-South					-5.6341***	[1.2347]
× South-North					-0.3907**	[0.1588]
× South-South					-0.1738	[0.3713]
ln(Pop. destination)	0.6433***	[0.0443]				
× Origin North			1.0799***	[0.0962]		
× Origin South			0.8178***	[0.0457]		
× North-North					1.1115***	[0.1030]
× North-South					-0.1363	[0.1650]
× South-North					0.8398***	[0.1198]
× South-South					0.6653***	[0.0729]
ln(Pop. × Origin)	0.5544***	[0.0307]				
× Origin North			0.7322***	[0.0618]		
× Origin South			0.6451***	[0.0232]		
× North-North					0.8484***	[0.1036]
× North-South					2.0524***	[0.3541]
× South-North					0.5847***	[0.1155]
× South-South					0.9086***	[0.1765]
Contiguity	1.1478***	[0.2325]	1.7603***	[0.1493]	1.2658***	[0.2550]
Colony	2.6209***	[0.1309]				
× Origin North			3.5571***	[0.2153]		
× Origin South			0.8475***	[0.1670]		
× North-North					3.5113***	[0.2718]
× North-South					-11.6176	[610912]
× South-North					2.8741***	[0.2608]
× South-South					0.1576	[0.4067]
Common language	0.3484***	[0.0652]	0.2949***	[0.0984]	0.3125*	[0.1808]
Share migration stock	0.0969***	[0.0023]				
× Origin North			0.0040	[0.0115]		
× Origin South			0.0950***	[0.0027]		
× North-North					0.0307***	[0.0078]
× North-South					0.0356	[0.0916]
× South-North					0.1000***	[0.0055]
× South-South					-0.3835	[0.2967]
South Origin			0.8562***	[0.2995]		
log likelihood	-144381.1		-137685.2821		-134883.9	

Nonlinear maximum likelihood estimation based on net migration as a dependent variable in the model given by (3). The model includes 21 destination and 21 source region dummy variables, whose parameter estimates are not shown in the table. Net migration corresponds to the period 2000-05, while the explanatory variables are evaluated in the year 2000.

for Climate Change (IPCC) by Lutz and K.C. (2013) (for population) and Crespo Cuaresma (2013) (for GDP). Projections are constructed around five narrative scenarios which correspond to different challenges in terms of mitigation and adapta-

