Stockholm Research Reports in Demography | no 2019:31

# Using Future Age Profiles to Improve Immigration Projections

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ISSN 2002-617X | Department of Sociology

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## Abstract

Young adults migrate more than elderly people. As populations in many origin countries get older, this may affect out-migration – and thus immigration to other countries. This is usually not taken into account in projections of future immigration, even though a marked ageing is expected to take place globally. We show how United Nations' projections of future age profiles in origin countries can be combined with emigration rates by age groups to improve national projections of immigration to a destination country, exemplified by Norway. Using several methods for projecting future migration, our results show that projected immigration tends to decline when taking expected ageing in origin regions into account. Further, we demonstrate how such declines in projected immigration affect the projections for the total Norwegian population up to 2100. Our results suggest that by taking changing age profiles in origin regions into account in immigration projections, the projected population size in Norway would be reduced equivalent to that of reducing the fertility assumptions by 0.1 children per woman.

***Keywords:*** *migration, immigration, population projections, age structure, ageing*

Stockholm Research Reports in Demography 2019:31
ISSN 2002-617X

## Introduction

Population projections are essential for planning in numerous areas, and thereby they shape future societies.

However, producing accurate population projections is challenging, mainly because it is hard to foresee the future of fertility, mortality and migration. Of these, migration is usually considered the most difficult component to forecast (Coleman, 2008; Bijak, 2011; Lee, 2011). The difficulty of forecasting migration is not primarily due to a lack of knowledge about the determinants of international migration; a vast body of literature has already identified several important determinants such as income differences, unemployment, legal changes and political unrest (Conte and Migali, 2019; de Haas, 2011; Hatton and Williamson, 2003, 2005; Karemera, Oguledo, and Davis, 2000; Kim and Cohen, 2010; Massey et al., 1993; Mayda, 2010; Ortega and Peri, 2013; Weber, 2019). The major challenge in forecasting migration is, rather, that many of these determinants are themselves hard to accurately project in the long term.

International and national agencies employ different approaches for projecting future migration (Cappelen et al., 2015), although models for forecasting migration are scarce and relatively underdeveloped (Raymer and Wiśniowski, 2018). Some agencies keep migration constant from the current level or make forecasts based on expert judgements. Others, such as the U. S. Census Bureau, project immigration of foreign-born using rates of emigration from origin countries (U. S. Census Bureau, 2018). Origin countries may be organized into regions, and rates of emigration are calculated by dividing annual figures of immigration from each origin region by figures for the population in these regions. Statistics Sweden uses emigration rates from the Nordic and EU countries in their population projections (Statistics Sweden, 2018), and Statistics Norway bases their immigration projection model on emigration rates from different parts of the world (Cappelen et al. , 2015).

In this century, a marked ageing is expected to take place globally. However, as far as we know, no national or international agency use estimates of changing age structure throughout the world in their immigration projection models. Taking this into account can be worth considering, for at least five reasons:

i) The propensity to emigrate is closely related to age, and age profiles of migration have proved quite regular across contexts (Raymer and Rogers, 2008; Raymer and

Wiśniowski, 2018; Rogers and Castro, 1981; Wiśniowski et al., 2016). Hence, there is reason to believe that changing age composition will affect out-migration.

ii) Unlike many other determinants of migration, relatively reliable forecasts exist for future age composition in all countries until 2100 (United Nations, 2019).

iii) These forecasts suggest marked changes in age profiles through this century, with potentially profound implications for international migration flows.

iv) Using different rates by age is already an integrated part of many population projections, even for projections of some migration flows.

v) Taking future age structures into account can be a relatively uncomplicated exercise, as we will show in this paper.

Utilizing migration age profiles in the pursuit of better migration forecasts has already been suggested by for instance Raymer and Wiśniowski (2018). Within the Bayesian framework, their model forecasts age and sex patterns of immigration and emigration based on observed overall migration flows by age and sex to and from a country, exemplified by considering South Korea, Sweden and Australia. We add to this literature by using *rates* (instead of absolute numbers) which we apply to *projected populations* in different origin regions, allowing us to take into account expected changes in population size and age structure in different parts of the world.

In the rest of this paper, we show how United Nations' projections of future age profiles in origin regions can be combined with rates of emigration by age groups to improve projections of immigration to a destination country, using Norway as a case. First, we briefly present the data used in this paper. Second, we introduce some relatively straightforward ways of incorporating data from the UN on changing age structures in origin regions into projections of future immigration. We use observed rates of emigration from origin regions for different age groups to project future rates, by several standard methods for extrapolating trends. Third, we show the differences in projected immigration between estimates based on disaggregated age groups versus similar estimates with no age disaggregation, and finally we show the effect of these differences on the projected future population size of Norway.

Our results show that the projected future total immigration to Norway declines when introducing age disaggregation, no matter which method is used. The effect on projected total population in Norway differs depending on the method used. For most methods, however, the effect of age disaggregation on the projected population in Norway is between 300,000 and 500,000 inhabitants in 2100, which is a sizeable effect for a population which in 2019 counts 5.3 million inhabitants. The effect size is similar to that of reducing the assumptions on fertility by 0.1 children per women throughout the projection period.

## Data and descriptives

To forecast future immigration to any country based on emigration rates from origin regions by age groups, at minimum two main data inputs are needed:

1) *Data on historic and future population in origin regions, by age groups.*
   We use the World Population Prospects (WPP) from United Nation's Population Division, which is freely available at https://population.un.org/wpp/. WPP offers estimates of the population in all countries back to 1950 by 5-years age groups, and also provides projections of population by 5-years age groups for all countries up until 2100. In this study, we use the medium variant from WPP 2019.[1]
2) *Data on immigration to the country of interest, by origin and age groups.*
   We use Statistics Norway's data on immigration to Norway, which are based on the Norwegian population register and cover all immigrants who have moved to Norway. Immigrants are defined as persons born abroad to foreign-born parents and grandparents and who have immigrated to Norway in order to stay for at least six months, with legal permission to stay. Immigrants who emigrated the same year as they came are removed from this sample; they constitute around 1,000 annually.

Dividing figures on annual migration from an origin region to Norway by the origin population will result in annual migration rates – either for the total population or for age groups. From these rates, forecasts of future rates can be made. Several methods can be used for such forecasts, such as an average over a given number of years, or different versions of extrapolations of the observed migration rates. The methods used in this paper will be elaborated on in more detail after the presentation of the origin country groups and age groups.

