Project 2006/S 100-106607/EN, LOT 2

Modelling of statistical data on migration and migrant populations

MIMOSA

Estimates of OD matrix by broad group of citizenship, sex and age, 2002-2007

10 December 2009

Prepared by
Joop de Beer and Rob van der Erf
NIDI, The Hague, The Netherlands
and
James Raymer
University of Southampton, United Kingdom

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

This document presents the final methodology used in the MIMOSA project to produce a consistent (harmonized) and complete set of migration flow estimates between 27 European Union countries and four EFTA countries (Iceland, Liechtenstein, Norway and Switzerland), along with the methodology used to disaggregate these flows by age, sex and citizenship. The methodology was developed over a period of three years. In the first year, a general framework for estimating the origin-destination matrix of flows over time was selected and developed. During the second year, this methodology was reviewed and revised and then extended to include age and sex disaggregations. At the same time, methodologies were proposed to estimate the origin-destination-specific flows by citizenship. In the end, we decided to extend the multiplicative framework used to disaggregate the flows by age and sex to also include citizenship, thus maintaining consistency with the previously estimated origin-destination migration totals.

The MIMOSA model for estimating international migration flows consists of three major steps. The first step estimates adjustment factors for 19 countries that report both immigration (I_{ij}) and emigration (E_{ij}) flow data. The second step estimates the missing origin-destination-specific data. Finally, these estimates are disaggregated by age, sex and citizenship. This report presents the methodologies used in each of the three steps (with the third step separated into two parts: (i) age and sex and (ii) citizenship) and the final results of migration by country of origin (31), country of destination (31), age (17), sex (2) and citizenship (3) for the years 2002-2007. As there are 569,160 cells in our final table of migration flows, we only present a selected set of results. The complete set of estimates is available from the NIDI website (http://www.nidi.knaw.nl/en/projects/230211/).

1.1. Background

The process of obtaining consistent international migration flow data involves overcoming several major data-related obstacles (Kelly 1987). Mainly, this involves combining information obtained from independent sources that may contain different conceptualisations of migration and varying levels of quality and estimating missing data. There has been a lot of work carried out on the data issues and migration typologies, for example, see Champion (1994), Kelly (1987), Kraly and Gnanasekaran (1987), Poulain (1994, 1995), Poulain *et al.* (2006), Raymer and Willekens (2008), United Nations (2002) and Willekens (1994, 1999, 2008). There are three reasons why migration data differ: the collection method, the definition and the timing criterion.

For this work, we estimate the migration flows according to the United Nations (1998) definition, which recommends that long-term international migrants be defined as persons who move to a country other than their usual residence for a period of at least one year (United Nations 1998). In reality, countries tend to gather migration data according to their own needs (often for legal purposes) or to be consistent with historical collection methods. Furthermore, until very recently, there have been no real incentives for countries to adjust their data collection methods to provide internationally comparable migration statistics. This means that one must have a good sense of the various migration data typologies and understanding about the determinants migration to produce reliable estimates of migration. As countries are now required to provide harmonised migration flow statistics to Eurostat as part of a new regulation passed by the European Parliament, this methodology is highly relevant, particularly since Article 9 of the Regulation states that 'As part of the statistics process, scientifically based and well documented statistical estimation methods may be used.'[1] Our proposed framework set out in this document helps countries achieve this aim, as well as providing useful estimates for a better understanding of the patterns of migration across Europe.

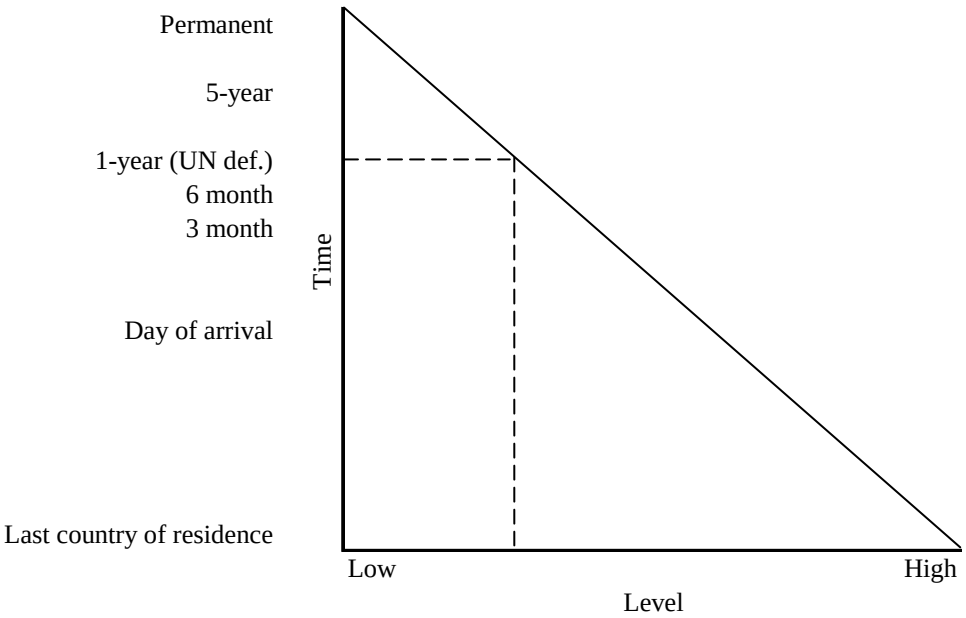
[1] http://www.europarl.europa.eu/sides/getDoc.do?objRefId=140109&language=EN.

1.2. Data Issues

The two main definitions of international migration flows refer to flows by origin and destination and flows by nationality. National statistical offices generally provide data on international migration flows by country of citizenship, with a large part of them also providing flows by country of origin and country of destination. However, data by country of citizenship are usually more complete and more reliable compared to data by country of origin and country of destination. For the latter, the category of unknown country of origin or unknown country of destination may be fairly substantial. Note, very few countries provide data on international migration flows by country of birth.

The timing criterion used to identify international migration flows varies considerably between countries. For population register data, international migration may refer to persons who have lived in a different country as much as three months, six months, or one year. In some cases (e.g., Germany), there are no specified definitions, whereas in others (e.g., Poland), a 'permanent' definition is used. The effect of timing criterions on levels of migration obtained from registers, residence permit databases or border crossing surveys is illustrated in Figure 1. Here, we assume the level of a migration flow is determined by the time spent in (or away from) the country of interest. Note that the relationships between different timings may, in fact, be non-linear, as Long and Boertlein (1990) show for different timings of internal transition migration in the United States. Also, the actual spacing between definitions could be different from what is expressed in the diagram; although, the relative rankings should remain the same. In the figure, the UN recommended 1-year definition lies on a continuum between ‘permanent’ to last country of residence’.

Figure 1. Conceptual framework for adjusting international migration flows due to different timings with the data coming from registers, residence permit databases or border crossing surveys



The permanent migration definition, representing a move in which the migrant essentially gives up his or her residence rights, has been used commonly in former Soviet Union countries in Central and Eastern Europe. This explains their very low reported flows (Nowok 2008). Last country of residence migration, on the other hand, refers to persons who ever lived abroad without a fixed time constraint. In between these two extremes are all sorts of possible definitions, including the UN's recommended one-year definition.

Inadequate data are data that may be considered unreliable. Inadequate data are more difficult to identify and correct. They can be often found by comparing them against the patterns captured by other countries or with expected patterns based on expert knowledge. The solutions to overcoming missing or inadequate data include collecting new data (time consuming and expensive), using ancillary data, smoothing the data, or estimation.

The two main sources of unreliability in migration statistics are under-registration of migrants and data coverage (Nowok *et al.* 2006, pp. 211-214). International migration data often contain inadequacies due to the collection method or due to non-participation of the migrants themselves (see Kupiszewska and Nowok 2008). Emigration data are particularly problematic because migrants may not notify the population register of their movement or may produce statements that are based on intentions. Surveys, such as the United Kingdom's International Passenger Survey, are particularly problematic for providing international migration data as the sample size must be very large in order to provide any level detail for analyses. Without a relatively large sample size, unexpected irregularities in the data are likely to appear.

The types of missing data found in European international migration data consist mainly of data not collected or provided to Eurostat by national statistical offices. There are many different types of missing data. For example, flows for certain countries may be missing for particular years or entirely. The reported flows are likely to have missed some groups of persons, for example, illegal migrants who do not participate, for obvious reasons, in a particular survey or register with the local residence authorities. Furthermore, migration data may be available only for the total population, not for more detailed demographic, socioeconomic or spatial characteristics required for a particular study.

To provide an example of what the data look like, consider the subset of flows between ten countries in the European Union for 2003 presented in Table 1. For each migration flow, there are two possible values: one reported by the receiving country (R) and one reported by the sending country (S). However, for the 2003 data, there are four data situations present: flows reported by both the receiving and sending country (e.g., Czech Republic to Germany or Spain to Italy), flows only reported by the receiving country (e.g., flows from France or Greece), flows only reported by the sending country (e.g., flows to France or Greece) or no flows reported (e.g., Belgium to France or France to Belgium). Furthermore, where flows are available from both the sending and receiving countries, the numbers rarely match. For example, one might take the average of the two reported flows from Germany to Spain (i.e., 13,746 + 16,236 / 2) as a reasonable estimate, as the numbers are relatively close to each other. However to take the average of the two reported flows from Spain to Germany (i.e., 14,647 + 2,109 / 2) would most likely result in a very poor estimate. In this situation, one might consider one flow to be more accurate than the other. Deciding which flow is more accurate than the other has consequences for the other situations where only one reported flow is available, e.g., from Spain to Belgium or from France to Spain.

Table 1. Double-entry matrix for selected countries in the European Union, 2003

		Destination									
From		BE	CZ	DK	DE	EE	GR	ES	FR	IE	IT
BE	R		80	587	4,291	…	…	3,037	…	…	1,959
	S		…	…	…	…	…	…	…	…	…
CZ	R	…		232	9,258	…	…	388	…	…	915
	S	78		47	950	2	66	70	283	31	197
DK	R	…	65		2,693	…	…	764	…	…	281
	S	511	180		2,540	133	229	1,720	1,333	264	782
DE	R	…	1,228	3,221		…	…	13,746	…	…	12,902
	S	4,623	8,909	2,712		597	18,106	16,236	19,060	2,415	33,802
EE	R	…	4	169	947		…	60	…	…	103
	S	…	…	…	…		…	…	…	…	…
GR	R	…	57	278	12,959	…		273	…	…	638
	S	…	…	…	…	…		…	…	…	…
ES	R	…	103	1,665	14,647	…	…		…	…	2,051
	S	647	34	130	2,109	4	38		2,474	487	801
FR	R	…	462	1,488	18,133	…	…	8,847		…	4,647
	S	…	…	…	…	…	…	…		…	…
IE	R	…	45	306	2,046	…	…	1,649	…		292
	S	…	…	…	…	…	…	…	…		…
IT	R	…	274	895	23,702	…	…	5,796	…	…	
	S	1,414	20	155	9,778	1	211	895	2,933	130	

Notes: R = receiving country's reported flows; S = sending country's reported flow; ... = no reported data available; BE = Belgium, CZ = Czech Republic, DK = Denmark, DE = Germany, EE = Estonia, GR = Greece, ES = Spain, FR = France, IE = Ireland and IT = Italy.

2. Methodology

2.1. Background

Wilson's (1971) introduction of families of spatial interaction models using entropy-maximization techniques, Snickars and Weibull's (1977) minimum information principle, and Bishop, Fienberg and Holland's (1975) text on discrete multivariate analysis provided the foundations for many important papers on the modelling of migration flows (see, e.g., Alonso 1986; Aufhauser and Fischer 1985; Bennett and Haining 1985; Flowerdew 1991; Flowerdew and Lovett 1988; Plane 1982; Willekens 1977, 1980, 1982, 1983; Willekens and Baydar 1985). Furthermore, Willekens (1980, 1983), Flowerdew and Aitkin (1982) and Plane (1982) demonstrated the linkages and equivalences between various statistical approaches to estimating migration flows, allowing for a generalization of the estimation process (see also Willekens 1994, 1999, forthcoming). Note, the models and approaches covered in this section focus on those designed to model migration matrices at the macro level.

In the early 1980s, Willekens (1982, 1983) proposed a log-linear approach to model spatial interaction in migration flow tables. A migration flow table can be considered a two-way (origin by destination) contingency table, where the cells represent counts of migrants. Auxiliary information may be included via offsets, including structural zeros to remove cells representing non-migrants or intra-national migrants from the estimation process. For example, a log-linear-with-offset model is specified as

$$\ln(\hat{n}_{ij}) = \lambda + \lambda_i^O + \lambda_j^D + \ln(n_{ij}^*), \quad (1)$$

where n_{ij}^* represents the offset or auxiliary information, λ is the overall effect, λ_i^O is the origin main effect and λ_j^D is the destination main effect. This model provides estimates of migration flows that are consistent with the observed (or estimated) margins of the migration flow table (i.e., n_{i+} and n_{+j}) but borrow the associations between origins and destinations from the offset, n_{ij}^* (Rogers et. al 2003). The advantage of the log-linear model over the general spatial interaction model is that it has a well-formed theory and methods, associated in the framework of contingency-table analysis or discrete multivariate analysis (Willekens 1994, 1999).

During the past ten years, there have been several papers focusing on describing and modelling the structures of migration found in tables cross-classified by origin, destination and age (Raymer ***et al***. 2006; Raymer and Rogers 2007; Rogers ***et al***. 2001, 2002a, 2002b; 2003). This (mathematical) approach has direct linkages with the log-linear (statistical) model approach above. The multiplicative component model for describing an origin (*O*) by destination (*D*) table of migration flows is specified as

$$n_{ij} = (T)(O_i)(D_j)(OD_{ij}), \; i \neq j \quad (2)$$

where n_{ij} is a migration flow from origin *i* to destination *j*. There are four multiplicative components in total: an overall level, two main effects and one two-way interaction or association component. The description and estimation centres on these components rather than on the flows themselves. For example, this analysis can be used to assess whether an increase in a particular flow occurred because of an increase in overall attractiveness of the region (i.e., marginal effect), because of an increase in the connectedness between two places (i.e., interaction effect), or as a consequence of both. The components are calculated with reference to the total level in the migration flow tables. The *T* component represents the total number of all migrants in the system, $T = n_{++}$. The main

effect components, O_i and D_j, represent proportions of all migration from each origin and to each destination, i.e., $O_i = n_{i+} / T$ and $D_j = n_{+j} / T$. The two-way interaction component represents the ratio of observed migration to expected migration (for the case of no interaction) and is calculated as $OD_{ij} = n_{ij} / [(T)(O_i)(D_j)]$. The OD_{ij} component captures the association or 'connectivity' between origins and destinations.

The multiplicative component model is useful framework for estimating migration flows because it makes a distinction between an overall level, main effects, and interaction effects in contingency tables with parameters that can be used to guide the estimation process. This means that one can focus on modelling the underlying structures of migration flows via the multiplicative components. Also, the estimation process can be carried out in a systematic manner working from marginal effects to interaction effects. Finally, as described in Sections 2.4 and 2.5 below, this model can be extended to include other categorical variables, such as age groups, sex, or citizenship. This modelling framework has been used, for example, to project future age-specific migration patterns in Italy (Raymer *et al*. 2006) and to construct missing origin-destination associations for migration between countries in Europe (Raymer 2007, 2008).

Finally, the log-linear-with-offset model (Equation 1) produces the same estimates as those obtained from iterative proportional fitting (Deming and Stephan 1940; Fienberg 1970; Haining *et al.* 1984; Johnston and Pattie 1993; Wong 1992), which is a relatively simple (mathematical) technique that has been used for 'updating' incomplete migration flow tables (Nair 1985; Rees and Duke-Williams 1997; Willekens 1982, 1983). As with the log-linear-with-offset model, this method may be used to revise a historical (or auxiliary) table of migration flows by forcing it to fit, bi-proportionally through iteration, a more recent set of marginal totals with missing cell counts, where the marginal totals may represent beginning and ending populations or total in-migration and out-migration by region or country.

2.2. Harmonisation

Because of all the differences in reported data, harmonisation of the reported data has been our most difficult task. Over the past three years, we have experimented with various approaches, which has resulted in the methodology set out in this subsection. The basic idea is to apply optimisation to minimise the differences between the two sets of reported data, pooled over time, according to a set of criteria. The result is a set of average 'adjustment factors' for both sending (E_{i+}) and receiving (I_{+j}) country data that are then used to obtain harmonised estimates of migration flows for countries providing data. The general methodology is set out below followed by the application in Section 3.

If we have a $N \times N$ receiving country matrix (I_{ij}) and a $N \times N$ sending country matrix (E_{ij}), the adjustment factors for the receiving country data, α_j, and the adjustment factors for the sending country data, β_i, can be estimated by assuming the following relationships:

$$\sum_j \hat{\alpha}_j I_{ij} = \hat{\beta}_i \sum_j E_{ij} \quad \text{for } i = 1,\ldots, N;\ i \neq j \tag{3}$$

and

$$\hat{\alpha}_j \sum_i I_{ij} = \sum_i \hat{\beta}_i E_{ij} \quad \text{for } j = 1, \ldots, N;\ i \neq j. \tag{4}$$

Equation (3) states that, for each country, the emigration total estimated on the basis of the adjusted receiving country matrix equals the emigration total estimated of the basis of the adjusted sending country matrix. Equation (4) does the same for immigration totals.

Equations (3) and (4) can be written as a homogeneous system of 2*N* linear equations with 2*N* unknowns:

$$\hat{\alpha}_2 I_{12} + \hat{\alpha}_3 I_{13} + ... + \hat{\alpha}_N I_{1N} - \hat{\beta}_1 \sum_j E_{1j} = 0$$

….

$$\hat{\alpha}_1 I_{N1} + \hat{\alpha}_2 I_{N2} + ... + \hat{\alpha}_{N-1} I_{NN-1} - \hat{\beta}_N \sum_j E_{Nj} = 0$$

$$\hat{\alpha}_1 \sum_i I_{i1} - \hat{\beta}_2 E_{21} - \hat{\beta}_3 E_{31} - ... - \hat{\beta}_N E_{N1} = 0$$

…

$$\hat{\alpha}_N \sum_i I_{iN} - \hat{\beta}_1 E_{N1} - \hat{\beta}_2 E_{N2} - ... - \hat{\beta}_{N-1} E_{NN-1} = 0 \qquad (5)$$

This system has an infinite number of solutions for α_j and β_i. In order to find a unique solution, a at least one restriction is required. For our estimates, we set the adjustment factor for Sweden's immigration data to equal one for the following two reasons: (i) the quality of Swedish immigration data is generally considered to be good and (ii) the definition used to measure Swedish immigration is consistent with the new EU regulation, i.e., a person is counted as immigrant if he or she intends to stay for at least twelve months). Finally, by multiplying the reported receiving country data by $\hat{\alpha}_j$ and the reported sending country data by $\hat{\beta}_i$, two estimated matrices are obtained with exactly the same marginal totals.

The basic assumption underlying the above harmonisation procedure is that the distributions of destinations reported by each country of origin and the distributions of origins reported by each country of destination are similar to each other. However, some of the origin-destination flows may differ considerably between the two harmonised tables of migration flows. To account for these differences, we introduce dummy variables for a small number of origin-destination flows, which are identified by analysing the differences in the two tables. In some cases, the indicator variable is applied to the receiving country data, whereas in others, it is applied to the sending country data.

Consider a particular flow, say from origin *p* to destination *q*, we can calculate two sets of ratios: $\hat{\gamma}_{pq} = \hat{\beta}_p E_{pq} / \hat{\alpha}_q I_{pq}$ or $\hat{\delta}_{pq} = \hat{\alpha}_q I_{pq} / \hat{\beta}_p E_{pq}$. However, introducing $\hat{\gamma}_{pq}$ or $\hat{\delta}_{pq}$ alters the overall estimates of α_j or β_i, respectively, as well as the consistency in the marginal totals. Therefore we have to adjust the system of linear equations by adding dummy variables (D_{ij}) for flows that exhibit large differences. For instance, if we find that only one particular flow in the sending country data (e.g., E_{pq}) needs a dummy variable, then Equations (3) and (4) can be rewritten as

$$\sum_j \hat{\alpha}_j I_{ij} = \hat{\beta}_i \sum_j E_{ij} (1 + \hat{\delta}^*_{pq} D_{ij}) \text{ for } i = 1,\ldots, N;\ i \neq j \qquad (6)$$

and

$$\hat{\alpha}_j \sum_i I_{ij} = \sum_i \hat{\beta}_i E_{ij} (1 + \hat{\delta}^*_{pq} D_{ij}) \quad \text{for } j = 1, ..., N;\ i \neq j \qquad (7)$$

where D_{ij} = 1 if $i = p$ and $j = q$, D_{ij} = 0 otherwise, and $\hat{\delta}^*_{pq} = \hat{\delta}_{pq} - 1$. The system of equations including I_{pq} and E_{pq} (Equation 5) can be rewritten as follows:

$$\hat{\alpha}_1 I_{p1} + ... + \hat{\alpha}_q I_{pq} + ... + \hat{\alpha}_N I_{pN} - \hat{\beta}_p E_{p1} - ... - \hat{\delta}_{pq}\hat{\beta}_p E_{pq} - ... - \hat{\beta}_p E_{pN} = 0$$

$$\hat{\alpha}_q \sum_i I_{iq} - \hat{\beta}_1 E_{1q} - ... - \hat{\delta}_{pq}\hat{\beta}_p E_{pq} - ... - \hat{\beta}_N E_{Nq} = 0 \quad (8)$$

In contrast with (5) these are non-linear equations. The values of the coefficients can be estimated by an iterative procedure, for example, by using 'Solver' in Microsoft Excel (as we did).

The above model can be extended to include additional dummies. We use three criteria for selecting dummies. First, they should be linked to flows that exhibit large differences in absolute terms. Second, the introduction of the dummy variable should improve the overall fit, i.e., both harmonised migration matrices are closer to each other than before. Third, the revised adjustment factors for the receiving and sending country data should appear reasonable.

Once the dummy variables have been introduced, the adjustment factors can be used to harmonise the reported flows outside the double-entry matrix (i.e., the matrix where two reported values are available). Note, unknowns are excluded from the estimation procedure throughout as the harmonisation procedure adjusts for these cases.

2.3. Missing Data

Once the available data have been harmonised, the next step is to estimate the migration flows for countries with missing data. We do this by first estimating the immigration and emigration totals, with separate estimates produced for migration from and to the 31 European countries and migration from and to the rest of the world. Second, we go through the details estimate the origin-destination associations.

For the estimation of immigration and emigration totals, we use four similar OLS regression models to estimate the natural logarithms of (1) immigration to the 31 European countries from the 31 European countries; (2) emigration from the 31 European countries to the 31 European countries; (3) immigration to the 31 European countries from the rest of the world; and (4) emigration to the rest of the world from the 31 European countries. The estimation of the regression coefficients are based on pooled data of the adjusted migration figures. The variables used to estimate the flows are population size (in thousands, natural logarithm), percentage of the population aged 65 and over, life expectancy of females, relative GDP, percentage urban, and dummy variables for Germany and for the calendar years.

Once the regression coefficients are estimated, they are then used to obtain estimates of the immigration and emigration totals for the countries with missing data. These estimates are then combined with the marginal totals of the adjusted data in order to obtain a complete set of margins for the European matrix (i.e., excluding the rest of world origin / destination). The immigration and emigration totals of this matrix are then proportionally adjusted to force the two totals to match each other. This is carried out by dividing the difference by two and proportionally subtracting that amount from the predicted immigration totals and proportionally adding it to the predicted emigration totals for the countries with missing data.

The missing origin-destination associations (i.e., OD_{ij} in Equation 2) are estimated based on the ratios of the harmonised origin-destination flows to the corresponding expected flows. The estimated marginal totals above are used to obtain expected flows (i.e., $e_{ij} = (T)(O_i)(D_j)$, assuming quasi-independence. Here, iterative proportional fitting is used to account for the structural zeros in the diagonal elements. Similar to the estimation of marginal totals, we use an OLS regression model to estimate the natural logarithms of available OD_{ij} terms, pooled over time. The variables used to estimate the associations are contiguity, dummy variables for migration between the new

accession countries and Ireland and the United Kingdom, language family, natural logarithm of GNI PPP, natural logarithm of distance, natural logarithm of foreign-born population stock associations between country *i* and *j*, and natural logarithm of trade associations between country *i* and *j*. Finally, once the missing origin-destination associations were estimated, they were then multiplied by the corresponding expected flows.

2.4. Disaggregation by sex and age

In this section, we disaggregate the origin-destination flows, estimated using the methodology in the previous section, by age and sex. Because the tables are more complicated, we denote cross-classified tables by letters. For example, OD is a two-way (origin by destination) table of migration flows, OAS is a three-way (origin by age by sex) table of migration flows and ODAS is a four-way (origin by destination by age by sex) table of migration flows. The full multiplicative component model for an ODAS table of migration flows is specified as

$$\begin{aligned} n_{ijx} = {} & (T)(O_i)(D_j)(A_x)(S_y) \\ & (OD_{ij})(OA_{ix})(OS_{iy})(DA_{jx})(DS_{jy})(AS_{xy}) \\ & (ODA_{ijx})(ODS_{ijy})(DAS_{jxy}) \\ & (ODAS_{ijxy}) \end{aligned} \tag{9}$$

where n_{ijxy} is an observed flow of migration from origin *i* to destination *j* for age group *x* (i.e., 0-4, 5-9, ..., 85+ years) and sex *y*. There are fifteen multiplicative components in total: an overall level (*T*), four main effects, six two-way interaction components, three three-way interaction components and a single four-way interaction component. For this study, however, we do not have complete information. Instead we only have three separate tables: (1) a complete origin by destination table (estimated), (2) an incomplete origin by age by sex table (provided by Eurostat) and (3) an incomplete destination by age and sex table (provided by Eurostat).

For the disaggregation by age and sex, we needed to identify an overall model that could accurately predict the migration flows. This was undertaken by comparing various unsaturated log-linear model fits of the two available three-way migration flow tables, i.e., OAS and DAS, for the 2002-2006 periods. According to the likelihood ratio statistic (used relatively), we found that the all two-way interaction models (OA, OS, AS and DA, DS, AS) predicted the three-way tables well. This means that we do not need to include the three-way interaction terms OAS_{ixy} and DAS_{jxy} in the overall model. Note, the two-way interactions between origin and sex (OS_{iy}) and destination and sex (DS_{jy}) and between age and sex (AS_{xy}) were significant but not as important as the interactions between origin and age (OA_{ix}) and destination and age (DA_{jx}).

Because ODA tables are not available for migration between countries in the European Union, we were not able to test whether the three-way interaction between origin, destination and age was significant. However, based on recent analyses of age-specific internal migration, we can assume these terms, for the most part, would not contribute much to the estimation of the flows. Raymer and Rogers (2007) and Raymer *et al.* (2006), for example, found that the models that included only the origin-age and destination-age interactions produced estimates that were nearly indistinguishable from the observed values in the complete ODAS table. Interestingly, there tends to be very little difference between male and female migration patterns in analyses of internal migration, whereas for these international migration data, there are significant differences.

The above analyses provide us with some direction on how to proceed with the combining of migration flow data. First, we do not need to include the complete data to produce accurate results. In fact, based on our analyses of the available data and analyses of internal migration in other

studies, we believe the following and relatively simple two-way interaction model will capture most of the international migration patterns between countries in the EU:

$$n^{*}_{ijxy} = (T)(O_i)(D_j)(A_x)(S_y)(OD_{ij})(OA_{ix})(OS_{iy})(DA_{jx})(DS_{jy})(AS_{xy}) \text{ , } \quad i \neq j \text{ . (10)}$$

with n^{*}_{ijxy} denoting an initial estimated set of migration flows. These flows are not constrained to any set of margins.