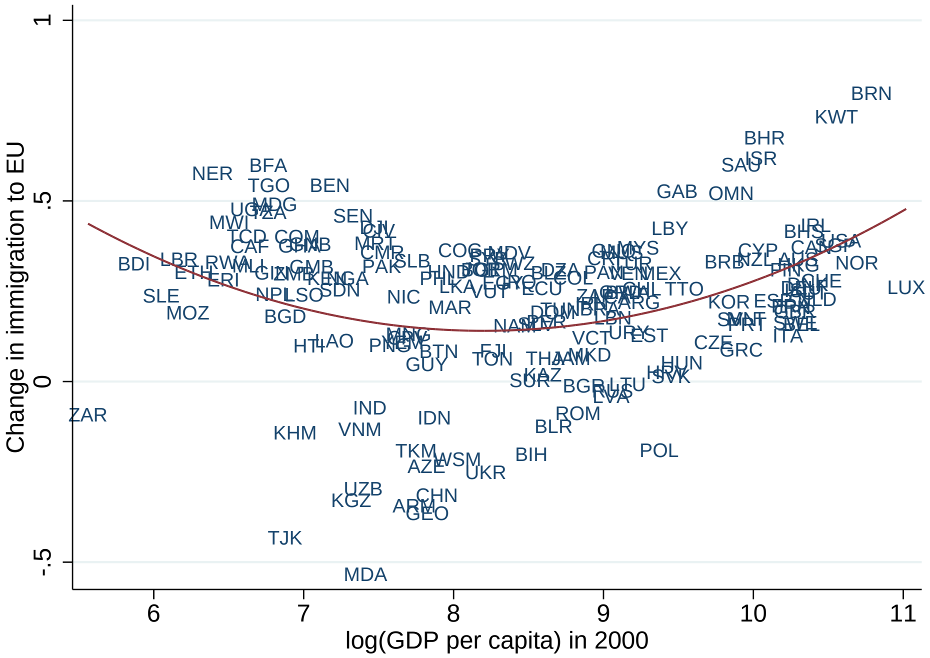

Figure 3 – Projected change in migration to EU15

tion to climate change. These scenarios are dubbed *Shared Socioeconomic Pathways* (Kriegler, O'Neill, Hallegatte, Kram, Lempert, Moss, and Wilbanks, 2013). We obtain projections of population and GDP for the Shared Socioeconomic Pathway which depicts the "middle-of-the-road" scenario, and as such is neither too optimistic nor too pessimistic concerning fertility reduction in developing economies and income convergence dynamics at the global level. Such a projection scenario provides a realistic benchmark to assess the changes in migration flows to Europe in the coming decades.

Using the projected population and GDP paths for all countries of the world obtained by the methods put forward by Lutz and K.C. (2013) and Crespo Cuaresma (2013), we compute the changes in migration flows to EU-15 countries for the period 2010-2050. We concentrate in the EU-15 group in order to explicitly address also the change in migration flows from Eastern Europe, which has been a prominent component of migration within Europe in the last decades. Figure 3 depicts the projected percent changes in migration flows towards Europe for the period 2010-2050 (by country of origin) against the current GDP per capita levels of the source countries. Such a graphical representation informs us about the expected change in the profile of migrants to Europe by country of origin over the coming decades.

The results in Figure 3 suggest that the projected demographic and economic developments at the global level are expected to increase migration flows to Europe in the next 35 years. The relative increase in migration flows by source country, however, is expected to be heterogeneous. Migration flows from Central and Eastern European countries to EU-15 economies are expected to remain roughly constant over the coming 35 years. The U-shaped relation between current income levels and expected increase in migration flows points towards a changing source country composition of immigrants, as in particular migrants from countries with currently low income levels are expected to significantly increase their share in total migration to Europe.[5]

This type of projection exercise can serve to inform policy makers in recipient countries of disaggregated migration trends and provide signals about, for example, changes in the skill profiles of immigrants.

5 Conclusions and paths of further research

A large body of literature is devoted to understanding the causes of bilateral migration flows. The majority of the empirical studies focus on North-South, North-North or South-North migration, as available data sets only cover immigration flows for receiving industrialized countries. We propose a method that allows to assess global migration flows using the fact that available net migration rates are nonlinear aggregates of bilateral migration flows. We show that a simple quasi-maximum likelihood method performs well for underlying bilateral specifications with relatively good eplanatory power for migration flows. Modelling the bilateral migration flows with the aid of simple gravity models and linking them to the net migration flows allows estimating the response of bilateral migration flows to changes in the explanatory variables.

Using a simple projection exercise for bilateral migration flows to Europe based on a realistic scenario for population and income dynamics, we exemplify how the method can be used to monitor future trends in migration and inform policy makers of changes in the composition of migrants by country of origin.

The specification used in the analysis has an illustrative character and can be extended further to account for parameter heterogeneity across world regions. The maximum likelihood estimation framework allows for a natural extension to Bayesian estimation methods, which in addition should allow for a straightforward (albeit arguably computationally expensive) assessment of model uncertainty. This avenue of research is already being carried out by the authors.

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[5] The income convergence trends embodied in the GDP projections used for the middle-of-the-road scenario of the Shared Socioeconomic Pathways is a central driving force of such a result. While income equalization over the period 2010-2100 is assumed in three out of the five Shared Socioeconomic Pathways, the U-shaped relationship in Figure 3 may change if population and GDP per capita projections based on diverging global income per capita dynamics are used.

References

ABEL, G. (2010): "Estimation of international migration ow tables in Europe.," *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 173, 797–825.

——— (2013): "Estimating Global Migration Flow Tables Using Place of Birth Data," *Demographic Research*, 28, 505–546.

BADINGER, H., AND J. CRESPO CUARESMA (2012): "Aggregravity: Estimating gravity equations without bilateral data," .

