Federal Planning Bureau
Economic analyses and forecasts

WORKING PAPER 7-18

A Multiregional Population Projection Model at the EU level

June 2018

Marie Vandresse, vm@plan.be

Avenue des Arts 47-49 – Kunstlaan 47-49
1000 Brussels

E-mail: contact@plan.be
http://www.plan.be

Federal Planning Bureau

The Federal Planning Bureau (FPB) is a public agency that carries out, in support of political decision-making, forecasts and studies on economic, social-economic and environmental policy issues and examines their integration into a context of sustainable development. It shares its expertise with the government, parliament, social partners, national and international institutions.

The FPB adopts an approach characterised by independence, transparency and the pursuit of the general interest. It uses high-quality data, scientific methods and empirical validation of analyses. The FPB publishes the results of its studies and, in this way, contributes to the democratic debate.

The Federal Planning Bureau is EMAS-certified and was awarded the Ecodynamic enterprise label (three stars) for its environmental policy.

url: http://www.plan.be
e-mail: contact@plan.be

Responsible publisher: Philippe Donnay
Legal Deposit: D/2018/7433/17

Federal Planning Bureau
Avenue des Arts - Kunstlaan 47-49, 1000 Brussels
phone: +32-2-5077311
fax: +32-2-5077373
e-mail: contact@plan.be
http://www.plan.be

A Multiregional Population Projection Model at the EU level

June 2018

Marie Vandresse, vm@plan.be

Abstract - This paper explores the possibility of building a multiregional model at the EU level based on Eurostat statistics on migration. These statistics are used to build a consistent origin-destination matrix for the EU Member States. In this case, 'consistent' means that the sum of all intra-EU movements should be equal to 0. This matrix is then used to compute migration rates between EU countries, which can be inserted into a multiregional population projection model. Migration flows with non-EU countries are also integrated into the model.

This paper shows that the currently available official statistics on migration flows can be used to build a multiregional migration model at the EU level. Although more developments should be implemented to test and improve the model, it produces promising results.

Jel Classification - J11
Keywords - demography, international migration, multiregional population projection

Table of contents

Executive summary **1**

Synthèse **3**

Synthese **5**

1. Introduction **7**

2. General overview of the model **9**

3. Intra-European migration **12**

3.1. Available data 12

3.2. Building the origin-destination matrix 12

3.2.1. Filling in the origin-destination matrix 13

3.2.2. Overview of the origin-destination matrix 15

3.3. Age distribution 18

3.4. Migration rates between Member States 18

4. Extra-European migration **21**

4.1. Immigration from the rest of the world 21

4.2. Emigration to the rest of the world 22

5. Population projections **24**

5.1. Assumptions 24

5.2. Results 27

5.3. Comparison with projections published by other institutions 29

6. Conclusion and outlook **31**

7. Bibliography **33**

8. Annex - population projection and demographic components by country **34**

8.1. Population 34

8.2. Births 35

8.3. Deaths 36

8.4. Net migration 37

List of tables

Table 1 Summary of alternative scenarios ····24
Table 2 Mortality and fertility assumptions by EU country (and Norway) ····25
Table 3 Extra-EU net migration in ALT1 and ALT3 (net migration tends to 0 by 2150) ····26
Table 4 Population projection by country – 2080 ····27

List of graphs

Graph 1 Immigration, emigration and net intra-EU migration, by EU country - comparison between the origin-destination (OD) matrix and the statistics for 2014 ····16
Graph 2 Intra-EU migration flows between Member States - share by origin and destination country – 2014 ··17
Graph 3 Origin-Destination Matrix - Age distribution ····18
Graph 4 Single migration rates (average over 2013-2015) ····19
Graph 5 Double migration rates (average over 2013-2015) ····20
Graph 6 Immigration from the rest of the world to EU countries: distribution by EU country (+ Norway) ····22
Graph 7 Emigration rate to non-EU countries, by EU country (+ Norway) ····23
Graph 8 Annual population growth rate by country in the four alternatives ····28
Graph 9 Comparison of different projections of EU population (including Norway) ····29
Graph 10 Net migration projection for the European Union (+ Norway) – comparison (intra-European migration flows included) ····30

Executive summary

The current population projections published at EU level by Eurostat are based on sound demographic backgrounds and methodologies. These could be improved by ensuring consistency in the migration flows between EU countries with the use of a multiregional population projection model. This is one of the motivations underpinning the methodology presented in this paper.

The first step towards building a multiregional migration model is to obtain an origin-destination matrix. This paper explores the possibility of building a multiregional migration model based on the Eurostat statistics on migration by country of previous and next residence, country of birth or citizenship. These statistics are used to build a consistent origin-destination matrix for the EU countries. In this case, 'consistent' means that the sum of all intra-EU movements should be equal to 0. This matrix is then used to compute migration rates between EU countries, which are fed into an EU-wide multiregional population projection model. Migration flows with non-EU countries are also integrated into the model.

Four alternative scenarios are projected with this multiregional population projection model: two scenarios differ as concerns intra-EU migration flows, while the other two relate to migrations to and from non-EU countries (the *rest of the world*). As regards migration rates between EU countries, the projection will be based either on the usual migration rates (population of the origin country in the denominator, called the 'single migration rate' in this document) or on double migration rates (population of both the countries of origin and of destination in the denominator). This second indicator assumes that an individual chooses a destination area depending on both push and pull factors.

The data used to build the EU origin-destination matrix comes from the available statistics published by Eurostat. The choice to rely on official Eurostat statistics is not an arbitrary choice. Eurostat compiles statistics by country, based on common definitions, which thus leads to a certain degree of statistical harmonisation. Furthermore, these statistics are freely accessible. The proposed model can thus be duplicated by any potentially interested person. Not all countries provide all the requested statistics. However, despite this weakness, a matrix of migration flows can still be drawn up to determine an assumption on the future development of intra-European migration. It is important to highlight that the intention is not to adapt official statistics but to build a consistent and coherent migration flow matrix to determine the relevant assumption.

For migration flows to and from non-EU countries, the first alternative considers that net migration tends to 0 in the long term. It is a long-term convergence assumption that is often implemented in population projection models when there are insufficient resources or data to model complex, less predictable or even unpredictable behaviours. The second alternative models immigration and emigration flows to and from non-EU countries separately, taking into account the population at risk of migration. These are the EU population when considering emigration to the rest of the world, and the population in the rest of the world in the case of emigration to European countries.

The model shows several strengths. First, it distinguishes between intra-European migration flows and flows to or from non-European countries. This distinction makes sense since the motivations that drive individuals to migrate and the ensuing administrative constraints differ widely between these two

regions. Second, the approach adopted for modelling intra-European migration flows ensures consistency between flows. In particular, total net migration between European countries is zero. Overall, the model is easy to interpret and can be easily updated or adapted, depending on available data or changes in migration behaviour.

The assumptions on fertility and mortality by age and sex are the same in the four alternative scenarios. These assumptions correspond to those retained in the baseline of the population projections published by Eurostat in 2017 (*2015-based population projections* - ESSPOP2015).

The projection results for the four alternative scenarios presented in this Working Paper are also compared with EU-level projections published by other institutions, namely the United Nations (United Nations 2017), Eurostat (ESSPOP2015) and the Wittgenstein Centre (Wittgenstein Centre for Demography and Global Human Capital, 2015). The two alternative scenarios which take extra-EU population growth into account lie in the upper bound of the projections published by the other institutions. The two alternatives based on net migration converging to 0 for extra-EU migration flows stand between the upper and the lower bounds. The methodology presented in this Working Paper produces promising results that encourage us to pursue our modelling efforts.

To make a parallel with the population projections published at the national level by the Federal Planning Bureau and Statbel (FPB and Statbel, 2018), these have been based on the same theoretical background for migration flows: for international migration, the population growth in the foreign countries is taken into account, whereas double migration rates are used for internal migration (migration between Belgium's districts). Furthermore, in the national population projections, the projection of immigration flows from the EU countries to Belgium also takes economic determinants into account.

Synthèse

Les projections démographiques à l'échelle européenne publiées actuellement par Eurostat reposent sur des fondements et méthodologies démographiques solides. Elles pourraient toutefois être améliorées par l'utilisation d'un modèle de projection de population multirégional qui assure la cohérence des flux migratoires entre les pays européens C'est un des motifs qui sous-tendent le développement de la méthodologie présentée ici.

La première étape du développement d'un modèle de migration multirégional consiste à construire une matrice origine-destination. Cette étude explore la possibilité de construire un modèle de migration multirégional à l'aide des statistiques d'Eurostat sur la migration par pays de résidence antérieure, par pays de prochaine résidence, par pays de naissance ou par nationalité. Ces statistiques sont utilisées pour construire une matrice origine-destination cohérente pour les pays de l'Union européenne (UE). Cette cohérence requiert que la somme de tous mouvements intra-européens soit égale à 0. La matrice ainsi construite permet de calculer les taux de migration entre les pays de l'UE, lesquels sont ensuite introduits dans un modèle de projection de population multirégional développé à l'échelle de l'UE. Les flux migratoires avec les pays hors de l'UE sont également modélisés.

Les projections sont réalisées selon quatre scénarios alternatifs : deux d'entre eux diffèrent sur le plan des flux migratoires intra-UE, tandis que les deux autres divergent au niveau des migrations au départ et à destination de pays hors de l'UE (le *reste du monde*). S'agissant des taux de migration entre pays de l'UE, la projection se base soit sur les taux de migration usuels (population du pays d'origine au dénominateur, appelés 'taux de migration simples' dans ce document), soit sur 'les taux de migration doubles' (population des pays d'origine et de destination au dénominateur). Ce second indicateur suppose qu'un individu choisit une région de destination en fonction à la fois de facteurs d'attraction et de répulsion.

Les données utilisées pour construire cette matrice origine-destination sont tirées des statistiques d'Eurostat. Le recours aux statistiques officielles d'Eurostat n'est pas un choix arbitraire. Eurostat établit, à partir de définitions communes, des statistiques par pays, ce qui garantir un certain degré d'harmonisation. En outre, ces statistiques sont librement accessibles. Le modèle proposé peut donc être reproduit par toute personne potentiellement intéressée. Toutefois, tous les pays ne fournissent pas l'ensemble des statistiques nécessaires. En dépit de cette faiblesse, une matrice des flux migratoires peut néanmoins être construite, sur base de laquelle des scénarios d'évolution future de la migration intra-européenne peuvent être élaborés. Il est important de souligner que l'intention n'est pas d'adapter les statistiques officielles, mais de construire une matrice cohérente et réaliste des flux migratoires en vue de formuler des hypothèses pertinentes.

En ce qui concerne les flux migratoires au départ et à destination de pays hors de l'UE, le premier scénario alternatif repose sur l'hypothèse selon laquelle le solde migratoire tend vers 0 à long terme. Il s'agit d'une hypothèse de convergence à long terme souvent appliquée dans les modèles de projection de population, à défaut de ressources ou de données suffisantes pour modéliser des comportements migratoires complexes et peu prévisibles, voire imprévisibles. Le second scénario alternatif modélise

séparément les flux d'immigration et les flux d'émigration au départ et à destination des pays hors de l'UE, en tenant compte de la population dans les pays de départ. Il s'agit de la population des pays de l'UE en ce qui concerne l'émigration vers le reste du monde et de la population du reste du monde en ce qui concerne l'émigration vers les pays de l'UE.

Le modèle possède plusieurs atouts. Premièrement, il distingue les flux migratoires intra-UE et les flux au départ et à destination de pays hors de l'UE. Cette distinction est opportune puisque les motivations qui poussent les individus à migrer et les contraintes administratives afférentes aux migrations diffèrent considérablement entre ces deux flux. Deuxièmement, l'approche adoptée pour modéliser les flux intra-européens satisfait la condition de cohérence selon laquelle le solde migratoire total entre pays de l'UE est égal à 0. De manière générale, le modèle peut être facilement interprété, mis à jour ou adapté, selon les données disponibles ou les évolutions dans les comportements migratoires.

Les hypothèses retenues quant à l'évolution future de la mortalité et de la fécondité sont identiques dans les quatre scénarios alternatifs. Elles correspondent aux hypothèses retenues dans les dernières projections démographiques publiées par Eurostat en 2017 (*2015-based population projections* - ESSPOP2015).

Les résultats de projection obtenus pour les quatre scénarios présentés dans cette étude sont comparés avec ceux de projections réalisées à l'échelle de l'UE par d'autres institutions, à savoir les Nations Unies (United Nations 2017), Eurostat (ESSPOP2015) et le Wittgenstein Center (Wittgenstein Centre for Demography and Global Human Capital, 2015). Les résultats des deux scénarios alternatifs qui tiennent compte de la croissance de la population hors de l'UE se situent dans la fourchette supérieure des projections publiées par ces institutions. Quant aux résultats des deux scénarios basés sur un solde migratoire extra-européen qui tend vers 0, ils se situent entre la limite supérieure et la limite inférieure. La méthodologie présentée dans ce working paper fournit des résultats prometteurs qui encouragent à poursuivre nos efforts de modélisation.

Enfin, il convient de remarquer que la modélisation des flux migratoires dans les projections démographiques publiées à l'échelle de la Belgique par le Bureau fédéral du Plan et Statbel (BFP et Statbel, 2018), repose sur des fondements théoriques identiques à ceux retenus dans la présente étude : la croissance démographique dans les pays étrangers est prise en compte au niveau de la migration internationale, tandis que les taux de migration doubles sont retenus pour la migration interne (migration entre les arrondissements belges). Cependant, dans les projections nationales, la projection des flux d'immigration au départ de pays européens et à destination de la Belgique tient compte de déterminants économiques.

Synthese

De huidige bevolkingsprojecties die op EU-niveau worden gepubliceerd door Eurostat zijn gebaseerd op degelijke demografische achtergronden en methodologieën. Ze zouden kunnen worden verbeterd door samenhang te verzekeren in de migratiestromen tussen EU-landen aan de hand van een multiregionaal bevolkingsprojectiemodel. Dit is één van de motieven die aan de grondslag liggen van de methodologie die in deze paper wordt voorgesteld.