[1] *Other variants are also available from WPP, such as for high and low fertility.*

*The country groups*

The categorization of origin country groups obviously depends on the national context and migration history. Norway has received immigrants from most countries in the world. Until the mid-1980s, immigrants mostly came from other Western countries. Immigration from non-Western countries has increased substantially since the mid-1980s, and after the EU enlargement in 2004 there was a steep increase in immigration from the new member states.

In this paper, the immigrants' origin countries have been grouped into three regions: Country group 1 includes Western Europe, US, Canada, Australia and New Zealand, Country group 2 includes the new, eastern EU member states, whereas the rest of the world comprises Country group 3. Figure 1 shows the immigration to Norway from these country groups since 1975. Since 2011, immigration from Country group 1 (Western countries) and Country group 2 (new, eastern EU states) has decreased markedly. This decline can mainly be explained by economic circumstances in Norway and in origin. Immigration from Country group 3 has not seen the same decrease, but peaked in 2016, which to a large extent was due to an influx of Syrian refugees. Immigrants from the three groups have to some degree met different sets of legal frameworks for entering and staying in Norway, and they tend to be driven by different reasons for immigration (Statistics Norway, 2019).

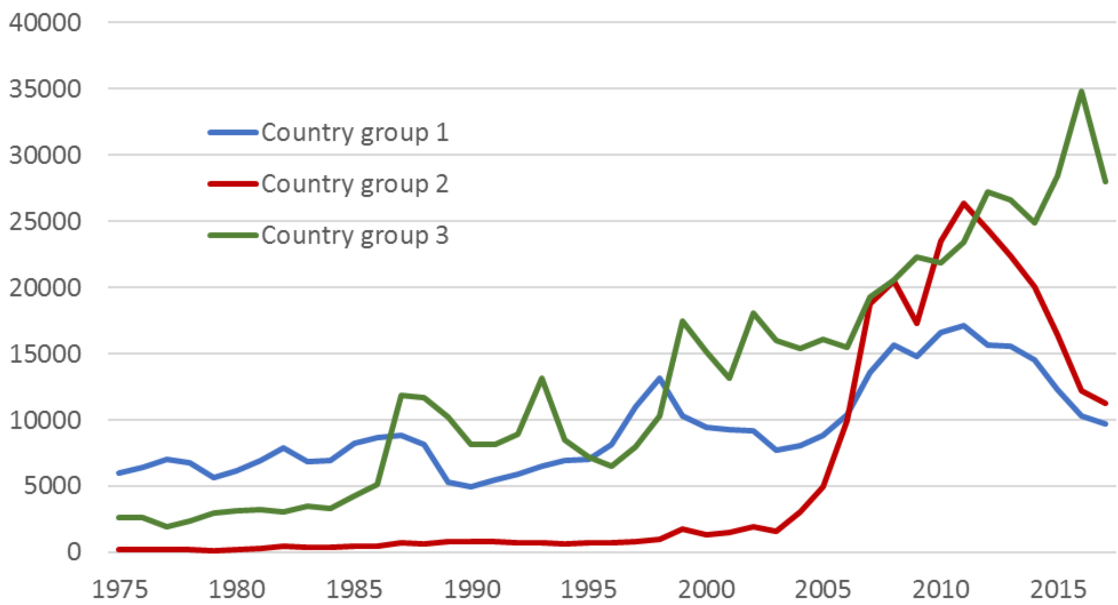


**Figure 1: Immigration to Norway from three origin country groups, 1975-2017.**

*The age groups*

Although immigrants from the three country groups differ, their age profiles at immigration have been relatively similar, and these profiles also tend to be quite stable over time. Figure 2 shows the arrival age of immigrants who moved to Norway from 1990 to 2017, by country group.

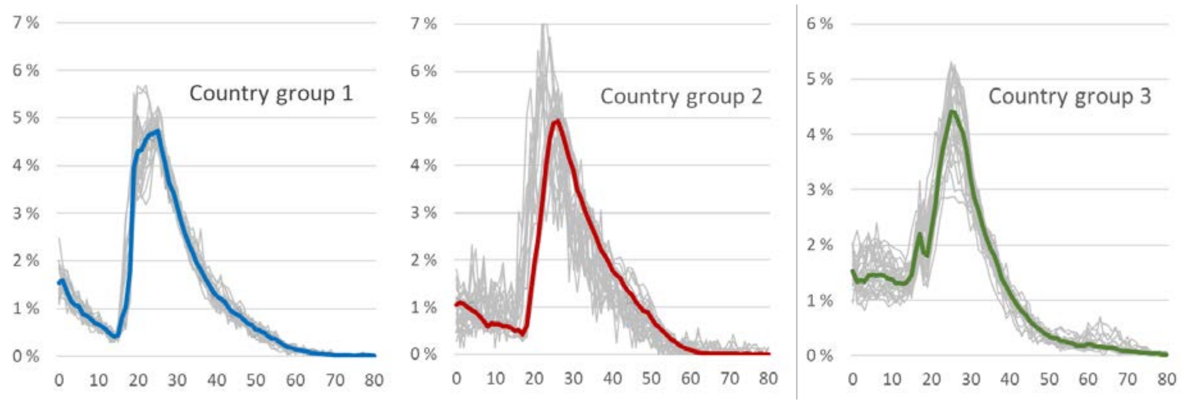


**Figure 2: Age profiles of immigrant arriving in Norway by origin country group, coloured lines show averages, thin grey lines show single arrival years, 1990-2017.**

The patterns shown in Figure 2 are fairly similar to many other age profiles of migration: The mid-20s is the most common arrival age for all the three groups. The youngest children also constitute a fair share of all immigrations, with declining shares until around age 15. Thereafter we see a sharp increase, before the shares fall again after the mid-20s. Very few immigrants arrive at old ages.

In this paper, we use three age groups, which can roughly be described as i) children (0-14 years), ii) peak migration age (15-39 years) and iii) older ages (40 years and older), see Figure 3. Many different age group classifications could be used employing our methods. We have preferred to keep the number of groups small to avoid groups with too few observations, and also to allow for possible slight changes in the age profiles over time. Since the WPP data on origin populations use five years age groups, we have ensured that the age division lines are divisible by 5.