The modelling strategy is therefore to calculate the two-way interaction components terms that include age and sex and estimate the component values for countries that did not provide data. All components are calculated with reference to the total level in the migration flow tables (see Raymer 2007 for a discussion of the advantages of the 'total reference coding scheme' for migration modelling). The *T* component represents the total number of all migrants in the system,

$$T = \sum_{ijxy} n_{ijxy} = n_{++++} \text{ .} \qquad (11)$$

The main effect components, O_i, D_j, A_x, and S_y, represent proportions of all migration from each origin, to each destination, in each age group and by sex, respectively, i.e.,

$$O_i = \frac{\sum_{jxy} n_{ijxy}}{\sum_{ijxy} n_{ijxy}} = \frac{n_{i+++}}{n_{++++}} \text{ ,} \qquad (12)$$

$$D_j = \frac{\sum_{ixy} n_{ijxy}}{\sum_{ijxy} n_{ijxy}} = \frac{n_{+j++}}{n_{++++}} \text{ ,} \qquad (13)$$

$$A_x = \frac{\sum_{ijy} n_{ijxy}}{\sum_{ijxy} n_{ijxy}} = \frac{n_{++x+}}{n_{++++}} \text{ ,} \qquad (14)$$

$$S_y = \frac{\sum_{ijx} n_{ijxy}}{\sum_{ijxy} n_{ijxy}} = \frac{n_{+++y}}{n_{++++}} \text{ ,} \qquad (15)$$

The two-way interaction components represent the ratios of observed migration to expected migration (for the case of no interaction) and are calculated as

$$OD_{ij} = \frac{n_{ij++}}{(T)(O_i)(D_j)} \text{ ,} \qquad (16)$$

$$OA_{ix} = \frac{n_{i+x+}}{(T)(O_i)(A_x)} \text{ ,} \qquad (17)$$

$$OS_{iy} = \frac{n_{i++y}}{(T)(O_i)(S_y)} \text{ ,} \qquad (18)$$

$$DA_{jx} = \frac{n_{+jx+}}{(T)(D_j)(A_x)}, \quad (19)$$

$$DS_{jy} = \frac{n_{+j+y}}{(T)(D_j)(S_y)}, \quad (20)$$

$$AS_{xy} = \frac{n_{++xy}}{(T)(A_x)(S_y)}. \quad (21)$$

These interaction components represent ratios of observed flows or marginal totals to expected ones (i.e., based on the assumption of independence between the variables). The OD_{ij} component captures the association or 'connectedness' between origins and destinations. The OA_{ix}, DA_{jx} and AS_{xy} components represent the deviations from the overall age profile of migration, A_x. For estimation purposes, its useful to know that they also represent ratios of the age compositions of emigration and immigration to the overall age composition of migration, i.e.,

$$OA_{ix} = \frac{n_{i+x+} / n_{i+++}}{n_{++x+} / n_{++++}}, \quad (22)$$

$$DA_{jx} = \frac{n_{+jx+} / n_{+j++}}{n_{++x+} / n_{++++}}, \quad (23)$$

$$AS_{xy} = \frac{n_{++xy} / n_{+++y}}{n_{++x+} / n_{++++}}. \quad (24)$$

Finally, the OS_{iy} and DS_{jy} components represent the deviations from the overall proportions of migration in each sex group, S_y. For estimation purposes, these also represent ratios of the sex-specific proportions of emigration and immigration from and to each country, respectively, to the corresponding overall proportions, i.e.,

$$OS_{iy} = \frac{n_{i++y} / n_{i+++}}{n_{+++y} / n_{++++}} \text{ and } DS_{jy} = \frac{n_{+j+y} / n_{+j++}}{n_{+++y} / n_{++++}}. \quad (25)$$

The estimation of migration flows based on the multiplicative components produces 'initial' estimates that need to be constrained to the estimated origin-destination migration flow totals. This is done by including the initial values as an offset in the following log-linear model:

$$\ln\left(n_{ijxy}\right) = \lambda + \lambda_i^O + \lambda_j^D + \lambda_{ij}^{OD} + \ln\left(n_{ijxy}^*\right), \quad (26)$$

where n_{ijxy}^* denotes the offset of initial values, obtained by multiplying the multiplicative components together (i.e., Equation 10), and the lambda parameters represent the constraints in a log-linear model weighted to the origin-destination migration flow totals estimated previously.

2.5. Disaggregation by citizenship

To disaggregate our estimates by citizenship, we use a similar modelling framework as described above for disaggregating origin-destination flows by age and sex. However, the main difference is that we are unable to produce origin-destination tables by citizenship, only disaggregated flows based on origins or destinations. This is because the citizenship data are provided for the total flows entering or leaving a country, from the perspective of the receiving or sending country. We know, for example, how many nationals left Germany and how many EU nationals entered Spain, however, we do not know how many German nationals migrated to Spain (or to other destinations). Thus, the best we can do is model the following two four-way tables:

$$n^{*}_{ixyz} = (T)(O_i)(A_x)(S_y)(C_z)(OA_{ix})(OS_{iy})(OC_{iz})(AS_{xy})(AC_{xz})(SC_{yz}) \quad (27)$$

$$n^{*}_{jxyz} = (T)(D_j)(A_x)(S_y)(C_z)(DA_{jx})(DS_{jy})(DC_{jz})(AS_{xy})(AC_{xz})(SC_{yz}), \quad (28)$$

where *C* denotes citizenship in category *z* (i.e., nationals, EU nationals and non-EU nationals). Here, the multiplicative components for the terms with citizenship are calculated similarly to those for age and sex above. One important difference is that the proportions and ratios may differ according to whether they are being calculated for immigration flows or emigration flows. For example, one might expect the A_x term to have a slightly older age profile for emigrants than for immigrants. Because we can't include origin-destination terms in the model, we must calculate them separately. In the equations below, the superscripts 1 and 2 are used to denote emigration and immigration, respectively. The calculations for the citizenship components are based on the available data. For missing data, we assume the two-way interaction terms are equal to unity. Refer to the previous section for the origin, destination, age and sex component calculations.

The main effect component for citizenship, for the available data, is calculated by

$$C^{1}_{z} = \frac{\sum_{ixy} n_{ixyz}}{\sum_{ixyz} n_{ixyz}} = \frac{n_{+++z}}{n_{++++}}. \quad (29a)$$

$$C^{2}_{z} = \frac{\sum_{jxy} n_{jxyz}}{\sum_{jxyz} n_{jxyz}} = \frac{n_{+++z}}{n_{++++}}. \quad (29b)$$

The two-way interaction components represent the ratios of observed migration to expected migration (for the case of no interaction) and, for terms involving citizenship, are calculated as

$$OC_{iz} = \frac{n_{i++z}}{(T)(O_i)(C_z)}, \quad (30)$$

$$DC_{jz} = \frac{n_{j++z}}{(T)(D_j)(C_z)}, \quad (31)$$

$$AC^{1}_{xz} = \frac{n_{+x+z}}{(T)(A_x)(C_z)}, \quad (32a)$$

$$AC^{2}_{xz} = \frac{n_{+x+z}}{(T)(A_x)(C_z)}, \quad (32b)$$

$$SC_{yz}^{1} = \frac{n_{++yz}}{(T)(S_y)(C_z)}. \quad (33a)$$

$$SC_{yz}^{2} = \frac{n_{++yz}}{(T)(S_y)(C_z)}. \quad (33b)$$

As described in the previous section for the disaggregations by age and sex, a log-linear with offset model can then be used to force the initial estimates obtained by multiplying all the terms in Equations (27) and (28) together to fit the estimated origin and destination migration flow tables, respectively. These models are specified as:

$$\ln\left(\hat{n}_{ixyz}\right) = \lambda + \lambda_i^O + \ln\left(n_{ixyz}^*\right), \quad (34)$$

$$\ln\left(\hat{n}_{jxyz}\right) = \lambda + \lambda_j^D + \ln\left(n_{jxyz}^*\right), \quad (35)$$

where n_{ixyz}^* and n_{jxyz}^* denote the offsets of initial values for the OASC and DASC tables obtained from Equations (27) and (28), respectively. The lambda parameters represent the constraints in the log-linear models, i.e., the initial values are re-weighted to the origin and destination margins estimated earlier.

3. Harmonisation of available origin-destination data

3.1. Estimation of adjustment factors

The method described above in Section 2.2 is applied in this section to estimate an origin-destination migration matrix for 19 European countries, listed in Table 2. First, to illustrate the methodology, we apply the method to the average values of immigration and emigration in the years 2002-2007. Later we produce estimates for individual years.

Table 2. Countries with international migration data by country of origin and destination

Austria	AT	Spain	ES	Luxembourg	LU	Sweden	SE
Cyprus	CY	Finland	FI	Latvia	LV	Slovenia	SI
Czech Republic	CZ	Iceland	IS	Netherlands	NL	Slovakia	SK
Germany	DE	Italy	IT	Norway	NO	United Kingdom	UK
Denmark	DK	Lithuania	LT	Poland	PL		

Although there are some data available for Portugal, Romania and Ireland, they have not been used because they cover only a portion of the migration flows (i.e., immigration of Portugal covers foreigners only, immigration of Romania covers foreigners only, emigration of Romania covers nationals only). Irish figures on migration to and from the UK, however, have been used to estimate the (lacking) UK figures for these flows. Furthermore, for Iceland, Italy and Luxembourg, the set of available data for the years 2002-2007 are not complete. For Iceland the average of 2002 and 2007 is used for the period 2002-2007. For Italy the average of 2002-2005 is applied. The distributions by origin and destination is lacking for Luxembourg in the year 2002. Here, data from 2003 has been used.

The average values of the reported migration flows by receiving country (upper sub-table) and sending country (lower sub-table) for the years 2002-2007 are presented in Table 3. The row headings refer to country of origin and the column headings refer to country of origin. A comparison of the upper and lower sub-tables shows that there are big differences between numbers reported by sending and receiving countries. According to the reported immigration numbers 671 thousand migrants per year moved between these 19 countries, whereas the reported emigration numbers add up 499 thousand migrants.

Comparing the column totals of the upper and lower half of Table 3 shows that for 11 countries the reported immigration totals are higher than the corresponding totals based on reported emigration numbers. For example, Germany reports that 256 thousand immigrants arrived from the 18 countries in this study, whereas these countries report that only 67 thousand emigrants moved to Germany. Furthermore, Germany reports that 137 thousand immigrants arrived from Poland, whereas Poland reports that only 14 thousand migrants were sent. One main explanation is the difference in the time constraint included in the definition of migration in Germany and Poland. Whereas according to the new regulation the criterion will be whether a person intends to stay for at least one year, the definition used by Germany generally does not include a time constraint, and Poland only regards a person as migrant if he or she intends to stay forever. So in comparison with the harmonized definition the number reported by Germany is expected to be too high, whereas the number reported by Poland will be too low.

Table 3. Average reported migration flows by origin and destination, according to receiving and sending countries, 2002-2007

From \ To	AT	CY	CZ	DE	DK	ES	FI	IS	IT	LT	LU	LV	NL	NO	PL	SE	SI	SK	UK	Total
Reported by immigration countries																				
AT		41	310	14257	303	774	109	33	774	17	8	9	559	111	180	307	100	208	1395	19496
CY	22		13	276	23	25	23	1	30	3	0	2	51	15	7	61	2	2	2533	3087
CZ	1316	118		9218	262	833	56	42	672	24	4	15	511	116	45	164	6	979	4109	18489
DE	15447	332	1362		4001	15982	921	255	12809	490	454	166	9182	2268	2876	3374	299	446	19039	89701
DK	203	25	46	2687		964	365	1413	265	85	11	46	475	2943	34	5264	3	21	1874	16721
ES	700	45	71	14703	1758		644	68	2044	252	24	18	3101	768	119	1300	8	36	14581	40239
FI	270	21	38	2173	414	844		45	235	43	3	43	379	799	6	3204	1	6	684	9208
IS	31	0	4	236	1665	131	50		35	10	0	6	75	373	11	462	1	2	417	3509
IT	1608	49	254	22196	986	9320	250	74		82	67	33	1811	246	309	599	79	109	5829	43900
LT	179	35	47	4496	1034	2274	73	272	378		1	236	302	926	43	574	0	5	2507	13380
LU	67	3	2	2282	162	123	50	27	213	5		2	161	18	5	90	5	1	682	3897
LV	83	104	13	2155	457	300	87	93	183	175	2		125	233	6	264	0	5	1227	5511
NL	791	70	255	13681	864	4762	261	55	905	41	27	20		711	163	979	12	41	6799	30436
NO	98	14	24	1378	3148	1696	845	364	167	87	2	24	453		48	5098	1	24	1667	15135
PL	5231	752	1608	136927	2436	8277	187	2229	9045	120	19	45	5744	4602		3718	3	276	36759	217977
SE	489	88	67	3348	3313	1826	3502	492	379	91	14	54	696	4917	113		15	20	3213	22635
SI	556	9	17	1798	46	136	6	9	321	2	1	1	90	14	2	42		16	0	3064
SK	3192	432	14064	11148	149	788	22	45	690	4	4	4	465	238	18	110	4		4584	35961
UK	1222	3170	506	13263	3482	38674	946	228	4553	875	39	190	5820	1624	1126	3114	22	116		78969
Total	31504	5306	18702	256221	24502	87725	8397	5741	33695	2407	682	913	30000	20921	5111	28723	559	2311	107897	671315
Reported by emigration countries																				
AT		18	937	6665	166	429	231	27	1022	111	45	42	426	87	2401	388	402	1778	901	16076
CY	6		21	57	6	19	12	0	39	9	2	18	10	2	111	13	0	32	371	724
CZ	186	13		560	24	35	28	2	112	10	3	7	81	16	583	24	8	9539	219	11449
DE	17787	271	8104		3095	16807	2371	287	31235	2455	1686	1494	9293	2122	100827	3974	2004	9456	17233	230499
DK	228	24	179	2612		1669	368	1347	716	655	138	316	602	2947	833	5253	31	95	3889	21898
ES	155	9	57	2686	157		110	9	1163	120	87	19	869	159	398	203	10	45	3430	9684
FI	97	23	42	758	400	671		53	203	21	71	27	233	777	63	3216	4	10	1175	7842
IS	13	2	17	205	1800	59	48		105	64	37	29	49	482	872	478	25	56	232	4570
IT	588	6	67	10206	149	1508	136	17		11	218	8	531	121	417	199	151	40	3508	17879
LT	48	8	54	1269	158	628	87	23	204		18	163	116	199	122	233	3	5	2638	5975
LU	31	3	13	911	99	79	35	19	175	4		4	97	12	23	73	5	11	166	1760
LV	18	8	6	302	45	18	46	5	51	138	6		20	34	26	67	1	2	196	987
NL	616	50	298	10493	533	3774	322	54	1278	54	191	33		731	1020	900	45	138	7953	28482
NO	69	17	43	709	3093	789	855	412	146	108	23	69	287		281	5083	5	61	1395	13444
PL	538	15	63	14417	111	341	20	46	505	6	23	3	557	127		303	2	10	5219	22306
SE	298	73	104	1634	3159	1348	3403	413	463	48	127	62	522	4746	354		27	29	3905	20713
SI	311	3	14	589	5	27	4	1	186	1	24	0	30	5	5	38		6	70	1319
SK	177	1	629	255	4	16	1	0	42	0	2	0	13	3	15	8	3		69	1235
UK	1593	4060	2692	12579	1932	33431	682	103	5270	1074	362	324	5943	1993	6507	2666	0	1053		82264
Total	22758	4600	13339	66905	14933	61649	8758	2818	42914	4887	3062	2619	19676	14561	114854	23117	2724	22364	52567	499105

Source: Eurostat.

The degree to which reported numbers may be too low or too high can be assessed by comparing the flows reported by sending countries with those reported by the receiving countries. For example, Poland reported that 22 thousand persons (on average) emigrated to the other 18 countries set out in the lower table in Table 3, whereas the other 18 countries reported that they received 218 thousand migrants from Poland (upper table). This suggests that the Polish emigration numbers may be as much as 10 times too low. For most other countries, the reported emigration numbers are also lower than the corresponding immigration numbers. One option could be to simply use the receiving country data or inflate the sending country data based on the difference between sending and receiving country data. However, these simple procedures would ignore the fact that the corresponding receiving country data may be biased as well. For example, as noted above Germany's immigration numbers are likely to be too high because of its vague migration definition. Hence, we believe that both sets of data should be used in the harmonisation of the migration data, i.e., the calculation of adjustment factors for receiving country data and sending country data should be estimated simultaneously.

The estimated adjustment factors, resulting from Equations (3) and (4) with the adjustment factor for Swedish equal to 1, are set out in Table 4. For 16 of the 19 countries the adjustment factor for sending country data exceeds 1, indicating that emigration flows tend to be underestimated in most countries. However, Table 3 shows that immigration numbers seem to be underestimated in several countries as well. This may seem contradictory since for many countries the reported immigration totals exceed the reported emigration numbers. To understand why this is, consider the harmonised flows set out in Table 5 relative to the reported numbers in Table 3. The flows in Table 5 are the result of multiplying the numbers in Table 3 by the adjustment factors in Table 4. In several cases, the reported receiving country flow is revised upwards even though its reported number is higher than the corresponding reported sending flow. For example, the average reported flow to the UK according (1) to sending country data is 53 thousand (see lower table in Table 3) and (2) to receiving country data is 108 thousand (see upper table in Table 3). The harmonised number is higher than both at 131 thousand (Table 5). The reason for this increase is due to the adjustment factors applied to the UK's immigration flows (i.e., 1.21) and Poland's emigration flows (i.e., 10.64). In both cases, the flows are revised upwards. Note, the adjustment factor for Poland's emigration data is higher than the ratio between Poland's average reported flow to the UK (5 thousand) and the UK's reported flow from Poland (37 thousand), which is around 7. Finally, the adjustment factors for most receiving country data are closer to 1 than the adjustment factors for sending country data, which suggests that the reported receiving country flows are more accurate than the sending country flows.

Table 4. Estimated adjustment factors for receiving and sending country flows, without dummy variables, 2002-2007 average

	Immigration	Emigration		Immigration	Emigration		Immigration	Emigration
AT	1.06	1.74	IS	0.57	0.74	PL	17.85	10.64
CY	1.06	5.29	IT	1.42	2.92	SE	1.00	1.21
CZ	2.14	3.33	LT	2.33	2.45	SI	5.18	2.71
DE	1.03	0.69	LU	5.65	2.43	SK	18.90	43.69
DK	0.74	0.80	LV	2.92	6.22	UK	1.21	1.18
ES	0.82	4.90	NL	0.97	1.25			
FI	1.26	1.22	NO	0.84	1.19			

Table 5. Estimated migration flows by country of origin and destination, without dummy variables, 2002/2007

From	AT	CY	CZ	DE	DK	ES	FI	IS	IT	LT	LU	LV	NL	NO	PL	SE	SI	SK	UK	Total
Based on numbers reported by immigration countries																				
AT		44	665	14680	226	635	137	19	1099	40	46	27	544	94	3220	307	517	3921	1692	27911
CY	24		27	284	17	20	30	1	42	8	1	4	49	13	125	61	9	41	3073	3827
CZ	1392	125		9492	195	683	70	24	954	56	24	45	498	98	806	164	29	18492	4984	38131
DE	16337	351	2920		2979	13108	1165	146	18182	1144	2568	485	8937	1915	51349	3374	1547	8421	23096	158025
DK	214	26	98	2767		790	461	809	375	198	63	135	462	2485	601	5264	16	400	2273	17438
ES	740	47	152	15139	1309		814	39	2902	589	137	51	3018	648	2128	1300	43	674	17688	47419
FI	285	23	82	2238	308	692		26	333	100	19	125	369	675	110	3204	4	117	830	9538
IS	33	0	9	243	1239	107	63		49	24	2	18	73	315	202	462	6	41	506	3392
IT	1701	52	545	22855	734	7644	317	42		191	379	97	1763	208	5514	599	409	2053	7071	52173
LT	190	37	100	4629	770	1865	92	156	536		7	688	294	782	765	574	1	88	3041	14615
LU	71	3	5	2350	121	101	63	15	302	12		4	157	15	86	90	26	22	827	4270
LV	87	110	28	2219	340	246	110	53	259	409	9		122	197	113	264	0	85	1488	6141
NL	837	74	547	14087	643	3905	330	31	1284	96	152	58		600	2910	979	62	778	8247	35623
NO	104	15	51	1419	2344	1391	1069	208	236	203	12	71	441		851	5098	3	457	2022	15993
PL	5533	795	3447	140992	1814	6789	236	1276	12840	281	105	131	5591	3886		3718	13	5209	44593	237249
SE	517	93	144	3447	2467	1497	4429	281	538	213	77	157	677	4153	2015		79	381	3897	25062
SI	588	9	35	1852	34	111	8	5	455	5	7	4	87	12	30	42		293	0	3576
SK	3376	456	30144	11478	111	646	28	25	980	10	25	12	453	201	318	110	22		5561	53958
UK	1293	3351	1085	13656	2593	31721	1196	130	6462	2042	221	554	5665	1372	20101	3114	111	2195		96862
Total	33321	5609	40085	263827	18243	71952	10619	3286	47829	5620	3855	2664	29199	17669	91245	28723	2896	43668	130892	851202
Based on numbers reported by emigration countries																				
AT		32	1626	11572	288	745	401	47	1774	193	78	73	739	152	4168	674	698	3087	1564	27911
CY	29		111	299	29	98	63	0	204	48	11	96	50	12	584	66	0	167	1960	3827
CZ	619	43		1866	79	115	94	8	372	33	9	22	269	52	1942	79	26	31771	730	38131
DE	12195	186	5556		2122	11523	1625	197	21414	1683	1156	1024	6371	1455	69125	2724	1374	6483	11815	158025
DK	181	19	142	2080		1329	293	1072	570	521	110	252	479	2347	663	4183	24	75	3097	17438
ES	759	42	281	13151	770		539	42	5695	585	428	95	4253	778	1949	992	48	221	16792	47419
FI	118	27	51	922	486	816		64	246	26	87	33	284	945	76	3912	5	12	1429	9538
IS	9	1	12	152	1336	44	36		78	48	27	22	36	358	647	355	19	42	172	3392
IT	1716	18	196	29781	436	4400	396	50		31	635	23	1549	353	1215	580	441	115	10237	52173
LT	116	18	131	3103	386	1537	212	57	498		45	399	285	486	298	571	8	13	6452	14615
LU	76	6	30	2210	240	193	86	47	425	9		11	235	30	55	177	12	26	402	4270
LV	112	50	34	1877	280	114	286	31	317	855	37		124	208	162	414	4	12	1222	6141
NL	771	62	373	13124	667	4721	402	68	1599	67	239	41		914	1275	1126	56	172	9947	35623
NO	82	20	51	844	3679	939	1017	490	173	128	28	81	342		334	6046	5	73	1660	15993
PL	5726	158	674	153342	1175	3627	214	491	5371	67	239	35	5928	1347		3217	19	110	55506	237249
SE	361	88	126	1976	3822	1631	4118	500	560	58	154	75	631	5742	429		32	34	4724	25062
SI	842	8	39	1597	14	73	11	2	505	2	66	1	81	13	13	103		15	191	3576
SK	7733	51	27481	11119	160	684	22	0	1820	0	80	0	546	131	648	364	124		2993	53958
UK	1875	4780	3170	14812	2274	39364	803	121	6205	1265	426	382	6998	2347	7662	3139	0	1240		96862
Total	33321	5609	40085	263827	18243	71952	10619	3286	47829	5620	3855	2664	29199	17669	91245	28723	2896	43668	130892	851202

3.2. Accounting for special cases

Even though the row and column totals in the migration matrices shown in the upper and lower half of Table 4 are equal, there are some remarkable differences in the estimates of specific origin-destination migration flows. For example, the upper half of Table 5 shows that the estimated migration from Germany to Poland is 51 thousand, whereas in the lower half, it is 69 thousand. This difference can be explained by the fact that the distribution of reported Polish immigration by country of origin is not consistent with the distribution of migration to Poland reported by other countries. For example, according to reported Polish immigration numbers in Table 3, 56% are from Germany. However, in the adjusted sending country table, located in the lower half of Table 5, 76% of migrants to Poland came from Germany. Since the latter share is higher than the former, the estimate exceeds that which is based on receiving country data. The estimated adjustment factor for Polish emigration data is 17.85. The adjustment factor of Polish immigration appears to be too low for the flow from Germany, while at the same time, too high for migration from other countries. Thus one inconsistency in the estimates of a particular migration flow may affect the estimates of other migration flows. In order to avoid these inconsistencies, we add dummy variables to the model resulting in additional adjustment factors that only apply to the flow between two specific countries. By means of introducing a dummy variable we can estimate to what extent the adjustment factor for Polish immigration data from Germany deviates from that to other countries. Similar differences between adjusted receiving and sending country numbers also occur for other migration flows.

The main criterion for selecting dummy variables is the size of the differences in the initial harmonised estimates based on reported receiving country and sending country data. We decided to use dummy variables for migration flows for which the difference between both estimates exceeded 10 thousand. Note that the number of dummies may be smaller than the number of flows for which both estimates show big differences, since introducing one dummy may reduce the differences for several flows simultaneously. The main reason for introducing dummies for flows with big differences is to maintain stability in the estimated patterns. Expert knowledge also plays a role in deciding whether the dummy variable should be applied to the receiving or sending country tables. Introducing a dummy for emigration from country *A* to *B* will lead to a change in the estimate of the adjustment factor of emigration from country *A*. In most cases this will lead to a reduction in the differences between estimates of emigration from country *A* to other countries than country B compared with the estimates of immigration of those countries as well. However, in some cases the differences may becomes worse. In those cases it may be decided to add an additional dummy.

In our testing of the revised model, we found that that only a few dummies are required to considerably improve the fit of the model. For the data in Table 3, the introduction of six dummy variables reduced the root mean square error of differences between the two matrices by one half. The adjustment factors resulting from the inclusion of six dummy variables are set out in Table 6. Because the introduction of dummy variables has an impact on the other flows, we discuss the importance of selection in more detail below.

For Polish immigration data, the impacts of introducing dummy variables are illustrated in Table 7. In comparing the third and fourth columns, the adjustment factor for Polish immigration in Table 4 (17.85) seems too low for estimating migration from Germany and too high for estimating migration from the UK. Introducing two dummies for both flows results in raising the adjustment factor for immigration from Germany from 17.85 to 24.87 (= 14.25 x 1.74) and reducing that for migration from the UK from 17.85 to 5.25 (= 14.25 x 0.37). The estimated Polish immigration numbers for the other countries decrease too (factor down from 17.85 to 14.25).

Table 6. Estimated adjustment factors for receiving and sending country flows, with dummy variables included, 2002-2007 average

	Immigration	Emigration		Immigration	Emigration		Immigration	Emigration
AT	1.17	1.35	IS	0.59	0.69	PL	14.25	18.31
CY	0.88	4.71	IT	1.48	2.44	SE	1.00	1.10
CZ	1.97	8.92	LT	2.16	2.15	SI	4.90	2.33
DE	0.81	0.71	LU	5.45	2.08	SK	8.34	39.40
DK	0.72	0.74	LV	2.78	5.44	UK	1.09	0.91
ES	0.73	4.32	NL	1.04	1.06			
FI	1.18	1.12	NO	0.81	1.10			

Estimates of coefficients of dummy variables	
Immigration in Poland from Germany	1.74
Immigration in Poland from the UK	0.37
Emigration from Poland to Germany	0.42
Emigration from Poland to the UK	0.42
Emigration from Germany to the UK	1.70
Emigration from the Czech Republic to Slovakia	0.10

In general, when comparing the receiving country figures with the sending country figures, the estimates come closer to each other after introducing (all of) the dummy variables, with the exception of the Czech Republic (as illustrated in Table 7). Here, the adjustment factor for the emigration data is raised from 3.33 (Table 4) to 8.93 (Table 6). One solution could be to add a dummy variable for emigration from Czech Republic to Poland, but since the difference between both estimates of that migration flow was not that big, we decided not to do so.

Table 7. Poland's reported and adjusted average immigration flows, 2002-2007 (x1 000)

	Immigration reported by PL	Emigration reported by other countries	Adjusted immigration of PL, no dummies	Adjusted emigration of other countries, no dummies	Absolute difference	Adjusted immigration of PL, with dummies	Adjusted emigration of other countries, with dummies	Absolute difference
AT	0.2	2.4	3.2	4.2	0.9	2.6	3.2	0.7
CY	0.0	0.1	0.1	0.6	0.5	0.1	0.5	0.4
CZ	0.0	0.6	0.8	1.9	1.1	0.6	5.2	4.6
DE	2.9	100.8	51.3	69.1	17.8	71.5	71.5	0.0
DK	0.0	0.8	0.6	0.7	0.1	0.5	0.6	0.1
ES	0.1	0.4	2.1	1.9	0.2	1.7	1.7	0.0
FI	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.0
IS	0.0	0.9	0.2	0.6	0.4	0.2	0.6	0.4
IT	0.3	0.4	5.5	1.2	4.3	4.4	1.0	3.4
LT	0.0	0.1	0.8	0.3	0.5	0.6	0.3	0.3
LU	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0
LV	0.0	0.0	0.1	0.2	0.0	0.1	0.1	0.1
NL	0.2	1.0	2.9	1.3	1.6	2.3	1.1	1.2
NO	0.0	0.3	0.9	0.3	0.5	0.7	0.3	0.4
PL								
SE	0.1	0.4	2.0	0.4	1.6	1.6	0.4	1.2
SI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SK	0.0	0.0	0.3	0.6	0.3	0.3	0.6	0.3
UK	1.1	6.5	20.1	7.7	12.4	5.9	5.9	0.0
Total	5.1	114.9	91.2	91.2	42.4	93.2	93.2	13.2

The adjustment of the Polish sending country data is illustrated in Table 8. Similarly to the Polish receiving data, dummies were introduced for flows to Germany and to the UK. Contrary to Polish receiving data, the resulting adjustment factors for both countries occurred in the same direction. The adjustment factor for Polish emigration shown in Table 4 (10.64) appeared to be too high for emigration to both Germany and the UK. Table 6 shows that the estimated dummy variable coefficients for both countries are equal (i.e., 0.42). Introducing the dummy variables leads to an increase in the adjustment factor for Polish emigration to the other countries from 10.64 to 18.31, whereas the adjustment factor for migration to Germany and to the UK decreases from 10.64 to 7.68.