De eerste stap naar de opbouw van een multiregionaal migratiemodel is een oorsprong-bestemmingsmatrix opstellen. In deze paper wordt de mogelijkheid onderzocht om een multiregionaal migratiemodel op te stellen aan de hand van Eurostat-statistieken over migratie volgens land van vorige en volgende verblijfplaats, land van geboorte of nationaliteit. Die statistieken worden gebruikt om een consistente oorsprong-bestemmingsmatrix voor alle EU-landen op te stellen. In dit geval betekent 'consistent' dat de som van alle intra-EU-bewegingen gelijk moet zijn aan nul. Deze matrix wordt vervolgens gebruikt om de migratiegraad tussen de EU-landen te berekenen, die in een EU-breed multiregionaal bevolkingsprojectiemodel kan worden ingevoerd. De migratiestromen met de niet-EU-landen worden ook opgenomen in het model.

De projecties zijn gebaseerd op vier alternatieve scenario's: twee scenario's verschillen op het vlak van migratiestromen binnen de EU, terwijl de andere twee scenario's betrekking hebben op de migraties van en naar de niet-EU-landen (*rest van de wereld*). Wat betreft de migratiegraad tussen de EU-landen, is de projectie gebaseerd op de gebruikelijke migratiegraad (bevolking van het land van herkomst in de noemer, die in deze paper 'enkele migratiegraad' wordt genoemd) of op de dubbele migratiegraden (bevolking van zowel de landen van herkomst als bestemming in de noemer). De tweede indicator houdt rekening met het idee dat een individu een gebied van bestemming kiest afhankelijk van push- en pullfactoren.

De gegevens die worden gebruikt om de EU-oorsprong-bestemmingsmatrix op te stellen zijn afkomstig van de beschikbare statistieken die door Eurostat zijn gepubliceerd. De keuze om officiële Eurostat-statistieken te gebruiken is geen willekeurige keuze. Eurostat stelt statistieken op naar land, die zijn gebaseerd op gemeenschappelijke definities en die dus kunnen leiden tot een bepaalde mate van statistische harmonisatie. Bovendien zijn die statistieken vrij toegankelijk. Het voorgestelde model kan dus worden gedupliceerd door eenieder die potentieel geïnteresseerd is. Niet alle landen leveren alle gevraagde statistieken. Ondanks deze zwakte kan er toch een matrix van migratiestromen worden opgesteld om een hypothese over de toekomstige evolutie van de intra-Europese migratie vast te stellen. We wijzen erop dat het niet de bedoeling is om officiële statistieken aan te passen, maar om een consistente en samenhangende migratiestroommatrix op te stellen om de relevante hypothese vast te stellen.

Voor de migratiestromen van en naar niet-EU-landen gaat het eerste alternatieve scenario ervan uit dat de nettomigratie op lange termijn naar nul neigt. Het is een convergentiehypothese op lange termijn die vaak wordt gebruikt in bevolkingsprojectiemodellen wanneer er onvoldoende middelen of gegevens zijn om complex, minder voorspelbaar of zelf onvoorspelbaar gedrag te modelleren. Het tweede alternatieve scenario modelleert de immigratie- en emigratiestromen van en naar de niet-EU-landen

afzonderlijk, waarbij rekening wordt gehouden met de bevolking in het land van vertrek. Dit is de EU-bevolking als de emigratie naar de rest van de wereld in aanmerking wordt genomen en de bevolking in de rest van de wereld in het geval van de emigratie naar de Europese landen.

Het model vertoont verschillende sterke punten. Ten eerste maakt het een onderscheid tussen intra-Europese migratiestromen en stromen van of naar niet-EU-landen. Dit onderscheid is zinvol, aangezien de motivaties die individuen ertoe aanzetten om te migreren en de daaruit voortvloeiende administratieve beperkingen sterk verschillen tussen die twee regio's. Ten tweede verzekert de benadering die wordt gebruikt om de intra-EU-migratiestromen te modelleren consistentie tussen de stromen. De totale nettomigratie tussen de EU-landen in het bijzonder bedraagt nul. Algemeen genomen is het model gemakkelijk te interpreteren en kan het gemakkelijk geactualiseerd of aangepast worden, afhankelijk van de beschikbare gegevens of de wijzigingen in het migratiegedrag.

De hypothesen met betrekking tot de vruchtbaarheid en het sterftecijfer naar leeftijd en geslacht zijn gelijk in de vier alternatieve scenario's. Deze hypothesen stemmen overeen met de hypothesen die zijn gebruikt in het referentiescenario van de bevolkingsprojecties die in 2017 door Eurostat zijn gepubliceerd (*2015-based population projections* - ESSPOP2015).

De projectieresultaten voor de vier alternatieve scenario's die in deze Working Paper worden voorgesteld, worden ook vergeleken met de projecties die op EU-niveau worden gepubliceerd door andere instellingen, met name de Verenigde Naties (Verenigde Naties, 2017), Eurostat (ESSPOP2015) en het Wittgenstein Centre (Wittgenstein Centre for Demography and Global Human Capital, 2015). De twee alternatieve scenario's die rekening houden met de bevolkingsgroei buiten de EU liggen in de bovengrens van de projecties die door de andere instellingen zijn gepubliceerd. De twee alternatieve scenario's die gebaseerd zijn op een nettomigratie die convergeert naar nul voor de migratiestromen buiten de EU liggen tussen de boven- en ondergrenzen. De methodologie die in deze Working Paper wordt voorgesteld, levert veelbelovende resultaten die ons aanmoedigen om onze modelleringsinspanningen voort te zetten.

Om een parallel te trekken met de bevolkingsprojecties die op nationaal niveau worden gepubliceerd door het Federaal Planbureau en Statbel (FPB en Statbel, 2018), deze zijn gebaseerd op dezelfde theoretische achtergrond voor migratiestromen: voor de internationale migratie wordt rekening gehouden met de bevolkingsgroei in de vreemde landen, terwijl dubbele migratiegraden worden gebruikt voor de interne migratie (migratie tussen de Belgische regio's). In de nationale bevolkingsprojecties houdt de projectie van de immigratiestromen van de EU-landen naar België bovendien rekening met economische determinanten.

1. Introduction

The current population projections published at EU level by Eurostat (ESSPOP2015) are based on sound demographic backgrounds and methodologies. Regarding international migration, net migration is projected using three types of models: nowcast, trend and convergence models. Emigration and immigration flows are then computed ex-post, using an assumption on the emigration rates and computing the immigration flows as the sum of net migration and emigrations. Such an approach could lead, however, to some inconsistencies. In particular, immigration and emigration flows are projected by country, independently of immigration and emigration flows in the other EU countries. Consequently, it does not implicitly guarantee that total net migration for all European countries sums to 0. Lack of high-quality statistics is an argument often put forward to justify this shortcoming. This paper explores the possibility of building a multiregional migration model based on the Eurostat statistics on migration by country of previous and next residence, country of birth or citizenship. These statistics are used to build a consistent origin-destination matrix for the EU Member States. In this case, 'consistent' means that the sum of all intra-EU movements equals 0. This matrix is then used to compute migration rates between EU countries, which are fed into an EU-wide multiregional population projection model.

Four alternative scenarios are projected with this multiregional population projection model: two alternatives concern migration within EU Member States, while the other two relate to migrations to and from the non-EU countries (the *rest of the world*).

As regards migration rates between EU countries, the projection will be based either on the usual migration rates (population of the origin country in the denominator, called the 'single migration rate' in this paper) or on double migration rates (population of both the countries of origin and destination in the denominator). This second indicator takes into account the idea that an individual chooses a destination area depending on both push and pull factors.

For migration flows to and from non-EU countries, the first alternative considers that net migration tends to 0 in the long term. It is a long-term convergence assumption that is often implemented in population projection models when there are insufficient resources or data to model complex, less predictable or even unpredictable behaviours. The second alternative models immigration and emigration flows to and from non-EU countries separately. The intention is not to predict migration flows, but to project realistic migration flows between EU countries and non-EU countries. As regards migration flows from non-EU countries to EU countries, the population at risk of migrating to EU countries is taken into account. This at-risk population is drawn from the world population projections published by the United Nations (United Nations, 2017). For emigration flows from EU countries to non-EU countries, emigration rates to non-EU countries are computed from the Eurostat database.

The next section gives a general description of the model used to project international intra-EU migration and international migration to and from the rest of the world. The third section describes in detail the method used to project international intra-EU migration: the different steps to build a matrix of migration flows by origin and destination countries and by age, using available Eurostat statistics. The successive steps to compute emigration rates from European countries to the rest of the world, and in

the opposite direction, are dealt with in the fourth section. The fifth section presents the population projections obtained with the set of international migration alternative scenarios: two for intra-EU migration and two for migration to and from the rest of the world (giving a total of four alternatives). The assumptions on future trends in mortality and fertility are the same in the four alternatives and match the assumptions used in the population projections published in 2017 by Eurostat (ESSPOP2015). The fifth section also compares the results obtained for the European Union with projections published by other institutions (United Nations, Eurostat and the Wittgenstein Centre for Demography and Global Human Capital).

The methodology presented in the Working Paper is being developed as part of the Working Group on Population Projection, chaired by Eurostat [1]. In particular, its work aims to provide alternative methodologies to the one currently used by Eurostat. Note that the population projections published by Eurostat cover 28 EU Member States and Norway. The population projections presented in this Working Paper, in particular the intra-European migration flows, also include Norway.

[1] The author thanks the participants in the Working Group on Population Projection for their comments and suggestions put forward at the meetings held in Lisbon (June 2017) and Riga (October 2017).

2. General overview of the model

The projection model of international migration distinguishes migration flows within the European Union and those between EU and non-EU countries (rest of the world), as in Box 1. This distinction makes sense since the motivations that drive individuals to migrate and the ensuing administrative constraints differ widely between these two regions of the world.

Intra-European migration flows

Intra-European migration flows are modelled in such a way that the projected emigration from country A to country B is identical to the projected immigration from country A into country B. To do so, an origin-destination flow matrix is estimated and used to calculate migration rates between European countries. These rates can be defined in two different ways:

$$\text{Single migration rate} \;=\; \mathrm{M}r1_{\mathrm{A,B}} = \frac{\mathrm{Flow_{A,B}}}{\mathrm{P_A}} \tag{1}$$

$$or\ \text{Double migration rate} = \; \mathrm{M}r2_{\mathrm{A,B}} = \frac{\mathrm{Flow_{A,B}}}{\mathrm{P_A + P_B}} \tag{2}$$

In equation (1), only the population in the origin country ($\mathrm{P_A}$) is taken into account in the denominator. It is the population at risk of emigration.

In equation (2), both the populations in the origin country ($\mathrm{P_A}$) and in the country of destination ($\mathrm{P_B}$, population likely to receive migrants) are taken into account. This indicator of migration flows better matches the various explanatory theories of internal migrations and, in particular, the models that are based on the premise that an individual chooses a destination area depending on both push and pull factors[2].

These flows are projected as follows, depending on the selected migration rate:

$$Flow^t_{A,B} = Mr1^t_{A,B} * (P^t_A) \tag{3}$$

$$or\ Flow^t_{A,B} = Mr2^t_{A,B} * (P^t_A + P^t_B) \tag{4}$$

Need for a migration flow matrix

The first step in computing migration rates between EU countries is to obtain a 29 * 29[3] migration flow matrix.

This matrix cannot be computed directly with the statistics available, notably from Eurostat. Available data by country are incomplete. Besides, for the countries that provide migration flow statistics according to the country of previous or next residence, country of birth or citizenship, there is no consistency between immigration from country B recorded by country A and emigration to country A recorded by

[2] See Courgeau (1991) and Bohnert et al. (2015) on the value of incorporating double rates in population projections.

[3] 28 EU Member States and Norway.

country B. Immigration and emigration statistics by country are sent independently to Eurostat by the National Institutes of Statistics. Eurostat collects statistics, without adjusting them to ensure some consistency.

One of the purposes of this document is to show how the available data on the Eurostat website were used to obtain a fictitious but realistic matrix that works in a projection model for international migration between EU countries. The different steps for obtaining this matrix are described in section 3.

Migration flows to and from the rest of the world

With respect to international migration to and from the rest of the world, two different approaches are considered.

The first considers that the net migration of each European country with all non-EU countries tends to 0 by 2150. This convergence assumption does not mean that there are no migration flows, but rather that they balance out over the very long term. This assumption has been incorporated into the assumption on international migration used in the population projections published by Eurostat (Eurostat, 2017). This approach has the advantage of being pragmatic but hardly reflects the complex mechanisms behind migration phenomena. It is also based on the idea that economic inequalities between countries will completely disappear in the long term, which tend to balance the migration flows.

The second approach models migration (immigration and emigration) flows and not net migration. Moreover, immigration from the rest of the world takes into account future population trends in this region of the world. The population at risk of emigration to EU countries is thus taken into account (equation 5). Emigration from European countries to the rest of the world (equation 6) is based on average observed emigration rates.