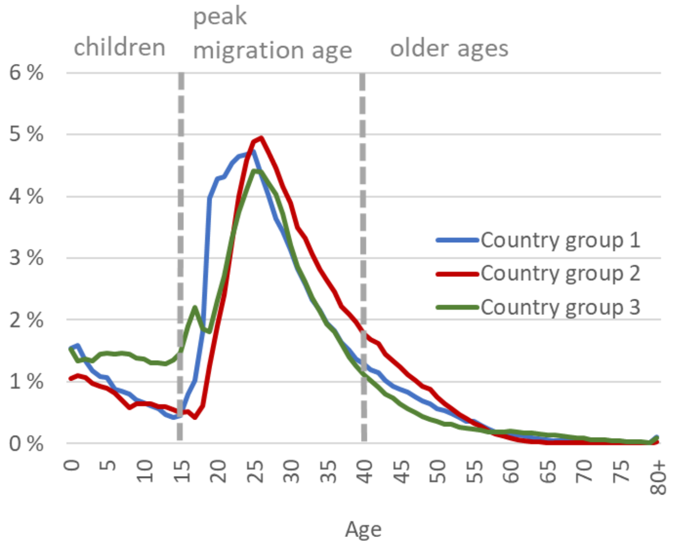


**Figure 3: Classification of immigrant's arrival ages in Norway and average age profiles for immigrants arriving 1990-2017, by origin country group.**

The WPP show that the share of the population in the peak migration ages is on the decline in most of the world. Figure 4 shows estimated and projected population (WPP, medium variant) by share in each age group, by origin country group. While the projected share of children is constant or declining, the share of population in the more sedentary older ages is expected to increase markedly, particularly in Country group 2 (new, eastern EU member states) and Country group 3 (rest of the world).

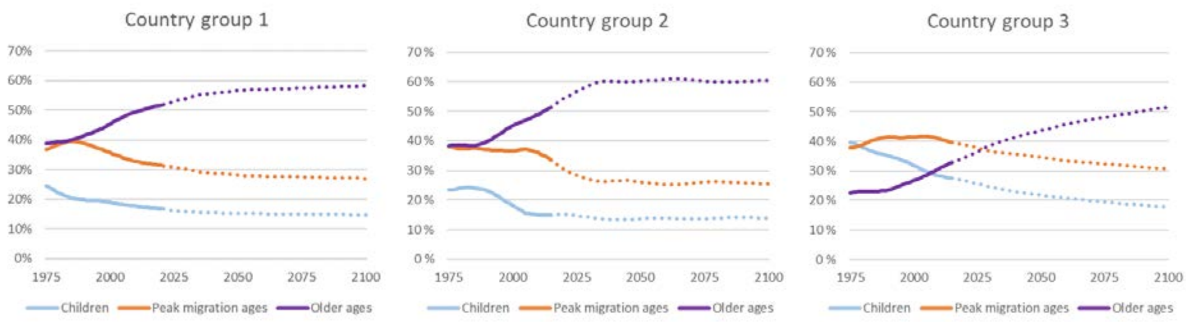


**Figure 4: Share of population in different age groups, estimated and projected by the WPP 2019 medium variant, by country groups, 1975-2100.**

The fact that most people migrate in ages that will constitute a decreasing share of the population in most origin regions, suggests that this may be an important factor to take into account when projecting future immigration. In the following, we show how this can be done.

## Methods

To provide estimates of how an immigration forecast model disaggregated by age groups would affect population projections, we apply a three-step procedure. First, we calculate emigration rates based on registered data up until 2017 (from Statistics Norway on immigration to Norway and from United Nation on population in the country groups). Figure A1 in the Appendix shows how these rates have changed over time, by age group and by country group. Second, we project future emigration rates for each of the three country groups, using several methods for extrapolation (elaborated below). For each method we make two different extrapolations: One based on emigration rates for the total population, and one based on separate rates for the three age groups defined above. These emigration rates are, in turn, applied to UN's projections of population in origin, for all ages and disaggregated into the three age groups. This gives us projections of future migration to Norway with and without the use of age profiles in origin.

Secondly, the differences between the two extrapolations (aggregated and disaggregated by age groups) are estimated, showing how immigration projections for Norway could change if changing age profiles in origin are taken into account. To illustrate the magnitude of these differences, we use the Norwegian model for official population projections to project future population in Norway with and without the differences. This gives us an impression of the cumulative, long term effect such a model change may have on population projections, exemplified by Norway.

*Projecting migration rates*

From observed annual migration rates, projections of future migration rates may be obtained in many ways. In this paper we consider several methods, as described below. For each method, we derive future migration rates for each of the three age groups as well as for the whole population, to compare projections from the age-disaggregated method with the method without disaggregation. This is done for all the three country groups / regions.

To make the description clear we need to introduce some symbols and formalism. Let $POP_{ajt}$ denote the population in age group *a* (*a*=1,2,3) in thousand persons in region *j* (*j*=1,2,3) in year $t$, and let $EMI_{ajt}$ denote the number of emigrants in age group $a$ ($a$=1,2,3) from region $j$ ($j$=1,2,3) to Norway in year $t$. We define the emigration rates in the different age groups as

$$emiint_{ajt} = \frac{EMI_{ajt}}{POP_{ajt}};\ j = 1,2,3; a = 1,2,3 \tag{1}$$

The total populations of a specific region and the total number of emigrants to Norway from this region are, respectively, given by

$$POP_{jt} = POP_{1jt} + POP_{2jt} + POP_{3jt};\ j = 1,2,3 \tag{2}$$

$$EMI_{jt} = EMI_{1jt} + EMI_{2jt} + EMI_{3jt};\ j = 1,2,3 \tag{3}$$

Given Eqs. (2) and (3), we define the aggregate emigration rates as

$$emiint_{jt} = \frac{EMI_{jt}}{POP_{jt}};\ j = 1,2,3 \tag{4}$$

We consider projections for the years 2018-2100.

We may group our different methods within two main categories. The first category is based on the mean (weighted or unweighted) of emigration rates over some years prior to 2018. The second category utilises time series processes, i.e., vector autoregressive (VAR) and autoregressive (AR) models, to forecast the emigration rates. A schematic overview of the different projection methods is given in Table 1. Below we give a more detailed description of the different main categories and their content.