Table 8. Poland's reported and adjusted average emigration flows, 2002-2007 (x1000)

	Emigration reported by PL	Immigration reported by other countries	Adjusted emigration of PL, no dummies	Adjusted immigration of other countries, no dummies	Absolute difference	Adjusted emigration of PL, with dummies	Adjusted immigration of other countries, with dummies	Absolute difference
AT	0.5	5.2	5.7	5.5	0.2	9.9	6.1	3.7
CY	0.0	0.8	0.2	0.8	0.6	0.3	0.7	0.4
CZ	0.1	1.6	0.7	3.4	2.8	1.2	3.2	2.0
DE	14.4	136.9	153.3	141.0	12.4	110.7	110.7	0.0
DK	0.1	2.4	1.2	1.8	0.6	2.0	1.7	0.3
ES	0.3	8.3	3.6	6.8	3.2	6.2	6.0	0.2
FI	0.0	0.2	0.2	0.2	0.0	0.4	0.2	0.1
IS	0.0	2.2	0.5	1.3	0.8	0.8	1.3	0.5
IT	0.5	9.0	5.4	12.8	7.5	9.2	13.4	4.1
LT	0.0	0.1	0.1	0.3	0.2	0.1	0.3	0.1
LU	0.0	0.0	0.2	0.1	0.1	0.4	0.1	0.3
LV	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
NL	0.6	5.7	5.9	5.6	0.3	10.2	6.0	4.2
NO	0.1	4.6	1.3	3.9	2.5	2.3	3.7	1.4
PL								
SE	0.3	3.7	3.2	3.7	0.5	5.5	3.7	1.8
SI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SK	0.0	0.3	0.1	5.2	5.1	0.2	2.3	2.1
UK	5.2	36.8	55.5	44.6	10.9	40.1	40.1	0.0
Total	22.3	218.0	237.2	237.2	47.9	199.7	199.7	21.4

The effect of the dummy variable added for Germany's reported flow to the UK is shown in Table 9. The two estimated flows show considerable differences without the inclusion of the dummy variable, particularly the reported emigration from Germany to Poland and to the UK. The Germany to Poland flow differences are taken care of by the dummy introduced previously (see Table 7). The adjustment factor for Germany's sending country data is below 1, implying that the reported flow is too high. However, for emigration to the UK this does not seem to be the case. The inclusion of a dummy variable for Germany's reported flow to the UK increases the adjustment factor from 0.69 to 1.21. The inclusion of this dummy variable had little effect on the adjustment factor applied to the other countries.

Table 9. Germany's reported and adjusted average emigration flows, 2002-2007 (x1000)

	Emigration reported by DE	Immigration reported by other countries	Adjusted emigration of DE, no dummies	Adjusted immigration of other countries, no dummies	Absolute difference	Adjusted emigration of DE, with dummies	Adjusted immigration of other countries, with dummies	Absolute difference
AT	17.8	15.4	12.2	16.3	4.1	12.6	18.1	5.5
CY	0.3	0.3	0.2	0.4	0.2	0.2	0.3	0.1
CZ	8.1	1.4	5.6	2.9	2.6	5.7	2.7	3.1
DE								
DK	3.1	4.0	2.1	3.0	0.9	2.2	2.9	0.7
ES	16.8	16.0	11.5	13.1	1.6	11.9	11.6	0.3
FI	2.4	0.9	1.6	1.2	0.5	1.7	1.1	0.6
IS	0.3	0.3	0.2	0.1	0.1	0.2	0.2	0.1
IT	31.2	12.8	21.4	18.2	3.2	22.2	18.9	3.2
LT	2.5	0.5	1.7	1.1	0.5	1.7	1.1	0.7
LU	1.7	0.5	1.2	2.6	1.4	1.2	2.5	1.3
LV	1.5	0.2	1.0	0.5	0.5	1.1	0.5	0.6
NL	9.3	9.2	6.4	8.9	2.6	6.6	9.6	3.0
NO	2.1	2.3	1.5	1.9	0.5	1.5	1.8	0.3
PL	100.8	2.9	69.1	51.3	17.8	71.5	71.5	0.0
SE	4.0	3.4	2.7	3.4	0.6	2.8	3.4	0.6
SI	2.0	0.3	1.4	1.5	0.2	1.4	1.5	0.0
SK	9.5	0.4	6.5	8.4	1.9	6.7	3.7	3.0
UK	17.2	19.0	11.8	23.1	11.3	20.8	20.8	0.0
Total	230.5	89.7	158.0	158.0	50.5	172.0	172.0	23.0

Instead of adding a dummy variable for Germany's reported flow to the United Kingdom, we could have instead added a dummy variable for the UK's reported flow from Germany. The results of this alternative situation are presented in Table 10. In this case, the adjustment factor for the UK's migration flow from Germany is almost halved from 1.21 without dummies to 0.64. Given the original values and the results of the former dummy variable inclusion, this estimate is considered to be less realistic. Hence on this basis, an example of expert knowledge, the dummy variable tied to Germany's emigration flow to the UK is preferred.

Table 10. The United Kingdom's reported and adjusted average immigration flows, 2002-2007 (x1000)*

	Immigration reported by UK	Emigration reported by other countries	Adjusted immigration of UK, no dummies	Adjusted emigration of other countries, no dummies	Absolute difference	Adjusted immigration of UK, with dummies	Adjusted emigration of other countries, with dummies	Absolute difference
AT	1.4	0.9	1.7	1.6	0.1	1.5	1.2	0.3
CY	2.5	0.4	3.1	2.0	1.1	2.8	1.7	1.0
CZ	4.1	0.2	5.0	0.7	4.3	4.5	2.0	2.5
DE	19.0	17.2	23.1	11.8	11.3	12.2	12.2	0.0
DK	1.9	3.9	2.3	3.1	0.8	2.0	2.9	0.8
ES	14.6	3.4	17.7	16.8	0.9	15.9	14.8	1.1
FI	0.7	1.2	0.8	1.4	0.6	0.7	1.3	0.6
IS	0.4	0.2	0.5	0.2	0.3	0.5	0.2	0.3
IT	5.8	3.5	7.1	10.2	3.2	6.4	8.6	2.2
LT	2.5	2.6	3.0	6.5	3.4	2.7	5.7	2.9
LU	0.7	0.2	0.8	0.4	0.4	0.7	0.3	0.4
LV	1.2	0.2	1.5	1.2	0.3	1.3	1.1	0.3
NL	6.8	8.0	8.2	9.9	1.7	7.4	8.5	1.0
NO	1.7	1.4	2.0	1.7	0.4	1.8	1.5	0.3
PL	36.8	5.2	44.6	55.5	10.9	40.1	40.1	0.0
SE	3.2	3.9	3.9	4.7	0.8	3.5	4.3	0.8
SI	0.0	0.1	0.0	0.2	0.2	0.0	0.2	0.2
SK	4.6	0.1	5.6	3.0	2.6	5.0	2.7	2.3
UK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	107.9	52.6	130.9	130.9	43.3	109.2	109.2	17.0

* For illustration only. This dummy variable was not included to produce the final estimates.

Finally, a dummy was needed for the migration from the Czech Republic to Slovakia (Table 11). Using the initial adjustment factor for Czech Republic's emigration (i.e., 3.33) inflates this flow to an unrealistic level, while at the same time is not high enough for the other flows. Including a dummy variable for this flow brings its adjustment factor down to 0.86 and increases the adjustment factor for the other countries to 8.92.

Table 12 presents the estimates of adjusted receiving and sending country data based on the revised adjustment factors that incorporated the six dummy variables listed at the bottom of Table 6. A comparison of Table 12 and Table 5 shows that the introduction of the dummy variables resulted in lower estimates on average (but still higher than the reported receiving country numbers in Table 3). For receiving country data, the estimates are considerably lower for Germany and Slovakia, whereas for sending country data, the estimates are considerably lower for Poland and the UK. The only flow that was considerably increased was Germany's emigration flow.

Table 11. The Czech Republic's reported and adjusted average emigration flows, 2002-2007 (x1000)

	Emigration reported by CZ	Immigration reported by other countries	Adjusted emigration of CZ, no dummies	Adjusted immigration of other countries, no dummies	Absolute difference	Adjusted emigration of CZ, with dummies	Adjusted immigration of other countries, with dummies	Absolute difference
AT	0.2	1.3	0.6	1.4	0.8	1.7	1.5	0.1
CY	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.0
CZ								
DE	0.6	9.2	1.9	9.5	7.6	5.0	7.5	2.5
DK	0.0	0.3	0.1	0.2	0.1	0.2	0.2	0.0
ES	0.0	0.8	0.1	0.7	0.6	0.3	0.6	0.3
FI	0.0	0.1	0.1	0.1	0.0	0.3	0.1	0.2
IS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IT	0.1	0.7	0.4	1.0	0.6	1.0	1.0	0.0
LT	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0
LU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LV	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
NL	0.1	0.5	0.3	0.5	0.2	0.7	0.5	0.2
NO	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.0
PL	0.6	0.0	1.9	0.8	1.1	5.2	0.6	4.6
SE	0.0	0.2	0.1	0.2	0.1	0.2	0.2	0.0
SI	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
SK	9.5	1.0	31.8	18.5	13.3	8.2	8.2	0.0
UK	0.2	4.1	0.7	5.0	4.3	2.0	4.5	2.5
Total	11.4	18.5	38.1	38.1	28.9	25.2	25.2	10.6

The differences between the upper and lower sub-tables in Table 12 are smaller than those in Table 5. The root mean square error (RMSE) of the differences in Table 5 equals 2131. For Table 12, it is 978. Thus, the introduction of six dummy variables reduced the RMSE by 54%. Instead of simply taking the average of these two tables as our final set of estimates, we think its better to take the harmonised receiving country data (upper sub-table in Table 12) as we believe the distributions are more reliable. This pertains only to the matrix of flows between the 19 countries that provided both sending and receiving migration flow data.

The adjustment factors set out in Table 6 can be used to adjust migration numbers to and from other countries as well, so that, for the 19 countries in this study, harmonised immigration, emigration and net migration totals can be obtained for the years 2002-2007. To maintain consistency and to provide smooth estimates over time, the following two decisions were made:

- the average adjustment factors in Table 6 are used to the estimate annual data, instead of separate estimates of year specific adjustment factors; and
- for countries exhibiting strong fluctuations in their annual distributions of flows by country of origin or destination, the average distributions for 2002-2007 are used. The countries that fall into this category are Cyprus, Czech Republic, Poland, Slovakia, Spain and the United Kingdom.

In harmonising the origin-destination migration flows, one has to take into account the number of unknowns in the migration statistics. If we assume, as we did, that the unknowns are distributed proportionally across countries, then the adjustment factors will take into account this effect. This means that we simply apply the adjustment factors to the reported migration flows, excluding unknowns.

Table 12. Estimated migration by country of origin and destination, including dummies, 2002/2007

From	To AT	CY	CZ	DE	DK	ES	FI	IS	IT	LT	LU	LV	NL	NO	PL	SE	SI	SK	UK	Total
Based on numbers reported by immigration countries																				
AT		36	610	11526	217	563	129	20	1144	37	44	26	584	90	2570	307	488	1730	1522	21642
CY	26		25	223	16	18	28	1	44	7	1	4	53	12	100	61	8	18	2764	3408
CZ	1547	103		7453	187	606	66	25	992	51	23	43	534	94	644	164	28	8158	4482	25200
DE	18148	291	2679		2864	11631	1092	152	18920	1057	2475	462	9586	1843	71514	3374	1462	3715	20770	172034
DK	238	21	90	2172		701	432	840	391	183	60	128	496	2391	480	5264	15	176	2044	16124
ES	822	39	139	11887	1259		763	40	3020	544	132	49	3237	624	1698	1300	41	297	15907	41798
FI	317	19	75	1757	296	614		27	347	92	18	119	395	649	88	3204	4	51	746	8819
IS	37	0	8	191	1192	95	59		51	22	2	17	78	303	162	462	6	18	455	3157
IT	1889	43	500	17945	706	6782	297	44		177	365	93	1891	200	4402	599	386	906	6359	43582
LT	211	31	92	3635	741	1655	86	162	558		7	656	316	752	610	574	1	39	2734	12858
LU	79	2	5	1845	116	89	59	16	315	11		4	168	15	69	90	24	10	744	3661
LV	97	91	26	1742	327	218	103	55	270	378	9		131	189	90	264	0	38	1338	5367
NL	930	61	502	11060	619	3465	309	33	1336	89	146	55		577	2323	979	59	343	7417	30305
NO	115	12	47	1114	2254	1234	1001	216	246	187	12	68	473		679	5098	2	201	1818	14778
PL	6146	659	3163	110701	1744	6024	221	1324	13361	259	101	125	5997	3739		3718	12	2298	40102	199695
SE	574	77	132	2706	2372	1328	4150	292	560	197	74	149	727	3996	1608		74	168	3505	22690
SI	653	8	32	1454	33	99	7	5	473	4	6	4	94	12	24	42		129	0	3079
SK	3750	379	27658	9012	107	574	26	26	1020	9	24	12	486	193	254	110	20		5001	48662
UK	1436	2780	996	10722	2493	28145	1121	135	6725	1886	213	528	6077	1320	5907	3114	105	968		74670
Total	37015	4654	36780	207145	17542	63841	9950	3411	49772	5190	3715	2540	31321	17000	93222	28723	2735	19264	117708	751530
Based on numbers reported by emigration countries																				
AT		24	1261	8973	223	578	311	36	1376	150	61	57	573	118	3232	523	541	2393	1213	21642
CY	26		99	266	26	87	56	0	181	42	10	86	45	11	520	59	0	148	1745	3408
CZ	1658	116		4999	213	309	253	21	998	89	25	58	721	140	5203	213	70	8158	1956	25200
DE	12616	192	5748		2195	11921	1681	203	22154	1741	1195	1060	6591	1505	71514	2818	1421	6707	20770	172034
DK	168	17	132	1924		1229	271	991	527	482	101	233	443	2170	613	3868	22	70	2863	16124
ES	669	37	247	11592	678		475	37	5020	516	377	83	3749	686	1718	875	42	195	14802	41798
FI	109	25	47	852	449	754		60	228	24	80	30	262	873	70	3617	5	11	1321	8819
IS	9	1	11	142	1243	41	33		73	44	25	20	34	333	602	330	17	39	160	3157
IT	1433	15	164	24877	364	3675	331	41		26	531	20	1294	295	1015	484	368	96	8551	43582
LT	102	16	115	2730	339	1352	187	50	438		39	351	250	428	263	502	7	11	5676	12858
LU	65	5	26	1895	205	165	73	40	364	8		9	201	26	47	152	10	22	345	3661
LV	98	44	30	1640	245	100	250	27	277	748	33		109	182	141	362	4	11	1068	5367
NL	656	53	317	11165	567	4016	342	57	1360	57	203	35		777	1085	958	48	146	8462	30305
NO	76	18	47	780	3399	867	940	453	160	118	26	75	316		309	5587	5	67	1534	14778
PL	9857	272	1160	110701	2023	6244	369	845	9247	116	412	61	10205	2319		5539	34	189	40102	199695
SE	327	80	114	1789	3460	1477	3728	453	507	52	139	68	571	5199	388		29	31	4277	22690
SI	725	7	33	1374	12	63	10	2	435	2	57	1	70	11	11	88		13	164	3079
SK	6974	46	24784	10028	144	617	20	0	1642	0	72	0	493	118	584	328	112		2699	48662
UK	1446	3685	2444	11418	1753	30345	619	93	4784	975	328	294	5395	1809	5907	2420	0	956		74670
Total	37015	4654	36780	207145	17542	63841	9950	3411	49772	5190	3715	2540	31321	17000	93222	28723	2735	19264	117708	751530

Table 13 compares the estimates of immigration and emigration totals with the reported numbers. Clearly the differences are very big for several countries. For example, Spain reports a net migration of 628 thousand, whereas our estimate is only 219 thousand. The reason is that our estimate of Spanish emigration is considerably higher than the reported number, while at the same time, our estimate of immigration is lower than the reported number. Cyprus, the Czech Republic and Slovakia report positive net migration, whereas we estimate negative totals. The opposite is true for the Netherlands. Finally, we estimate a much higher positive net migration for Germany, Italy and the United Kingdom and much higher negative net migration for Poland.

Table 13. Reported and estimated total immigration, emigration and net migration, 2002/2007

	Reported			Estimated		
	immigration	emigration	net migration	immigration	emigration	net migration
AT	113.3	75.0	38.3	112.3	65.9	46.4
CY	18.7	7.7	10.9	15.3	35.1	-19.8
CZ	65.2	29.9	35.3	126.4	180.6	-54.2
DE	740.3	641.9	98.4	585.5	439.8	145.8
DK	54.4	44.4	10.0	38.7	30.7	7.9
ES	726.4	98.9	627.5	450.1	231.3	218.7
FI	21.0	12.6	8.4	24.9	14.3	10.6
IS	7.3	5.9	1.4	4.4	4.0	0.3
IT	343.3	48.6	294.8	514.1	125.5	388.6
LT	6.4	12.6	-6.1	13.8	27.0	-13.3
LU	13.6	10.2	3.4	17.2	11.2	6.0
LV	2.1	3.4	-1.2	5.9	18.3	-12.4
NL	105.0	114.5	-9.5	110.1	85.1	25.0
NO	43.4	22.8	20.6	35.1	21.7	13.4
PL	9.7	28.1	-18.4	159.2	307.0	-147.8
SE	75.1	38.8	36.2	74.8	38.6	36.3
SI	15.5	9.8	5.7	7.0	5.9	1.1
SK	6.7	2.0	4.7	46.2	70.5	-24.3
UK	481.3	324.3	157.0	528.1	295.8	232.3

4. Estimating the missing origin-destination data

4.1. Immigration and emigration totals

To extend the migration matrix from 19 to 31 countries (all 27 EU countries plus 4 EFTA countries) estimates of migration flows between the 12 countries with missing data are needed. This requires estimates of total migration flows to and from these countries as well as estimates of origin-destination patterns. Regression analysis is used to estimate total immigration from the 30 other European countries and total immigration from the rest of the world to each of the 12 countries with missing data. Accordingly, emigration to the 30 other European countries and to the rest of the world is estimated.[2] These regression models are also described in Raymer and Abel (2008).

The regression equations include the following dependent variables for the 19 countries, covering the years 2002 up to 2007:

- natural logarithm of estimated immigration from EU27+4 (lnI27+4);
- natural logarithm of estimated immigration from rest of the world (lnIrest);
- natural logarithm of estimated emigration to EU27+4 (lnE27+4);
- natural logarithm of estimated emigration to rest of the world (lnErest).

The following independent variables have been used:

- natural logarithm of population size (lnpop);
- percentage 65+ in the total population (p65);
- life expectancy at birth of women (le_f)
- GDP per capita, E27=100 (gdp);
- percentage urban area (purban);
- dummy variables for the calendar years (d03, d04, d05, d06, d07);
- special dummy variable for Germany (de).

The results of the regression analyses are presented in Table 14.

Table 14. Regression analyses for 19 countries, 2002-2007

	Coefficients				Standard Error				t Stat				P-value			
	I27+4	Irest	E27+4	Erest	I27+4	Irest	E27+4	Erest	I27+4	Irest	E27+4	Erest	I27+4	Irest	E27+4	Erest
Intercept	-3.57	-13.00	10.36	6.22	2.16	2.63	1.74	3.96	-1.65	-4.95	5.96	1.57	0.10	0.00	0.00	0.12
lnpop	0.92	1.16	0.87	0.94	0.04	0.04	0.03	0.07	24.87	25.90	29.25	13.81	0.00	0.00	0.00	0.00
p65	-0.19	-0.08	-0.24	-0.18	0.03	0.03	0.02	0.05	-6.74	-2.24	-10.54	-3.57	0.00	0.03	0.00	0.00
le_f	0.08	0.17	-0.07	-0.03	0.03	0.04	0.02	0.05	2.78	4.73	-2.97	-0.58	0.01	0.00	0.00	0.56
gdp	0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	5.81	-1.52	4.22	-2.59	0.00	0.13	0.00	0.01
purban	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	2.48	1.58	2.50	1.86	0.01	0.12	0.01	0.07
d03	0.12	0.03	0.06	0.05	0.15	0.18	0.12	0.27	0.80	0.16	0.52	0.20	0.42	0.87	0.60	0.84
d04	0.27	0.03	0.21	0.14	0.15	0.18	0.12	0.27	1.82	0.16	1.74	0.52	0.07	0.87	0.09	0.60
d05	0.40	0.05	0.30	0.24	0.15	0.18	0.12	0.27	2.70	0.27	2.55	0.88	0.01	0.79	0.01	0.38
d06	0.48	0.10	0.42	0.40	0.15	0.18	0.12	0.27	3.23	0.53	3.46	1.47	0.00	0.60	0.00	0.14
d07	0.66	0.12	0.53	0.41	0.15	0.18	0.12	0.28	4.38	0.63	4.39	1.50	0.00	0.53	0.00	0.14
de	0.51	-0.38	0.80	0.50	0.22	0.26	0.17	0.39	2.35	-1.46	4.63	1.26	0.02	0.15	0.00	0.21

Adjusted R square for I27+4: 0.90; Irest: 0.92; E27+4: 0.91; Erest: 0.75.
Number of observations: 114.

[2] For Switzerland the available totals for immigration and emigration have been used instead of the regression results. For France, the result of the regression analyses for immigration from the rest of the world was overruled by the estimate that this share is 65% of the total immigration (see Thierry and Xavier, 2008).

4.2. Origin-destination associations

We also use ordinarly least squares regression to estimate the missing origin-destination associations. On the basis of the estimated immigration and emigration totals, 'expected' migration flows between the 12 countries with missing data can be obtained, assuming quasi-independence. This model implies, for example, that if the total number of migrants to country *b* is twice the total number of migrants to country *c*, then the expected migration from country *a* to *b* would be twice that that to country *c*. However, if countries *a* and *c* are neighbouring countries and have the same common language, then the actual migration may be higher. For these types of reasons, we find that actual migration patterns often differ considerably from the expected patterns. Thus, there is a need to estimate the missing ratios or interaction terms. If the ratios are larger than one, we can say the two countries have higher actual flows to expected. Those with values less than one are said to be lower than expected. On the basis of the harmonised migration flows for the 19 countries, regression equations are estimated in which the natural logarithm of the origin-destination interactions are the dependent variable and variables such as contiguity and language family are explanatory variables. The regression resulted in an R^2 of 0.41. The coefficients from this regression, set out in Table 15, were then used to estimate the origin-destination interactions between the 12 countries with missing data. The resulting estimates of interaction terms are shown in Table 16. Finally, multiplying the expected migration flows by these estimated interactions yielded the estimates of the flows between the 12 countries with missing data.

Table 15. Coefficients from regression to predict the natural logarithm of origin-destination association terms (OD_{ij}), 2002-2007 average

Variable	B	Std. Error	t	Sig.
(Constant)	-0.4900	0.2416	-2.0280	0.0426
Contiguity	0.5501	0.0684	8.0473	0.0000
Accession dummy	0.9980	0.1545	6.4605	0.0000
Language family	0.1002	0.0705	1.4226	0.1549
ln GNI PPP ratios	0.1300	0.0157	8.2544	0.0000
ln Distance	0.0405	0.0339	1.1964	0.2316
ln Foreign-born association	0.2471	0.0123	20.0733	0.0000
ln Trade association	0.3291	0.0201	16.3728	0.0000

Table 16. Estimated origin-destination association terms for the flows between the 12 countries with missing data

	To											
From	BE	BG	CH	EE	FR	GR	HU	IE	LI	MT	PT	RO
BE		0.69	0.48	0.40	2.13	0.71	0.40	0.38	0.28	0.38	0.63	0.48
BG	0.48		0.38	0.45	0.40	4.57	0.53	0.21	0.19	0.60	0.31	5.85
CH	0.49	0.95		0.39	1.69	0.80	0.50	0.40	3.08	0.40	1.03	0.55
EE	0.28	0.46	0.23		0.18	0.20	0.42	0.37	0.09	0.78	0.22	0.27
FR	2.27	0.98	1.55	0.47		0.68	0.48	0.48	0.45	0.76	2.94	0.71
GR	0.48	5.80	0.40	0.56	0.41		0.55	0.21	0.40	1.40	0.29	2.49
HU	0.47	1.08	0.46	0.43	0.43	0.43		0.25	0.14	0.21	0.31	4.10
IE	0.66	0.51	0.46	0.40	0.33	0.31	0.14		0.28	0.35	0.31	0.36
LI	0.27	0.70	2.53	0.25	0.56	0.46	0.46	0.21		0.40	0.41	0.46
MT	0.38	0.49	0.18	0.73	0.56	0.25	0.21	0.41	0.08		0.25	0.14
PT	0.54	0.68	0.54	0.31	2.06	0.20	0.12	0.20	0.44	0.38		0.39
RO	0.31	2.47	0.23	0.21	0.42	1.16	3.42	0.21	0.10	0.41	0.31	

5. Origin-destination estimates, 2002-2007

In this section, the final origin-destination migration flow estimates for 2002-2007, resulting from methodology carried out in Section 4, are presented. The final and harmonised totals of immigration, emigration and net migration are presented in Tables 17, 18 and 19, respectively. The final set of complete matrices for the years 2002 to 2007 are presented in Annex A.

According to our estimates migration within the EU27+4 increased steadily from 1.3 million in 2002 to 2.0 million in 2007. For immigration from the rest of the world the trend is also rising, except for the year 2005. Emigration to the rest of the world increased considerably after 2005, especially from Spain. The estimated annual net migration from the rest of the world was around 900 thousand per year from 2002-2007.

Most Central and Eastern European countries exhibited persistent losses due to net migration, especially within the European Union (see, e.g., Bulgaria, Poland and Romania). For most West European countries, especially the bigger ones, most of the positive net migration was attributed to migration from countries outside the EU (see, e.g., Germany, Spain, France, Italy and the UK).