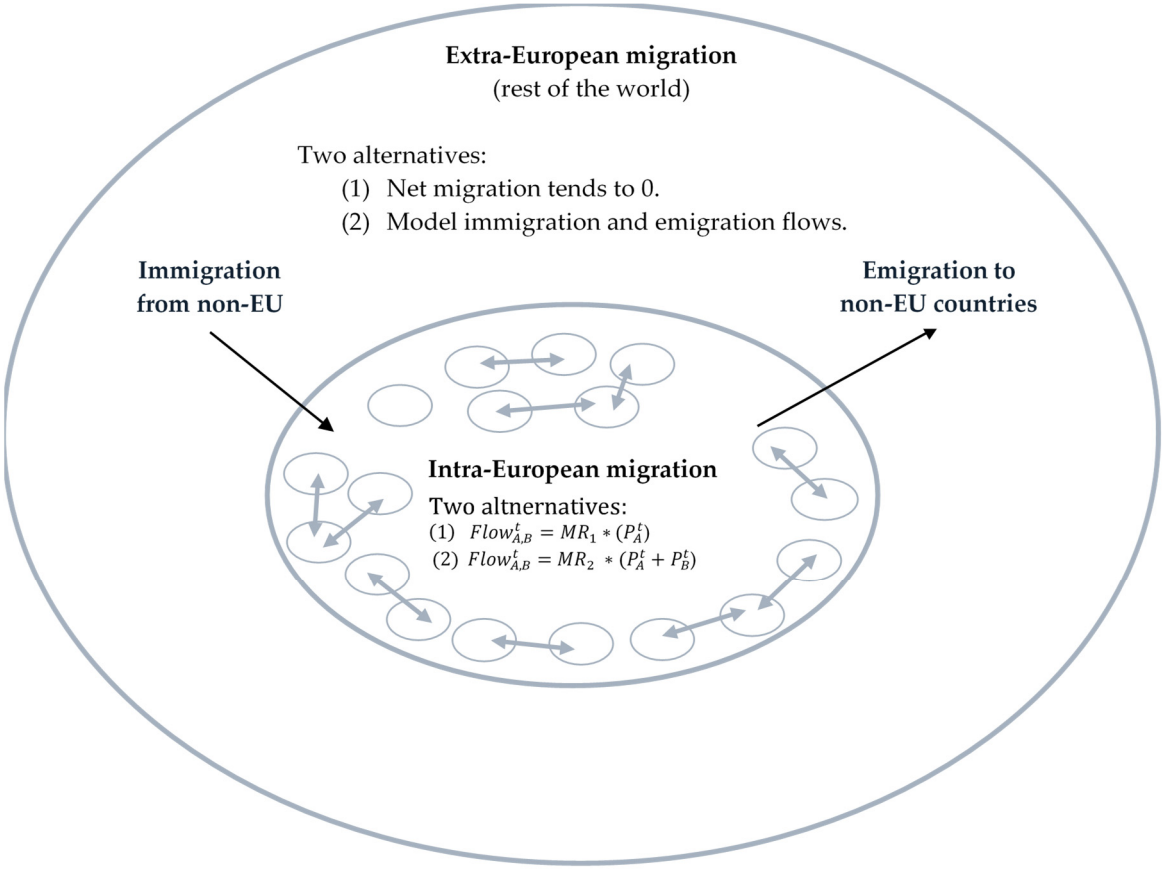
So:

$$\mathrm{Immi}^{t}_{\mathrm{fromRoW,toEU}} = \mathrm{EmiRate}^{t}_{\mathrm{fromRoW}} * (\mathrm{P}^{t}_{\mathrm{RoW}}) \tag{5}$$

$$\mathrm{Emi}^{t}_{\mathrm{fromEuA,toRow}} = \mathrm{EmiRate}^{t}_{\mathrm{fromEuA}} * (\mathrm{P}^{t}_{\mathrm{PopA}}) \tag{6}$$

Several assumptions will have to be made, about emigration rates from or to the rest of the world and expected trends in the population growth outside the EU. These assumptions are detailed in section 4.

Box 1 Overview of the international migration model



Notes :
MR_1 = single migration rates; MR_2 = double migration rates (see equations (1) and (2)).
P_A = population in the origin country; P_B = population in the destination country.

3. Intra-European migration

This section first deals with the data available to calculate an origin-destination migration flows matrix for all European Union[4] Member States. The necessary steps to obtain such a migration matrix, regardless of age, are subsequently described, as well as the age distribution.

3.1. Available data

Eurostat statistics currently appear to be the most relevant to this work to ensure maximum data consistency (in particular as regards definitions of immigration and emigration concepts). "*Migration statistics have been partially harmonized by an EU Regulation in 2007[5], replacing former data collections where data were provided on voluntary basis only. The disaggregation of the data that countries are obliged to provide in accordance to this EU regulation is however kept to a level that the member countries have by then considered feasible, mostly just the main aggregates. Still today, parts of the migration statistics which are disseminated by Eurostat are collected on voluntary basis*" (Eurostat, 2017a). As a result of these new provisions, the statistics that Eurostat has been publishing since 2007 are of better quality. Only statistics available since 2008 have thus been used in this work. These are available on the Eurostat website.

In the current stage of model development, three sets of statistics on migration flows are used as from 2008:

– Immigration by country of previous residence (migr_imm5prv)

– Immigration by country of birth (migr_imm4ctb)

– Emigration by country of next usual residence (migr_emi3nxt).

3.2. Building the origin-destination matrix

The 29 * 29 origin-destination matrix is based on the following principle: immigration statistics are generally more reliable than emigration statistics (individuals generally have a greater interest in registering in a country of arrival rather than announcing their departure).

Emigration statistics are used when immigration statistics are lacking. By way of illustration, if statistics on immigration from country B to country A are not available, but statistics on emigration from country B to country A are, the latter will be used to fill in the cell for the flows from B to A.

Before detailing the procedure, it is important to keep in mind its main objective: to create a matrix of consistent and coherent flows to establish assumptions for a projection of international migration between European countries and not to adjust or correct official Eurostat statistics. Ultimately, the purpose of the matrix is to estimate migration rates between European countries.

4 As a reminder, including Norway

5 European Parliament and Council Regulation (EC) No 862/2007 on Community statistics on migration and international protection

3.2.1. Filling in the origin-destination matrix

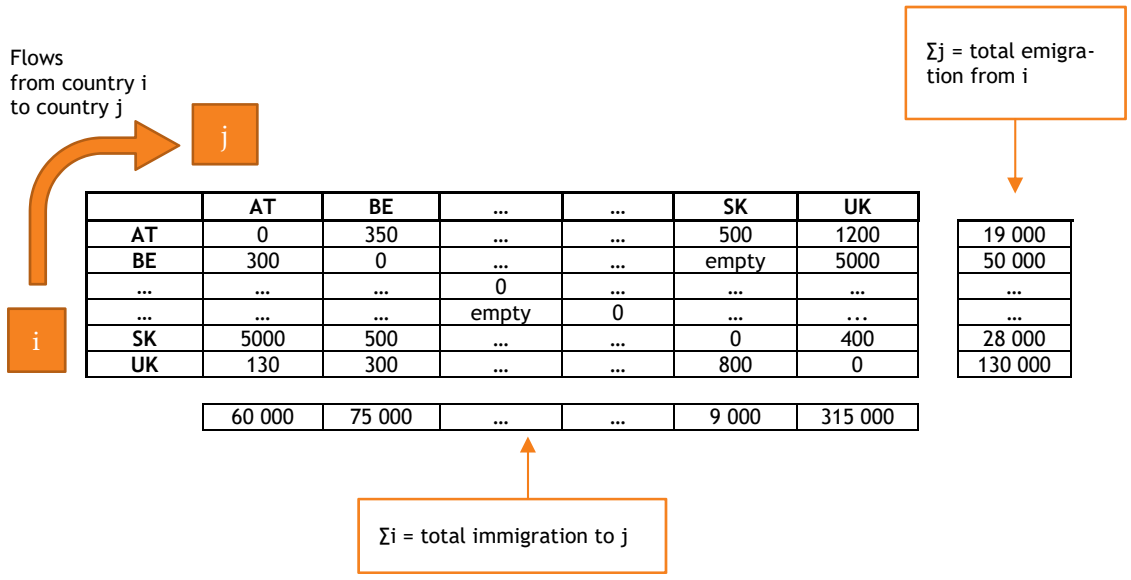
This section describes the successive steps that are taken to complete the missing data (from 2008 to 2015) in the O-D table.

Filling the matrix with available data

In the next three steps, the matrix is filled with immigration and emigration data:

- **STEP 1**: Fill in the cells with statistics on immigration by country of previous residence.
- **STEP 2**: (if cell still empty after step 1): Fill in the cells with statistics on immigration by country of birth.
- **STEP 3**: (if cell still empty after step 2): Fill in the cells with statistics on emigration by country of next residence.

Box 2 Schematic representation of the matrix after STEP 3



	AT	BE	…	…	SK	UK	
AT	0	350	…	…	500	1200	19 000
BE	300	0	…	…	empty	5000	50 000
…	…	…	0	…	…	…	…
…	…	…	empty	0	…	…	…
SK	5000	500	…	…	0	400	28 000
UK	130	300	…	…	800	0	130 000
	60 000	75 000	…	…	9 000	315 000	

⇨ Total immigration in EU from EU ≠ Total emigration from EU to EU: not consistent

There are no statistics available for Germany on the Eurostat website. Destatis (Federal Statistical Office of Germany) has official national data but does not transmit them to Eurostat. Nevertheless, Destatis provided us with immigration statistics by country of previous residence and emigration statistics by country of next residence for the year 2014, which have been integrated into the matrix. Since Germany is an important immigration and emigration country, it seemed more relevant to take these data into account, even if they do not match exactly the Eurostat definition of migration.

STEP 4: After step 3, some cells (10%) remain empty. The main countries concerned are Cyprus, Greece, Spain, France, Malta, Poland, Portugal and the United Kingdom. The empty cells are replaced by a non-zero value[6], which will be adjusted in the next step.

Making some adjustments to the completed matrix

The completed matrix needs to be adjusted somewhat, because:

- *emigration to* as a proxy for *immigration from* (step 3) leads to an under-reporting of immigration;
- net migration within the EU should be 0 (total immigration-total emigration within EU28 (+NO) = 0), which is not the case at this stage of the procedure.

The following two steps aim to adjust the value in each cell so that the column and row totals equal the target totals. Those target totals have been defined so that net migration for the EU is 0.

STEP 5: Set, for each country, immigration and emigration target totals.

- The immigration target for a country = total intra-EU immigration to that country (published in the Eurostat database - immigr_prevres).
- The emigration target by country is defined as follows:

  sum (target immigration by country) * share of each country in the total EU28 (+ Norway) emigration

  where the share of each country in total emigration is based on statistics on total emigration by country, published by Eurostat (emi1nextres).

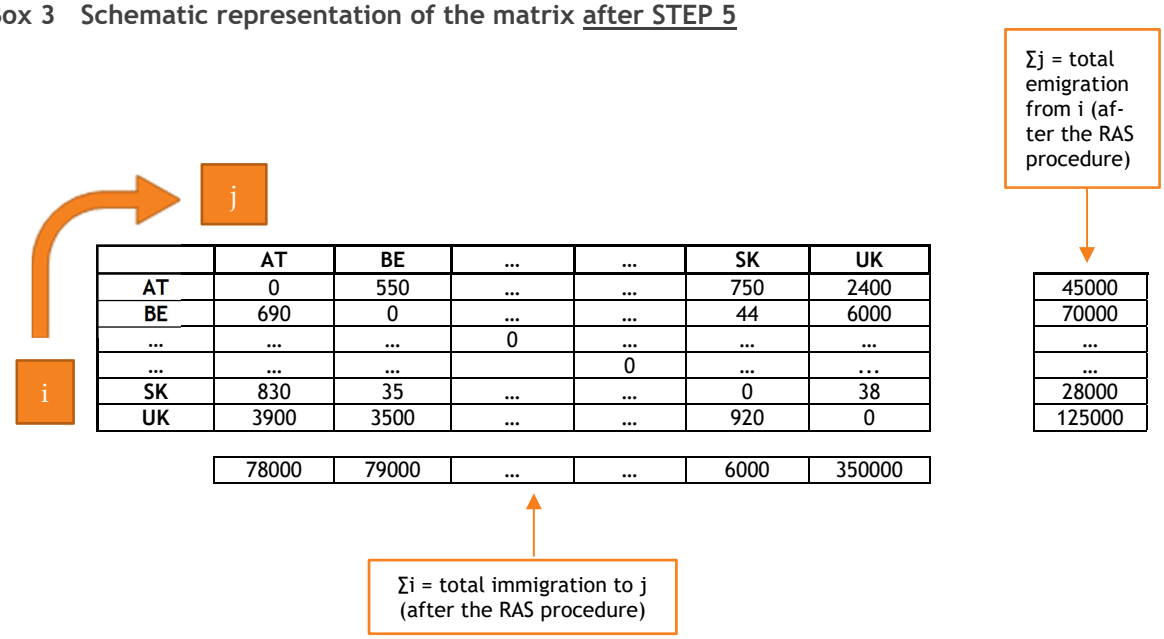
STEP 6: Adjust each cell of the matrix so that row and column totals match the target totals.

This is done by applying the RAS algorithm (= iterative proportional fitting procedure) on the origin-destination matrix. This technique adjusts an initial matrix so that row and column totals match the pre-set totals.

At the end of step 6, the sum of the columns equals the sum of the rows, and EU net migration (including Norway) is 0.

[6] For each country with missing data, these non-zero values have been set as the difference between the total immigration from intra EU countries and the sum of non-zero cells, divided by the number of zero-cells for that country. This is a provisional working assumption.

Box 3 Schematic representation of the matrix after STEP 5



	AT	BE	…	…	SK	UK	
AT	0	550	…	…	750	2400	45000
BE	690	0	…	…	44	6000	70000
…	…	…	0	…	…	…	…
…	…	…		0	…	…	…
SK	830	35	…	…	0	38	28000
UK	3900	3500	…	…	920	0	125000
	78000	79000	…	…	6000	350000	

⇨ Total immigration into EU from EU = Total emigration from EU to EU: consistency is achieved

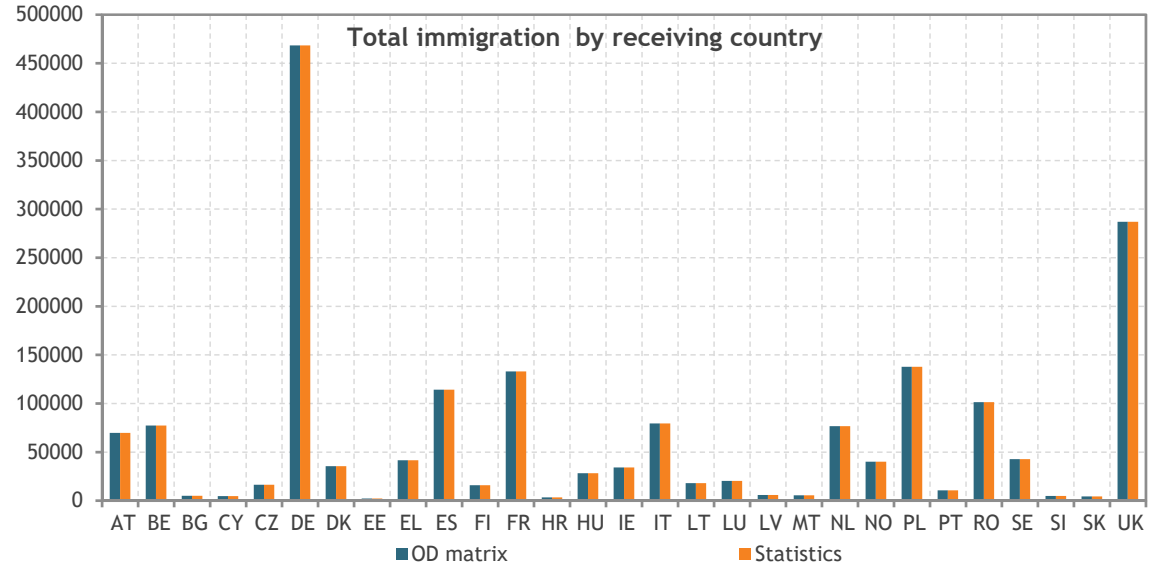
3.2.2. Overview of the origin-destination matrix