***Projections based on historical means of emigration rates (Category M1)***

Our first method is based on using arithmetic means of emigration rates using the period 2008-2017. These are given by

$$emiint\_10_{aj} = \frac{1}{10}\sum_{t=2008}^{2017} emiint_{ajt};\ j = 1,2,3; a = 1,2,3 \tag{5}$$

and

$$emiint\_10_{j} = \frac{1}{10}\sum_{t=2008}^{2017} emiint_{jt};\ j = 1,2,3 \tag{6}$$

The emigration to Norway by individual age groups from region *j* is then given by

$$EMI_{ajt}^{M1.1} = emiint\_10_{aj} \times POP_{ajt}; \; j = 1,2,3; a = 1,2,3; t = 2018,...,2100 \quad (7)$$

From (7) it follows that the projected aggregate emigration from region *j* to Norway is given by

$$EMI(dis)_{ajt}^{M1.1} = EMI(dis)_{1jt}^{M1.1} + EMI(dis)_{2jt}^{M1.1} + EMI(dis)_{3jt}^{M1.1}, \; j = 1,2,3; t = 2108,...,2100 \quad (8)$$

Using the aggregate rates for the total emigration to Norway from region *j* instead, we have

$$EMI(agg)_{jt}^{M1.1} = emiint\_10_{j} \times POP_{jt}; \; j = 1,2,3; t = 2108,...,2100 \quad (9)$$

The notation (*dis*) and (*agg*) above is used to distinguish between aggregate immigration to Norway from region *j* projected by the disaggregated and the aggregated method, respectively. This is valid for all cases, not only for *M*1.1.

Our second case, which we refer to as *M*1.2, is virtually identical to the first method, the only difference being that the means are based on the shorter period 2013-2017.

Whereas the two cases above are based on an unweighted mean, the third and last case of this main category, M1.3, is based on a weighting scheme. The emigration rate in the last year with data is given the largest weight. Then, the weight decreases for each year one goes further back in time. A correction has been carried through such that the weights sum to unity. Formally, we have

$$emiint\_10w_{aj} = \sum_{t=2008}^{2017} \omega_{t-2008} \times emiint_{ajt}; \; j = 1,2,3; a = 1,2,3 \quad (10)$$

and

$$emiint\_10w_{j} = \sum_{t=2008}^{2017} \omega_{t-2008} \times emiint_{jt}; \; j = 1,2,3, \quad (11)$$

where the weights are given as

$$\omega_j = \frac{0.5 \times (1-0.5)^j}{1-(1-0.5)^{10}}; \; j = 0,...,9 \quad (12)$$

It follows from Eq. (12) that

$$\sum_{j=0}^{9} \omega_j = 1, \tag{13}$$

and that all the weights are positive. Corresponding to Eqs. (7)-(9) we now have

$$EMI_{ajt}^{M1.3} = emiint\_10w_{aj} \times POP_{ajt};\ j = 1,2,3; a = 1,2,3; t = 2108,...,2100, \tag{14}$$

$$EMI(dis)_{ajt}^{M1.3} = EMI(dis)_{1jt}^{M1.3} + EMI(dis)_{2jt}^{M1.3} + EMI(dis)_{3jt}^{M1.3},\ j = 1,2,3; t = 2108,...,2100 \tag{15}$$

and

$$EMI(agg)_{jt}^{M1.3} = emiint\_10w_j \times POP_{jt};\ j = 1,2,3; t = 2108,...,2100 \tag{16}$$

Instead of using arithmetic means, as in conjunction with methods *M1.1* and *M1.2,* one may alternatively employ geometrical or harmonic means.[2]

***Projections based on time series models (Category M2)***

We use either AR or VAR models with different number of lags. Altogether we consider four different cases within this category. Cases *M*2.1 and *M*2.3 are based on a lag length of one whereas cases *M*2.2 and *M*2.4 are based on a lag length of two. Cases *M*2.1 and *M*2.2 are based on VAR models using the disaggregate approach, whereas cases *M*2.3 and *M*2.4 are based on AR models using the disaggregate approach for total emigration from an origin region to Norway. All the variables are log-transformed for *Category M*2. In the following a detailed description for case *M2.1* is presented. Consider the following VAR(1) model for the three variables $emiint_{1jt}, emiint_{2jt}$ and $emiint_{3jt}$ (*j*=1,…,3):

$$\begin{aligned}\log(emiint_{1jt}) = \lambda_{1j} + \eta_{11j} \times \log(emiint_{1j,t-1}) + \eta_{12j} \times \log(emiint_{2j,t-1}) + \\ \eta_{13j} \times \log(emiint_{3j,t-1}) + \varepsilon_{1jt};\ j = 1,2,3,\end{aligned} \tag{17}$$

$$\begin{aligned}\log(emiint_{2jt}) = \lambda_{2j} + \eta_{21j} \times \log(emiint_{1j,t-1}) + \eta_{22j} \times \log(emiint_{2j,t-1}) + \\ \eta_{23j} \times \log(emiint_{3j,t-1}) + \varepsilon_{2jt};\ j = 1,2,3,\end{aligned} \tag{18}$$

$$\begin{aligned}\log(emiint_{3jt}) = \lambda_{3j} + \eta_{31j} \times \log(emiint_{1j,t-1}) + \eta_{32j} \times \log(emiint_{2j,t-1}) + \\ \eta_{33j} \times \log(emiint_{3j,t-1}) + \varepsilon_{3jt};\ j = 1,2,3.\end{aligned} \tag{19}$$

[2] *However, in the current study the results based on geometric and harmonic means gave broadly the same results as those based on the arithmetic means and are hence not reported.*

In Eqs. (17)-(19) $\lambda_{aj}, \eta_{ikj}; a,i,k = 1,...,3$ are unknown parameters to be estimated and $\varepsilon_{ajt}$ ( $a, j = 1,...,3$ ) are error terms. The vector $\varepsilon_{jt} = \begin{bmatrix} \varepsilon_{1jt}, & \varepsilon_{2jt}, & \varepsilon_{3jt} \end{bmatrix}^{/}$ is assumed to be a white noise vector process with $E(\varepsilon_{jt}\varepsilon_{jt}^{/}) = \Omega$ , where $\Omega$ is an unconstrained positive definite covariance matrix. Using this model, the emigration rates for the three age groups in origin region *j* may be forecasted iteratively by employing the following recursive equations