BAKEWELL, O. (2009): "South-South Migration and Human Development: Reflections on African Experiences," Human Development Reports Research Paper 2009/07, United Nations Development Programme.

BEINE, M., F. DOCQUIER, AND C. OZDEN (2011): "Diasporas," *Journal of Development Economics*, 95(1), 30–41.

CLARK, X., T. J. HATTON, AND J. G. WILLIAMSON (2007): "Explaining U.S. Immigration, 1971-1998," *The Review of Economics and Statistics*, 89(2), 359–373.

CRESPO CUARESMA, J. (2013): "Income Projections for Climate Change Research: A Framework Based on Human Capital Dynamics," *Mimeo.*

DOCQUIER, F., AND A. MARFOUK (2006): "International migration by educational attainment (1990-2000)," *International migration, remittances and the brain drain*, pp. 151–199.

GROGGER, J., AND G. H. HANSON (2011): "Income maximization and the selection and sorting of international migrants," *Journal of Development Economics*, 95(1), 42–57.

HEAD, K., T. MAYER, AND J. RIES (2010): "The Erosion of Colonial Trade Linkages after Independence," *Journal of International Economics*, 81(1), 1–14.

KAREMERA, D., V. I. OGULEDO, AND B. DAVIS (2000): "A gravity model analysis of international migration to North America," *Applied Economics*, 32(13), 1745–1755.

KIM, K., AND J. E. COHEN (2010): "Determinants of International Migration Flows to and from Industrialized Countries: A Panel Data Approach Beyond Gravity1," *International Migration Review*, 44(4), 899–932.

KRIEGLER, E., B. O'NEILL, S. HALLEGATTE, T. KRAM, R. LEMPERT, R. MOSS, AND T. WILBANKS (2013): "The need for and use of socio-economic scenarios for climate change analysis: A new approach based on shared socio-economic pathways," *Global Environmental Change*, forthcoming.

LUTZ, W., AND S. K.C. (2013): "The Human Core of the SSPs: Population Scenarios by Age, Sex and Level of Education for all Countries to 2100," *Mimeo.*

OECD (2012): "Stocks and flows of immigrants, 2000-2010," *International Migration Database.*

Ortega, F., and G. Peri (2009): "The Causes and Effects of International Migrations: Evidence from OECD Countries 1980-2005," Working Paper 14833, National Bureau of Economic Research.

——— (2013): "The Effect of Income and Immigration Policies on International Migration," *Migration Studies*, 1(1), 47–74.
ΩÖzden, Parsons, Schiff, and Walmsley

Özden, a., C. R. Parsons, M. Schiff, and T. L. Walmsley (2011): "Where on Earth is Everybody? The Evolution of Global Bilateral Migration 19602000," *The World Bank Economic Review*, 25(1), 12–56.

Pedersen, P. J., M. Pytlikova, and N. Smith (2008): "Selection and Network Effects. Migration flows into OECD countries 1990–2000," *European Economic Review*, 52(7), 1160 – 1186.

Proietti, T. (2006): "On the Estimation of Nonlinearly Aggregated Mixed Models," *Journal of Computational and Graphical Statistics*, 15(1), pp. 18–38.

Ravenstein, E. G. (1885): "The Laws of Migration," *Journal of the Statistical Society of London*, 48(2), pp. 167–235.

——— (1889): "The Laws of Migration," *Journal of the Royal Statistical Society*, 52(2), pp. 241–305.

Tinbergen, J. (1962): *Shaping the World Economy; Suggestions for an International Economic Policy.* Twentieth Century Fund, New York.

United Nations (2011): "International Migration Report 2009: A Global Assessment," ST/ESA/SER.A/316, Department of Economic and Social Affairs, Population Division.

Vanderkamp, J. (1977): "The Gravity Model and Migration Behaviour: An Economic Interpretation," *Journal of Economic Studies*, 4(2), 89–102.