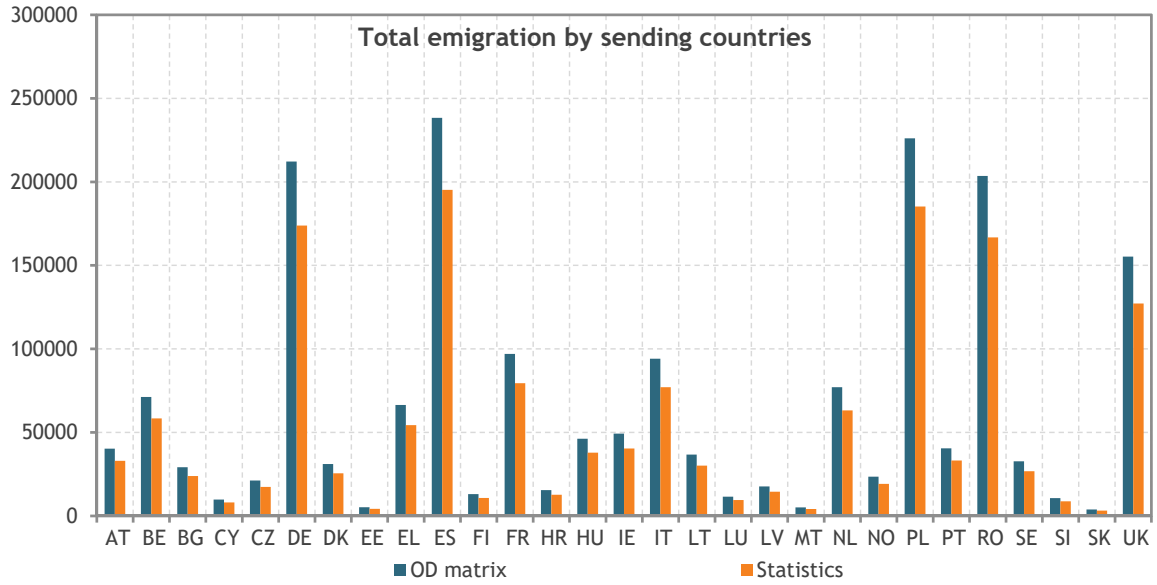
Graph 1 gives an overview of the O-D matrix – after applying the RAS procedure – for all countries (EU Member States and Norway). The results are compared with the statistics available on the Eurostat website.

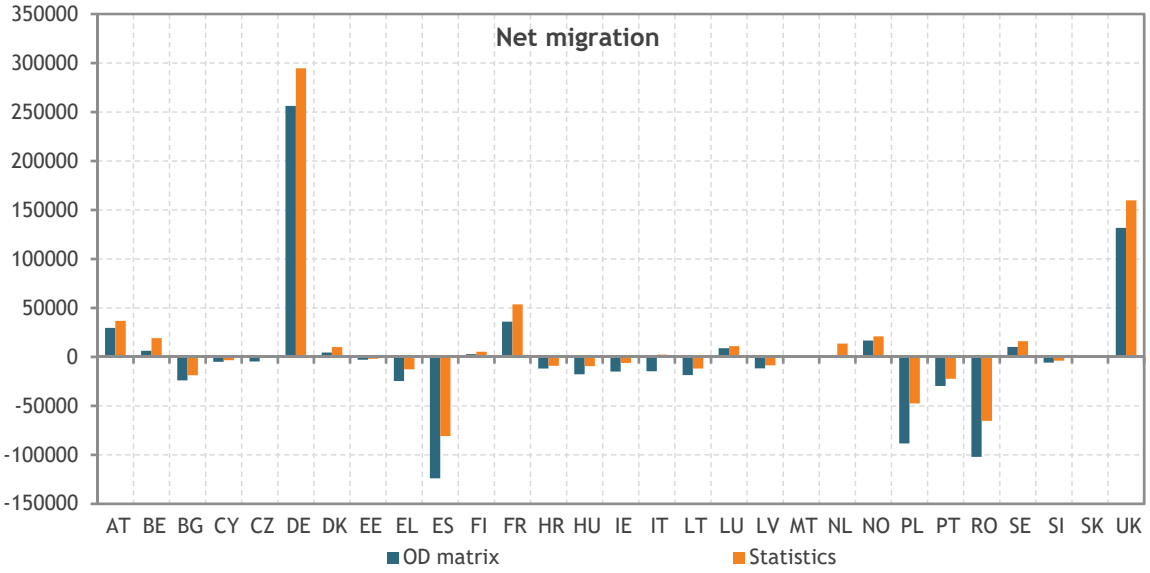
By definition, there is no difference between total immigration (from the other European countries) as published by Eurostat and total immigration filled into the O-D matrix. The Eurostat statistics are regarded as the target value for total intra-EU immigration by country.

For emigration, the graph shows that emigration, as recorded in the Eurostat statistics, is underestimated. Based on statistics, the sum of net migration by country is different from zero, which is not consistent. This sum is equal to zero in the O-D matrix. Net migration by country computed in the O-D matrix is fairly close to the statistical data.

Graph 1 **Immigration, emigration and net intra-EU migration, by EU country - comparison between the origin-destination (OD) matrix and the statistics for 2014**

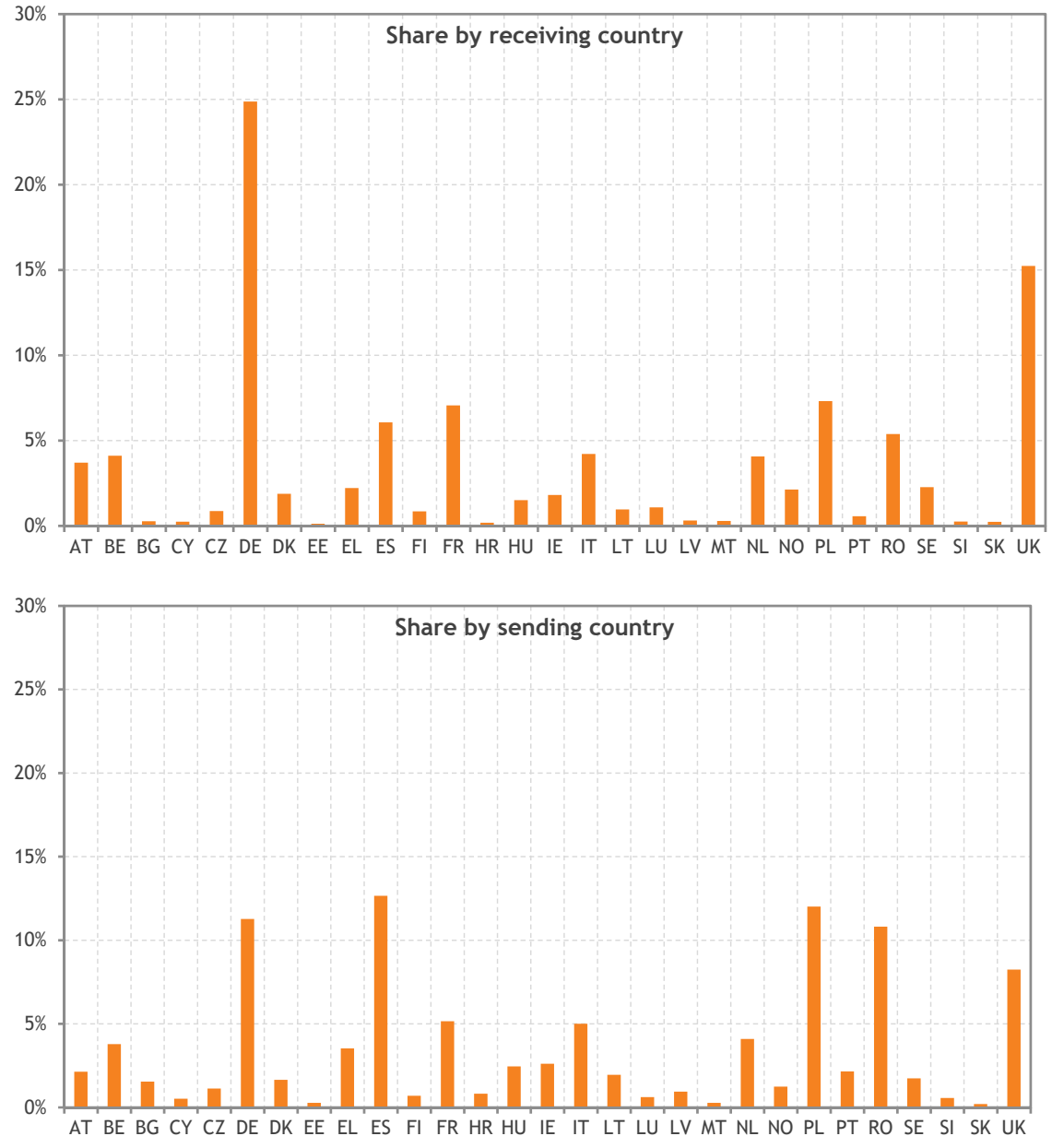






Graph 2 shows the shares of intra-European migration flows by country of origin and destination country, from the O-D matrix and conforms to the Eurostat statistics. By building the consistent O-D matrix, the statistics could be adjusted and those that are missing completed.

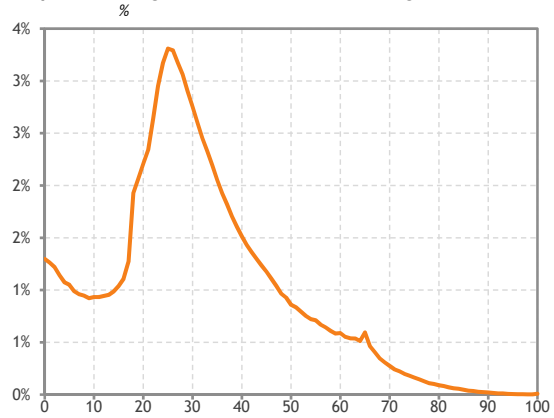
Graph 2 **Intra-EU migration flows between Member States - share by origin and destination country - 2014**
%



Source: Statistics: Eurostat, O-D matrix: FPB

3.3. Age distribution

Graph 3 Origin-Destination Matrix - Age distribution



Source: Eurostat, FPB calculations

Migration behaviour differs according to the age of individuals. It is therefore important to take this into account and calculate migration rates by age. The O-D matrix calculated above must therefore be broken down by age[7]. Since not all countries provide statistics by age to Eurostat, a different strategy is needed. The age distribution (graph 3) is thus based on the average distribution observed, for the 2012-2015 period over a set of countries for which data are available: Belgium, Bulgaria, Spain, Finland and Italy.

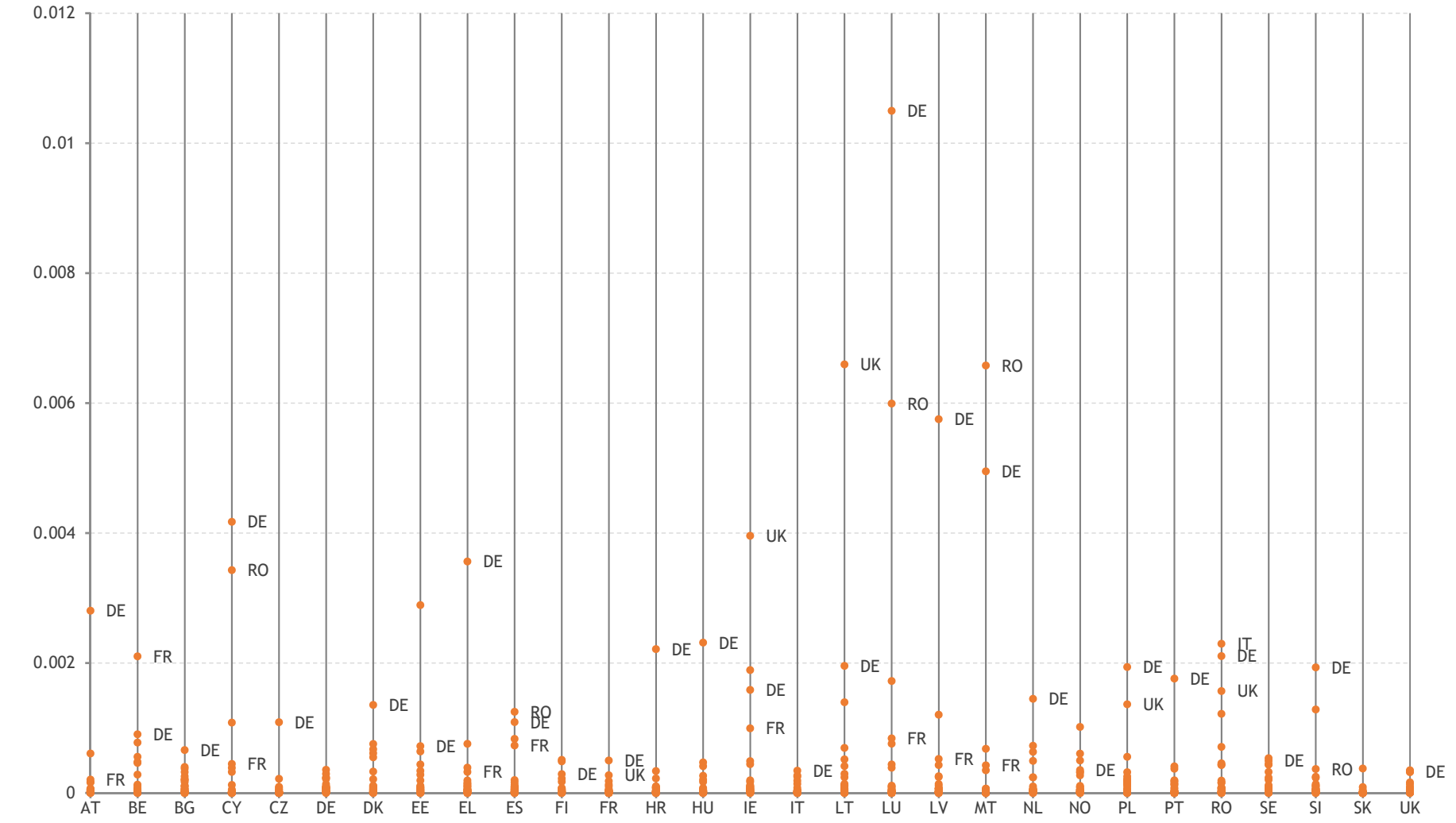
3.4. Migration rates between Member States

The origin-destination matrix by age is then used to calculate migration rates between Member States, using equation (1) or (2). For the projections presented in section 5, migration rates by age are calculated based on all flows fed into the O-D matrix for the years 2012 to 2015 and on the population in each country measured over the same period. To have a sufficient number of observations by age, it is best to work over several observed years rather than just one.