$$emiint\_M2.1_{1jt} = \exp(\hat{\lambda}_{1j} + \hat{\eta}_{11j} \times \log(emiint\_M2.1_{1j,t-1}) + \hat{\eta}_{12j} \times \log(emiint\_M2.1_{2j,t-1}) + \hat{\eta}_{13j} \times \log(emiint\_M2.1_{3j,t-1})); j = 1,2,3; t = 2018,...,2100 \tag{20}$$

$$emiint\_M2.1_{2jt} = \exp(\hat{\lambda}_{2j} + \hat{\eta}_{21j} \times \log(emiint\_M2.1_{1j,t-1}) + \hat{\eta}_{22j} \times \log(emiint\_M2.1_{2j,t-1}) + \hat{\eta}_{23j} \times \log(emiint\_M2.1_{3j,t-1})); j = 1,2,3; t = 2018,...,2100 \tag{21}$$

$$emiint\_M2.1_{3jt} = \exp(\hat{\lambda}_{3j} + \hat{\eta}_{31j} \times \log(emiint\_M2.1_{1j,t-1}) + \hat{\eta}_{32j} \times \log(emiint\_M2.1_{2j,t-1}) + \hat{\eta}_{33j} \times \log(emiint\_M2.1_{3j,t-1})); j = 1,2,3; t = 2018,...,2100, \tag{22}$$

where

$emiint\_M2.1_{aj2017} = emiint_{aj2017}$, $a, j$ = 1,…,3. In Eqs. (20)-(22) a ^ denotes an OLS estimate. In conjunction with the aggregate method we use an AR(1)-model, i.e.,

$$\log(emiint_{jt}) = \lambda_j + \eta_j \times \log(emiint_{j,t-1}) + \varepsilon_{jt}; j = 1,2,3, \tag{23}$$

where $\lambda_j$ and $\eta_j$ (*j*=1,…,3) denote unknown parameters to be estimated and $\varepsilon_{jt}$ is a white noise error term. Using this model, the emigration rate for country group *j* may be forecasted iteratively by employing the following recursive equation

$$emiint\_M2.1_{jt} = \exp(\hat{\lambda}_j + \hat{\eta}_j \times \log(emiint\_M2.1_{j,t-1})); j = 1,2,3; t = 2018,...,2100, \tag{24}$$

where $emiint\_M2.1_{j2017} = emiint_{j2017}$, $j = 1,...,3$. Again a ^ denotes an OLS estimate.

The projected emigration to Norway by individual age groups from country group *j* is then, for case *M*2.1, given by

$$EMI_{ajt}^{M2.1} = emiint\_M2.1_{aj} \times POP_{ajt}; j = 1,2,3; a = 1,2,3; t = 2108,...,2100 \tag{25}$$

From (25) it follows that the projected aggregate emigration from country group *j* to Norway is given by

$$EMI(dis)_{ajt}^{M2.1} = EMI(dis)_{1jt}^{M2.1} + EMI(dis)_{2jt}^{M2.1} + EMI(dis)_{3jt}^{M2.1},\ j = 1,2,3; t = 2108,...,2100. \tag{26}$$

Using the aggregate rates for the total emigration to Norway from country group *j* instead, we have

$$EMI(agg)_{jt}^{M2.1} = emiint\_M2.1_j \times POP_{jt};\ j = 1,2,3; t = 2108,...,2100 \tag{27}$$

**Table 1. An overview of projection methods for emigration rates used in this study.**

| Main category | Case | Description |
|---|---|---|
| **M1** | | **Weighted and unweighted mean of historical emigration rates** |
| | M1.1 | 10 years unweighted mean (2008-2017) |
| | M1.2 | 5 years unweighted mean (2013-2017) |
| | M1.3 | Weighted mean using the years 2008-2017, most recent year has most weight |
| **M2** | | **VAR and AR models** |
| | M2.1 | VAR(1) models for the three emigration rates according to age group. AR(1) model for the aggregate emigration rate (in the aggregate case). |
| | M2.2 | VAR(2) models for the three emigration rates according to age group. AR(2) model for the aggregate emigration rate (in the aggregate case). |
| | M2.3 | AR(1) models for the emigration rates for both the aggregated and age-disaggregated approach. |
| | M2.4 | AR(2) models for the emigration rates for both the aggregated and age-disaggregated approach. |

# Results

In Figure 5, the difference between the solid and the dotted lines of the same colour shows the effect of estimating future immigration using age groups. For the solid lines, no age information was used, whereas the dotted lines show the sum of immigration estimated separately for each of the three age groups. When the dotted line lies below the solid line of the same colour, introducing age disaggregation in the forecast reduces the projected future immigration to Norway.