Table 17. Final harmonised estimates of immigration totals, 2002-2007

	Immigration EU27+4 (x 1 000)						Immigration rest (x 1 000)					
	2002	2003	2004	2005	2006	2007	2002	2003	2004	2005	2006	2007
AT	36.8	43.8	55.7	60.1	59.5	68.7	58.4	62.3	68.2	65.3	47.7	47.4
BE	34.2	35.8	37.1	41.1	50.3	53.9	39.7	41.1	46.0	49.6	55.5	59.9
BG	17.3	19.0	19.8	19.2	20.7	22.8	10.4	10.9	11.8	12.1	12.5	12.6
CH	73.4	71.4	69.5	69.2	79.5	107.1	52.7	48.4	50.7	49.1	48.1	58.5
CY	7.4	8.6	11.3	12.6	8.0	9.8	4.4	5.1	6.7	7.5	4.8	5.8
CZ	28.0	37.6	33.5	37.8	42.7	65.4	58.6	78.8	70.2	79.1	89.5	137.1
DE	285.6	271.6	299.8	312.1	314.3	337.9	390.4	336.5	296.1	248.8	211.6	208.5
DK	18.8	18.3	19.2	20.4	23.1	26.6	18.1	17.1	16.4	16.9	17.4	19.6
EE	2.3	1.8	2.9	2.4	2.8	2.7	1.8	1.8	2.0	2.1	2.2	2.2
ES	116.8	161.8	165.1	173.4	202.3	230.3	183.0	254.6	259.3	272.4	318.5	362.9
FI	12.3	12.5	13.7	14.5	15.0	16.6	9.1	8.5	10.3	10.9	11.5	14.3
FR	88.4	90.6	97.6	105.1	124.9	134.4	164.3	168.2	181.2	195.3	232.0	249.6
GR	29.9	27.3	30.2	30.4	30.9	32.0	31.1	32.2	32.8	34.5	36.0	36.9
HU	21.3	21.1	23.3	24.6	25.4	27.2	17.2	17.3	18.3	18.5	20.4	20.6
IE	32.2	31.5	33.4	39.2	55.5	50.6	11.4	12.4	13.1	14.2	15.8	17.2
IS	1.9	2.6	3.2	3.8	4.4	5.3	0.6	0.6	0.8	0.9	1.1	0.9
IT	100.6	205.2	177.3	143.3	155.5	155.0	223.7	453.9	441.5	312.6	357.9	357.9
LI	0.2	0.2	0.3	0.2	0.4	0.5	0.1	0.1	0.1	0.1	0.1	0.1
LT	2.3	2.8	5.8	8.4	9.3	10.4	8.7	7.4	5.9	6.2	7.3	8.1
LU	15.9	16.5	16.9	17.7	15.1	16.3	0.8	0.8	0.7	0.8	0.8	0.8
LV	1.4	1.6	2.6	3.3	4.3	7.4	2.5	2.3	2.0	2.0	3.5	2.4
MT	1.3	1.3	1.2	1.4	1.6	1.6	1.1	1.1	1.1	1.3	1.2	1.4
NL	42.3	40.0	44.1	45.9	52.9	66.0	84.3	69.2	54.8	51.0	53.4	56.6
NO	14.4	13.0	14.1	16.7	21.9	32.3	18.3	16.2	15.4	15.6	15.0	17.6
PL	70.8	75.7	102.0	100.6	115.9	160.9	37.2	39.8	53.6	52.9	61.0	84.7
PT	18.8	18.7	19.2	19.8	24.2	28.6	27.3	28.1	30.2	32.5	36.1	35.5
RO	28.9	33.7	35.5	39.0	46.6	57.6	33.9	35.6	36.0	37.5	40.0	42.5
SE	29.6	29.0	29.4	31.1	39.1	45.5	34.4	34.4	32.3	33.8	56.4	53.8
SI	3.6	2.9	3.1	3.9	3.9	4.8	3.5	3.0	4.1	3.5	3.1	2.5
SK	10.0	11.2	19.2	40.6	54.3	37.1	6.1	6.8	11.7	24.6	33.0	22.6
UK	139.7	155.3	187.1	179.1	190.4	189.3	284.4	318.0	381.8	365.8	389.8	388.1
Total	1286.5	1462.3	1573.2	1616.9	1794.9	2004.7	1817.5	2112.5	2155.0	2017.4	2183.3	2328.9

Table 18. Final harmonised estimates of emigration totals, 2002-2007

	Emigration EU27+4 (x 1 000)						Emigration rest (x 1 000)					
	2002	2003	2004	2005	2006	2007	2002	2003	2004	2005	2006	2007
AT	26.0	28.5	31.3	33.9	39.3	42.2	21.9	29.0	31.3	34.2	39.0	38.9
BE	30.3	31.7	33.1	34.4	36.5	40.5	17.3	18.3	19.5	21.2	25.1	24.9
BG	31.3	40.1	39.9	37.4	40.0	62.1	20.6	20.9	21.8	23.6	27.0	26.8
CH	60.1	59.3	59.5	60.5	65.2	68.8	18.4	17.5	20.2	21.6	23.0	21.4
CY	9.1	6.8	9.0	12.1	9.6	13.6	24.2	14.4	20.3	32.4	22.2	36.8
CZ	29.6	30.5	34.8	36.5	43.3	34.2	157.8	166.8	169.7	117.3	163.1	99.9
DE	216.1	225.7	261.9	259.7	279.2	332.3	187.6	180.8	189.0	172.6	168.1	165.7
DK	17.3	17.5	18.4	18.7	20.4	20.9	11.2	11.4	12.2	12.7	12.8	10.8
EE	4.9	4.9	6.1	6.3	7.1	7.9	4.3	4.1	4.0	4.0	4.4	4.1
ES	54.5	67.5	66.5	71.5	106.2	148.7	53.9	94.6	81.1	100.1	209.4	334.1
FI	11.2	10.7	11.2	10.8	10.8	11.5	3.2	2.9	3.9	3.2	3.3	3.1
FR	79.1	82.3	89.2	94.9	101.6	112.1	78.2	84.3	90.3	98.2	115.7	116.8
GR	25.9	24.2	24.7	24.5	23.1	25.2	13.5	13.2	13.3	14.1	15.2	15.2
HU	27.0	26.4	31.5	35.3	37.3	42.6	26.4	26.9	28.4	30.4	34.2	33.7
IE	14.6	15.4	18.0	19.1	21.8	25.7	11.7	12.3	13.4	14.7	17.3	17.5
IS	3.4	3.1	3.2	3.2	3.4	3.6	0.4	0.6	0.7	0.8	0.8	1.1
IT	75.0	80.2	78.5	78.2	78.1	85.0	44.8	48.7	43.4	48.2	46.3	46.3
LI	0.2	0.2	0.3	0.3	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1
LT	9.9	11.2	16.7	19.9	18.9	20.3	10.2	13.7	12.5	10.2	9.2	9.4
LU	9.1	9.8	10.2	10.7	10.4	11.6	0.9	1.0	0.8	1.2	0.7	0.9
LV	6.1	5.5	6.7	7.2	8.5	7.9	12.3	8.5	9.5	7.4	17.1	12.9
MT	1.3	1.4	1.4	1.4	1.7	1.7	2.3	2.4	2.5	2.6	2.9	2.8
NL	44.0	44.5	47.4	51.2	55.3	57.8	27.6	29.9	33.3	37.8	40.9	40.9
NO	16.7	16.5	15.9	15.1	15.8	16.3	6.0	6.0	5.7	5.5	5.7	5.3
PL	162.9	179.1	223.1	247.4	288.7	280.6	66.9	56.7	51.4	60.6	127.9	96.7
PT	27.5	29.5	30.2	30.8	33.4	37.6	14.4	15.0	16.1	16.7	19.2	19.1
RO	111.9	214.9	203.7	181.8	205.2	242.4	75.4	74.2	75.5	78.5	87.5	84.3
SE	23.1	24.3	25.7	27.0	28.5	30.8	9.8	10.5	11.3	11.9	14.8	13.7
SI	4.0	3.6	4.2	3.7	3.8	4.5	1.9	1.8	1.8	1.7	2.0	2.3
SK	42.7	48.5	50.6	57.9	61.8	72.8	10.5	8.9	11.8	20.8	23.0	13.7
UK	111.7	118.7	120.2	125.5	139.7	143.4	159.7	163.9	162.0	171.4	192.9	165.8
Total	1286.5	1462.3	1573.2	1616.9	1794.9	2004.7	1093.5	1139.1	1156.9	1175.9	1470.8	1465.2

Table 19. Final harmonised estimates of net migration, 2002-2007

	Net migration EU27+4 (x 1 000)						Net migration rest (x 1 000)					
	2002	2003	2004	2005	2006	2007	2002	2003	2004	2005	2006	2007
AT	10.8	15.2	24.5	26.2	20.2	26.5	36.5	33.4	36.9	31.1	8.7	8.5
BE	3.9	4.1	4.0	6.6	13.8	13.5	22.4	22.8	26.5	28.4	30.4	35.0
BG	-14.0	-21.1	-20.1	-18.2	-19.3	-39.3	-10.2	-10.0	-10.0	-11.4	-14.4	-14.2
CH	13.3	12.1	10.0	8.8	14.3	38.3	34.3	30.9	30.5	27.4	25.1	37.1
CY	-1.7	1.8	2.4	0.5	-1.6	-3.8	-19.8	-9.2	-13.6	-24.9	-17.5	-31.0
CZ	-1.6	7.1	-1.4	1.3	-0.6	31.1	-99.2	-88.0	-99.5	-38.1	-73.6	37.2
DE	69.4	45.9	37.9	52.5	35.1	5.6	202.8	155.7	107.2	76.2	43.5	42.8
DK	1.4	0.8	0.8	1.7	2.6	5.7	6.9	5.7	4.2	4.2	4.6	8.8
EE	-2.5	-3.1	-3.2	-3.9	-4.3	-5.1	-2.5	-2.3	-2.0	-1.9	-2.2	-1.9
ES	62.2	94.3	98.7	101.8	96.1	81.6	129.2	160.0	178.2	172.4	109.1	28.8
FI	1.1	1.8	2.5	3.7	4.3	5.1	5.9	5.7	6.4	7.7	8.3	11.2
FR	9.4	8.3	8.3	10.2	23.4	22.3	86.1	83.8	90.8	97.0	116.3	132.7
GR	4.0	3.1	5.6	5.9	7.8	6.8	17.6	19.0	19.5	20.4	20.7	21.7
HU	-5.8	-5.3	-8.2	-10.7	-11.8	-15.4	-9.2	-9.5	-10.1	-12.0	-13.8	-13.2
IE	17.6	16.2	15.4	20.1	33.8	25.0	-0.3	0.1	-0.3	-0.5	-1.5	-0.3
IS	-1.5	-0.5	0.0	0.7	1.0	1.8	0.2	0.0	0.1	0.1	0.2	-0.2
IT	25.5	125.0	98.7	65.1	77.4	70.0	178.9	405.2	398.2	264.4	311.7	311.7
LI	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	-0.1	-0.1
LT	-7.6	-8.5	-10.8	-11.5	-9.6	-9.9	-1.6	-6.3	-6.6	-4.0	-1.9	-1.4
LU	6.8	6.8	6.7	7.0	4.7	4.7	-0.1	-0.2	-0.2	-0.5	0.1	0.0
LV	-4.6	-3.9	-4.1	-3.9	-4.2	-0.5	-9.8	-6.2	-7.5	-5.5	-13.6	-10.5
MT	0.1	0.0	-0.2	0.0	-0.1	-0.1	-1.2	-1.3	-1.4	-1.3	-1.7	-1.4
NL	-1.6	-4.5	-3.4	-5.3	-2.5	8.3	56.7	39.3	21.5	13.2	12.5	15.7
NO	-2.3	-3.5	-1.7	1.6	6.1	16.1	12.3	10.1	9.7	10.1	9.3	12.4
PL	-92.0	-103.5	-121.1	-146.8	-172.8	-119.8	-29.7	-16.9	2.2	-7.7	-66.9	-12.0
PT	-8.8	-10.8	-11.1	-11.0	-9.2	-9.0	12.9	13.2	14.1	15.8	16.9	16.4
RO	-83.1	-181.2	-168.1	-142.8	-158.6	-184.8	-41.5	-38.6	-39.4	-41.1	-47.5	-41.8
SE	6.5	4.7	3.6	4.1	10.6	14.7	24.6	23.9	21.1	21.9	41.6	40.1
SI	-0.4	-0.8	-1.1	0.2	0.1	0.3	1.6	1.3	2.2	1.8	1.2	0.2
SK	-32.8	-37.2	-31.4	-17.4	-7.6	-35.7	-4.5	-2.1	-0.1	3.9	10.0	8.9
UK	28.0	36.6	66.9	53.6	50.6	45.9	124.7	154.1	219.8	194.4	197.0	222.4
Total	0.0	0.0	0.0	0.0	0.0	0.0	724.0	973.4	998.2	841.6	712.5	863.7

6. Disaggregration by sex and age

In this section, we first describe the age- and sex-specific multiplicative components used to disaggregate the origin-destination tables from 2002-2007. Unfortunately, at the time of this writing, the 2007 age- and sex-specific data were not available. However, we believe this is not a major problem as there are fairly strong regularities exhibited in the age and sex patterns over time. The model related to this section is specified in Equation (10). In Section 6.2, we present the estimates constrained to the origin-destination migration flow tables set out in Appendix (see also Equation 26). Because of the large number of cells resulting from the estimation process (221,184 cells!), we focus our analysis on four flows: Norway to Sweden (good data sources), Germany to Italy (reasonable data sources), Poland to United Kingdom (poor data sources) and France to Belgium (missing data). The full set of results will be made available on the NIDI website.

6.1. Available data

The age and sex main effect components (i.e., A_x and S_y , respectively) are presented in Figure 2 and Table 20, respectively. These components represent the average of the available immigration and emigration data obtained from origin by age by sex (OAS) and destination by age by sex (DAS) tables. The origin-age components (i.e., OA_{ix}) for Norway, Germany and Poland are presented in Figure 3. The destination -age components (i.e., DA_{jx}) for Sweden, Spain and the United Kingdom are presented in Figure 4. Note, the ratios for France and Belgium were set to equal 1, as the data for these countries were not available. We did this for all countries not providing data, implying that the patterns for these countries come from the main effects of age and sex (i.e., those presented in Figure 2 and Table 20). Finally, the other components of OS_{iy}, DS_{jy}, and AS_{xy} are presented in Table 21, Table 22 and Figure 5, respectively.

Figure 2. Estimated proportions of all migration by age group (A_x), 2002-2006

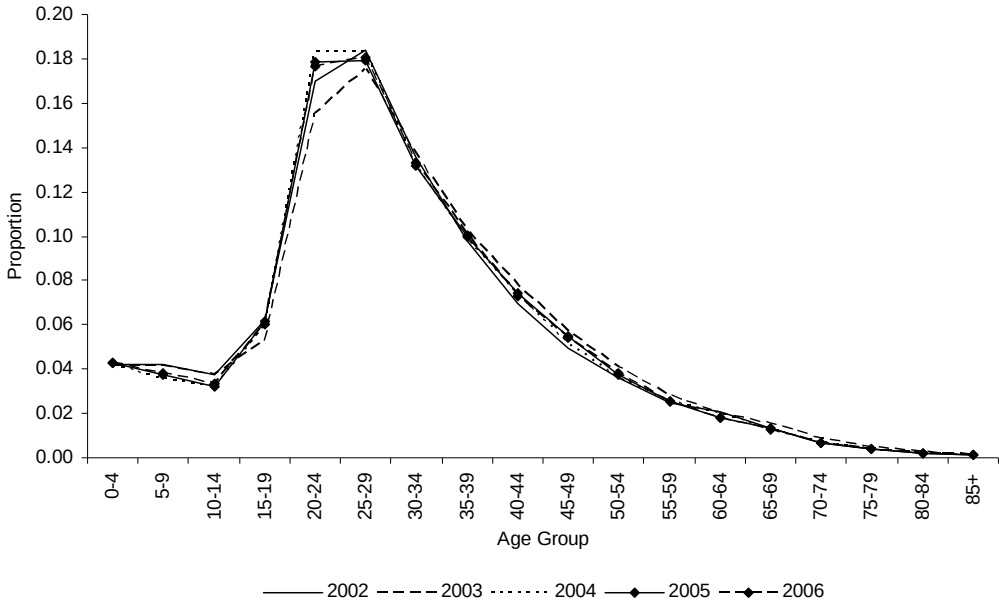


Table 20. Estimated proportions of all migration by sex group (S_y), 2002-2006

Sex	2002	2003	2004	2005	2006
Female	0.451	0.442	0.453	0.463	0.457
Male	0.549	0.545	0.559	0.566	0.561

Figure 3. Origin-age components (OA_{ix}) of migration from Norway, Germany and Poland, 2002-2006

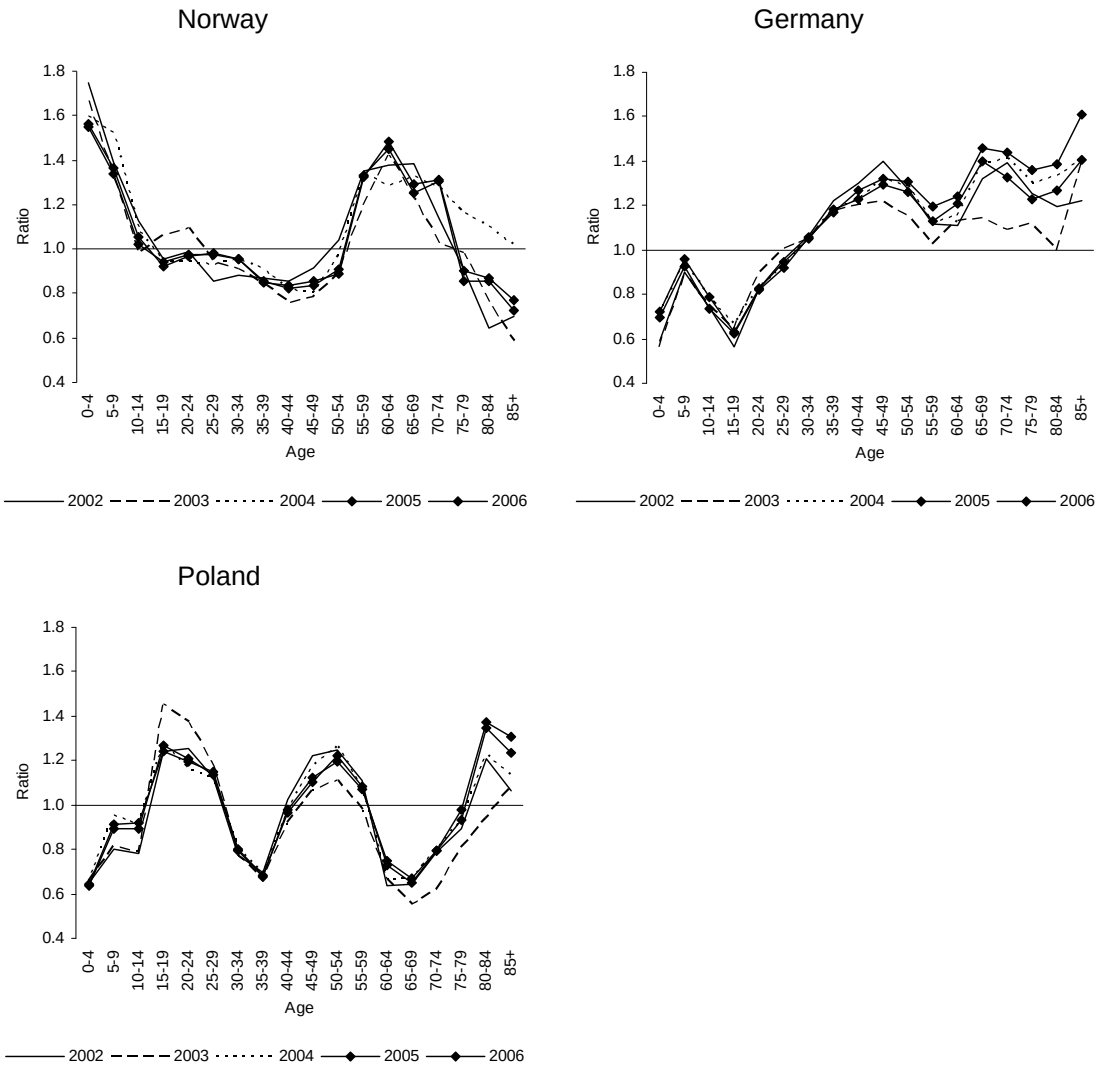


Figure 4. Destination-age components (DA_{jx}) of migration to Sweden, Italy and the United Kingdom, 2002-2006

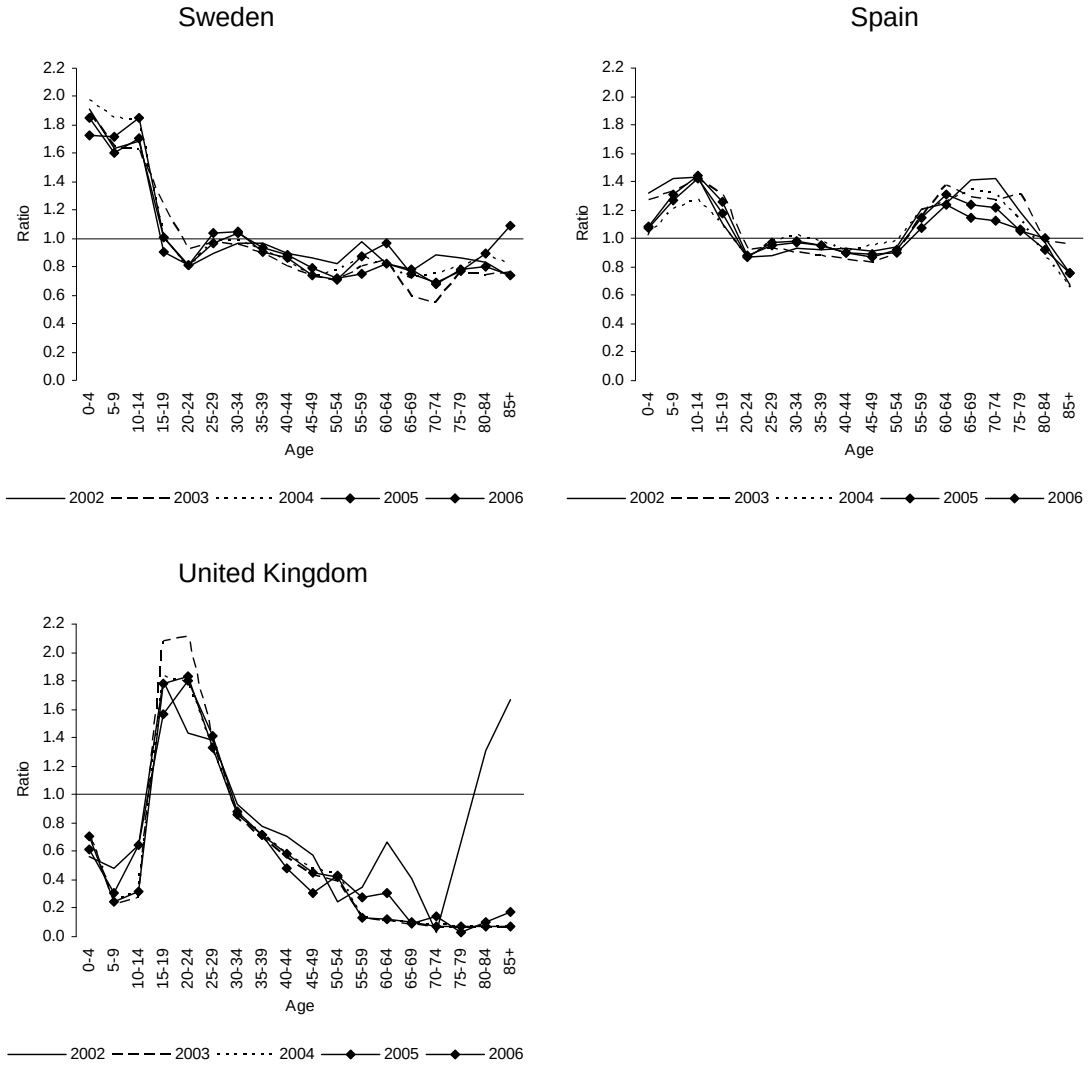


Table 21. Origin-sex components (OS_{iy}) of migration, 2002-2006

	Female					Male				
Country	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
AT	**0.914**	**0.914**	0.914	0.876	0.889	**1.049**	**1.049**	1.049	1.051	1.058
BE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BG	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CH	1.063	1.082	1.051	1.024	1.037	0.949	0.957	0.938	0.930	0.937
CY	1.153	1.447	1.508	1.430	1.503	0.874	0.661	0.567	0.598	0.558
CZ	0.694	0.691	0.667	0.855	**0.855**	1.251	1.273	1.249	1.069	**1.069**
DE	0.828	0.845	0.826	0.819	0.838	1.141	1.149	1.120	1.098	1.099
DK	1.053	1.077	1.050	1.031	1.027	0.956	0.961	0.939	0.925	0.946
EE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ES	1.137	1.038	0.973	0.946	0.924	0.887	0.992	1.001	0.994	1.029
FI	1.129	1.172	1.101	1.106	1.097	0.894	0.884	0.897	0.863	0.889
FR	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
GR	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
HU	1.010	1.016	**1.000**	0.824	0.799	0.992	1.010	**1.000**	1.094	1.132
IE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
IS	1.084	**1.084**	**1.084**	**1.084**	**1.084**	0.931	**0.931**	**0.931**	**0.931**	**0.931**
IT	0.971	0.996	**0.996**	**0.996**	**0.996**	1.024	1.027	**1.027**	**1.027**	**1.027**
LI	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
LT	1.072	1.202	1.167	1.112	1.123	0.941	0.860	0.844	0.858	0.867
LU	0.995	1.080	0.958	0.898	0.943	1.004	0.958	1.013	1.034	1.014
LV	1.020	1.137	1.114	1.203	1.158	0.984	0.913	0.887	0.784	0.839
MT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
NL	1.037	1.067	1.045	1.027	1.046	0.970	0.969	0.942	0.927	0.930
NO	1.073	1.068	1.070	1.056	**1.056**	0.940	0.968	0.922	0.904	**0.904**
PL	**0.918**	**0.918**	**0.918**	**0.918**	0.918	**1.035**	**1.035**	**1.035**	**1.035**	1.035
PT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
RO	1.212	1.327	1.374	1.349	1.364	0.826	0.758	0.675	0.664	0.671
SE	1.061	1.101	1.055	1.014	1.023	0.950	0.942	0.934	0.939	0.949
SI	1.132	1.121	0.995	1.139	1.123	0.892	0.925	0.983	0.836	0.867
SK	1.425	0.915	0.917	1.140	1.042	0.651	1.092	1.046	0.835	0.933
UK	1.047	0.962	1.091	**1.000**	**1.000**	0.961	1.054	0.905	**1.000**	**1.000**
REST	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

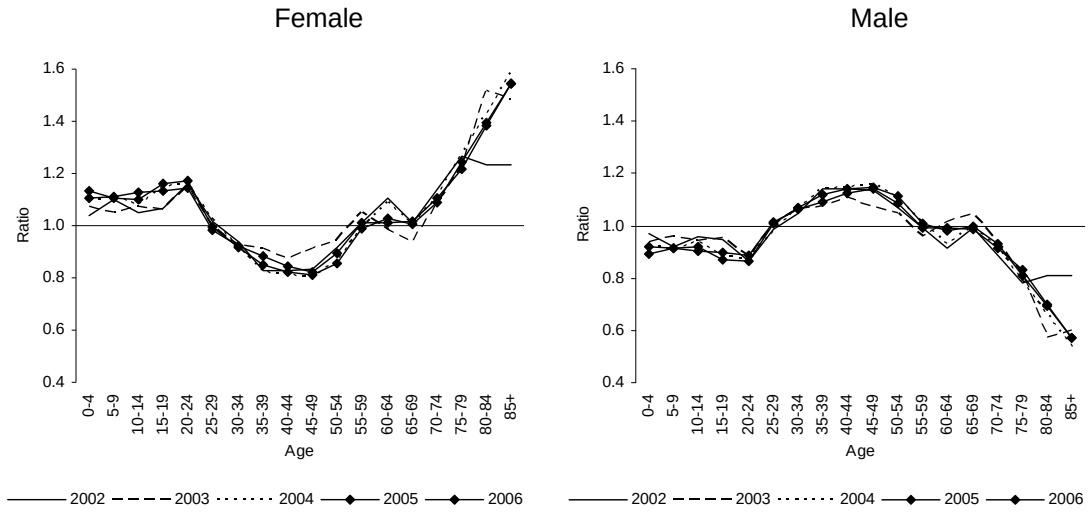
Note, **Boldface** denotes estimated.