For illustrative purposes, single and double migration rates are presented, regardless of age, in graph 4 and graph 5. The graphs read as follows: the first vertical line represents the emigration rate from Austria to each of the other Member States. These Member States are represented by points. For Austria, the main attraction country is Germany; for Belgium, France; and so on.

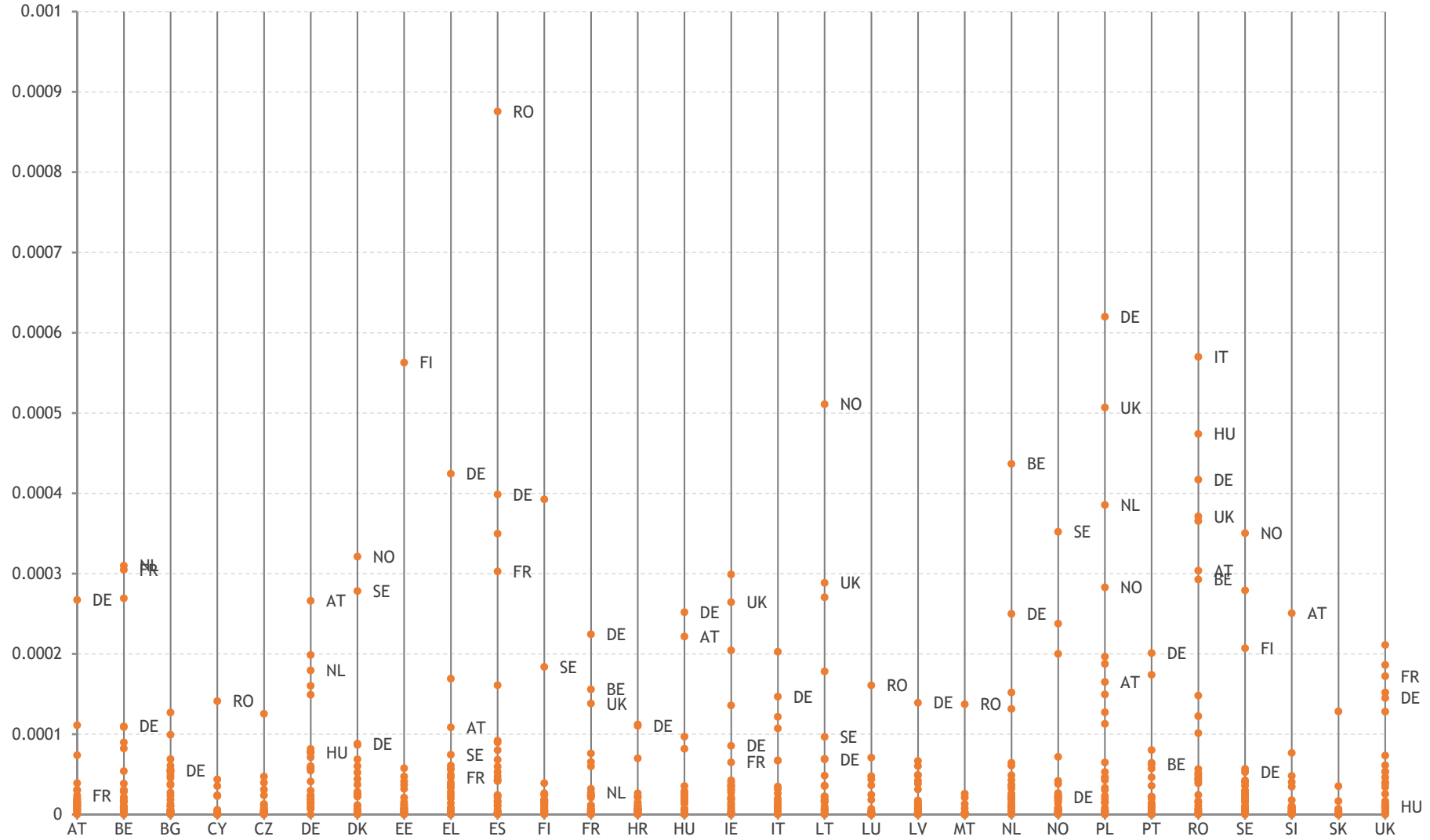
7 A distinction by sex could also be relevant; such a development could be considered at a future stage.

Graph 4 Single migration rates (average over 2013-2015)



Source: Eurostat, FPB calculations

Graph 5 **Double migration rates (average over 2013-2015)**



4. Extra-European migration

As mentioned in section 2, two different approaches are used in the projection model for international migration between EU Member States and the rest of the world. In the first approach, net migration of each EU member country tends towards 0 by 2150. This scenario does not require additional assumptions. In the second approach, which models immigration and emigration flows from or to the rest of the world separately, additional assumptions must be made to calculate immigration and emigration levels. This section describes these additional assumptions.

4.1. Immigration from the rest of the world

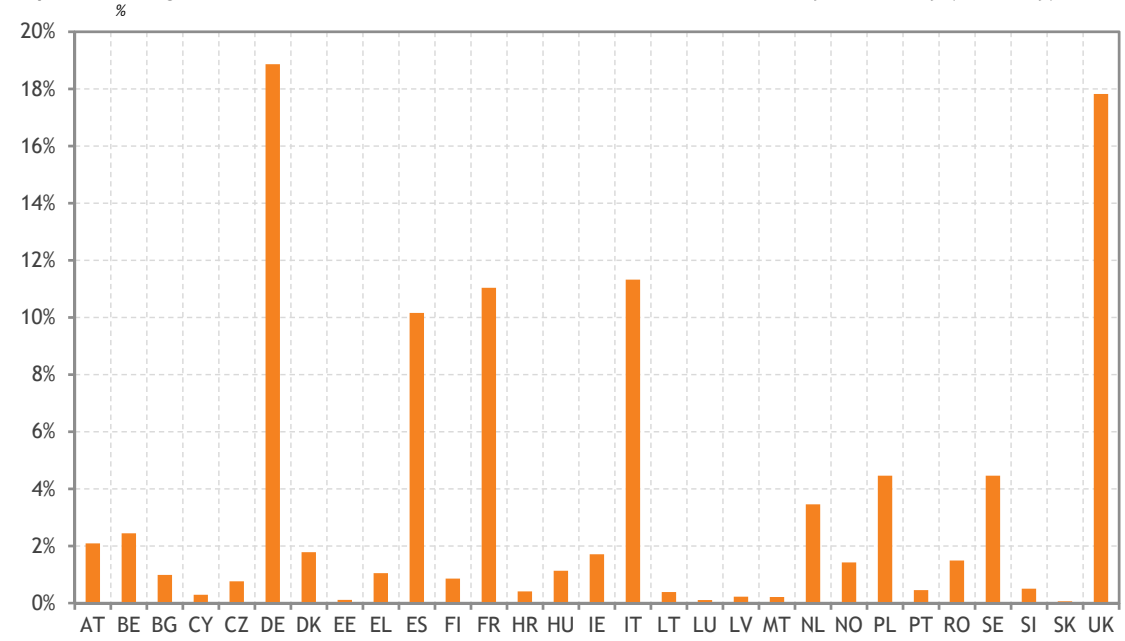
- **STEP 1**: Determine total immigration from the rest of the world to all Member States (a). To this end, we use total immigration into all European countries from non-European countries, as published by Eurostat (immigr_prevres in the Eurostat database).
- **STEP 2**: Calculate the rate of emigration from the rest of the world to all EU countries. Immigration calculated in (a) must then be divided by the observed population in the rest of the world. The rest of the world's population is calculated from the population statistics published by the United Nations:

$$\text{EmiRate}^{t}_{\text{fromRow,toEU}} = \frac{Immi_{fromRoW,toEu}}{Pop_{RoW}} \qquad (6)$$

  The average rate of emigration from the rest of the world to the European Union equals 0.29 per thousand over the 2013-2014 period.

- **STEP 3**: The projected immigration from the rest of the world to all European Member States is obtained by multiplying the projected population in the rest of the world by the rate of emigration to European countries. The projected population in the rest of the world is drawn from the world population projections published by the United Nations (United Nations, 2015).
- **STEP 4**: The previous step determined a total flow of immigration to European countries from the rest of the world. This flow must then be distributed among the European Member States, by age and sex:
  1. The *distribution by age and sex* is based on the average distribution observed for Belgium, Bulgaria, Spain, Finland and Italy. These countries provide data by age and sex, which is not the case for all other European countries.
  2. The *distribution by country* is then based on the average distribution observed in 2013 and 2014 (see graph 6).

Graph 6 **Immigration from the rest of the world to EU countries: distribution by EU country (+ Norway)**



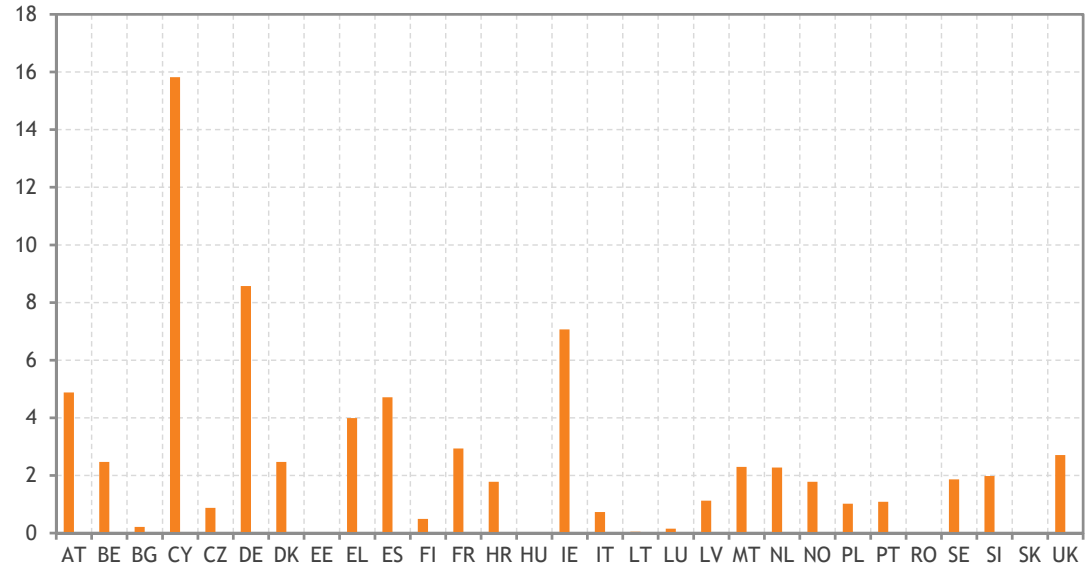
Source: Eurostat, FPB calculations

4.2. Emigration to the rest of the world

Based on the statistics that are available on the Eurostat website, three steps have to be taken once again to determine the emigration rate by age and by European country to the rest of the world.

- **STEP 1**: Determine total emigration by European country to the rest of the world. This information is published by Eurostat in the following statistics: emigration by country of next usual residence (and select the total of non-EU countries).
- **STEP 2**: Data by age are incomplete in the statistics on emigration by country of next usual residence. The breakdown by age is, by default, based on the age distribution as set out in the O-D matrix (see section 3.1). At this stage, it is thus assumed that the age distribution of emigration to the rest of the world is identical to the one used for emigration to the EU countries.
- **STEP 3**: The emigration rate by age is then obtained by dividing the emigration by age by European country to the rest of the world by the population by age in the European country concerned. Average rates of emigration to the rest of the world over the 2012-2014 period, without distinction of age, are presented in graph 7.

Graph 7 **Emigration rate to non-EU countries, by EU country (+ Norway)**
Per 1000



Source: Eurostat, FPB calculations

5. Population projections

The multiregional population projection model is tested using the four alternative scenarios, which differ according to the method used either to calculate intra-European migration flows (single or double migration flows) or to determine international migration to and from the rest of the world (net migration tends to 0 or progresses in line with world population growth). The alternative scenarios are summarised in table 1. The projection period runs to 2080.

Table 1 Summary of alternative scenarios

	Intra-European migration	Migration to and from the rest of the world
Alternative 1 (ALT1)	Single migration rate (Mr1)	Net migration tends to 0
Alternative 2 (ALT2)	Single migration rate (Mr1)	Depends on the population in RoW
Alternative 3 (ALT3)	Double migration rate (Mr2)	Net migration tends to 0
Alternative 4 (ALT4)	Double migration rate (Mr2)	Depends on the population in RoW

The model is written in Python and uses the LArray package[8] (Bryon *et al.*, 2018).

5.1. Assumptions

a. Fertility and mortality

The assumptions on fertility and mortality by age and sex are the same in the four alternatives and correspond to those retained in the baseline of the population projections published by Eurostat in 2017 (ESSPOP2015). These assumptions are summarised in table 2 by the total fertility rate and life expectancy at birth. For more details on these assumptions, see Eurostat (2017b).