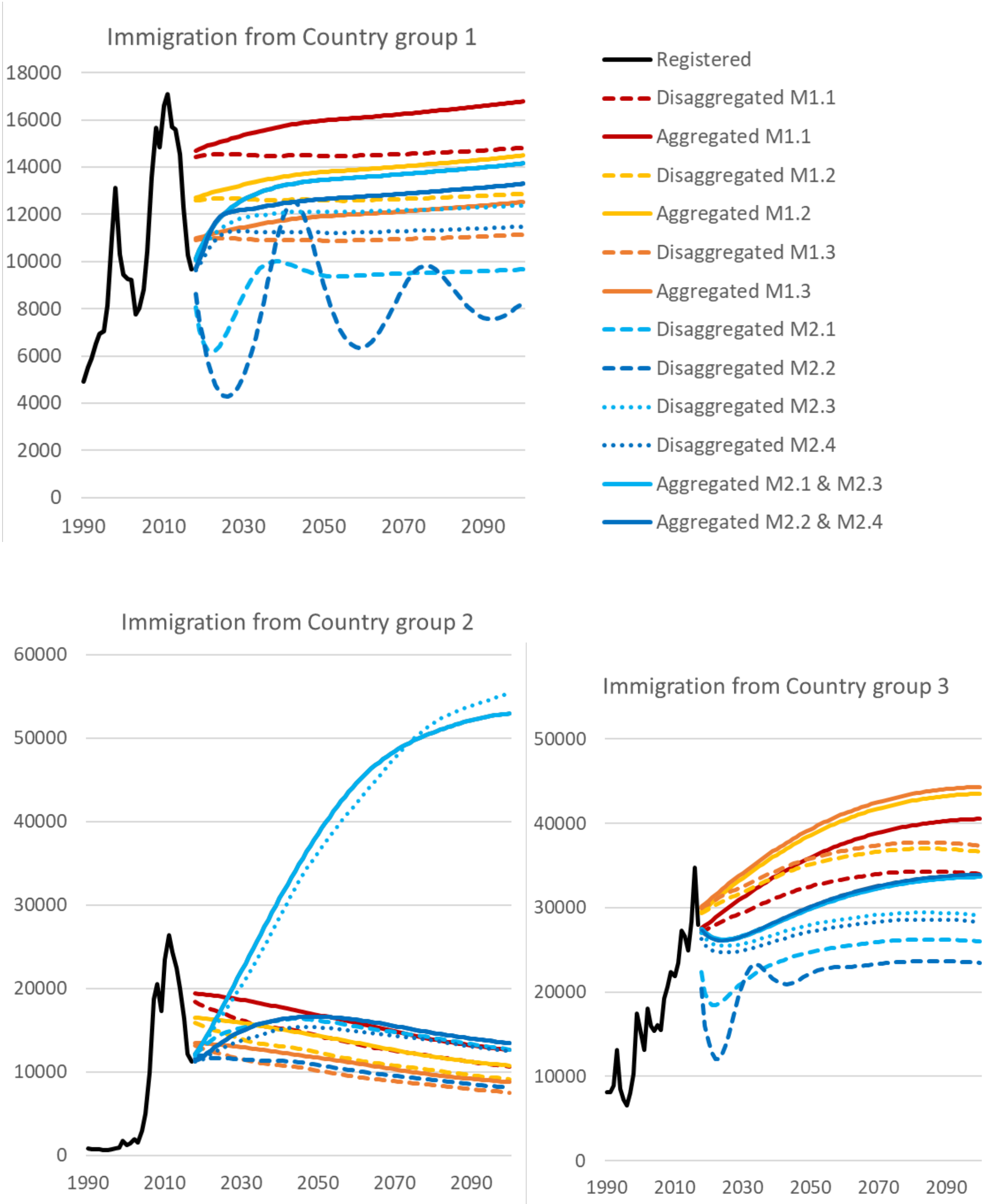


**Figure 5: Immigration to Norway from three origin country groups, registered 1990-2017 and projected 2018-2100 by different methods (displayed in different colours), using disaggregated age groups in origin regions (dotted/dashed lines) or no age disaggregation (solid lines).**

The results are almost univocal: For Country group 1 (Western countries) projected future immigration to Norway declines with age disaggregation, no matter which method we employ. The same is the case for Country group 3 (rest of the world). For Country group 2 (new Eastern EU member states), six out of seven methods yielded similar results. For the last method, *M*2.3, introducing age disaggregation reduced projected immigration during most of the projection period, but not in the far future. For the whole projection period taken together, however, the aggregate method in *M*2.3 yielded higher immigration projections than the corresponding age-disaggregated method. However, we think that the projections for Country group 2 produced by method *M*2.3 are far too high both in the disaggregate and aggregate case.[3] It is striking that the projections in this case deviate so substantially from those obtained by employing methods *M*2.1 (in the disaggregate case), *M*2.2 and *M*2.4. It may indicate that the time-series models used in *M*2.3 are relatively more mis-specified than the other time series processed involved in our analysis. For all the AR-/VAR-models we have left out possible intervention variables in order to have simpler and more mechanical specifications.[4]

In the Appendix, Figure A2 shows the sum of these results across country groups. More detailed figures on the differences by country groups and models are shown in Figure A3.

Since we are not primarily interested in the *levels* of the forecasts from each of these models, but the difference between the age-aggregated and –disaggregated approach, in Figure 6 we only show the differences between aggregated and disaggregated results within each method, summarized over the three country groups. The lower the line, the more negative is the effect of introducing age disaggregation in projections of immigration.

[3] *Recall that method M2.3 coincides with method* M*2.1 in the aggregate case.*

[4] *On other occasions we have made use of a level shift variable to pick up the effect of the extension of EU in 2004, which gave individuals in most of the countries in Country group 2 much easier access to Norway. The level shift variable is 0 until 2003, 0.67 in 2004 and 1 from 2005 onwards. Incorporating this dummy variable, possibly alongside some other intervention variables, could have generated predictions using M2.3 that would have been more in line with those obtained using the other time series models.*

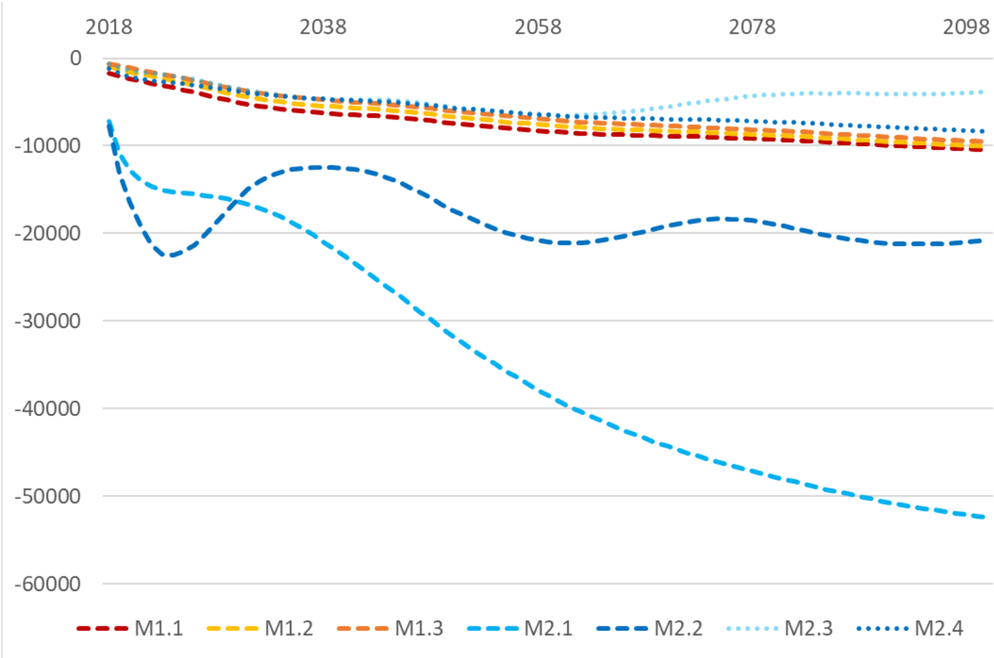


**Figure 6: Difference in annual immigration to Norway if method disaggregates by age. Sum of the three origin country groups.**

The results based on methods *M*2.1 and *M*2.2 deviate somewhat from the others in that the effects are quite large, and we judge them not to be credible. As revealed by Figure A3 in Appendix, these results are related to Country group 2 in the case of method *M*2.1 and Country group 3 in case of methods *M*2.2. For both country groups it may be advantageous to include intervention variables in the time series models to pick up effects of important events that have occurred during the estimation period.  For most of the other methods used, annual total forecasted immigration would be between 100 and 1,000 persons lower if future age profiles in origin regions were to be taken into account.