Table 22. Destination-sex components (DS_{jy}) of migration, 2002-2006

	Female					Male				
Country	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
AT	**1.026**	**1.026**	1.026	1.021	1.021	**0.979**	**0.979**	0.979	0.984	0.983
BE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BG	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CH	1.095	1.093	1.101	1.084	1.071	0.922	0.924	0.921	0.934	0.945
CY	1.201	1.048	1.188	1.288	1.435	0.835	0.961	0.852	0.774	0.659
CZ	0.846	0.755	0.810	0.846	0.846	1.126	1.202	1.150	1.121	1.121
DE	0.952	0.948	0.944	0.952	0.922	1.039	1.043	1.044	1.038	1.061
DK	1.114	1.101	1.127	1.128	1.098	0.907	0.917	0.900	0.900	0.923
EE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ES	1.054	1.056	1.029	1.046	1.079	0.956	0.954	0.977	0.964	0.938
FI	1.107	1.113	1.139	1.121	1.099	0.912	0.907	0.891	0.905	0.922
FR	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
GR	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
HU	0.989	0.939	1.104	0.985	1.025	1.009	1.050	0.918	1.012	0.981
IE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
IS	1.144	**1.144**	**1.144**	**1.144**	**1.144**	0.882	**0.882**	**0.882**	**0.882**	**0.882**
IT	1.127	1.128	**1.128**	**1.128**	**1.128**	0.896	0.894	**0.894**	**0.894**	**0.894**
LI	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
LT	0.997	1.000	1.057	0.997	0.991	1.003	1.000	0.955	1.002	1.007
LU	1.018	1.035	1.014	1.036	**1.036**	0.985	0.971	0.989	0.972	**0.972**
LV	0.951	0.747	0.915	0.990	1.032	1.040	1.208	1.067	1.008	0.975
MT	0.947	**0.947**	**0.947**	**0.947**	**0.947**	1.043	**1.043**	**1.043**	**1.043**	**1.043**
NL	1.083	1.103	1.154	1.139	1.112	0.932	0.916	0.878	0.891	0.912
NO	1.149	1.133	1.160	1.134	**1.134**	0.877	0.891	0.874	0.895	**0.895**
PL	**1.024**	**1.024**	**1.024**	**1.024**	1.024	**0.981**	**0.981**	**0.981**	**0.981**	0.981
PT	1.178	1.175	1.240	**1.240**	**1.240**	0.854	0.856	0.811	**0.811**	**0.811**
RO	1.068	1.031	0.985	0.976	0.871	0.944	0.974	1.011	1.019	1.102
SE	1.089	1.110	1.143	1.110	1.070	0.927	0.910	0.887	0.914	0.945
SI	0.709	0.728	0.599	0.592	0.485	1.239	1.224	1.316	1.319	1.404
SK	0.981	0.902	0.887	0.824	0.827	1.016	1.081	1.089	1.138	1.136
UK	1.071	1.263	1.157	1.073	1.057	0.942	0.783	0.877	0.943	0.955
REST	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Note, **Boldface** denotes estimated.

Figure 5. Age-sex components (AS_{xy}) of migration, 2002-2006



6.2. Estimates

In this section, we present a sample of the results for migration between from Norway to Sweden (Figure 6), Germany to Spain (Figure 7), Poland to the United Kingdom (Figure 8) and France to Belgium (Figure 9).

Figure 6. Estimated migration flows from Norway to Sweden by age and sex, 2002-2007

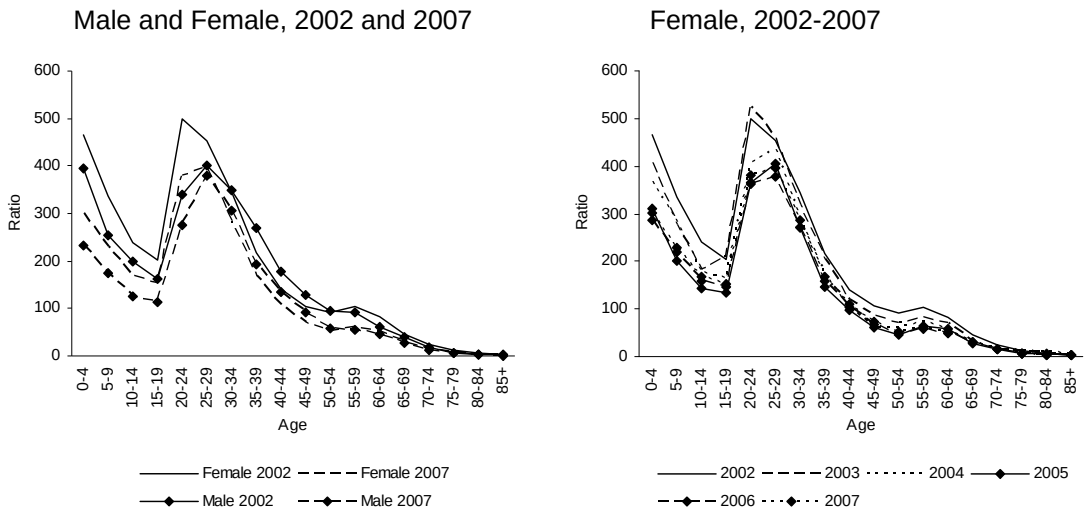


Figure 7. Estimated migration flows from Germany to Spain by age and sex, 2002-2007

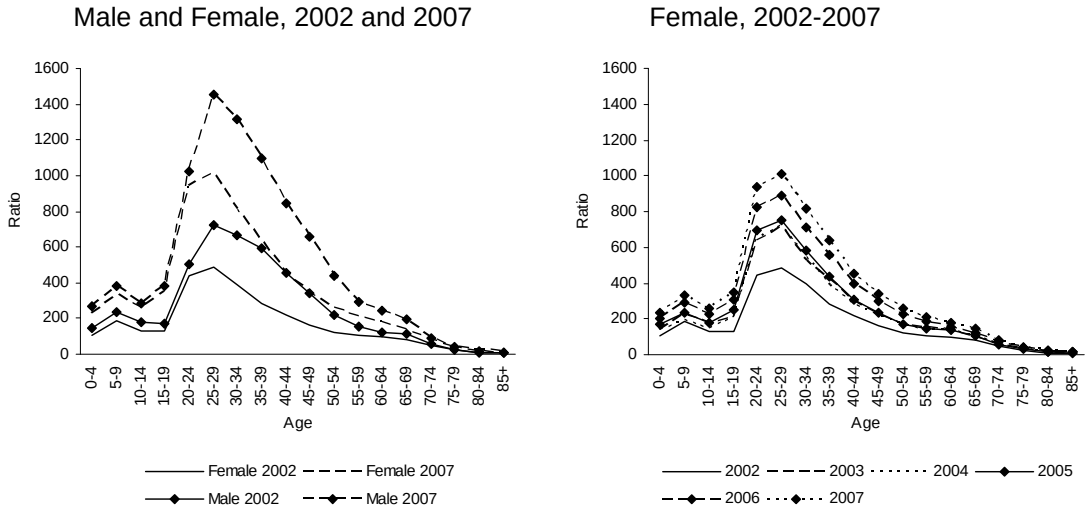


Figure 8. Estimated migration flows from Poland to United Kingdom by age and sex, 2002-2007

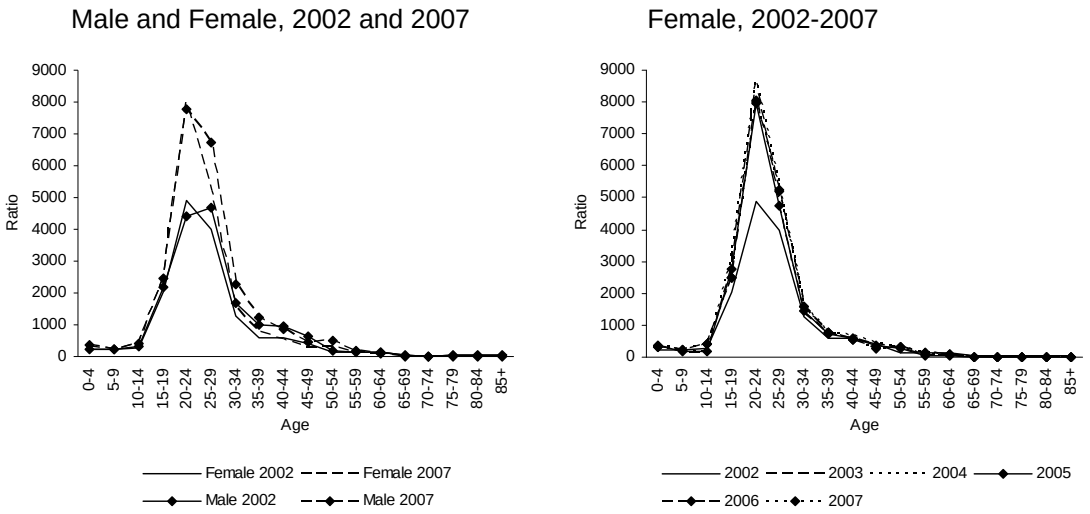
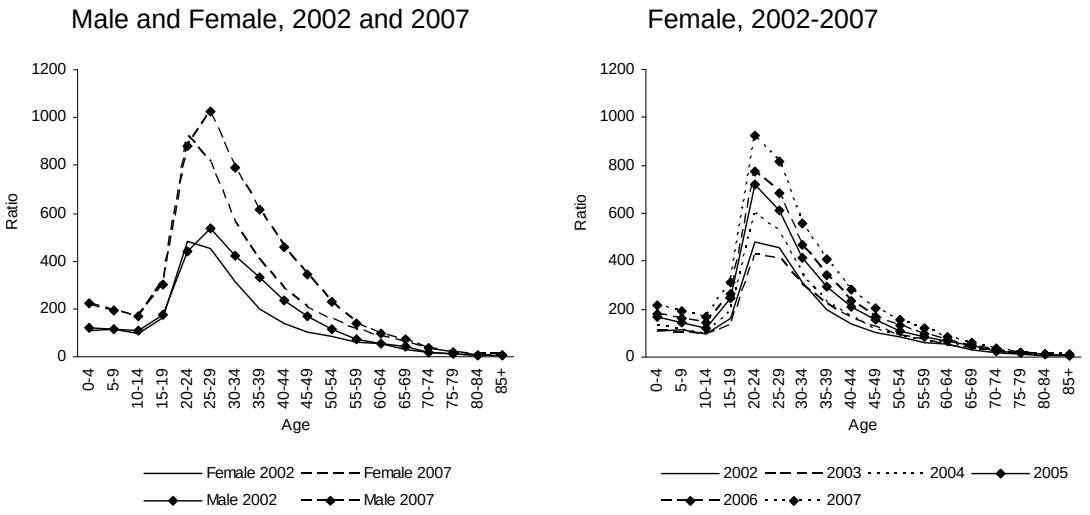


Figure 9. Estimated migration flows from France to Belgium by age and sex, 2002-2007



7. Disaggregation by citizenship

In this section, we present the data used to disaggregate the origin flows and destination flows by age, sex and citizenship for 2002-2007 and the resulting two four-dimensional migration flow tables, denoted by OASC and DASC, respectively. Note, at the time of this writing, the 2007 data were not available. As with the disaggregations by age and sex, we used the 2006 patterns to represent the 2007 patterns. The models for the citizenship disaggregations are specified in Equations (27) and (34) and (28) and (35), respectively.

7.1. Available data

The C_z terms are set out in Table 23 for immigration and emigration flows. The main change over time found in these figures was the increased proportions of migration consisting of EU nationals after 2004. For example, in 2006, 12 percent of all immigrants were nationals, 35 percent were EU nationals and 54 percent were non-EU nationals. In 2002, the corresponding percentages were 20 percent, 15 percent and 65 percent, respectively.

Table 23. Proportions of available migration data in each citizenship group, 2002-2006

Citizenship	2002	2003	2004	2005	2006
A. Immigration					
Nationals	0.197	0.206	0.145	0.126	0.115
EU Nationals	0.153	0.208	0.249	0.348	0.349
Non-EU Nationals	0.650	0.586	0.607	0.526	0.535
B. Emigration					
Nationals	0.377	0.429	0.287	0.330	0.367
EU Nationals	0.184	0.268	0.310	0.345	0.316
Non-EU Nationals	0.439	0.304	0.403	0.325	0.317

The origin-citizenship (OC_{iz}) and destination-citizenship (DC_{jz}) terms are set out in Table 24. Ratios greater than one indicate larger proportions in that category. Values less than one indicate the opposite. Note, for countries that have some data, but not for all years, the missing cells in Tables 24 and 25 have been filled in with the nearest neighbour values. The OC_{iz} and DC_{jz} terms for countries with completely missing data are set to unity. Setting the ratios to unity imposes the overall proportions contained in the main effect C_z term. Finally, we tried to maintain the patterns reported by the country, even in situations where they appeared questionable (e.g., Poland's very low levels of reported EU national and non EU national migration. Future work could exclude these from the estimation.

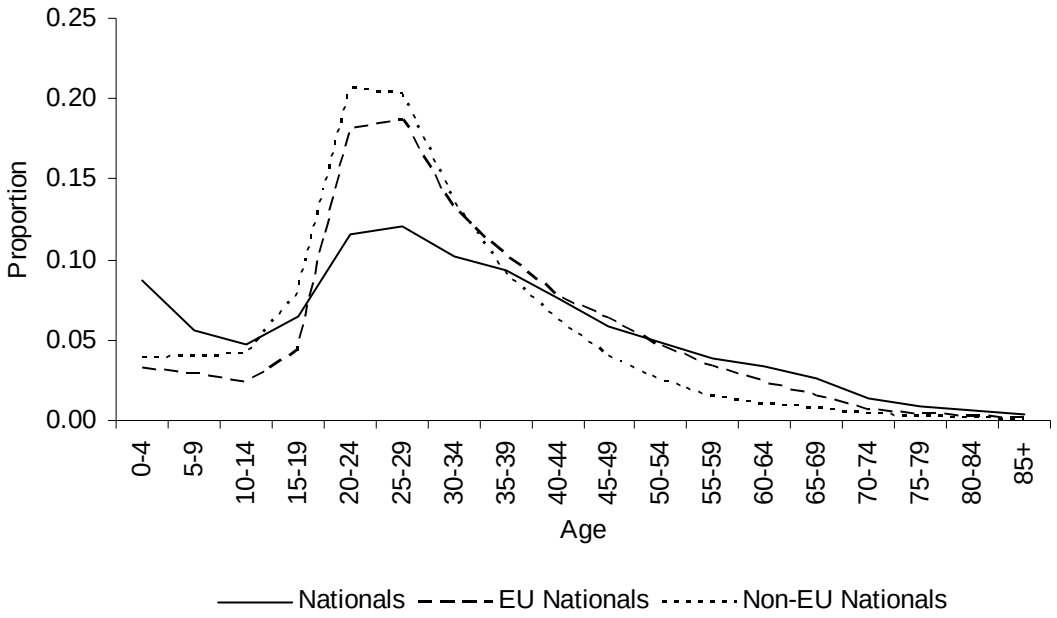
Table 24. Ratios of observed proportions of emigration and immigration by citizenship to overall observed proportions (OC_{iz} and DC_{jz}) for available data, 2002-2006

	OC_{iz}						DC_{jz}					
Country	2002	2003	2004	2005	2006	2007	2002	2003	2004	2005	2006	2007
A. Nationals												
AT	0.984	0.866	1.290	0.934	0.764	0.764	0.735	0.704	1.000	1.105	1.340	1.340
CH	0.843	0.782	1.168	1.021	0.918	0.918	0.898	0.851	1.112	1.290	1.389	1.389
CY	0.590	0.315	0.341	0.090	0.150	0.150	0.676	0.580	0.554	0.827	0.557	0.557
CZ	0.129	0.113	0.169	0.147	0.132	0.132	0.218	0.209	0.342	0.227	0.247	0.247
DE	0.501	0.474	0.751	0.698	0.662	0.662	1.109	1.057	1.576	1.440	1.356	1.356
DK	1.570	1.357	2.004	1.734	1.535	1.535	2.132	2.156	3.046	3.407	3.437	3.437
ES	2.151	1.330	0.831	0.859	0.422	0.422	0.422	0.575	0.391	0.405	0.391	0.391
FI	2.086	1.894	2.412	2.385	2.115	2.115	2.280	2.292	2.997	3.208	3.319	3.319
HU	0.760	0.425	0.478	0.280	0.271	0.271	0.507	0.486	0.691	0.796	0.868	0.868
IS	1.997	1.757	2.619	2.281	2.052	2.052	2.840	2.723	3.868	4.454	4.860	4.860
IT	2.164	1.910	2.847	2.480	2.231	2.231	1.058	0.525	0.746	0.859	0.937	0.937
LT	1.300	1.602	3.024	2.589	2.224	2.224	0.803	1.350	4.226	5.513	6.174	6.174
LU	0.332	0.255	0.420	0.416	0.401	0.401	0.466	0.425	0.655	0.698	0.762	0.762
LV	0.641	0.657	1.199	1.530	1.710	1.710	0.739	1.030	1.838	2.695	1.537	1.537
NL	1.812	1.593	2.387	2.158	1.933	1.933	1.449	1.440	2.123	2.489	2.874	2.874
NO	1.234	0.977	1.407	1.267	1.140	1.140	1.180	1.240	1.632	1.742	1.901	1.901
PL	2.643	2.324	3.465	3.017	2.715	2.715	4.215	4.042	5.741	6.612	7.215	7.215
PT							1.860	1.709	2.604	2.999	3.272	3.272
SE	1.512	1.325	1.955	1.770	1.510	1.510	1.305	1.205	1.609	1.699	1.392	1.392
SI							0.795	0.665	1.069	0.924	0.765	0.765
SK	0.648	0.570	0.812	1.847	1.379	1.379	4.067	1.476	1.643	1.475	0.896	0.896
UK	1.428	1.256	1.872	1.630	1.467	1.467	1.241	1.190	1.690	1.947	2.124	2.124
B. EU Nationals												
AT	1.262	0.866	0.749	0.974	1.119	1.119	1.858	1.367	1.143	1.115	1.281	1.281
CH	2.279	1.559	1.356	1.248	1.360	1.360	2.571	2.135	1.944	1.457	1.503	1.503
CY	1.107	0.730	0.370	0.646	0.353	0.353	3.536	2.366	2.385	1.797	1.113	1.113
CZ	2.059	1.413	1.222	1.098	1.196	1.196	3.086	2.271	1.544	0.764	0.761	0.761
DE	1.073	1.353	1.228	1.219	1.344	1.344	0.858	1.428	1.373	1.294	1.387	1.387
DK	0.786	0.696	0.609	0.548	0.637	0.637	0.857	0.929	0.867	0.721	0.849	0.849
ES	0.316	0.314	0.412	0.530	0.693	0.693	0.893	0.766	0.733	1.030	1.036	1.036
FI	0.446	0.369	0.552	0.348	0.423	0.423	0.638	0.873	0.800	0.618	0.684	0.684
HU	0.348	0.237	1.012	1.634	1.564	1.564	3.195	2.351	1.965	1.405	1.399	1.399
IS	0.754	0.517	0.447	0.402	0.438	0.438	0.968	0.712	0.595	0.426	0.424	0.424
IT	0.300	0.185	0.160	0.144	0.157	0.157	0.487	0.258	0.216	0.154	0.154	0.154
LT	0.329	0.123	0.112	0.092	0.141	0.141	0.674	0.570	0.402	0.191	0.146	0.146
LU	3.723	2.423	2.127	2.047	2.286	2.286	4.448	3.246	2.779	2.124	2.115	2.115
LV	0.534	0.443	0.490	0.289	0.279	0.279	0.792	1.520	1.640	1.177	1.089	1.089
NL	0.868	0.629	0.526	0.437	0.491	0.491	1.135	1.002	1.082	0.857	0.903	0.903
NO	1.783	1.239	1.073	0.985	1.073	1.073	1.552	1.276	1.220	1.011	1.007	1.007
PL	0.009	0.006	0.006	0.005	0.005	0.005	0.248	0.182	0.152	0.109	0.108	0.108
PT							0.872	0.714	0.495	0.354	0.352	0.352
SE	1.182	0.851	0.757	0.672	0.693	0.693	1.240	1.057	1.035	0.812	0.762	0.762
SI							0.220	0.289	0.093	0.386	0.249	0.249
SK	1.892	1.298	1.179	0.302	0.579	0.579	0.122	1.389	1.946	1.405	1.384	1.384
UK	0.755	0.518	0.448	0.402	0.439	0.439	0.999	0.735	0.615	0.439	0.437	0.437
C. Non-EU Nationals												
AT	0.904	1.308	0.986	1.094	1.154	1.154	0.879	0.974	0.941	0.899	0.744	0.744
CH	0.600	0.815	0.606	0.716	0.735	0.735	0.661	0.650	0.586	0.629	0.588	0.588
CY	1.307	2.205	1.955	2.299	2.632	2.632	0.501	0.663	0.539	0.514	1.022	1.022
CZ	1.304	1.887	1.423	1.762	1.809	1.809	0.746	0.827	0.934	1.340	1.318	1.318
DE	1.397	1.431	1.002	1.074	1.048	1.048	1.000	0.828	0.710	0.701	0.671	0.671
DK	0.600	0.765	0.584	0.734	0.744	0.744	0.690	0.620	0.566	0.610	0.574	0.574
ES	0.299	1.139	1.573	1.641	1.976	1.976	1.201	1.232	1.255	1.122	1.107	1.107
FI	0.300	0.296	0.336	0.285	0.285	0.285	0.697	0.592	0.605	0.725	0.707	0.707
HU	1.479	2.484	1.364	1.059	1.280	1.280	0.633	0.701	0.678	0.781	0.768	0.768
IS	0.247	0.358	0.270	0.334	0.343	0.343	0.449	0.498	0.481	0.555	0.545	0.545
IT	0.294	0.434	0.327	0.405	0.416	0.416	1.103	1.430	1.382	1.592	1.566	1.566
LT	1.023	0.924	0.239	0.349	0.441	0.441	1.136	1.030	0.475	0.457	0.444	0.444
LU	0.434	0.797	0.547	0.483	0.409	0.409	0.350	0.406	0.353	0.329	0.324	0.324
LV	1.503	1.976	1.250	1.216	0.897	0.897	1.128	0.805	0.538	0.478	0.826	0.826
NL	0.359	0.491	0.374	0.421	0.428	0.428	0.832	0.845	0.698	0.739	0.660	0.660
NO	0.471	0.822	0.653	0.745	0.765	0.765	0.816	0.818	0.759	0.815	0.802	0.802
PL	0.005	0.008	0.006	0.007	0.007	0.007	0.202	0.223	0.216	0.249	0.245	0.245
PT							0.769	0.853	0.824	0.950	0.934	0.934
SE	0.485	0.672	0.505	0.566	0.716	0.716	0.851	0.908	0.840	0.957	1.071	1.071
SI							1.246	1.370	1.355	1.424	1.540	1.540
SK	0.929	1.344	0.997	0.881	0.982	0.982	0.276	0.695	0.459	0.619	0.772	0.772
UK	0.736	1.064	0.802	0.994	1.020	1.020	0.927	1.027	0.993	1.144	1.125	1.125

In examining the age patterns of migration by citizenship group, we found strong stability in the patterns over time. Thus, we just present the average 2002-2006 age profiles in Figure 10 to get a sense of how the patterns differed by citizenship for immigrants and emigrants. As we can see in the figure, nationals have higher proportions of child migrants and lower proportions of young adult migrants relative to EU nationals and non-EU nationals. EU nationals and non-EU nationals closely resemble the overall age profile of migration, albeit with EU nationals having slightly lower proportions of child migrants and the non-EU nationals having a more narrow labour force peak. These proportions were used to calculate the AC_{xz} ratios. Finally, we show the proportions of male immigration and emigration by citizenship in Table 25, which are used to calculate the SC_{yz} ratios.

Figure 10. Age profiles of immigration and emigration by citizenship, average 2002-2006

A. Immigration



B. Emigration

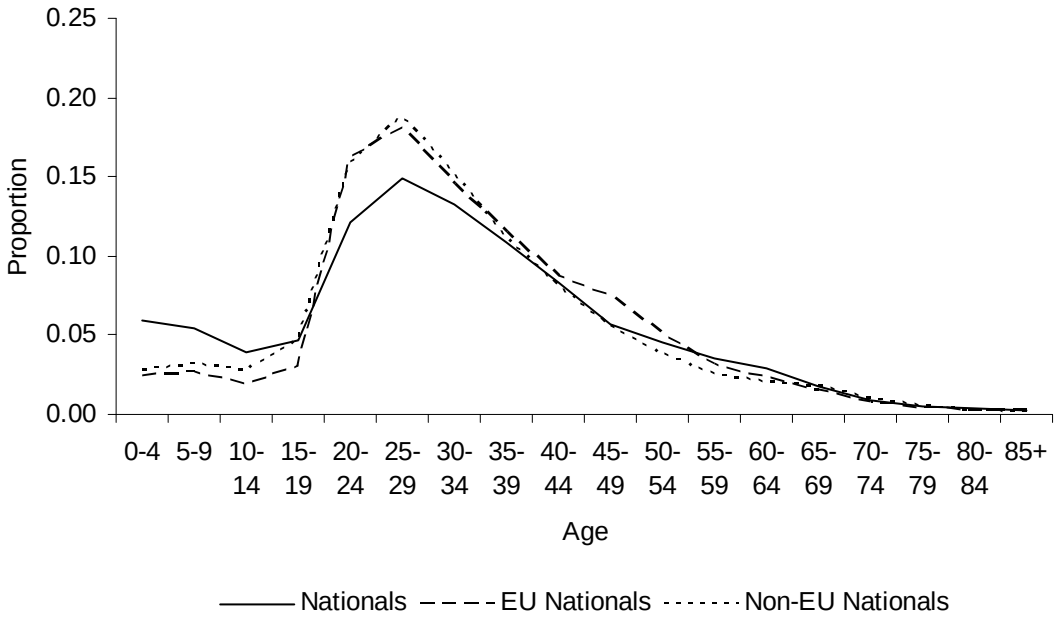


Table 25. Proportions of male immigration and emigration by citizenship to overall observed for available data, 2002-2006

Citizenship	2002	2003	2004	2005	2006
A. Immigration					
Nationals	0.539	0.517	0.557	0.546	0.550
EU Nationals	0.557	0.572	0.583	0.577	0.581
Non-EU Nationals	0.528	0.519	0.528	0.534	0.528
B. Emigration					
Nationals	0.536	0.548	0.542	0.532	0.539
EU Nationals	0.572	0.628	0.623	0.622	0.625
Non-EU Nationals	0.611	0.607	0.586	0.593	0.596

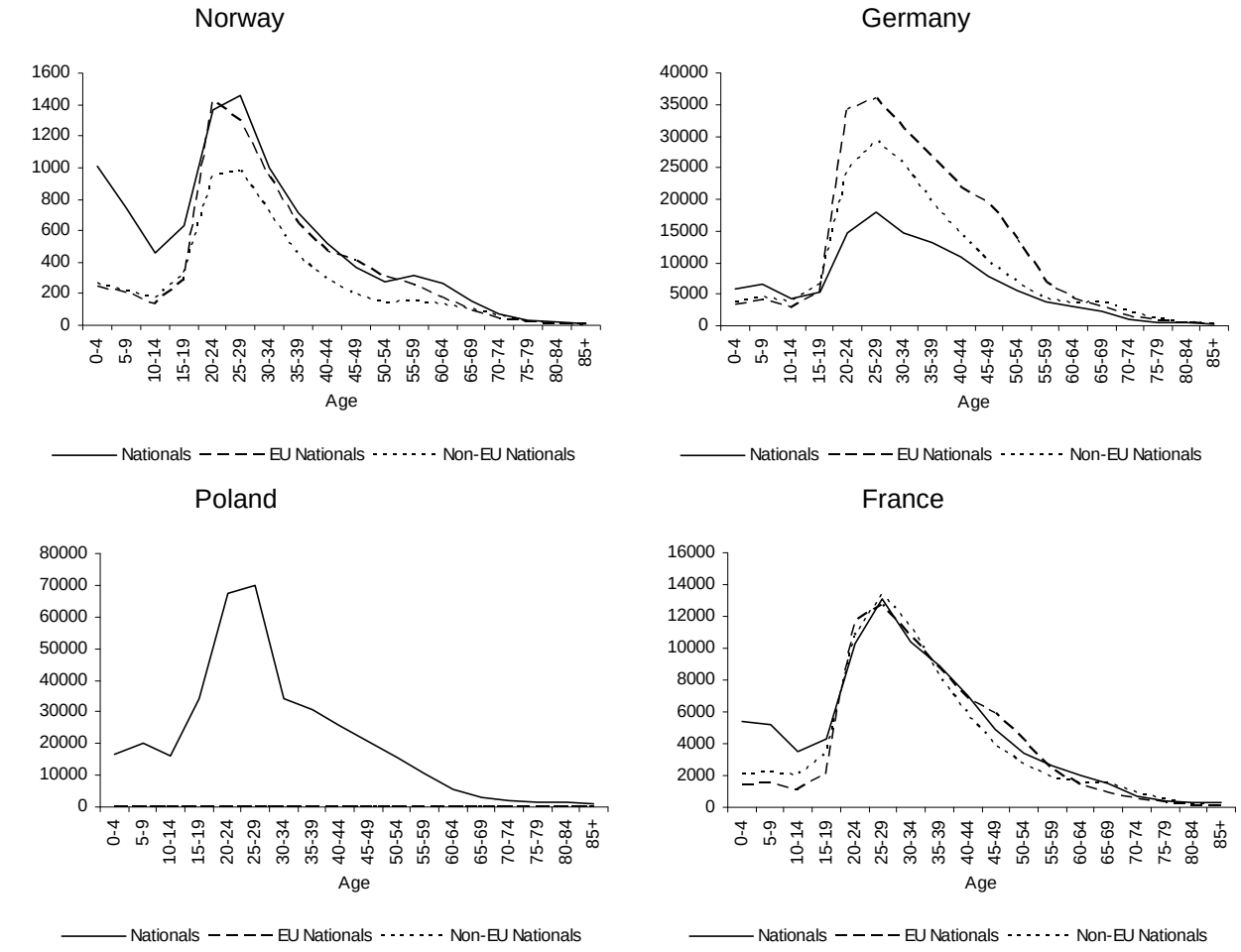
7.2. Estimates

In this Section, we use the proportions and ratios described in Section 7.1 to disaggregate the origin, age and sex and destination, age and sex patterns of migration into citizen groups. Again, the unavailable citizenship patterns for 2007 are taken from the previous year. We also continue the analysis in Section 6 by focusing on the patterns exhibited by emigration from Norway, Germany, Poland and France (Section 7.2.1) and immigration to Sweden, Spain, United Kingdom and Belgium (Section 7.2.2). The full set of results will be made available on the NIDI website.