8 LArray - N-dimensional labelled arrays in Python

Table 2 Mortality and fertility assumptions by EU country (and Norway)

	Total fertility rate		Life expectancy at birth			
	2015	2080	2015		2080	
			Females	Males	Females	Males
Austria	1.49	1.70	83.4	78.5	91.2	87.3
Belgium	1.70	1.84	83.2	78.2	91.2	87.2
Bulgaria	1.52	1.82	77.9	71.1	89.2	84.9
Croatia	1.40	1.70	80.4	74.1	90	85.8
Cyprus	1.30	1.67	83.4	79.5	91.1	87.9
Czech Republic	1.57	1.84	81.5	75.4	90.4	86.2
Denmark	1.71	1.84	82.6	78.5	91	87.2
Estonia	1.59	1.83	81.7	72.6	90.6	85.4
Finland	1.65	1.83	84	78.4	91.1	87
France	1.96	1.99	85	78.7	92	87.6
Germany	1.49	1.72	83	78	91	87.1
Greece	1.33	1.70	83.4	78.2	91.3	87.5
Hungary	1.45	1.82	79	72	89.9	85.5
Ireland	1.92	1.97	83.3	79.3	91.3	87.5
Italy	1.34	1.71	84.6	79.9	91.7	87.8
Latvia	1.70	1.88	79.3	69.1	89.9	84.5
Lithuania	1.70	1.85	79.5	68.8	90	84.6
Luxembourg	1.47	1.73	84.2	78.8	91.7	87.4
Malta	1.45	1.77	83.2	78.8	91.5	87.8
Netherlands	1.65	1.84	83	79.6	91	87.5
Norway	1.73	1.85	84.1	80.1	91.3	87.5
Poland	1.32	1.74	81.2	73.3	90.6	85.9
Portugal	1.31	1.65	84.1	77.8	91.3	87
Romania	1.47	1.90	78.5	71.2	89.7	85.3
Slovakia	1.40	1.85	80.1	73	90.3	85.7
Slovenia	1.57	1.85	83.4	77.7	91.1	87
Spain	1.33	1.89	85.3	79.7	92	87.9
Sweden	1.85	2.04	84	80.3	91.3	87.6
United Kingdom	1.80	1.89	82.7	78.9	91.1	87.5

Source: Eurostat (Esspop2015)

b. International migration between EU countries (+ Norway)

In alternative 1 and alternative 2, intra-European migration flows are obtained using single migration rates by age (see equation (1)) computed from the origin-destination matrix. These rates are constant over the whole projection period (2016-2080) and correspond to the average rates over the 2012-2015 period.

In alternative 3 and alternative 4, intra-European migration flows are obtained using double migration rates by age (see equation (2)) computed from the origin-destination matrix. These rates are also constant over the entire projection period (2016-2080) and correspond to the average rates over the 2012-2015 period in the origin-destination matrix.

c. International migration to and from the rest of world

In alternative 1 and alternative 3, net migration (by age) tends to 0 by 2150. The gradual decrease towards 0 starts in the observed year 2014[9]. Net migration observed in 2015 in some European countries is indeed largely influenced by the inflow of asylum seekers into Europe. At this stage, it was decided not to take this observation into account due to a lack of homogeneity in the counting and reporting of this inflow in immigration statistics (see footnote 10).

[9] For Cyprus, the starting value had to be adjusted to avoid a population below 0 after a few years. The net migration observed in recent years is indeed exceptionally low (and negative).

Table 3 Extra-EU net migration in ALT1 and ALT3 (net migration tends to 0 by 2150)

	2014	2080
Austria	62771	25211
Belgium	28585	9908
Bulgaria	-2112	671
Croatia	-10220	-2084
Cyprus	-15000	81
Czech Republic	1429	2977
Denmark	23962	12693
Estonia	-733	84
Finland	16021	8849
France	45820	-29494
Germany	560672	245510
Greece	-47791	-2871
Hungary	12368	10175
Ireland	-13511	-10095
Italy	141303	77950
Latvia	-12327	-174
Lithuania	11049	2025
Luxembourg	-8652	-2773
Malta	3039	833
Netherlands	32423	9854
Norway	37595	11827
Poland	-46024	11270
Portugal	-30056	-4617
Romania	-36836	7586
Slovakia	1713	2447
Slovenia	-490	-125
Spain	-94976	-19599
Sweden	75729	20124
United Kingdom	312905	97225

Source: 2014: Observation: Eurostat, 2080: projection, FPB

In alternative 2 and alternative 4, migration flows are projected by taking into account populations at risk of migration, namely the population in European countries in the case of emigration to the rest of the world and the population in the rest of the world in the case of emigration to European countries.

Immigration to European countries is determined by multiplying the projections of the rest of the world's population by emigration rates from the rest of the world to EU countries as computed in section 4.1. These rates are defined by the average over the 2012-2014 period[10], and are held to be constant over the entire projection period. The projections of the rest of the world's population are drawn from the baseline published by the United Nations. The projection of emigration from European countries to the rest of the world is in turn based on emigration rates, which are set at the average over the 2012-2014 period (graph 7) and kept constant over the whole projection period.

[10] It was decided not to take the 2015 observation into account in the calculation of the average emigration rates from non-EU countries to EU countries. An unusually large flow of asylum seekers headed for Europe that year. Some countries included asylum seekers in their 2015 statistics, others only refugees and still others did not report those flows in their statistics. The data are not sufficiently homogeneous and could therefore bias the calculation of average emigration rates from the rest of the world to each country in the European Union.

5.2. Results

The projection results for the four alternative scenarios are summarised in table 4 and graph 8. Overall, some major trends emerge, regardless of the alternative that is considered:

– Luxembourg has the highest population growth by 2080: a growth of more than 60% compared to 2015. Norway, Sweden and UK are also characterised by sustained growth.

– By contrast, Greece, Lithuania and Latvia record the lowest population growth.

– Eastern European countries generally see their population decrease in the four alternative scenarios. But some Southern countries (Portugal and Spain in particular) are also expected to face negative population growth.

Table 4 **Population projection by country - 2080**
In absolute terms and percentage growth compared to 2015

	2015	ALT1		ALT2		ALT3		ALT4	
Austria	8576.3	9700.2	**13.1%**	11083.7	**29.2%**	10024.0	**16.9%**	11405.4	**33.0%**
Belgium	11237.3	11049.4	**-1.7%**	12890.5	**14.7%**	10933.1	**-2.7%**	12925.0	**15.0%**
Bulgaria	7202.2	4723.8	**-34.4%**	5692.8	**-21.0%**	4435.2	**-38.4%**	5387.8	**-25.2%**
Croatia	4225.3	2579.3	**-39.0%**	2876.6	**-31.9%**	2257.1	**-46.6%**	2542.2	**-39.8%**
Cyprus	847.0	556.3	**-34.3%**	613.3	**-27.6%**	395.2	**-53.3%**	511.2	**-39.7%**
Czech Republic	10538.3	7881.5	**-25.2%**	9286.7	**-11.9%**	7615.0	**-27.7%**	9056.2	**-14.1%**
Denmark	5659.7	6008.1	**6.2%**	7560.2	**33.6%**	6056.9	**7.0%**	7747.1	**36.9%**
Estonia	1314.9	990.4	**-24.7%**	1127.7	**-14.2%**	867.8	**-34.0%**	991.6	**-24.6%**
Finland	5471.8	5666.3	**3.6%**	6455.1	**18.0%**	5682.0	**3.8%**	6444.7	**17.8%**
France	66488.2	79219.9	**19.1%**	83654.7	**25.8%**	81389.8	**22.4%**	85188.9	**28.1%**
Germany	81197.5	90328.6	**11.2%**	103029.9	**26.9%**	97574.4	**20.2%**	109647.8	**35.0%**
Greece	10858.0	4885.7	**-55.0%**	6577.0	**-39.4%**	2791.9	**-74.3%**	4944.1	**-54.5%**
Hungary	9855.6	7471.9	**-24.2%**	8741.8	**-11.3%**	6903.1	**-30.0%**	8174.7	**-17.1%**
Ireland	4628.9	4638.8	**0.2%**	5045.3	**9.0%**	4694.1	**1.4%**	4990.3	**7.8%**
Italy	60795.6	48660.4	**-20.0%**	58703.9	**-3.4%**	48536.6	**-20.2%**	58656.3	**-3.5%**
Latvia	1986.1	1103.2	**-44.5%**	1246.2	**-37.3%**	645.2	**-67.5%**	783.3	**-60.6%**
Lithuania	2921.3	1756.4	**-39.9%**	2072.6	**-29.1%**	669.1	**-77.1%**	1031.8	**-64.7%**
Luxembourg	563.0	922.2	**63.8%**	929.6	**65.1%**	1338.7	**137.8%**	1236.1	**119.6%**
Malta	429.3	404.7	**-5.7%**	592.5	**38.0%**	420.1	**-2.2%**	678.5	**58.0%**
Netherlands	16900.7	16460.0	**-2.6%**	19007.9	**12.5%**	16526.5	**-2.2%**	19100.8	**13.0%**
Norway	5166.5	7020.6	**35.9%**	8410.5	**62.8%**	7407.1	**43.4%**	8820.3	**70.7%**
Poland	38005.6	26431.0	**-30.5%**	30824.5	**-18.9%**	22430.5	**-41.0%**	26898.3	**-29.2%**
Portugal	10374.8	5743.8	**-44.6%**	5798.3	**-44.1%**	4957.9	**-52.2%**	4899.2	**-52.8%**
Romania	19870.6	12303.0	**-38.1%**	14455.4	**-27.3%**	9549.9	**-51.9%**	11433.6	**-42.5%**
Slovakia	5421.3	4425.9	**-18.4%**	4518.8	**-16.6%**	4401.5	**-18.8%**	4478.8	**-17.4%**
Slovenia	2062.9	1549.5	**-24.9%**	1985.5	**-3.8%**	1403.4	**-32.0%**	1877.4	**-9.0%**
Spain	46449.6	30450.7	**-34.4%**	39584.6	**-14.8%**	27495.7	**-40.8%**	37703.4	**-18.8%**
Sweden	9747.4	14384.4	**47.6%**	17945.4	**84.1%**	15213.3	**56.1%**	18910.1	**94.0%**
United Kingdom	64875.2	82911.5	**27.8%**	93403.8	**44.0%**	87955.7	**35.6%**	98066.4	**51.2%**

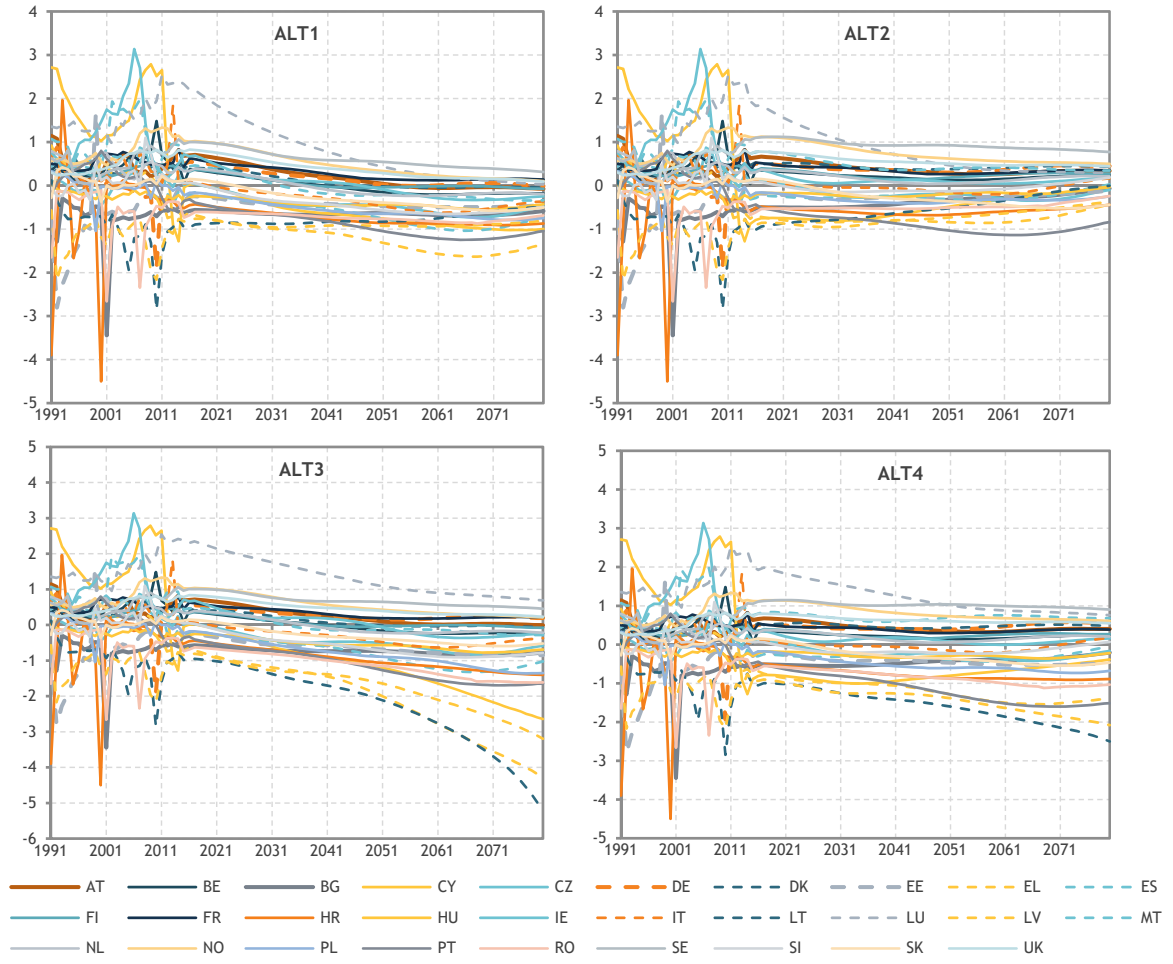
Source: 2014: Observation: Eurostat, 2080: projection, FPB

The analysis shows the impact of the methodological choices made for each alternative scenario on population growth. By comparing alternatives 1 and 2 or 3 and 4, the differences between these alternative scenarios with respect to migration flows to and from the rest of the world are highlighted. Logically, the expected positive population growth in non-European countries stimulates net migration in each European country and consequently their population growth. While the average annual growth rate varies between -1.5% and +0.5% depending on the country in alternative 1, it fluctuates between

-1% and +1% in alternative 2. Similarly, it varies between -4% and +0.75% depending on the country in alternative 3 and between -2% and +1% in alternative 4.