*Effect on the projected population*

One way to measure the long-term effect of this change, could be to simply add up the annual differences in projected immigration over the projection period. However, this does not necessarily correspond to the effect on the population size, since some immigrants emigrate from Norway, whereas some die and some give birth. By using the Norwegian model for (official) population projections, we have calculated the effect on the projected total population in Norway. This model is a cohort-component model where different immigrant groups have different rates for fertility and emigration out from Norway, by origin region (corresponding to the country groups described above) and their duration of stay, as well as by age and sex (Syse et al., 2018). Mortality rates are similar for immigrants and natives. We use the same rates for fertility, mortality and out-migration as were used in the last official Norwegian population projection (published in 2018). The only differences from these projections are the changes made in immigration assumptions for each country group, where the differences resulting from age disaggregation were subtracted from the original immigration assumptions.

In Figure 7 the differences in projected population size of Norway due to the introduction of age disaggregation are shown. Not surprisingly, the differences are largest (more than two million inhabitants in 2100) for the *M*2.1 model, which also showed the largest differences in projected immigration.

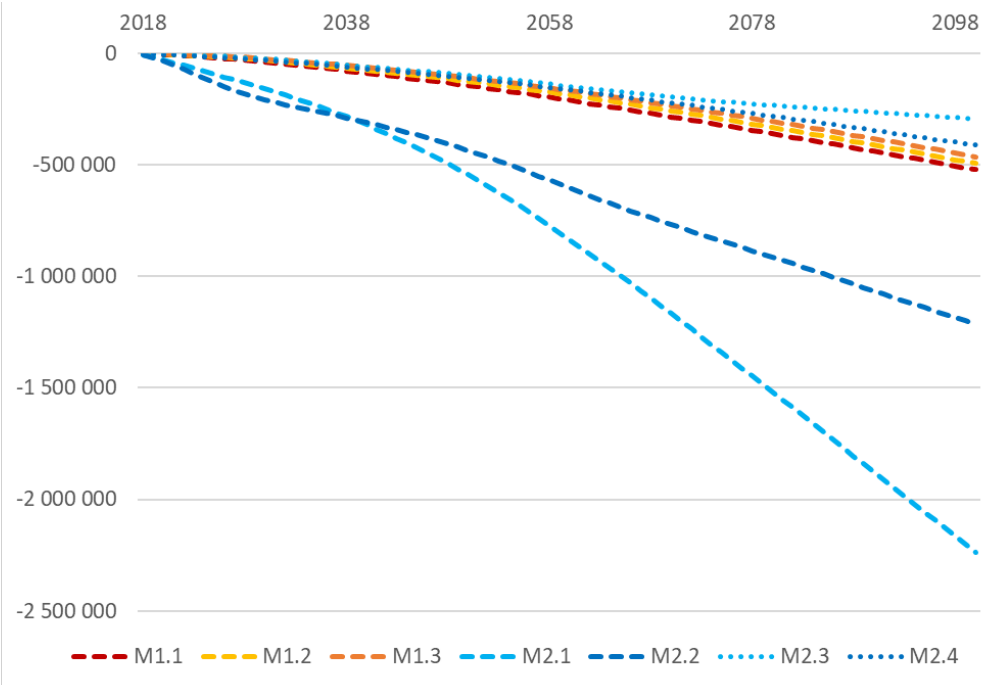


**Figure 7: Differences in projected population size in Norway caused by introducing age disaggregation into immigration projections.**

For most methods, however, the effect on the projected population in Norway in 2100 lies between 300,000 and 500,000 inhabitants. This is a considerable effect, given that Norway's population in January 2019 was 5.3 million, and it is projected to increase to about 7.3 million in 2100 according to the official projection's main alternative. For comparison, Norway's capital Oslo has 690,000 inhabitants and the second largest city Bergen has 280,000. However, given the large uncertainty in population projections, the size of this effect may rather be illustrated by comparing with the effect of changing other assumptions: If the assumption on fertility had been reduced by 0.1 children per women, the effect on projected population size in 2100 would have been around 450,000, almost the same as the effect of disaggregating by age using the majority of our methods. Or to put it differently: Disaggregation by age in the immigration projections would have approximately the same effect on future population size as reducing the assumptions on future period total fertility rate by 0.1 children per woman.

## Conclusion and further work

Population projections are essential tools in planning for our future societies. However, they are uncertain, not the least because projections of future immigration are very uncertain.

In the literature on determinants of migration, a lot of work has been devoted to estimating the effect of different factors on migration flows. However, for these estimates to be useful for migration projections, also forecasts of the relevant factors must be available, which seldom is the case in the very long term. Here, we instead focus on a nearly neglected demographic factor relevant for migration, which has the potential to be more rewarding for immigration projections, and for which there exists relatively reliable forecasts: Ageing in origin regions.

Population ageing is already taking place in most countries of the world, as a result of declined fertility and increasing life expectancy, and it is expected to continue in the years to come. This ageing can have clear implications on migration flows, simply by reducing the share of population with the largest risk of migration. By making explicit in immigration projections the role of this profound international demographic process of ageing, we are treating international migration as an integrated part of other global demographic patterns and processes.

Using different simple projections method, we have found that accounting for ageing in origin regions tends to lower the projected immigration to Norway in the period 2018-2100. We have compared two strategies for projecting immigration to Norway from three different regions. First we neglect the age structure and project emigration rates from the regions to Norway for all ages in total. Second, we utilise specific emigration rates for three age groups in three global country-group regions. We find that the effects of disaggregating by age are sizeable, although they vary somewhat between the different methods. In most methods, however, disaggregation by age in the immigration projections has approximately the same effect on future population size as reducing the assumptions on future period total fertility rate by 0.1 children per woman.

Thus, although many trends such as cheaper transport and more transnational ties may suggest increasing migration between countries in the years to come, our results suggest that ageing in origin is likely to pull in the other direction and contribute to less migration.