7.2.1. Origin, Age, Sex and Citizenship estimates

The patterns of emigration by age, sex and citizenship presented in Figures 11-15 give an indication of the variety of patterns estimated.

Figure 11. Estimated age patterns of emigration from Norway, Germany, Poland and France, 2007



Note: y-axes are on different scales.

Figure 12. Estimated age patterns of female emigration from Norway by citizenship, 2002-2007

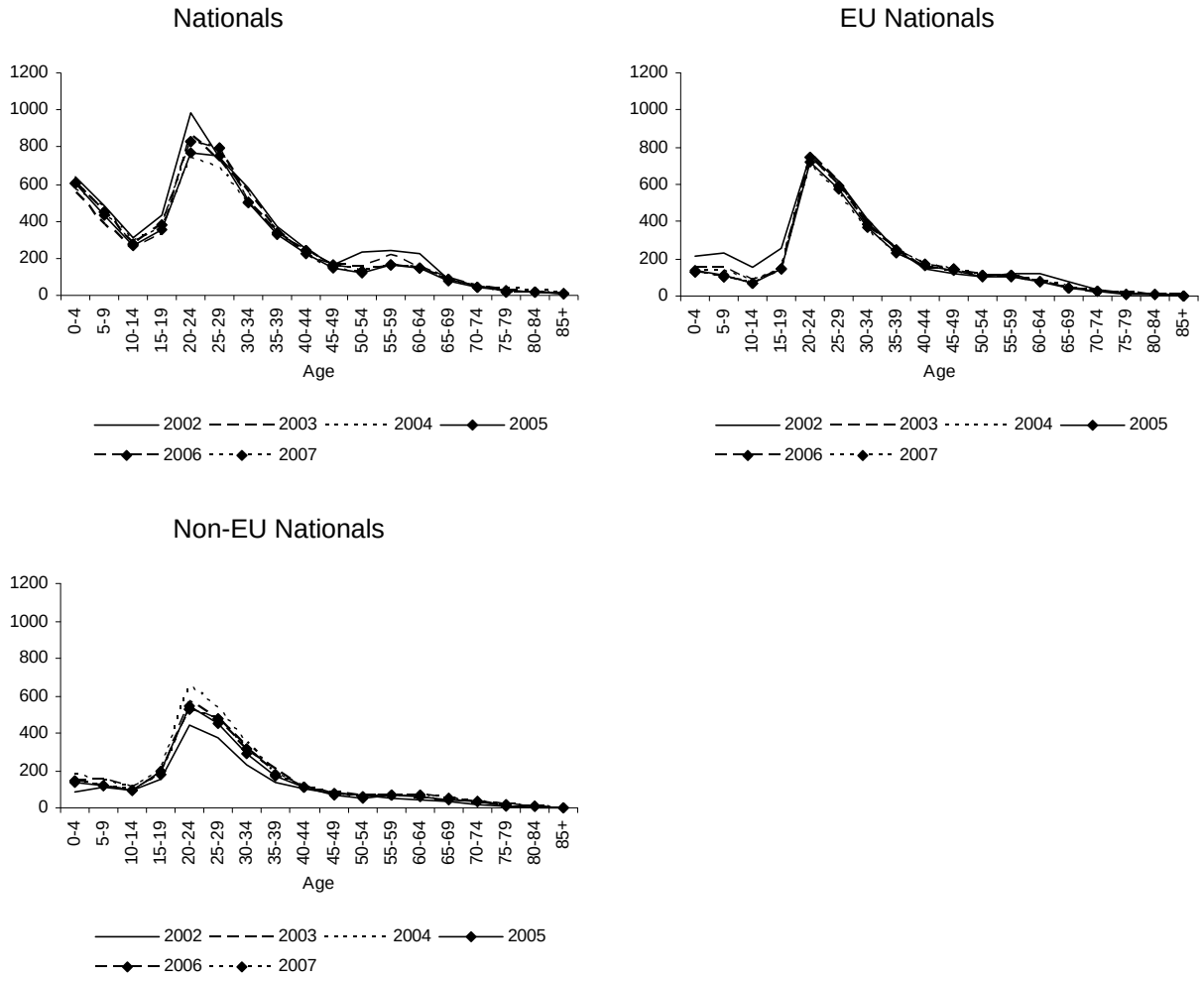


Figure 13. Estimated age patterns of female emigration from Germany by citizenship, 2002-2007

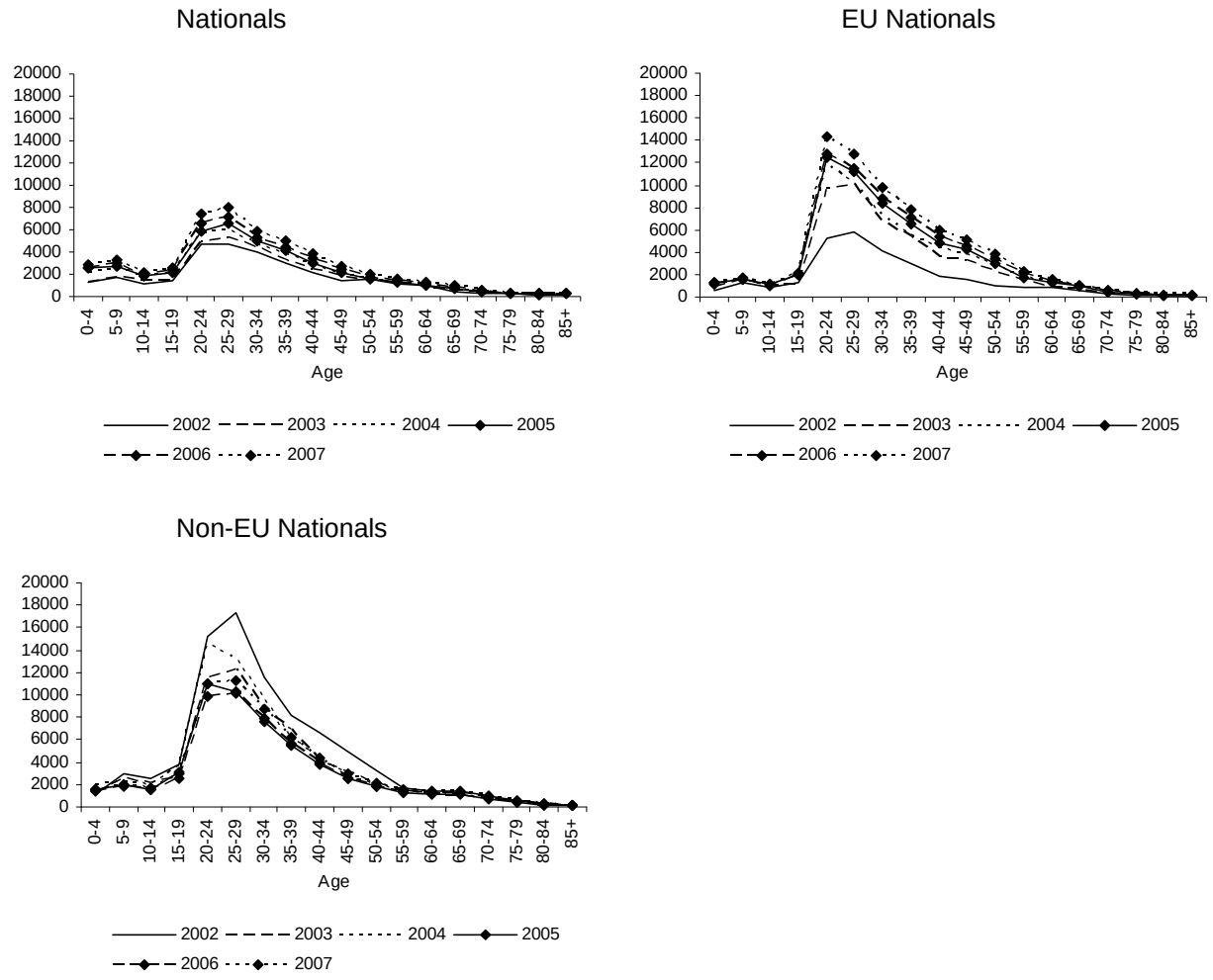
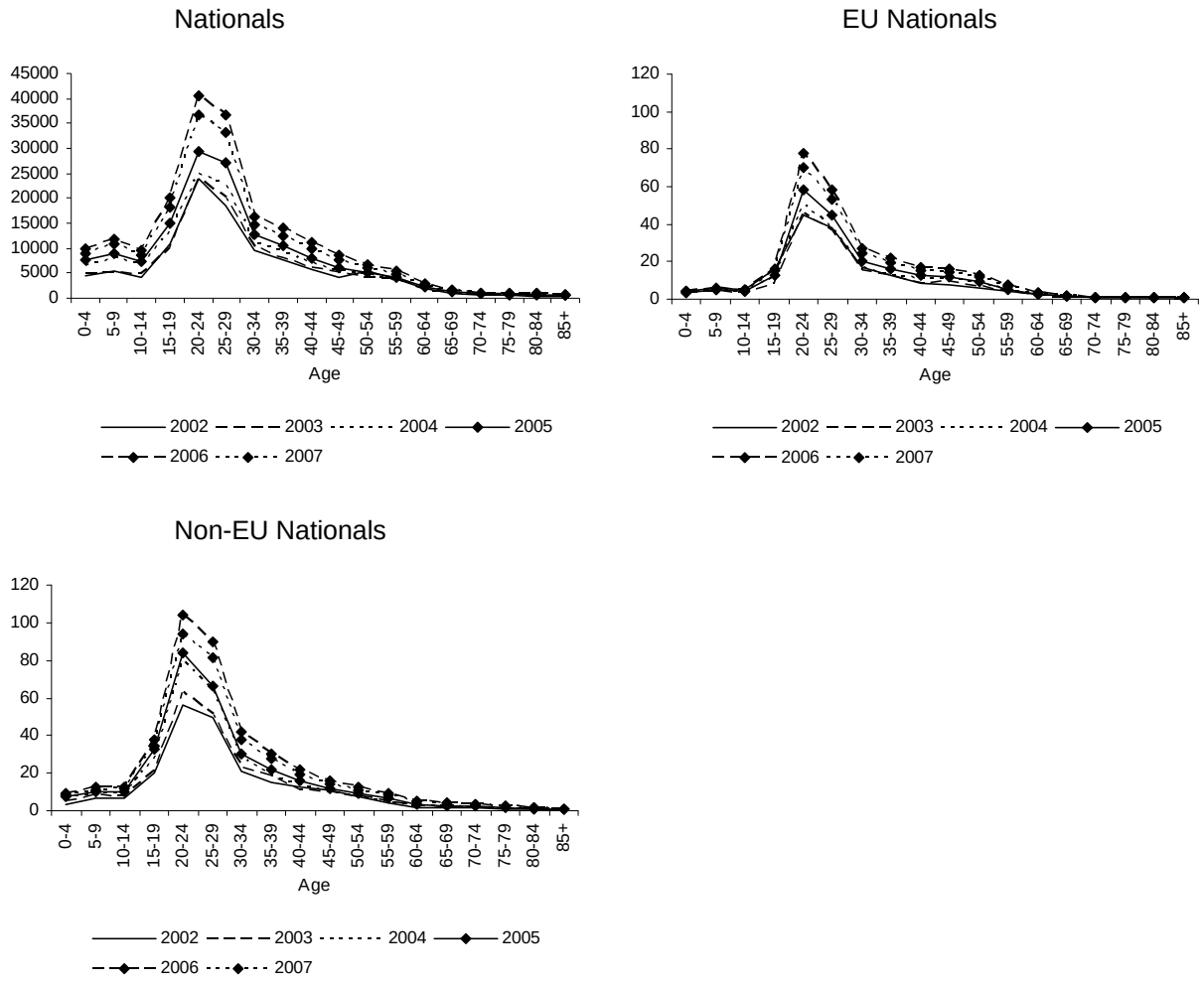
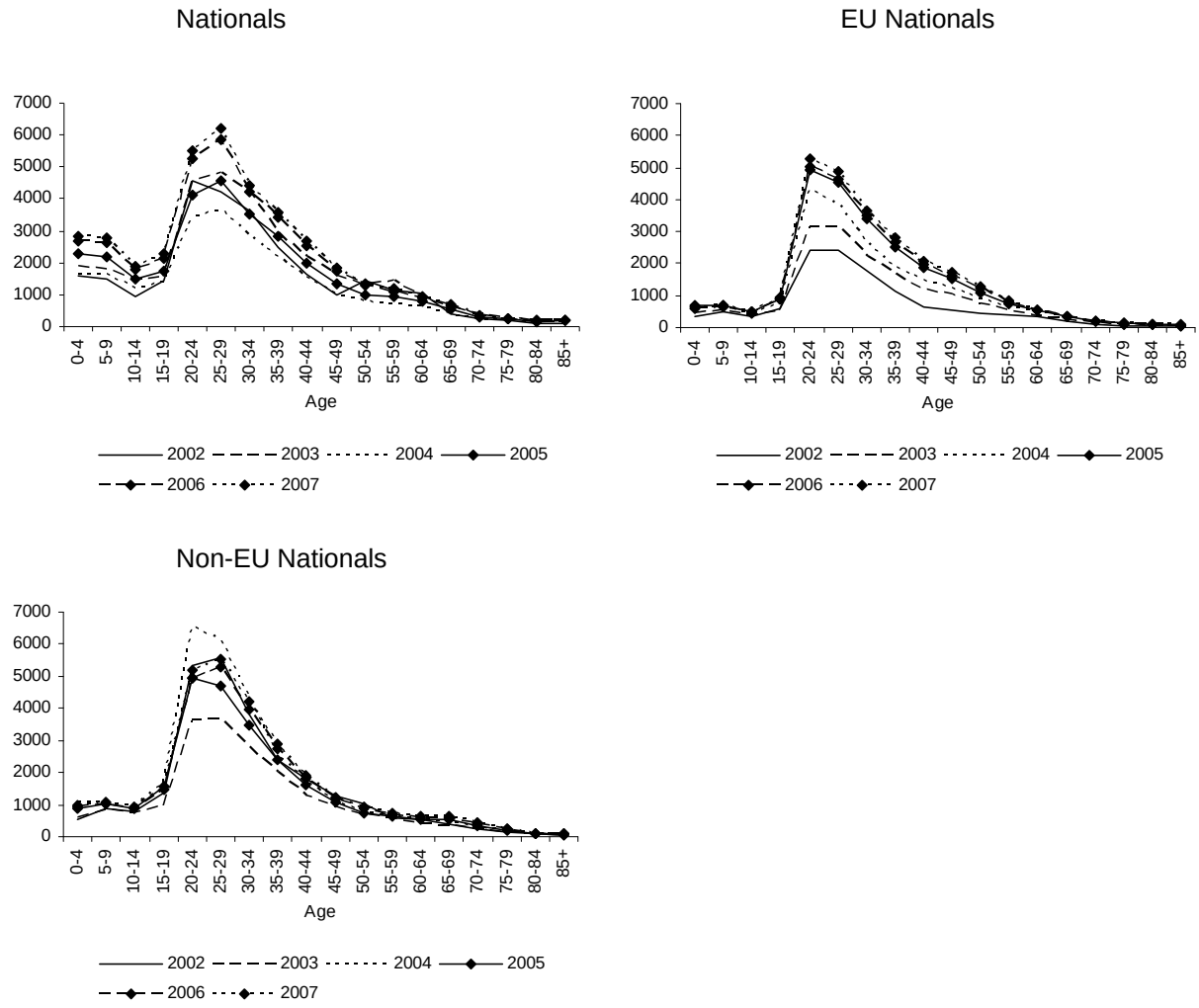


Figure 14. Estimated age patterns of female emigration from Poland by citizenship, 2002-2007



Note: y-axes are on different scales.

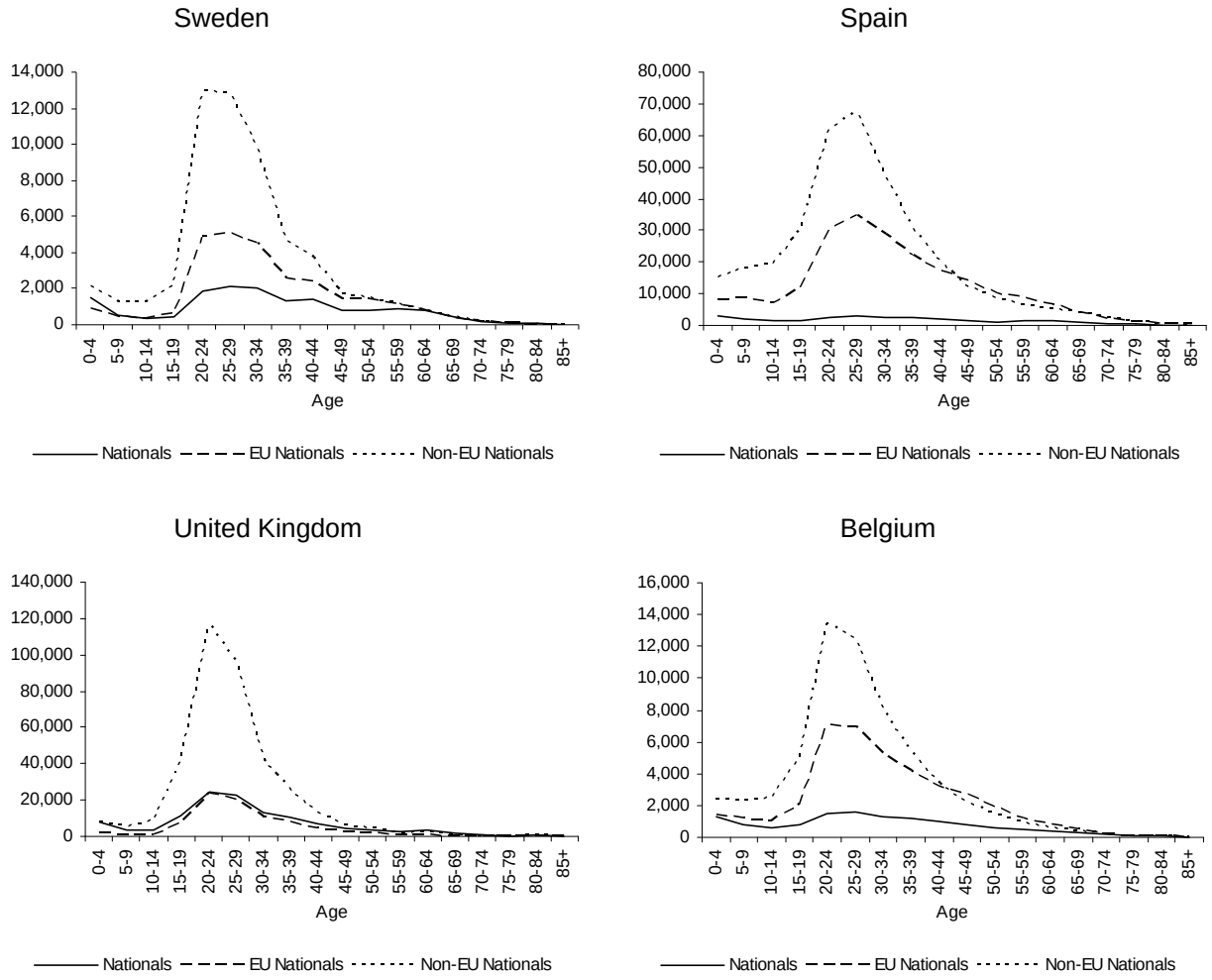
Figure 15. Estimated age patterns of female emigration from France by citizenship, 2002-2007



7.2.2. Destination, Age, Sex and Citizenship estimates

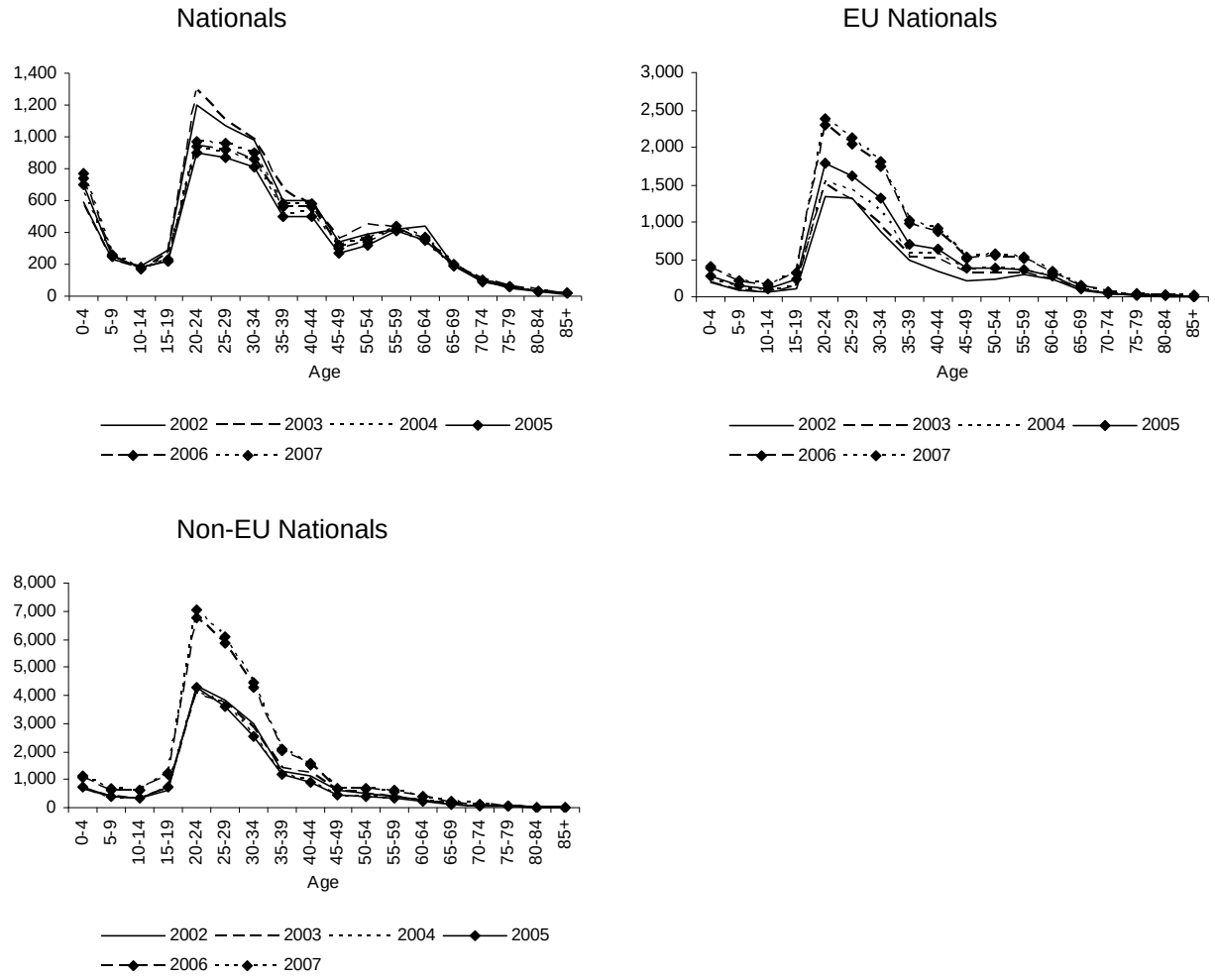
As with the previous sub-section, the patterns of immigration by age, sex and citizenship presented in Figures 16-20 illustrate, not only the variety in the patterns, but also the differences between immigration and emigration.

Figure 16. Estimated age patterns of immigration to Sweden, Spain, United Kingdom and Belgium, 2007



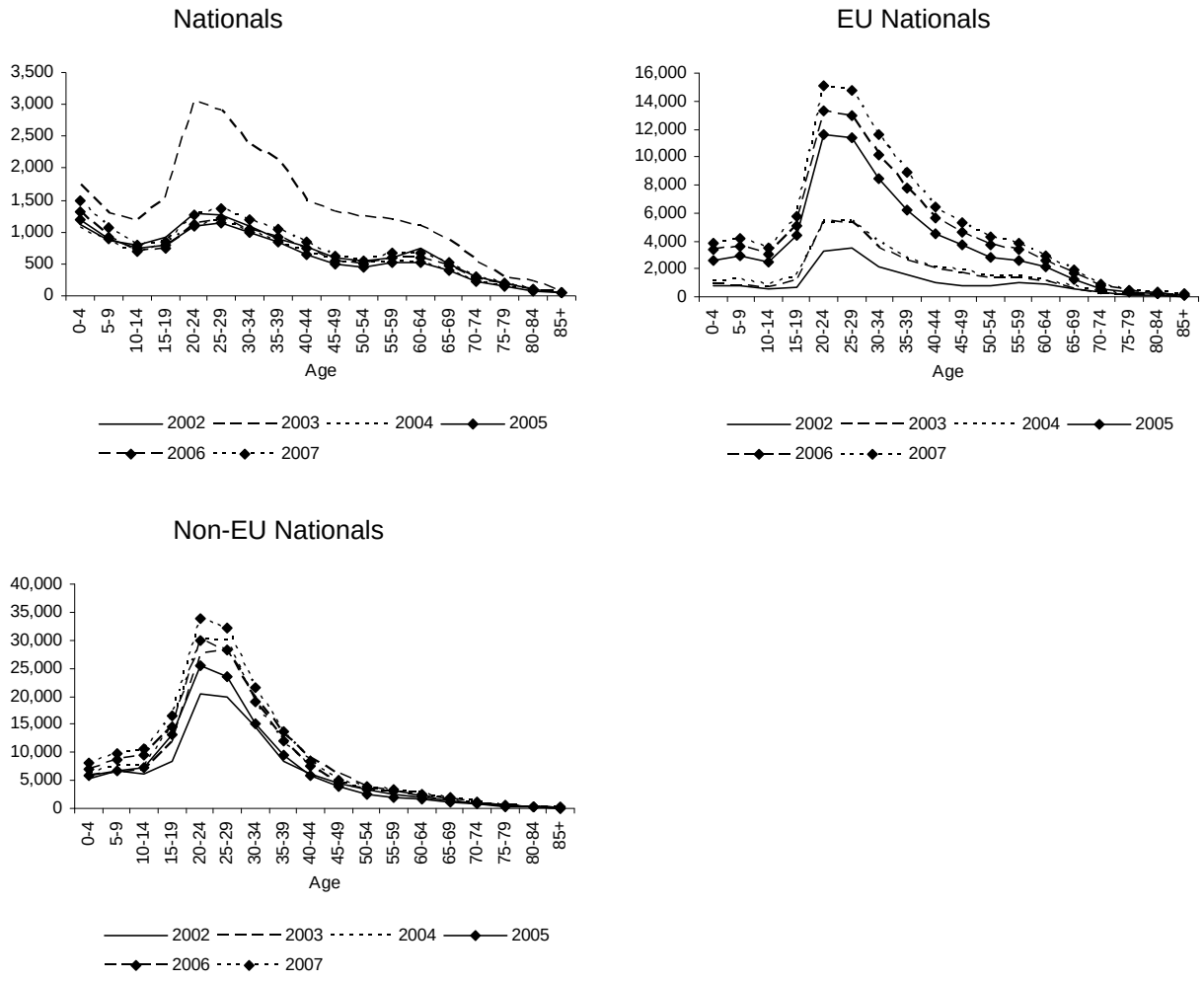
Note: y-axes are on different scales.