Graph 8 **Annual population growth rate by country in the four alternatives**

%



Source:
1991-2015: Observation: Eurostat
2016-2080: projection, FPB

Concerning intra-European migration, the population of both the countries of origin and of destination can be integrated by taking into account double migration rates (ALT3 and ALT4). Consequently, European countries facing higher population growth attract more people from the other European countries; this further stimulates growth in the host country. By contrast, countries with lower population growth attract fewer migrants from Europe, which further weakens their population growth. The comparison of ALT1 and ALT3 in graph 8 highlights these effects. These two scenarios only differ in the intra-European migration assumption. The assumption is based on simple migration rates in ALT1, while it is based on double migration rates in ALT3. In ALT1, annual population growth varies between -1.5% and +0.5% depending on the country. In ALT3, it fluctuates between -4% and +0.75%. In the latter, countries experiencing low growth see it slow down further, while the opposite holds true for countries with relatively higher growth.

The projected population growth and its components, for the four alternatives, are graphically presented for each country in the Annex.

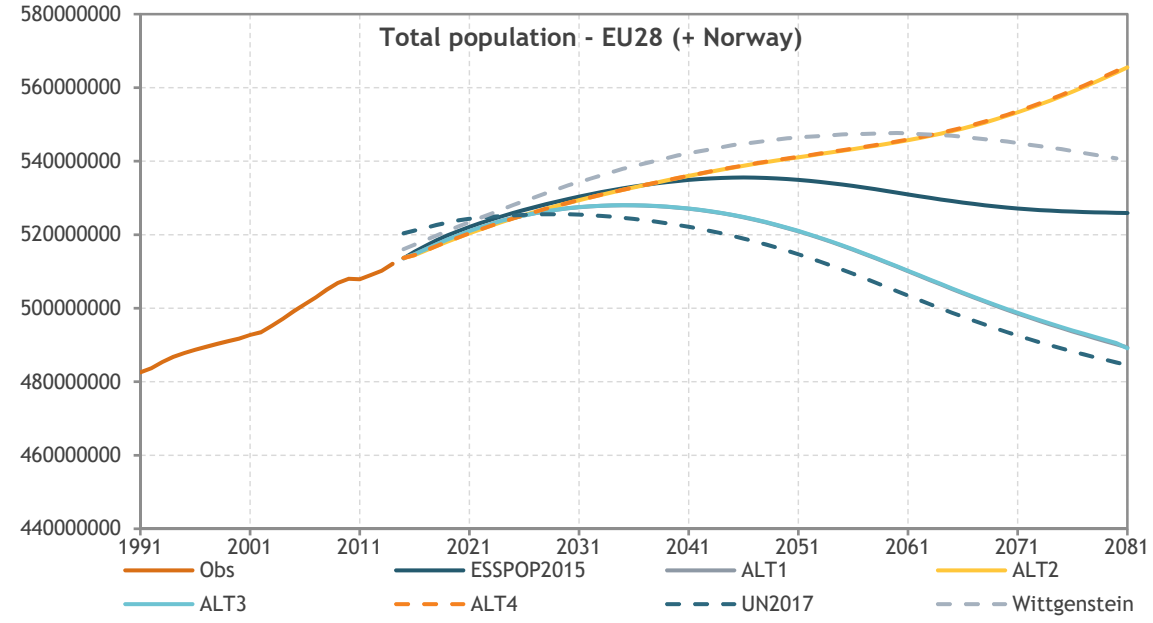
5.3. Comparison with projections published by other institutions

Population projections are the result of a set of assumptions on future trends in mortality, fertility and internal and international migration. A comparison of the projections published by different institutions not only makes it possible to show the uncertainty surrounding demographic projections (like any population projection) but also to infer a set of likely scenarios.

Population trends in the European Union, as they emerge from the four alternative scenarios presented above, are compared (graph 9) to those projected by the United Nations (United Nations, 2017), Eurostat (ESSPOP2015) and the Wittgenstein Centre (Wittgenstein Centre for Demography and Global Human Capital, 2015). In the three cases, the "medium scenario" has been chosen.

It should be noted that the choice of the single or double migration rates as presented in the four alternative scenarios in section 5.2 has no impact on the population growth of the European Union. Whatever the scenario with single or double migration rates, total intra-European net migration is equal to 0. Internal migration scenarios only impact the distribution of flows between European countries. Consequently, the evolution of the total population of the European Union is identical in ALT1 and ALT3, as well as in ALT2 and ALT4[11].

Graph 9 Comparison of different projections of EU population (including Norway)



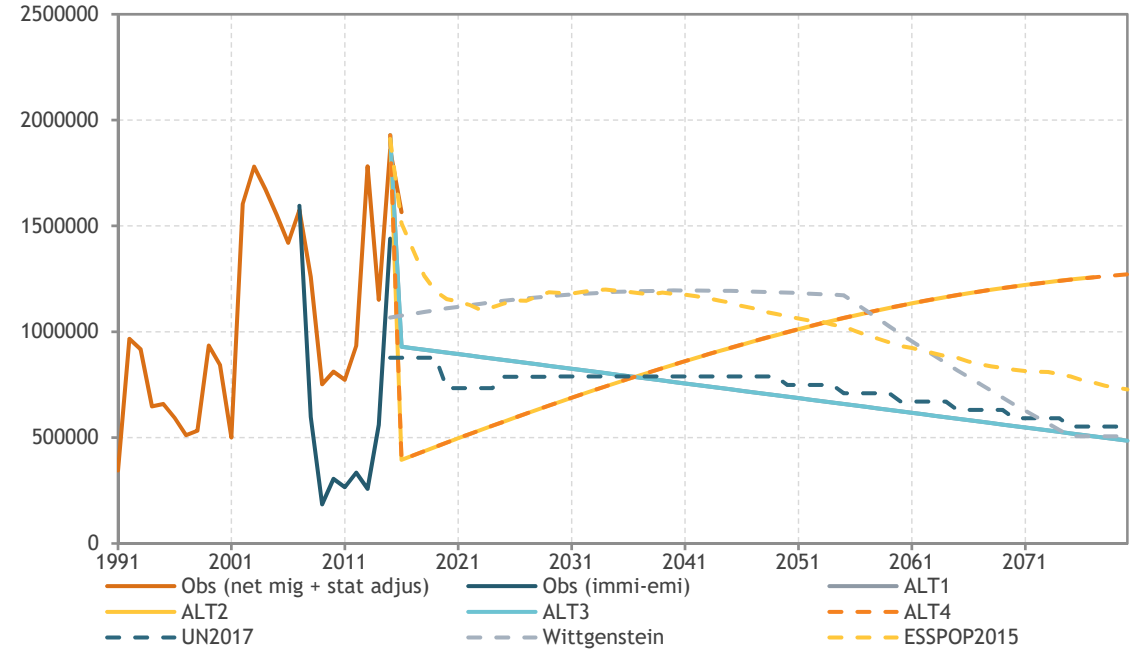
Sources: Eurostat, UN, Wittgenstein Centre and FPB.

[11] The difference cannot be seen in the graphs. In absolute terms, there is however a slight difference linked to fertility and mortality levels, which differ according to the country.

The projections in ATL2 and ALT3 show the highest population growth. The EU population is projected to reach 570 million people by 2080. The projection of the Wittgenstein Centre for Demography follows a relatively similar trend up to 2050, then starts to decrease, contrary to ALT2 and ALT3. These two different developments are largely justified by the assumptions on the future evolution of international migration. While net migration is on the rise, up from 500 000 in 2015 to 1 300 000 in 2080 in ALT2 and ALT4, it goes downwards, starting from 1 million in 2015 to reach 500 000 in 2080 in the scenario of the Wittgenstein Centre for Demography. As a reminder, the ALT2 and ALT4 scenarios take into account the world population growth outside the European Union (as projected by the United Nations). The migration scenario of the Wittgenstein Centre for Demography relies on average immigration and emigration rates, calculated on the basis of the latest years observed. The rates are kept constant until 2060 and then tend towards an average level for all countries.

The Medium scenario published in 2017 by the United Nations assumes a negative long-term population growth in the European Union, like ALT1 and ALT3. Moreover, assumptions on net migration are quite similar (see graph 10).The United Nations considers that net migration per country remains stable until 2050 (at the average level recorded during the last years observed) in the Medium scenario and afterwards gradually halves by 2100 (for more details on the methodology, see United Nations, 2017). In these three scenarios (UN2017, ALT1 and ALT3), the EU population decreases to 485 million in 2080. The population projection published by Eurostat (ESSPOP2015) falls between the highest and lowest scenarios. The differences between all these scenarios are mainly explained by differences in future migrations trends.

Graph 10 Net migration projection for the European Union (+ Norway) - comparison (intra-European migration flows included)



Source: Eurostat, UN, Wittgenstein Centre and BFP.

6. Conclusion and outlook

The approach presented in this Working Paper for modelling international migration in population projections at the European level has several advantages. First, the method distinguishes between intra-European migration flows and flows to or from non-European countries. This distinction makes sense since the motivations that drive individuals to migrate and the ensuing administrative constraints differ widely between these two regions. Second, the approach adopted to model intra-European migration flows ensures consistency between flows. In particular, total net migration between European countries is zero. This consistency is achieved using migration rates between European countries calculated using data available on the Eurostat website. Overall, the model is easy to interpret and can be easily updated or adapted, depending on available data or changes in migratory behaviour. Finally, the assumptions are built on theoretical grounds (pull and push model for intra-European migration and migratory pressure for migration to and from non-European countries). Expert opinions can be sought to determine assumptions about future rate changes (constant rates, trends, distinction between short and long term, etc.). The method relies on a set of assumptions to build the matrix of intra-European migration flows. It should be noted that the number of assumptions made is linked to the lack of comprehensive and consistent data. This number could therefore be considered too high and limit the value of the model. However, the choice to rely on official Eurostat statistics is not neutral. Eurostat compiles statistics by country, based on common definitions, which leads to statistical harmonisation. Furthermore, these statistics are freely accessible. The proposed model can thus be duplicated by any potentially interested person. However, not all countries provide all the requested statistics. Despite this weakness, a matrix of migration flows could be developed to determine an assumption on the future development of intra-European migration. It is important to highlight that the intention is not to adapt official statistics but to build a consistent and coherent migration flow matrix to determine an assumption.

This work is still ongoing and could continue to be improved. In particular, migration rates are held to be constant in projections in this paper. This assumption could be replaced by migration rates that would follow trends observed in the more recent or distant past. Similarly, short-term and long-term trends could be differentiated. The short-term trend could indeed depend more on cyclical events (economic situation, insecurity, geopolitical context, etc.).

The model could also benefit from comments provided by members of the Working Group on Population Projection, which is chaired by Eurostat. This working group brings together national experts in demographic projections, who are representatives of statistical institutes. Several suggestions have already been put forward during this working group's meetings but have not yet been tested. Concerning the origin-destination matrix of migration flows, it was suggested that the matrix be completed using all the immigration and emigration statistics available on the Eurostat website, including immigration and emigration by country of birth. This would at least allow the stability of the model to be analysed, depending on the statistics used and the periods selected to calculate the average rates.

It was also suggested that emigration rates from the rest of the world to Europe should be taken into account, with an age distinction. Given the specific age profile of migrants and the expected changes in the age structure of the world population, this distinction is indeed relevant and should be integrated

into the model. Another interesting option that can be considered to fill the data gap would be to identify similar groups of countries and thus reduce the dimensions of the migration flow matrix.

To conclude, this present exercise shows that the official statistics on migration flows can be used to build a multiregional migration model at the EU level and that more developments should be tested to improve the model. Compared to other projection models at the European level, the provisional results here indicate that the model produces promising results and encourage us to pursue our modelling efforts.

7. Bibliography

BOHNERT, N., CHAGNON, J., SIMON COULOMBE, S., ET AL. (2015), *Projections démographiques pour le Canada (2013 à 2063), les provinces et les territoires (2013 à 2038) : rapport technique sur la méthodologie et les hypothèses*, Statistique Canada.

BRYON G., DAMMAN, A., DE MENTEN, G., DUYCK, J., ET AL. (2014*), LArray - N-dimensional labelled arrays in Python*, Federal Planning Bureau, Brussels, Belgium. URL http://larray.readthedocs.io/

COURGEAU, D. (1991), *Perspectives avec migrations*, Population, 46ème année, n°6, pp.1513-1530.

EUROSTAT (2017a), *Methodology for the migration assumptions in the 2015-based population projections*, Eurostat Technical Note, ESTAT/F-2/GL, 5 July 2017.

EUROSTAT (2017b), *Summary methodology of the 2015-based population projections*, ESTAT/F-2/GL, 3 March 2017.

FEDERAL PLANNING BUREAU, Statbel, 2018, Perspectives démographiques 2017-2070, Population et ménages, Documents perspectives, 2018.