Appendix

Table 3 – List of countries and corresponding income groups

South		North		
Low income	Lower middle income	Higher middle income	High income: OECD	High income: non-OECD
Bangladesh	Angola	Albania	Australia	Bahamas, The
Benin	Armenia	Algeria	Austria	Bahrain
Burkina	Belize	Argentina	Belgium	Barbados
Burundi	Bhutan	Azerbaijan	Canada	Brunei Darussalam
Cambodia	Bolivia	Belarus	Czech Republic	Croatia
Central Afr Rep	Cameroon	Bosnia and Herz	Denmark	Cyprus
Chad	Cape Verde	Botswana	Finland	Equatorial Guin
Comoros	China	Brazil	France	Estonia
Congo, Dem Rep	Congo, Rep.	Bulgaria	Germany	Hong Kong SAR
Eritrea	Cote d’Ivoire	Chile	Greece	Israel
Ethiopia	Djibouti	Colombia	Hungary	Kuwait
Gambia, The	Ecuador	Costa Rica	Iceland	Latvia
Ghana	Egypt, Arab Rep.	Dominican Rep	Ireland	Macao SAR
Guinea	El Salvador	Fiji	Italy	Malta
Guinea-Bissau	Georgia	Gabon	Japan	Oman
Haiti	Guatemala	Grenada	Korea, Rep	Qatar
Kenya	Guyana	Iran, Islamic Rep.	Luxembourg	Saudi Arabia
Kyrgyz Rep	Honduras	Jamaica	Netherlands	Singapore
Lao PDR	India	Kazakhstan	New Zealand	Trinidad and Tob
Liberia	Indonesia	Lebanon	Norway	United Arab Emir
Madagascar	Iraq	Libya	Poland	
Malawi	Jordan	Lithuania	Portugal	
Mali	Lesotho	Macedonia, FYR	Slovak Republic	
Mauritania	Maldives	Malaysia	Slovenia	
Mozambique	Micronesia, Fed St	Mauritius	Spain	
Myanmar	Moldova	Mexico	Sweden	
Nepal	Mongolia	Namibia	Switzerland	
Niger	Morocco	Panama	United Kingdom	
Rwanda	Nicaragua	Peru	United States	
Sierra Leone	Nigeria	Romania		
Solomon Islands	Pakistan	Russian Fed		
Tajikistan	Papua New Guin	South Africa		
Tanzania	Paraguay	St Lucia		
Togo	Philippines	St Vincent & Gren		
Uganda	Samoa	Suriname		
Zambia	Senegal	Turkey		
	Sri Lanka	Uruguay		
	Sudan	Venezuela		
	Swaziland			
	Syrian Arab Rep			
	Thailand			
	Timor-Leste			
	Tonga			
	Tunisia			
	Turkmenistan			
	Ukraine			
	Uzbekistan			
	Vanuatu			
	Vietnam			
	Yemen, Rep			

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Project Information

Welfare, Wealth and Work for Europe

A European research consortium is working on the analytical foundations for a socio-ecological transition

Abstract

Europe needs a change: The financial crisis has exposed long neglected deficiencies in the present growth path, most visibly in unemployment and public debt. At the same time Europe has to cope with new challenges ranging from globalisation and demographic shifts to new technologies and ecological challenges. Under the title of Welfare, Wealth and Work for Europe – WWWforEurope – a European research consortium is laying the analytical foundations for a new development strategy that enables a socio-ecological transition to high levels of employment, social inclusion, gender equity and environmental sustainability. The four year research project within the 7th Framework Programme funded by the European Commission started in April 2012. The consortium brings together researchers from 33 scientific institutions in 12 European countries and is coordinated by the Austrian Institute of Economic Research (WIFO). Project coordinator is Karl Aiginger, director of WIFO.

For details on WWWforEurope see: www.foreurope.eu

Contact for information

Kristin Smeral
WWWforEurope – Project Management Office
WIFO – Austrian Institute of Economic Research
Arsenal, Objekt 20
1030 Vienna
wwwforeurope-office@wifo.ac.at
T: +43 1 7982601 332

Domenico Rossetti di Valdalbero
DG Research and Innovation
European Commission
Domenico.Rossetti-di-Valdalbero@ec.europa.eu

Partners

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