Figure 17. Estimated age patterns of female immigration to Sweden by citizenship, 2002-2007



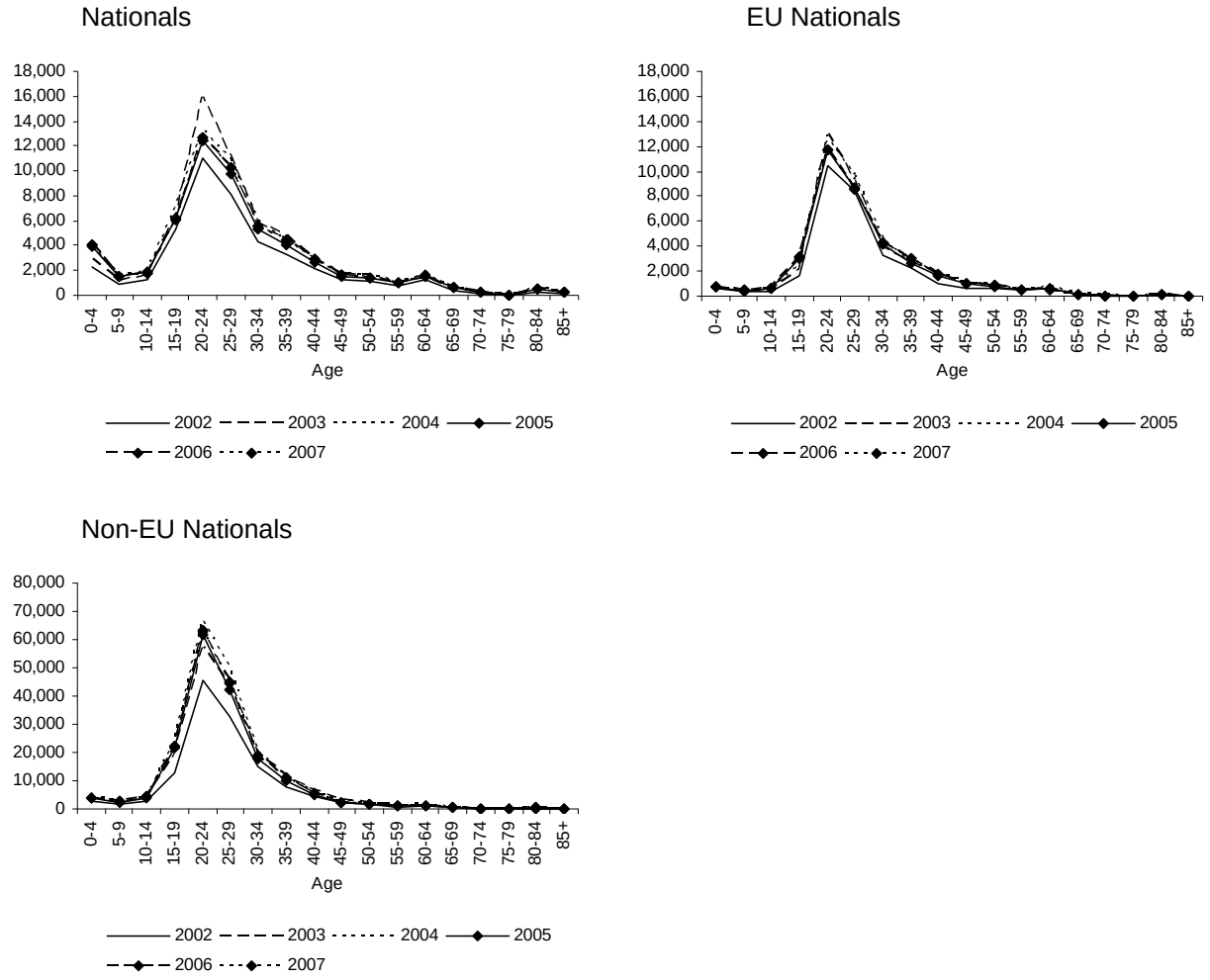
Note: y-axes are on different scales.

Figure 18. Estimated age patterns of female immigration to Spain by citizenship, 2002-2007



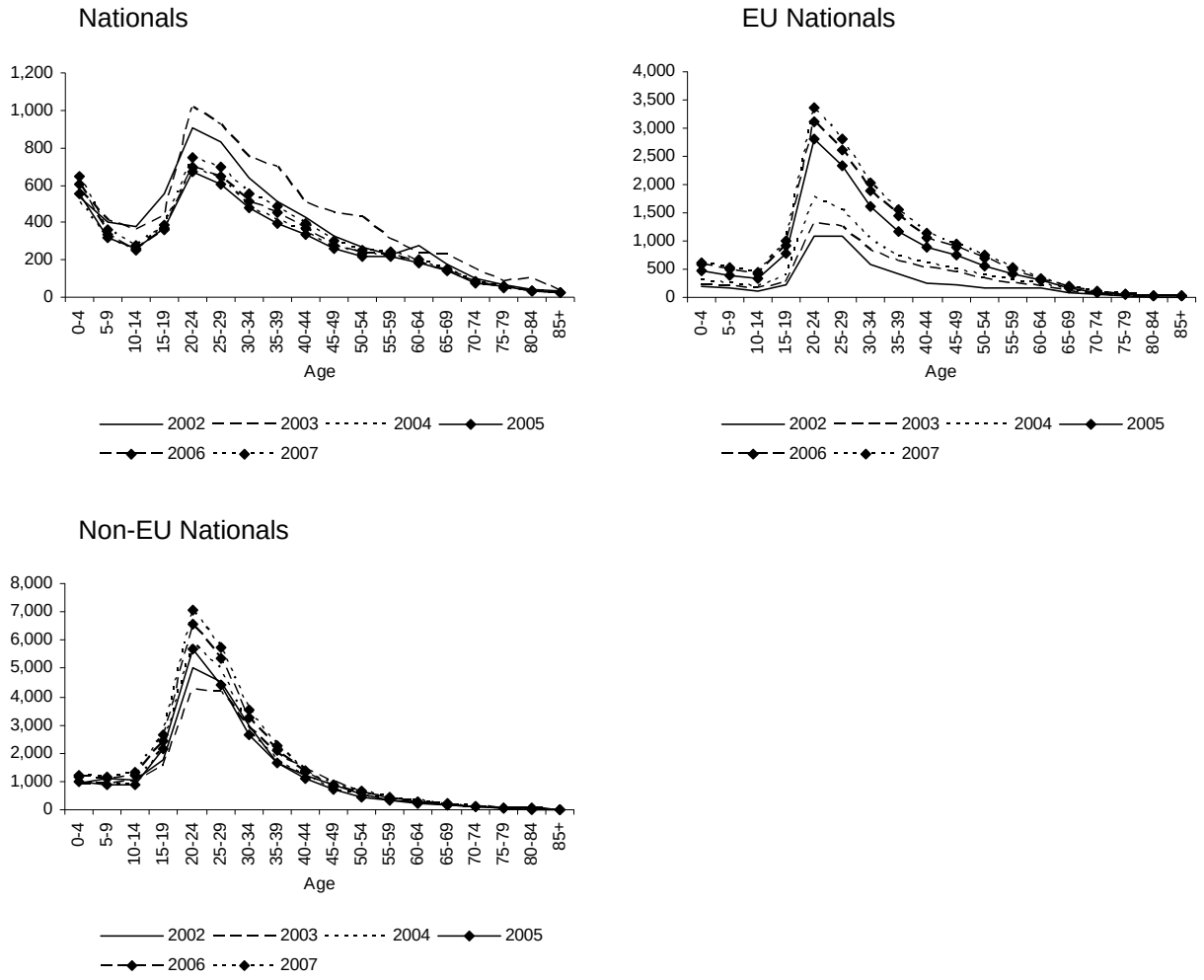
Note: y-axes are on different scales.

Figure 19. Estimated age patterns of female immigration to United Kingdom by citizenship, 2002-2007



Note: y-axes are on different scales.

Figure 20. Estimated age patterns of female immigration to Belgium by citizenship, 2002-2007



Note: y-axes are on different scales.

8. Summary

The MIMOSA model for estimating international migration flows is the first of its kind. We have overcome major data inconsistencies and missingness to produce what we believe are very reasonable estimates of detailed flows over time. In fact, we believe our estimates are much better than those currently reported in the Eurostat database. These estimates provide a complete and more consistent picture of population movements occurring in Europe. The approach is based on a closed system of movements, that is, an emigrant from one place must be an immigrant to another.

The methodology is flexible to account for various types of migration data and can incorporate expert judgements in situations where the estimates do not appear reasonable. The results are useful for understanding migration patterns, population projections or even as a diagnostic tool for statistical offices assessing their own data.

9. References

Alonso W (1986) Systematic and log-linear models: From here to there, then to now, and this to that. Center for Population Studies, Harvard University, Cambridge, Massachusetts.

Bennett RJ and Haining RP (1985) Spatial structure and spatial interaction models: Modeling approaches to the statistical analysis of geographical data. *Journal of the Royal Statistical Society Series A* 148:1-27.

Bishop YMM, Fienberg SE and Holland PW (1975) *Discrete multivariate analysis: Theory and practice*. Cambridge: The MIT Press.

Champion AG (1994) International migration and demographic change in the developed world. *Urban Studies* 31(4/5):653-677.

Deming WE and Stephan FF (1940) On a least squares adjustment of a sampled frequency table when the expected marginal totals are known. *The Annals of Mathematical Statistics* 11(4):424-444.

Fienberg SE (1970) An iterative procedure for estimation in contingency tables. *The Annals of Mathematical Statistics* 41(3):907-917.

Flowerdew R (1991) Poisson regression modelling of migration. In *Migration models: Macro and micro approaches*, Stillwell J and Congdon P, eds., pp. 92-112. London: Belhaven Press.

Flowerdew R and Aitkin M (1982) A method for fitting the gravity model based on the Poisson distribution. *Journal of Regional Science* 22:191-202.

Flowerdew R and Lovett A (1988) Fitting constrained Poisson regression models to interurban migration flows. *Geographical Analysis* 20(4):297-307.

Fotheringham AS, Brunsdon C and Charlton M (2000) *Quantitative geography: Perspectives on spatial data analysis*. London: Sage.

Haining R, Griffith DA and Bennett R (1984) A statistical approach to the problem of missing spatial data using a first-order Markov model. *The Professional Geographer* 36(3):338-345.

Johnston RJ and Pattie CJ (1993) Entropy-maximizing and the iterative proportional fitting procedure. *The Professional Geographer* 45(3):317-322.

Kelly JJ (1987) Improving the comparability of international migration statistics: Contributions by the Conference of European Statisticians from 1971 to date. *International Migration Review* (Special Issue: Measuring international migration: Theory and Practice) 21(4):1017-1037.

Kraly EP and Gnanasekaran KS (1987) Efforts to improve international migration statistics: A historical perspective. *International Migration Review* (Special Issue: Measuring international migration: Theory and Practice) 21(4):967-995.

Kupiszewska D and Nowok B (2008) Comparability of statistics on international migration flows in the European Union. In *International migration in Europe: Data, models and estimates*, Raymer J and Willekens F, eds., pp. 41-71. Chichester: Wiley.

Long JF and Boertlein CG (1990) Comparing migration measures having different intervals. Current Population Reports No. 166, U.S. Census Bureau, Washington, DC.

Nair PS (1985) Estimation of period-specific gross migration flows from limited data: Bi-proportional adjustment approach. *Demography* 22(1):133-142.

Nowok B (2008) Evolution of international migration statistics in selected Central European countries. In *International migration in Europe: Data, models and estimates*, Raymer J and Willekens F, eds., pp. 73-87. Chichester: Wiley.

Nowok B, Kupiszewska D and Poulain M (2006) Statistics on international migration flows. In *THESIM: Towards Harmonised European Statistics on International Migration*, Poulain M, Perrin N and Singleton A, eds., pp. 203-231. Louvain: UCL Presses.

Plane DA (1982) An information theoretic approach to the estimation of migration flows. *Journal of Regional Science* 22(4):441-456.

Poulain M (1994) Internal mobility in Europe: The available statistical data. Working Paper No. 17, Conference of European Statisticians, Commission of the European Communities (Eurostat), Mondorf-les-Bains, Luxembourg.

Poulain M (1995) Towards a harmonisation of migration statistics within the European Community. In *Demographic consequences of international migration*, Voets S, Schoorl J and de Bruijn B, eds., pp. 11-25. The Hague: Netherlands Interdisciplinary Demographic Institute.

Poulain M, Perrin N and Singleton A, eds. (2006) *THESIM: Towards Harmonised European Statistics on International Migration*. Louvain: UCL Presses.

Raymer J (2007) The estimation of international migration flows: A general technique focused on the origin-destination association structure. *Environment and Planning A* 12:371-388.

Raymer J (2008) Obtaining an overall picture of population movement in the European Union. In *International migration in Europe: Data, models and estimates*, Raymer J and Willekens F, eds., pp. 209-234. Chichester: Wiley.

Raymer J and Abel G (2008) The MIMOSA model for estimating international migration flows in the European Union. Joint UNECE/Eurostat Work Session on Migration Statistics, Working paper 8. Geneva: UNECE / Eurostat. Available at http://www.unece.org/stats/documents/ece/ces/ge.10/2008/wp.8.e.pdf

Raymer J, Bonaguidi A and Valentini A (2006) Describing and projecting the age and spatial structures of interregional migration in Italy. *Population, Space and Place* 12:371-388.

Raymer J and Rogers A (2007) Using age and spatial flow structures in the indirect estimation of migration streams. *Demography* 44(2):199-223.

Raymer J and Willekens F, eds. (2008) *International migration in Europe: Data, Models and Estimates*. Chichester, Wiley.

Rees PH and Duke-Williams O (1997) Methods for estimating missing data on migrants in the 1991 British census. *International Journal of Population Geography* 3:323-368.

Rogers A, Willekens FJ, Little JS and Raymer J (2002a) Describing migration spatial structure. *Papers in Regional Science* 81:29-48.

Rogers A, Willekens FJ and Raymer J (2001) Modeling interregional migration flows: Continuity and change. *Mathematical Population Studies* 9:231-263.

Rogers A, Willekens FJ and Raymer J (2002b) Capturing the age and spatial structures of migration. *Environment and Planning A* 34:341-359.

Rogers A, Willekens FJ and Raymer J (2003). Imposing age and spatial structures on inadequate migration-flow datasets. *The Professional Geographer* 55(1):56-69.

Snickars F and Weibull JW (1977) A minimum information principle: Theory and practice. *Regional Science and Urban Economics* 7:137-168.

Thierry X (2008) Towards a harmonization of European statistics on international migration. *Population and Sociétiés* 442 (February):1-4.

United Nations (1998) Recommendations on statistics of international migration. Statistical Papers Series M, No. 58, Rev. 1. Statistics Division, Department of Economic and Social Affairs, United Nations, New York.

United Nations (2002) Measuring international migration: Many questions, few answers. Population Division, Department of Economic and Social Affairs, United Nations, New York.

Willekens FJ (1977) The recovery of detailed migration patterns from aggregate data: An entropy maximizing approach. RM-77-58, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Willekens FJ (1980) Entropy, multiproportional adjustment and the analysis of contingency tables. *Systemi Urbani* 2/3:171-201.

Willekens FJ (1982) Multidimensional population analysis with incomplete data. In *Multidimensional mathematical demography*, Land K and Rogers A, eds., pp. 43-111. New York: Academic Press.

Willekens FJ (1983) Log-linear modelling of spatial interaction. *Papers of the Regional Science Association* 52:187-205.

Willekens F (1994) Monitoring international migration flows in Europe: Towards a statistical data base combining data from different sources. *European Journal of Population* 10:1-42.

Willekens FJ (1999) Modeling approaches to the indirect estimation of migration flows: From entropy to EM. *Mathematical Population Studies* 7(3):239-278.

Willekens F (2008) Models of migration: Observations and judgement. In *International migration in Europe: Data, models and estimates*, Raymer J and Willekens F, eds., pp. 117-147. Chichester: Wiley.

Willekens FJ and Baydar N (1985) Hybrid log-linear models. In *Measuring the unmeasurable*, Nijkamp P, Leitner H and Wrigley N, eds. Dordrecht: Martinus Nijhoff.

Wilson AG (1971) A family of spatial interaction models, and associated developments. *Environment and Planning* 3:1-32.

Wong DWS (1992) The reliability of using the iterative proportional fitting procedure. *The Professional Geographer* 44(3):340-348.

ANNEX A. Estimated migration matrices 2002-2007

Table 26. Estimated migration matrix, 2002

From \ To	AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IS	IT	LI	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	UK	EU27+4	Rest	Total
AT		162	662	1371	28	418	11643	230	16	375	120	524	320	1722	77	14	1383	34	15	37	6	7	590	68	1743	211	1653	318	441	600	1220	26005	21855	47860
BE	204		63	417	31	93	3589	436	12	1598	179	5880	190	85	170	20	2669	1	37	4202	8	13	5593	161	833	145	162	387	64	60	3002	30303	17291	47595
BG	1645	160		212	370	1081	10696	104	9	8733	55	704	782	71	59	11	1801	1	11	5	3	13	459	102	330	46	1272	168	10	309	2041	31262	20625	51887
CH	1497	401	134		48	270	13603	678	18	4089	325	7222	330	164	276	26	19037	23	26	361	22	22	1651	240	962	368	287	812	705	310	6150	60053	18372	78425
CY	20	64	1518	83		17	210	9	17	12	31	178	3036	176	73	1	16	0	0	0	0	39	30	9	68	9	1224	59	0	6	2216	9122	24216	33339
CZ	1249	406	4901	832	79		9014	145	19	403	56	1607	337	190	214	4	487	0	13	16	22	14	410	64	436	111	1933	151	24	2828	3594	29562	157832	187394
DE	11048	3238	6158	19187	224	1837		2537	435	7737	1012	14054	14184	11640	1868	116	16804	75	408	2279	211	65	8310	1277	48487	8025	12649	2699	1626	1288	16654	216131	187586	403717
DK	210	385	40	640	17	62	2336		129	467	427	1085	201	88	229	673	430	13	188	73	83	13	485	2626	325	94	80	4250	0	61	1639	17350	11227	28576
EE	36	28	8	37	21	12	801	168		61	1633	92	10	17	31	15	84	0	58	10	156	5	50	141	19	10	17	345	0	5	987	4856	4309	9165
ES	604	1467	795	4121	30	95	12471	1155	12		622	4643	116	108	869	34	3421	25	78	146	11	8	2948	615	1152	1798	3154	1166	24	103	12754	54548	53861	108410
FI	266	250	9	521	14	52	1781	284	406	408		427	78	148	154	25	374	0	220	10	64	1	426	1015	60	31	27	3532	0	18	598	11199	3216	14415
FR	807	5409	405	6068	80	444	15053	1030	64	5886	333		826	455	970	28	7229	10	129	5159	53	121	3220	417	2907	3082	1097	877	69	299	16538	79064	78202	157266
GR	502	165	346	223	2715	67	12865	189	11	255	83	737		76	60	1	1016	1	4	26	3	32	1124	72	781	43	550	595	10	41	3323	25918	13460	39378
HU	2746	301	120	483	118	68	13914	105	16	398	118	1437	139		132	4	716	1	9	42	14	9	571	82	169	88	1684	274	24	633	2605	27021	26438	53459
IE	155	515	69	582	47	70	1803	267	18	870	181	1326	123	44		3	480	2	17	16	11	18	693	56	1390	106	182	351	5	29	5166	14596	11741	26337
IS	29	17	2	28	0	5	238	1186	10	63	53	45	3	0	6		28	0	13	0	22	6	102	495	110	15	4	485	20	6	365	3356	448	3804
IT	1628	2852	268	21717	33	343	21733	675	2	4512	269	5892	595	314	305	23		7	54	355	31	236	1833	176	2984	383	1572	508	333	314	5099	75049	44819	119867
LI	26	2	1	36	0	1	65	19	0	9	1	25	2	2	2	0	4		0	0	0	0	7	0	10	2	3	0	5	1	0	222	90	312
LT	116	39	9	83	24	63	3343	598	86	1101	78	222	13	9	142	55	195	0		5	451	0	163	235	414	24	2	261	0	13	2193	9935	10244	20179
LU	76	2087	9	441	2	3	1406	112	6	59	58	2339	41	32	82	14	371	0	2		0	9	180	11	47	972	24	93	0	3	596	9075	906	9981
LV	79	16	16	70	70	18	1775	326	653	145	63	571	5	11	38	11	189	0	425	0		0	96	138	61	11	11	189	0	13	1073	6073	12294	18367
MT	12	27	6	21	14	3	90	15	3	10	2	210	9	6	25	0	195	0	0	0	0		43	15	8	8	7	29	10	6	483	1256	2301	3557
NL	688	9863	72	1973	47	344	11299	634	15	2305	270	3651	508	312	525	32	1455	1	39	131	25	32		392	1575	755	139	780	49	119	5947	43978	27615	71592
NO	90	173	35	292	9	32	1240	2453	65	821	1242	462	55	26	60	257	307	1	50	5	22	5	445		461	77	68	6374	0	70	1458	16656	5988	22644
PL	2954	3312	178	2842	507	2168	81629	689	11	4007	113	6110	1479	170	13079	160	5740	13	272	52	64	19	2375	570		136	53	1186	15	797	32155	162853	66861	229714
PT	348	192	42	313	10	29	7119	122	6	6099	62	3803	36	17	58	8	669	1	0	2676	8	9	1726	80	81		89	178	10	22	3715	27528	14429	41957
RO	4960	465	650	576	370	659	19856	208	18	46306	39	3357	888	2081	270	10	26767	1	4	21	17	41	655	171	122	203		366	0	1596	1261	111941	75406	187347
SE	572	415	24	1017	59	91	2814	1710	91	884	3857	976	530	153	238	234	558	1	112	57	72	54	710	3699	1090	110	73		73	58	2810	23144	9768	32912
SI	456	89	9	663	6	22	1923	26	0	66	2	114	42	26	7	1	378	2	0	0	6	0	69	2	16	14	0	14		45	0	3999	1867	5866
SK	2639	220	103	3555	291	18960	9378	52	0	382	15	608	103	659	304	4	610	5	2	26	8	0	267	98	172	47	145	76	5		4010	42743	10521	53264
UK	1095	1528	602	4990	2138	683	11887	2610	181	18724	1031	20148	4955	2455	11904	117	7154	0	157	193	56	514	7110	1323	4005	1848	693	3120	108	336		111664	159686	271350
EU27+4	36758	34247	17256	73394	7403	28010	285574	18769	2329	116786	12330	88448	29935	21256	32225	1901	100570	219	2341	15905	1450	1307	42343	14352	70818	18773	28855	29643	3628	9989	139652			
Rest	58365	39693	10391	52686	4395	58636	390425	18085	1842	183034	9091	164260	31074	17222	11438	609	223743	53	8690	768	2535	1082	84347	18295	37210	27301	33870	34398	3506	6055	284370			
Total	95123	73940	27647	126080	11798	86645	675998	36855	4171	299820	21420	252708	61009	38478	43664	2510	324313	272	11031	16674	3985	2389	126690	32647	108028	46074	62724	64041	7134	16044	424023			

Table 27. Estimated migration matrix, 2003

From \ To	AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IS	IT	LI	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	UK	EU27+4	Rest	Total
AT		238	1010	1312	32	562	10879	188	23	521	109	574	458	2359	92	16	1446	18	30	38	11	8	532	63	1865	242	3278	333	269	675	1364	28544	28959	57503
BE	314		65	363	36	125	3469	420	12	2223	218	5774	190	86	186	16	2894	1	22	4380	31	13	5584	151	891	146	164	399	93	67	3357	31689	18288	49977
BG	1962	159		183	432	1452	10841	93	9	12149	32	684	773	72	64	8	6043	1	6	5	8	13	501	91	353	46	1278	156	15	348	2282	40058	20882	60940
CH	1693	355	122		49	320	12028	575	16	5021	392	6264	292	147	266	22	20428	19	45	332	39	19	1319	287	909	328	257	841	511	308	6070	59274	17482	76756
CY	25	38	900	42		23	210	24	10	17	26	106	1800	104	43	1	38	0	4	0	0	23	33	11	72	5	726	44	5	7	2478	6816	14355	21171
CZ	1411	429	5179	759	93		7485	166	20	561	56	1699	356	201	226	15	1352	0	24	16	6	15	348	57	467	117	2042	123	34	3184	4019	30458	166783	197242
DE	14380	3279	7155	16708	261	2467		2306	423	10764	956	13519	12842	10943	1713	124	19058	52	554	2375	220	85	8270	1243	51881	6298	13706	2872	1185	1450	18621	225712	180819	406531
DK	239	376	60	570	19	83	2177		98	649	440	982	169	88	194	699	415	6	175	76	61	10	495	2317	348	128	91	4603	24	69	1833	17493	11415	28908
EE	43	27	8	31	25	16	766	121		84	1531	86	9	16	32	14	152	0	114	11	192	5	55	88	21	9	17	311	0	6	1103	4893	4113	9006
ES	723	2577	1396	6248	35	128	11842	1192	22		720	8156	203	189	1527	34	3030	44	183	153	6	14	2917	552	1232	3159	5541	1234	29	116	14261	67462	94610	162072
FI	295	276	4	482	17	69	1782	301	350	568		319	63	108	124	24	411	0	69	11	106	2	378	759	64	29	8	3395	0	20	669	10702	2880	13582
FR	871	5339	412	5211	93	597	14660	1065	62	8188	370		814	455	1042	30	6864	9	86	5377	33	117	3048	374	3111	3063	1098	931	113	336	18492	82259	84346	166605
GR	546	157	339	184	3170	90	10477	199	10	355	75	687		74	62	2	942	1	17	27	11	30	921	79	836	42	531	585	29	47	3715	24241	13193	37433
HU	3049	303	124	423	138	91	12099	122	16	554	90	1419	139		144	6	1158	1	11	44	6	9	520	59	181	89	1720	244	29	713	2913	26413	26890	53303
IE	162	536	74	527	55	94	1654	219	18	1211	173	1352	127	47		4	431	2	84	16	17	19	642	62	1487	111	192	230	0	33	5776	15355	12299	27655
IS	39	13	2	22	0	7	221	1103	9	88	62	37	2	2	5		78	0	4	0	14	3	65	319	117	23	5	474	0	7	408	3130	631	3761
IT	1715	3447	380	24542	39	461	19162	641	2	6277	248	7150	514	395	317	32		0	101	370	47	300	1734	187	3193	356	1772	473	240	354	5701	80150	48699	128850
LI	21	2	1	30	0	1	53	8	0	13	0	24	2	2	2	0	16		0	0	0	0	0	1	10	2	3	1	0	2	0	193	94	286
LT	141	110	15	192	28	85	2795	502	73	1532	52	308	32	15	594	106	579	0		5	406	0	181	215	443	118	6	232	0	15	2452	11232	13719	24951
LU	67	2327	10	424	2	4	1397	140	6	83	40	2608	46	35	92	14	359	0	2		0	10	173	18	50	1084	27	78	10	4	667	9777	1011	10788
LV	80	0	11	104	82	24	1589	273	239	202	75	152	11	0	60	33	285	0	382	0		0	77	128	65	201	5	182	0	15	1200	5475	8456	13930
MT	5	26	6	18	16	5	79	13	3	14	1	201	9	6	27	1	270	0	2	0	0		46	4	9	8	6	33	5	7	540	1359	2362	3721
NL	770	9878	104	1672	55	462	10522	587	19	3207	283	3589	513	257	488	29	1319	0	86	136	22	35		360	1685	709	179	707	39	134	6649	44498	29878	74376
NO	128	124	35	284	11	43	1163	2366	75	1142	1173	468	53	58	89	212	341	0	82	5	47	3	497		493	69	58	5807	5	79	1630	16543	6005	22548
PL	3494	2810	151	2081	592	2912	84827	712	9	5575	105	5184	1255	144	11096	755	16209	11	244	54	42	16	2199	476		115	45	1134	10	897	35953	179107	56725	235832
PT	388	192	43	273	12	39	6224	122	6	8485	66	3729	36	17	64	37	702	1	28	2789	6	9	1690	60	86		90	143	15	24	4154	29530	14974	44503
RO	6081	445	640	479	432	885	19448	178	17	64416	55	3144	847	2017	281	13	110662	1	9	22	3	38	734	152	131	196		352	10	1797	1410	214894	74205	289100
SE	557	450	41	832	69	122	2746	1937	108	1229	4074	1036	559	139	225	243	632	1	125	60	111	21	666	3679	1167	101	47		88	66	3142	24273	10493	34766
SI	437	93	5	383	7	30	1660	22	0	91	7	110	19	12	5	3	582	2	2	0	6	0	63	6	17	7	0	22		50	0	3640	1760	5400
SK	2738	186	87	2596	340	25467	8638	60	0	531	14	514	87	558	257	15	1118	4	11	27	14	0	199	80	184	40	123	56	24		4483	48453	8903	57356
UK	1386	1569	618	4420	2496	917	10669	2654	185	26047	1083	20676	5085	2520	12216	116	7341	0	263	202	97	528	6131	1134	4285	1897	711	3022	78	378		118724	163877	282601
EU27+4	43759	35760	18997	71394	8637	37581	271562	18309	1842	161795	12526	90551	27304	21065	31531	2623	205157	174	2766	16534	1561	1346	40018	13010	75654	18738	33725	29017	2862	11205	155343			
Rest	62317	41056	10863	48389	5132	78762	336520	17094	1799	254619	8541	168165	32164	17340	12429	624	453924	53	7448	801	2251	1097	69169	16155	39814	28142	35584	34389	3046	6817	317963			
Total	106076	76816	29859	119783	13769	116343	608083	35403	3641	416414	21067	258716	59468	38406	43960	3246	659080	227	10214	17335	3812	2443	109187	29165	115468	46881	69309	63406	5907	18022	473306			