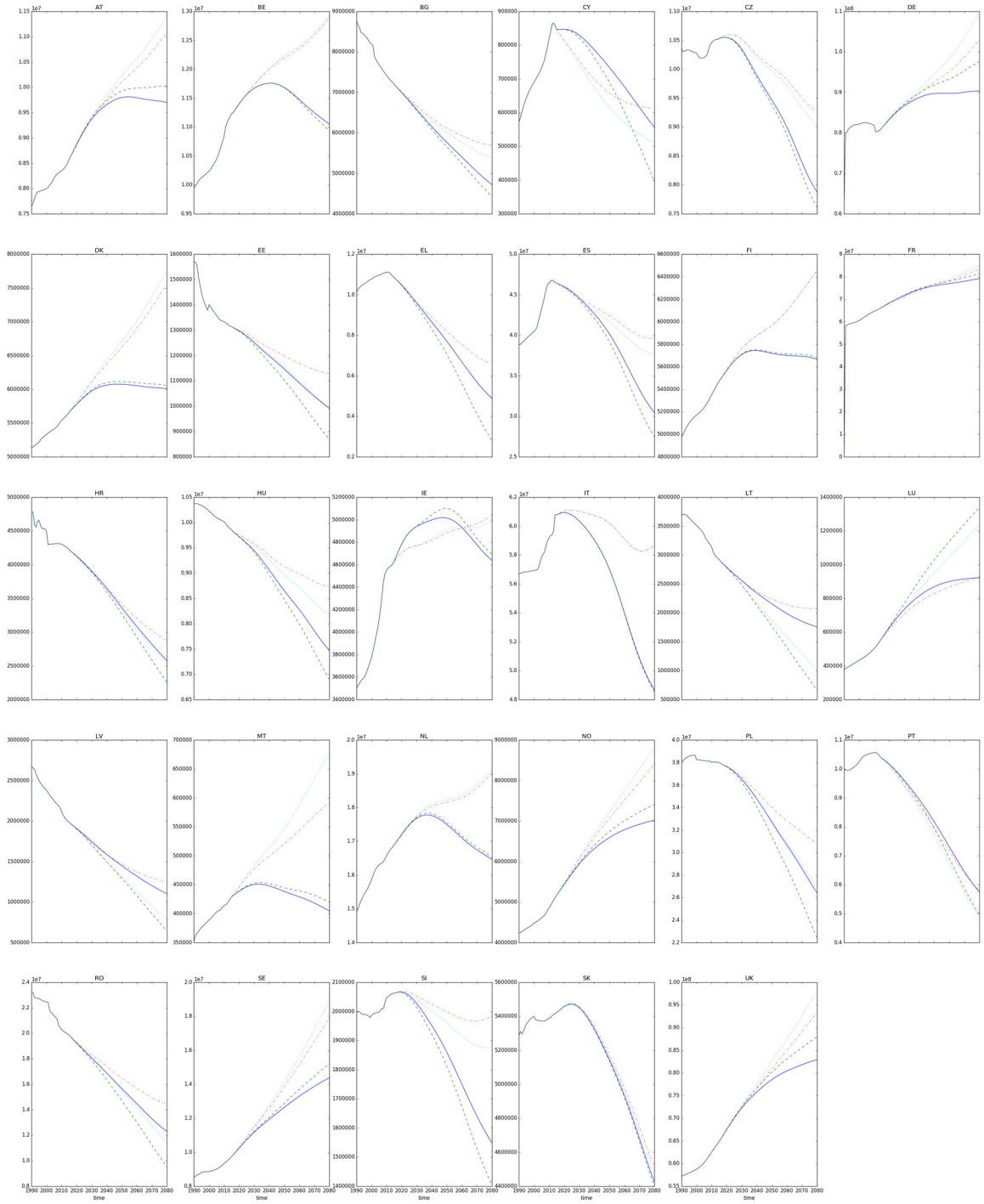
LUTZ, W., BUTS, W.P. AND KC, S. (ed.) (2014). *World Population & Human Capital in the Twenty-First Century*, Oxford, Oxford University Press.

UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, POPULATION DIVISION (2017). *World Population Prospects: The 2017 Revision, Methodology of the United Nations Population Estimates and Projections*, Working Paper No. ESA/P/WP.250. New York: United Nations.

WITTGENSTEIN CENTRE FOR DEMOGRAPHY AND GLOBAL HUMAN CAPITAL (2015), Wittgenstein Centre Data Explorer Version 1.2. Available at: http://www.wittgensteincentre.org/dataexplorer

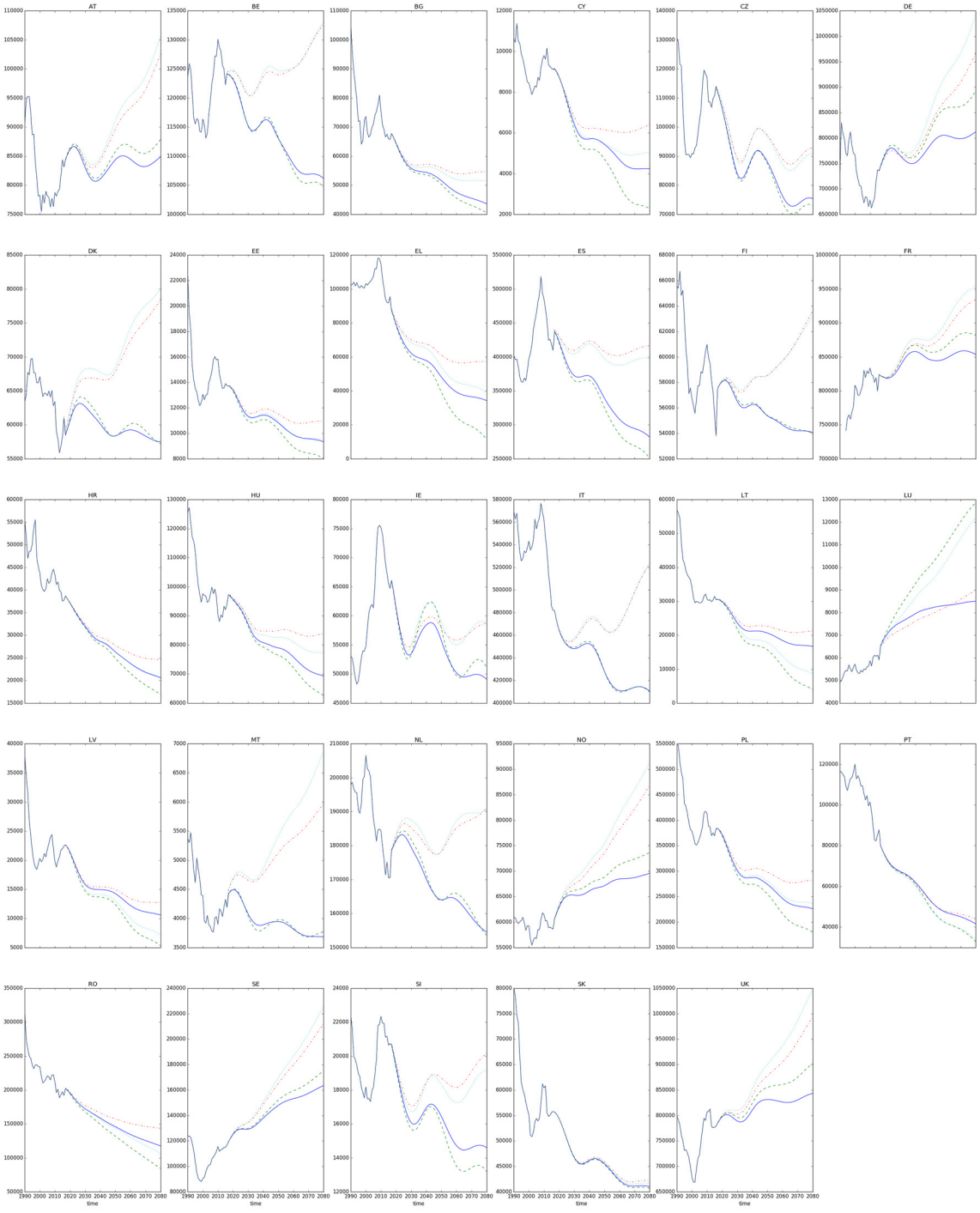
8. Annex - population projection and demographic components by country

8.1. Population



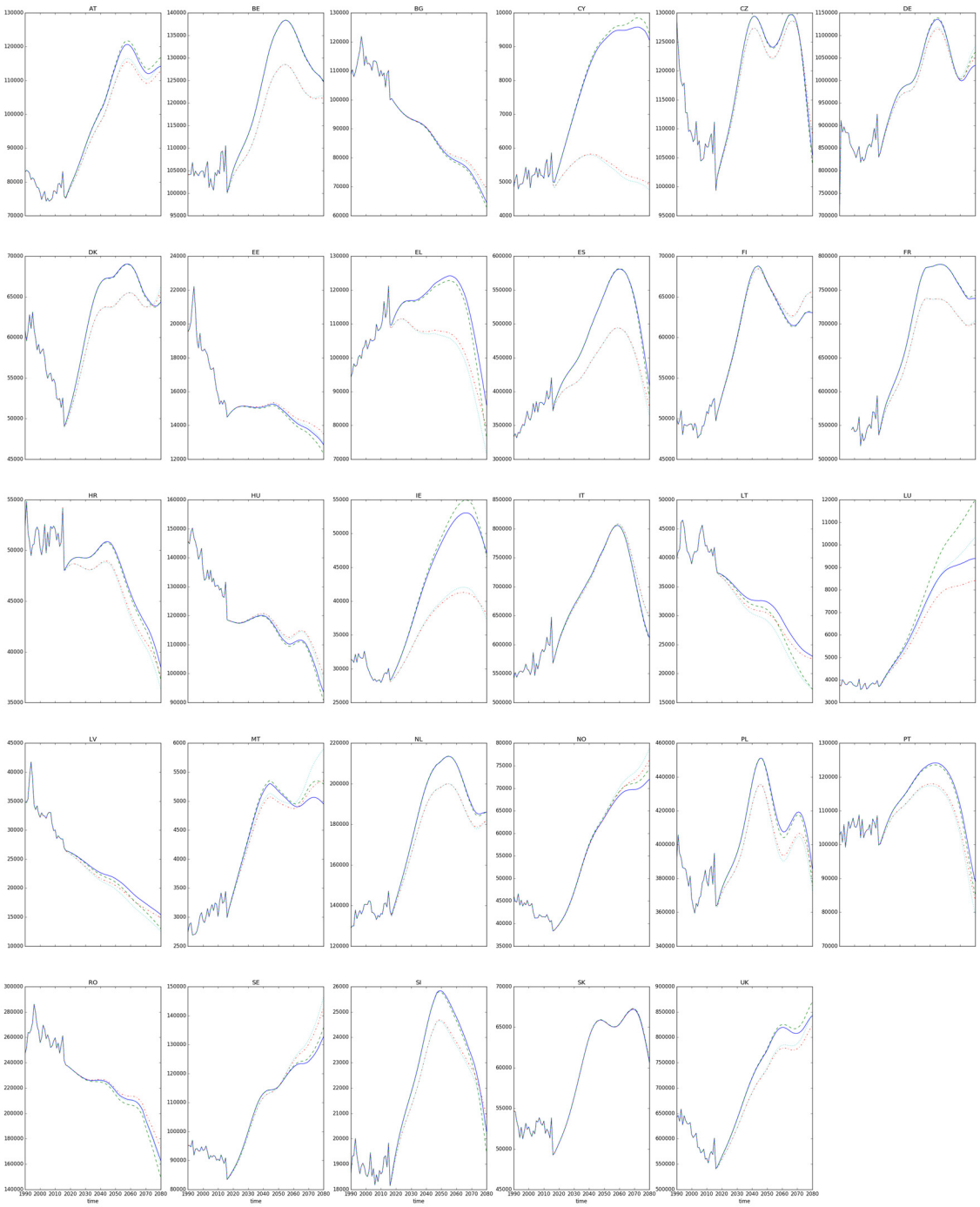
ALT1: ____ ALT2: _._._ ATL3: _ _ _ ALT4: ...

8.2. Births



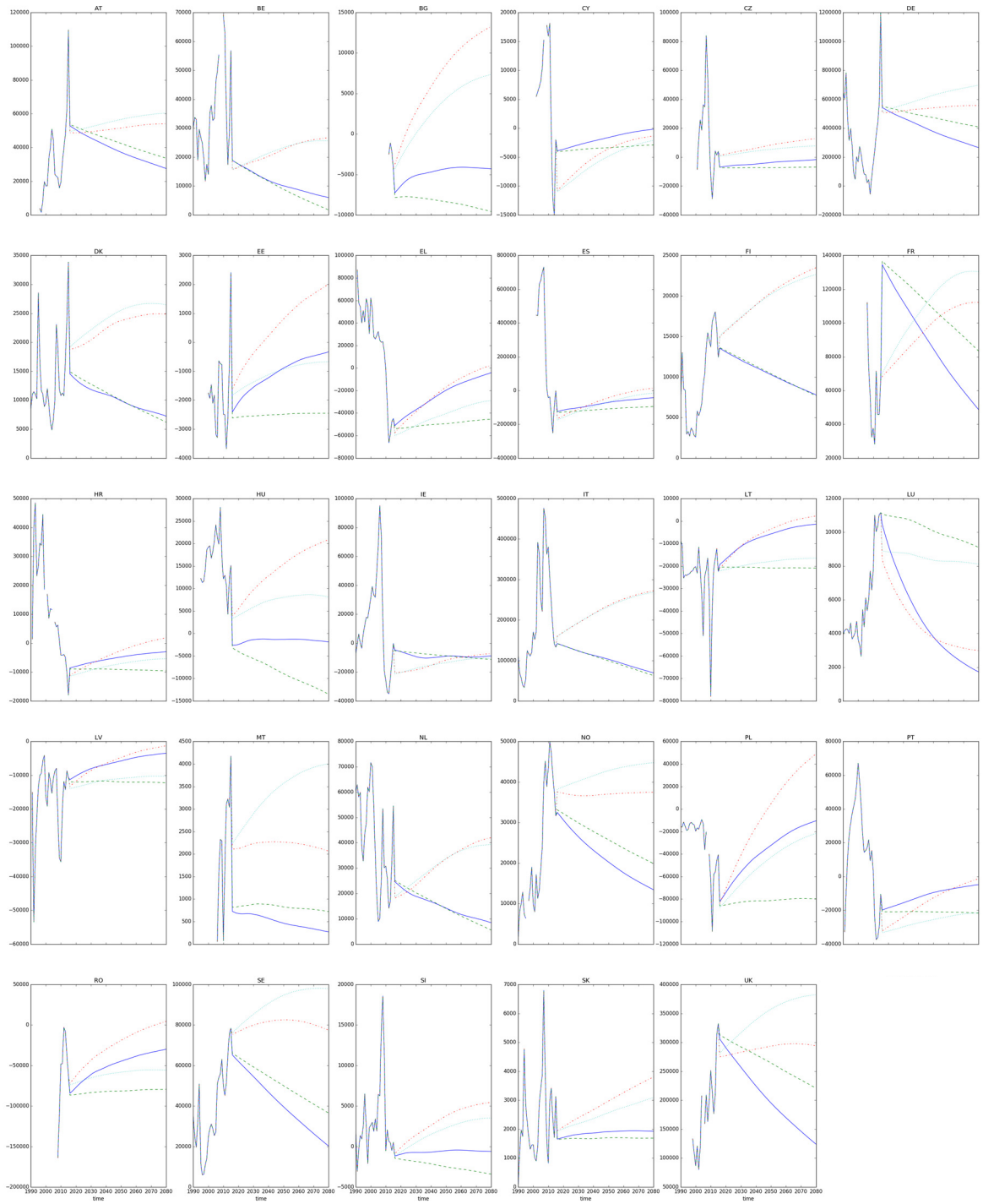
ALT1: ____ ALT2: _._._ ATL3: _ _ _ ALT4:

8.3. Deaths



ALT1: ____ ALT2: _._._ ATL3: _ _ _ ALT4: ...

8.4. Net migration



ALT1: ____ ALT2: _._._ ATL3: _ _ _ ALT4: ...