Table 28. Estimated migration matrix, 2004

From \ To	AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IS	IT	LI	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	UK	EU27+4	Rest	Total
AT		230	1299	1382	43	500	10887	195	24	531	116	683	444	2524	127	19	911	31	63	71	22	15	546	91	2512	252	4367	252	318	1157	1638	31251	31263	62514
BE	374		77	406	48	111	3516	378	14	2263	220	6988	212	99	222	20	1882	2	56	4326	25	14	5537	155	1200	167	186	395	39	115	4031	33079	19539	52618
BG	1970	189		209	567	1293	9365	99	10	12371	56	845	883	84	78	10	5749	1	108	22	0	15	436	88	476	53	1480	119	15	595	2740	39926	21848	61774
CH	2088	456	160		70	307	13830	722	21	5508	482	8348	360	186	350	30	12705	25	77	368	21	23	1388	230	1319	412	321	724	532	568	7851	59481	20245	79726
CY	21	54	1274	57		20	208	10	14	17	28	149	2547	148	61	1	65	0	4	0	0	33	50	15	98	8	1027	55	5	12	2975	8957	20315	29271
CZ	1766	436	5269	741	122		7851	178	21	571	56	1728	362	204	230	18	1233	0	69	27	14	16	590	93	629	119	2078	120	24	5455	4825	34846	169668	204514
DE	17492	3501	7163	18277	342	2197		2396	559	10961	1070	14786	14552	12169	1765	152	20129	47	1356	2490	473	92	9053	1343	69893	6453	14071	2957	1288	2484	22359	261872	188966	450838
DK	256	332	49	602	25	74	2165		100	661	449	1054	156	113	197	858	403	6	192	60	145	13	473	2351	469	92	99	4674	5	118	2201	18391	12218	30609
EE	70	30	9	33	33	14	694	115		86	2197	99	10	18	36	17	165	0	67	33	242	5	152	126	28	10	18	421	0	10	1325	6063	4035	10099
ES	792	2208	1196	5136	46	114	11647	1187	18		730	6988	174	162	1308	42	2886	38	539	71	28	12	2950	583	1660	2707	4747	1174	10	199	17124	66477	81064	147541
FI	336	288	25	392	22	62	1802	281	960	579		509	101	157	180	29	307	1	116	5	136	3	363	526	86	52	18	3035	10	34	803	11221	3891	15112
FR	1064	6315	497	5907	122	532	14851	1113	74	8337	344		923	530	1263	37	5319	11	168	5443	56	130	2997	373	4191	3535	1262	982	88	576	22203	89244	90350	179594
GR	506	182	400	205	4156	80	8799	185	12	362	94	825		84	74	2	776	1	43	22	14	33	953	60	1126	47	598	491	24	80	4461	24695	13346	38041
HU	3712	361	151	483	180	81	14544	163	19	564	132	1752	159		176	7	873	1	11	22	14	10	678	73	244	104	1993	267	34	1222	3498	31526	28374	59900
IE	179	677	95	638	72	83	1338	188	23	1233	109	1770	154	58		5	646	3	405	49	70	22	515	65	2004	137	236	237	10	57	6935	18012	13376	31388
IS	27	15	2	23	0	6	212	1229	10	89	51	41	2	2	6		37	0	13	0	6	4	82	243	158	26	6	428	0	12	490	3221	702	3922
IT	1781	3203	188	21019	51	410	17319	681	20	6391	273	7952	656	366	895	39		56	201	365	64	83	1653	185	4302	412	1638	496	392	606	6846	78540	43363	121903
LI	79	3	1	36	0	1	55	9	0	13	6	31	2	2	2	0	10		0	0	0	0	4	2	14	2	3	3	0	3	0	281	98	380
LT	213	198	69	280	36	76	4013	674	93	1560	105	458	80	13	2171	130	702	0		16	685	0	475	425	597	194	6	444	0	26	2944	16680	12458	29138
LU	79	2477	15	356	3	4	1606	123	10	84	69	2579	31	10	104	17	275	4	2		0	4	161	13	67	1196	15	89	24	7	801	10224	842	11067
LV	142	54	16	166	108	21	1956	282	408	206	95	212	16	5	266	40	270	0	317	22		0	162	110	88	11	0	218	0	25	1441	6658	9532	16190
MT	14	31	7	20	22	4	68	11	3	15	5	249	10	7	32	1	117	0	2	0	0		53	3	12	9	7	26	0	11	648	1389	2513	3902
NL	889	10073	77	1475	72	412	10531	597	33	3265	303	3662	535	401	629	36	1337	2	93	120	22	40		488	2271	738	226	823	69	229	7984	47433	33295	80728
NO	128	134	34	210	14	39	1112	2262	60	1163	1151	420	52	54	64	261	185	0	218	5	67	4	468		664	53	78	4884	5	135	1957	15879	5694	21573
PL	8355	2548	137	1811	776	2594	112605	904	8	5676	159	4701	1138	131	10064	927	16243	10	252	49	75	14	5296	1281		104	41	2521	15	1537	43170	223143	51449	274592
PT	345	226	52	309	16	35	5033	149	7	8640	63	4564	41	20	77	45	561	2	101	2991	14	10	1408	75	116		104	171	5	42	4987	30209	16052	46260
RO	6294	526	772	543	567	788	19262	190	20	65594	69	3855	961	2350	341	16	94966	2	9	38	8	43	742	185	176	226		332	24	3080	1693	203671	75457	279128
SE	544	361	31	867	91	108	2817	2269	137	1252	4230	1037	533	190	236	299	510	1	185	87	89	35	653	3501	1572	103	55		69	112	3773	25745	11258	37003
SI	704	156	7	392	9	27	1949	24	0	93	1	147	9	30	21	4	397	7	4	11	3	2	77	8	23	2	2	41		86	0	4239	1811	6050
SK	4089	247	116	3309	446	22683	9475	72	0	541	17	683	116	741	342	19	1118	5	11	27	6	0	493	112	248	53	163	119	15		5383	50647	11826	62473
UK	1435	1551	611	4193	3273	817	10283	2481	183	26523	1055	20441	5027	2491	12077	142	6474	0	1167	196	309	522	5645	1343	5773	1875	703	2885	103	648		120225	162013	282238
EU27+4	55744	37064	19797	69477	11331	33494	299791	19169	2864	165149	13732	97559	30248	23349	33392	3222	177251	255	5849	16935	2606	1198	44055	14146	102015	19151	35548	29383	3123	19240	187087			
Rest	68156	46011	11835	50711	6730	70150	296131	16449	2011	259276	10253	181182	32840	18261	13114	766	441516	55	5899	665	2037	1106	54753	15397	53637	30192	36032	32332	4054	11680	381786			
Total	123901	83075	31632	120188	18061	103645	595922	35618	4875	424425	23986	278741	63088	41610	46507	3988	618767	310	11748	17600	4643	2303	98808	29544	155652	49344	71580	61715	7177	30920	568873			

Table 29. Estimated migration matrix, 2005

From \ To	AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IS	IT	LI	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	UK	EU27+4	Rest	Total
AT		320	1407	1285	47	564	11123	187	27	558	140	824	456	3064	105	23	835	28	47	38	22	12	540	96	2477	312	4685	253	450	2440	1570	33937	34175	68112
BE	369		89	420	53	126	3450	357	16	2378	224	7979	237	111	271	24	1839	2	67	4271	25	17	5830	173	1184	196	211	375	34	243	3863	34432	21185	55617
BG	1744	225		222	629	1458	7294	82	12	12999	45	991	1012	97	97	12	3570	1	75	5	3	18	434	95	469	65	1722	101	0	1256	2626	37361	23553	60914
CH	2025	514	180		76	339	13929	656	23	5654	495	9300	391	204	416	34	11988	28	75	250	66	27	1216	274	1271	474	355	881	789	1171	7351	60452	21638	82090
CY	32	86	2029	83		23	226	15	22	18	19	238	4058	235	97	1	55	0	13	0	8	53	58	8	96	12	1636	40	20	25	2851	12058	32363	44421
CZ	1685	302	3642	468	135		7492	188	14	600	53	1194	250	141	159	21	897	0	97	44	22	11	576	82	620	83	1436	133	29	11509	4624	36508	117269	153777
DE	20288	3122	6312	18038	380	2478		2681	370	11516	1111	12736	11975	11669	1448	180	19690	52	1505	2735	526	80	9536	1707	68929	5142	14298	2944	1557	5241	21426	259676	172573	432249
DK	298	328	46	580	28	83	2158		82	694	414	959	149	141	190	1018	315	1	183	22	145	17	444	2354	463	90	112	5008	15	249	2109	18694	12733	31427
EE	58	33	10	33	36	16	625	137		90	2445	109	11	19	43	20	165	0	52	0	373	6	109	171	27	12	19	424	0	22	1269	6332	4041	10373
ES	884	2726	1477	5791	51	129	11322	1327	23		748	8627	215	200	1615	50	2742	47	776	158	39	15	3012	612	1637	3341	5861	1254	39	419	16409	71544	100073	171617
FI	325	232	15	461	24	70	1754	263	613	608		330	74	72	161	34	295	1	60	44	192	1	400	483	85	35	9	3282	0	73	770	10765	3249	14014
FR	1181	7679	604	6414	135	600	15040	1223	90	8760	435		1083	628	1619	43	5929	13	166	5704	100	164	3151	470	4133	4380	1503	1047	157	1215	21276	94944	98218	193161
GR	482	204	447	204	4613	91	7836	161	13	380	116	911		91	87	2	839	1	37	54	8	38	1020	76	1110	53	654	524	10	169	4275	24506	14076	38583
HU	4338	423	177	505	200	92	15507	223	22	593	132	2027	180		218	9	874	1	6	33	8	12	709	86	240	124	2285	322	29	2577	3352	35304	30434	65738
IE	192	829	116	699	80	94	1254	189	28	1296	129	2143	182	70		6	570	3	912	38	184	28	530	72	1976	171	283	230	10	120	6646	19079	14695	33774
IS	53	16	3	23	0	7	151	1142	11	94	44	46	2	3	6		62	0	37	5	11	4	51	238	156	29	6	450	10	25	469	3155	773	3927
IT	1969	3459	344	18032	56	463	16386	667	41	6716	271	9105	697	388	848	46		27	241	436	97	176	1793	183	4243	446	2289	508	470	1278	6560	78234	48229	126463
LI	56	3	1	36	0	1	36	7	0	14	1	34	2	2	2	0	31		0	0	3	0	3	2	14	2	3	0	0	6	0	261	102	363
LT	300	247	103	141	40	85	4421	800	69	1639	87	448	65	17	4461	154	756	0		0	735	4	400	636	588	138	13	709	0	55	2821	19931	10222	30153
LU	70	2277	2	453	3	4	1944	91	17	89	40	2930	54	25	75	20	254	2	9		14	4	132	23	66	1136	48	90	20	14	767	10672	1229	11901
LV	102	136	11	114	119	24	2023	314	397	216	134	239	33	0	451	48	334	0	420	11		0	158	142	87	5	11	249	0	53	1381	7212	7444	14656
MT	11	34	8	19	24	5	90	22	4	15	4	266	10	7	37	1	121	0	0	16	3		30	1	11	10	8	26	0	24	621	1428	2566	3995
NL	1119	11281	119	1608	80	465	11242	543	50	3431	348	4210	687	435	701	43	1235	5	103	174	36	52		657	2239	905	229	955	64	484	7651	51153	37847	89000
NO	122	120	35	202	16	44	1071	2147	69	1222	896	466	73	41	84	309	151	1	224	33	50	1	433		655	54	60	4317	0	284	1875	15055	5472	20528
PL	8512	3002	162	1949	862	2926	128673	1491	10	5964	165	5539	1341	154	11858	1099	15253	12	308	98	64	17	6966	2658		123	48	3516	20	3242	41368	247398	60620	308018
PT	397	259	59	315	18	39	4534	147	9	9078	51	5157	45	22	93	54	626	2	95	3040	19	12	1313	98	114		116	195	5	88	4779	30780	16716	47496
RO	6265	595	872	549	629	889	18908	253	23	68921	75	4308	1049	2592	406	19	65655	2	15	33	3	50	584	186	174	260		374	5	6498	1623	181814	78545	260360
SE	606	348	31	873	101	122	2657	2482	181	1315	4681	1082	526	198	265	354	539	0	265	82	189	34	686	3747	1550	123	64		64	237	3615	27017	11904	38921
SI	688	191	14	339	10	30	1223	39	0	98	8	110	9	12	21	4	536	0	9	5	0	0	97	11	23	7	2	41		182	0	3711	1744	5454
SK	4416	434	203	5304	495	25586	9581	107	0	568	44	1199	203	1301	600	22	1232	9	15	54	3	0	538	109	245	92	286	99	29		5159	57934	20758	78692
UK	1557	1641	646	4051	3633	921	10196	2498	194	27869	1107	21628	5319	2636	12778	169	5929	0	2570	278	356	552	5124	1249	5693	1984	743	2738	118	1366		125543	171418	296961
EU27+4	60143	41068	19162	69211	12574	37773	312144	20438	2431	173392	14460	105137	30389	24576	39212	3820	143318	239	8385	17661	3305	1405	45873	16698	100577	19804	38996	31085	3943	40566	179104			
Rest	65288	49611	12131	49059	7468	79128	248767	16949	2101	272427	10948	195255	34497	18454	14172	908	312596	60	6242	763	1973	1290	51041	15586	52897	32529	37454	33848	3511	24644	365848			
Total	125432	90678	31293	118270	20042	116901	560910	37387	4532	445820	25407	300393	64886	43031	53384	4728	455914	299	14627	18424	5279	2695	96915	32284	153474	52333	76450	64933	7453	65210	544952			

Table 30. Estimated migration matrix, 2006

From \ To	AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IS	IT	LI	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	UK	EU27+4	Rest	Total
AT		346	1396	2285	30	638	11900	246	48	652	128	967	543	3415	209	27	1144	123	39	49	36	7	617	111	2858	343	5012	324	827	3270	1673	39263	38961	78224
BE	316		97	425	34	142	3327	379	18	2780	242	8848	245	122	318	27	2321	2	101	3296	78	16	6420	163	1366	215	233	429	113	326	4116	36512	25090	61603
BG	1545	254		226	400	1649	6189	74	13	15195	50	1106	1053	107	115	14	4291	1	45	5	6	17	471	72	541	71	1918	119	0	1684	2798	40030	26952	66982
CH	2151	535	182		45	360	14440	748	23	6213	429	9581	376	208	454	37	14944	25	71	150	58	24	1528	283	1378	482	365	832	455	1475	7363	65215	23003	88218
CY	20	59	1394	53		26	217	16	15	21	24	164	2788	162	67	1	44	0	11	5	3	36	66	14	111	8	1124	77	20	34	3038	9617	22240	31857
CZ	1590	419	5064	600	86		6846	218	20	702	84	1661	348	196	221	24	992	0	56	5	36	15	624	115	716	115	1997	209	24	15425	4927	43335	163065	206400
DE	21697	3220	5073	20315	242	2803		3201	367	13463	1162	12618	11102	11079	1653	209	18920	71	1240	2479	690	88	10883	2097	79514	4975	14792	4090	1283	7024	22830	279181	168116	447296
DK	222	304	60	448	18	94	2072		84	812	418	843	130	148	188	1177	391	4	147	93	153	21	509	2298	534	95	121	6432	15	334	2247	20411	12823	33234
EE	55	36	10	32	23	18	502	147		106	3240	117	11	20	49	23	142	0	43	16	267	5	91	198	32	12	21	466	0	29	1352	7064	4418	11482
ES	891	5704	3090	11181	33	146	11496	1321	48		832	18050	449	418	3379	58	3020	97	789	136	72	31	3521	716	1888	6991	12262	1459	88	562	17484	106212	209378	315589
FI	356	210	12	377	16	79	1604	326	742	711		376	53	69	270	40	347	0	52	16	120	15	351	471	98	27	10	3092	5	97	820	10760	3267	14027
FR	1220	8528	651	6441	86	678	15438	1257	98	10241	483		1110	681	1881	50	6335	13	164	5050	128	155	3505	510	4767	4757	1648	1216	176	1629	22671	101566	115725	217291
GR	432	210	448	191	2937	103	7241	180	14	444	95	930		92	94	3	893	1	26	22	8	33	1227	75	1281	54	667	640	5	226	4555	23126	15242	38368
HU	4569	450	183	487	127	104	15582	231	23	693	102	2136	177		242	10	905	1	9	16	14	11	693	106	277	129	2404	521	24	3454	3572	37253	34231	71484
IE	173	972	132	740	51	106	1394	193	32	1515	156	2484	197	80		7	532	3	1652	76	340	28	492	63	2279	196	327	310	5	160	7081	21777	17317	39095
IS	41	17	3	23	0	8	165	1202	12	110	82	50	3	3	7		51	0	24	0	14	4	64	251	180	31	7	475	5	34	500	3366	844	4210
IT	1977	3240	295	17340	36	523	16274	747	16	7851	344	7524	616	366	591	54		23	263	316	139	199	2053	217	4894	399	1818	789	485	1713	6990	78091	46278	124369
LI	47	3	1	33	0	1	51	7	0	16	1	34	2	2	3	0	16		0	0	0	0	2	1	16	2	3	0	0	8	0	249	117	367
LT	282	157	116	100	26	96	3983	993	62	1916	107	422	54	11	2826	178	558	0		0	827	9	313	1088	679	131	11	889	0	74	3006	18911	9232	28143
LU	92	2334	10	289	2	5	2111	110	12	103	63	2579	25	23	56	23	315	0	24		8	2	177	11	77	982	19	84	20	18	817	10391	678	11069
LV	85	82	5	189	76	27	1691	377	549	253	110	772	27	33	1028	55	270	11	369	22		11	136	240	100	33	16	370	0	71	1471	8477	17096	25573
MT	18	37	9	19	15	5	119	25	4	18	5	287	10	8	42	1	176	0	0	0	6		79	9	13	10	9	26	10	32	662	1653	2924	4578
NL	1013	12776	134	1855	51	525	11362	672	49	4011	322	4088	691	414	759	50	1336	2	101	158	89	33		741	2583	1045	293	1319	69	649	8152	55342	40881	96224
NO	112	155	45	201	10	49	962	2224	64	1428	799	390	62	29	62	358	246	0	246	5	83	20	507		755	64	88	4489	5	381	1998	15836	5656	21492
PL	7220	6336	341	3795	548	3309	132299	2672	20	6972	263	11689	2829	326	25023	1271	13361	25	270	120	181	36	8576	6014		260	102	6409	5	4345	44079	288695	127923	416618
PT	375	280	62	308	11	44	4560	180	9	10612	79	5518	45	23	105	62	640	2	54	2817	39	11	1771	90	132		124	211	15	118	5092	33390	19196	52586
RO	5633	654	931	545	401	1006	19277	244	24	80569	121	4683	1063	2777	467	23	74512	2	13	33	11	47	750	190	201	280		348	5	8708	1729	205244	87507	292751
SE	714	440	38	896	64	138	2572	2598	174	1538	4086	1233	704	207	345	409	560	0	203	60	186	70	822	4230	1788	153	94		49	318	3852	28544	14809	43353
SI	787	189	12	493	6	34	935	39	0	114	8	121	9	21	47	5	473	19	6	0	3	7	122	11	26	9	0	62		244	0	3806	1979	5785
SK	4321	480	225	5423	315	28934	9254	117	0	664	18	1329	225	1441	664	26	1020	10	9	0	17	0	695	261	283	102	317	149	39		5497	61833	22995	84829
UK	1510	1846	727	4206	2313	1042	10432	2316	218	32578	1185	24332	5984	2965	14376	195	6725	0	3295	191	682	621	5797	1302	6567	2232	836	3295	137	1831		139736	192852	332587
EU27+4	59462	50275	20748	79517	8002	42692	314295	23061	2761	202300	15037	124933	30931	25443	55538	4415	155479	433	9319	15138	4293	1571	52861	21949	115935	24204	46639	39131	3883	54271	190373			
Rest	47706	55520	12509	48069	4754	89482	211637	17427	2194	318468	11530	232019	35969	20429	15809	1050	357945	62	7340	795	3526	1180	53385	14980	61020	36091	40042	56407	3143	33027	389826			
Total	107168	105795	33257	127586	12756	132174	525932	40488	4955	520768	26566	356952	66900	45872	71347	5465	513423	494	16658	15933	7819	2751	106246	36929	176955	60295	86681	95538	7026	87298	580199			

Table 31. Estimated migration matrix, 2007

From \ To	AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IS	IT	LI	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	UK	EU27+4	Rest	Total
AT		320	1335	3785	37	977	12728	256	40	743	159	968	462	3848	217	25	1144	176	26	33	56	24	679	113	3967	285	4883	361	622	2236	1666	42171	38877	81048
BE	376		110	566	41	217	3394	360	20	3168	278	10523	282	134	391	12	2321	2	97	3536	56	20	7184	158	1896	237	280	423	69	223	4098	40471	24890	65361
BG	2525	303		310	490	2526	16737	226	15	17317	150	1354	1247	121	145	5	4291	1	69	16	799	22	5050	161	752	81	2369	1106	0	1151	2786	62126	26769	88895
CH	2533	593	198		53	533	15168	656	25	6836	502	10870	413	218	532	28	14426	24	79	145	60	28	1562	313	1847	507	418	954	1188	974	7077	68761	21414	90175
CY	40	98	2310	103		40	265	24	25	24	38	271	4620	268	111	0	44	0	11	0	14	60	78	15	154	14	1862	90	0	23	3025	13626	36847	50474
CZ	1579	257	3102	432	105		6027	228	12	800	90	1017	213	120	136	45	992	0	50	33	156	9	654	155	994	70	1223	250	29	10548	4905	34233	99897	134130
DE	23985	3345	5945	30339	296	4293		4066	373	15343	1238	12704	11064	12577	1800	187	18920	55	1276	2495	651	85	11465	3387	110379	4956	17061	4682	1831	4803	22731	332333	165674	498008
DK	202	252	48	598	22	144	2127		63	925	447	836	105	124	168	1006	391	1	216	38	184	25	568	2402	741	67	102	6615	29	228	2237	20910	10833	31743
EE	55	40	11	41	28	27	587	157		120	3727	134	12	21	57	15	142	0	37	0	320	6	97	333	44	13	24	471	0	20	1347	7888	4106	11995
ES	1039	9102	4930	20986	40	223	12543	1372	76		927	28803	717	667	5393	46	3020	155	897	131	136	50	4074	665	2622	11155	19567	1515	54	384	17408	148696	334109	482805
FI	324	184	15	583	19	121	1819	322	940	810		356	80	55	237	29	347	1	37	22	95	13	454	641	136	30	13	2888	10	66	817	11465	3104	14569
FR	1237	10186	762	8819	105	1039	15868	1210	111	11671	463		1314	772	2382	45	6335	13	140	5448	139	198	3889	674	6618	5403	2036	1407	122	1114	22573	112095	116838	228933
GR	450	252	527	262	3592	157	7202	170	16	506	120	1144		105	119	3	893	1	30	27	14	43	1328	75	1778	62	827	761	5	154	4535	25159	15241	40400
HU	5422	521	207	645	156	159	18498	359	25	790	297	2533	203		297	12	905	1	4	27	6	13	1100	180	385	142	2876	852	44	2362	3556	42581	33737	76318
IE	177	1203	160	1050	62	163	1505	213	38	1726	196	3152	242	94		10	532	3	1906	76	974	37	668	108	3164	231	419	367	39	110	7050	25675	17508	43184
IS	31	10	3	22	0	13	158	1289	10	125	63	35	1	6	5		51	0	43	5	33	1	105	274	249	43	8	457	0	23	498	3561	1098	4658
IT	2264	3240	295	20396	44	802	16793	823	16	8947	376	7524	616	366	591	64		23	201	349	178	199	2278	250	6794	399	1818	820	397	1171	6960	84992	46278	131269
LI	52	3	2	41	0	2	47	10	0	18	0	39	3	2	3	0	16		0	0	0	0	0	2	22	2	4	0	20	5	0	292	116	408
LT	213	226	123	134	31	148	3253	877	77	2183	87	396	75	11	3478	269	558	0		16	832	4	362	1914	942	90	19	906	5	50	2993	20273	9441	29713
LU	89	2381	21	406	3	7	2606	120	23	118	84	2722	75	71	52	18	315	0	26		3	15	188	12	106	1117	25	105	73	13	814	11608	867	12475
LV	94	152	98	239	93	41	1420	392	321	288	142	266	38	11	990	99	270	0	354	0		0	156	379	139	38	11	377	0	49	1465	7921	12904	20825
MT	26	41	9	24	19	8	122	15	4	21	8	326	12	8	49	2	176	0	9	0	0		52	7	18	11	10	46	0	22	659	1703	2805	4508
NL	1100	12734	322	2363	62	805	11405	679	28	4571	329	3938	758	492	686	33	1336	0	112	158	136	44		826	3586	936	417	1291	64	444	8117	57771	40900	98670
NO	112	104	44	265	12	76	1136	2071	78	1628	749	325	46	44	45	175	246	0	304	16	136	24	485		1049	68	48	4714	0	260	1990	16251	5280	21531
PL	6342	4789	258	3374	671	5069	124171	3996	15	7946	524	8836	2139	246	18915	2488	13361	19	209	234	326	27	10572	11435		196	77	7540	10	2971	43888	280645	96700	377345
PT	374	333	72	420	14	68	4954	190	10	12094	73	6716	53	26	132	122	640	2	97	3078	45	14	2188	144	183		152	206	10	81	5070	37560	19116	56676
RO	10836	773	1079	739	490	1541	35133	631	28	91820	223	5674	1246	3117	585	26	74512	2	9	54	150	59	2450	474	279	314		2457	15	5955	1722	242392	84317	326709
SE	451	388	64	1117	78	212	2632	3235	163	1753	3973	1087	642	226	330	350	560	1	289	98	248	64	824	5119	2482	108	137		103	217	3836	30785	13737	44521
SI	846	222	7	1001	8	52	1032	46	2	130	17	124	16	14	30	10	473	23	4	22	6	0	135	31	37	12	5	73		167	0	4543	2327	6870
SK	4298	285	133	3787	385	44321	7748	232	0	757	50	789	133	856	394	49	1020	6	9	11	22	0	722	500	392	61	188	162	10		5473	72792	13652	86445
UK	1633	1587	625	4253	2829	1596	10868	2400	187	37128	1264	20915	5144	2549	12357	153	6725	0	3864	218	1667	534	6653	1567	9117	1919	719	3624	88	1252		143435	165770	309205
EU27+4	68704	53924	22816	107099	9787	65378	337945	26625	2744	230305	16594	134377	31970	27168	50629	5326	154961	511	10403	16287	7440	1618	66021	32315	160871	28569	57598	45520	4836	37078	189294			
Rest	47419	59937	12612	58535	5816	137071	208508	19604	2219	362941	14266	249557	36921	20567	17174	877	357945	61	8086	850	2438	1432	56565	17636	84706	35498	42543	53840	2536	22585	388136			
Total	116124	113861	35428	165634	15603	202449	546454	46229	4963	593247	30860	383934	68891	47735	67803	6202	512906	572	18489	17137	9878	3049	122587	49951	245577	64067	100141	99360	7373	59664	577429			