Since the UN data are freely available, including information on ageing in origin countries is possible in all national contexts, as long as national data on immigration by origin country exist. The UN publishes its data at the country-level, which allows for large flexibility when it comes to tailoring the country-groupings to mirror the immigration situation in the destination country studied.

It is possible that the effects of changing age structure may in fact be stronger than we estimate. Smaller cohorts may meet quite different opportunities in their home country compared to what larger cohorts do (Pampel and Peters, 1995). For instance, their possibilities in the labour market may be different, with less competition for jobs, while different demands or expectations in the family sphere may also emerge with fewer siblings to take care of elderly parents. Such factors may increase the propensity for smaller cohorts to stay in their country of origin.

In addition to the relatively simple methods shown here, other methods can also be employed for projecting future migration rates. In this paper we have not utilized economic (incentive) variables when projecting the emigration rates. The most recent official population published by Statistics Norway employed econometric models that resemble those reported by Cappelen et al. (2015). These are dynamic single equation models for the total emigration rates, and  economic incentive variables were relative income variables, operationalized as the ratio between purchasing power adjusted GNP per capita in Norway and GNP per capita in an origin region, unemployment rates both in the origin region and in Norway, and for Country group 3 also the stock of immigrants from this region already living in Norway as a proxy for network effects. Furthermore, some dummy variables were included to capture the effects of special events. Also within this framework, it should be possible to use a more disaggregated approach, in which each of the three regions has a set of regression equations, where the left-hand variables are (logs of) emigrations rates for the three age groups we have considered in this paper. Another future line of work includes adapting the age profiles used when distributing immigrants by age in single years into the cohort-component model, so that it corresponds to the immigrations projected for each age group.

In conclusion, the results of this study make a case for accounting for changing age profiles in origin regions when projecting future immigration to any country, irrespective of the method currently in use. Although this is only one of a multitude of factors that may affect future migration flows, it is one of very few where really long-term forecasts exist.

## Acknowledgements

We are grateful for constructive comments provided by Gunnar Andersson, Astri Syse and Michael Thomas, as well as participants at Stockholm University's SUDA Colloquium and the Nordic 2019 meeting for population projections in Copenhagen. This work has been supported by Statistics Norway and the Swedish Research Council (Vetenskapsrådet) through the Swedish Initiative for Research on Microdata in the Social and Medical Sciences (SIMSAM), grant number 340-2013-5164.

## References


Bijak, J. 2011. Forecasting International Migration in Europe: A Bayesian View. Dordrecht: Springer.

Cappelen, Å., T. Skjerpen, and M. Tønnessen. 2015. Forecasting Immigration in Official Population Projections Using an Econometric Model. International Migration Review, 49(4), 945–980.

Coleman, D. 2008. The demographic effects of international migration in Europe. Oxford Review of Economic Policy, 24(3), 452–476.

Conte, A., and S. Migali. 2019. The role of conflict and organized violence in international forced migration. Demographic Research, 41(14), 393–424.

de Haas, H. 2011. The determinants of international migration. IMI Working Papers (32) International Migration Institute.

Hatton, T. J., and J. G. Williamson. 2003. Demographic and Economic Pressure on Emigration out of Africa. Scandinavian Journal of Economics, 105(3), 465–486.

Hatton, T. J., and J. G. Williamson. 2005. What fundamentals drive world migration? In: Borjas G.J., Crisp J. (eds) Poverty, International Migration and Asylum. Studies in Development Economics and Policy. Palgrave Macmillan, London

Karemera, D., V. I. Oguledo, and B. Davis. 2000. A gravity model analysis of international migration to North America. Applied Economics, 32(13), 1745–1755.

Kim, K., and J. E. Cohen. 2010. Determinants of International Migration Flows to and from Industrialized Countries: A Panel Data Approach beyond Gravity. International Migration Review, 44(4), 899–932.

Lee, R. 2011. The outlook for population growth. Science, 333(6042), 569–573.

Massey, D. S., J. Arango, G. Hugo, A. Kouaouci, A. Pellegrino, and J. E. Taylor. 1993. Theories of international migration: A review and appraisal. Population and Development Review, 43, 1–466.

Mayda, A. M. 2010. International migration: A panel data analysis of the determinants of bilateral flows. Journal of Population Economics, 23(4), 1249–1274.

Ortega, F., and G. Peri. 2013. The effect of income and immigration policies on international migration. Migration Studies, 1(1), 47–74.

Pampel, F. C., and H. E. Peters. 1995. The Easterlin Effect. Annual Review of Sociology, 21(1), 163–194.

Raymer, J. and A. Wiśniowski. 2018. Applying and testing a forecasting model for age and sex patterns of immigration and emigration. Population Studies, 72(3), 339–355.

Raymer, J. and A. Rogers. 2008. Applying model migration schedules to represent age-specific migration flows." International migration in Europe: Data, models and estimates (2008): 175-192.

Rogers, A., and L. J. Castro. 1981. Model migration schedules. International Institute for Applied System Analysis, Austria

Statistics Norway.2019. Immigrants by reason for migration. Statistics accessed September 2019 at https://www.ssb.no/en/befolkning/statistikker/innvgrunn

Statistics Sweden. 2018. Sveriges framtida befolkning 2018–2070.

Syse, A., S. Leknes, S. Løkken, and M. Tønnessen. 2018. Norway's 2018 population projections Main results, methods and assumptions. Reports 2018/22, Statistics Norway.

United Nations. 2019. World Population Prospects 2019. Population Division, Department of Economic and Social Affairs. Accessed September 2019 at https://population.un.org/wpp/

United States Census Bureau. 2018. Methodology, Assumptions, and Inputs for the 2017 National Population Projections. Accessed September 2019 at https://www2.census.gov/programs-surveys/popproj/technical-documentation/methodology/methodstatement17.pdf

Weber, H. 2019. Can Violent Conflicts Explain the Recent Increase in the Flow of Asylum Seekers From Africa Into Europe? Journal of Immigrant and Refugee Studies, 17(4), 405–424. https://doi.org/10.1080/15562948.2018.1517424

Wiśniowski, A., J. J. Forster, P. W. F. Smith, J. Bijak, and J. Raymer. 2016. Integrated modelling of age and sex patterns of European migration. Journal of the Royal Statistical Society: Series A, 179(4), 1007–1024.

## Appendix: Additional figures

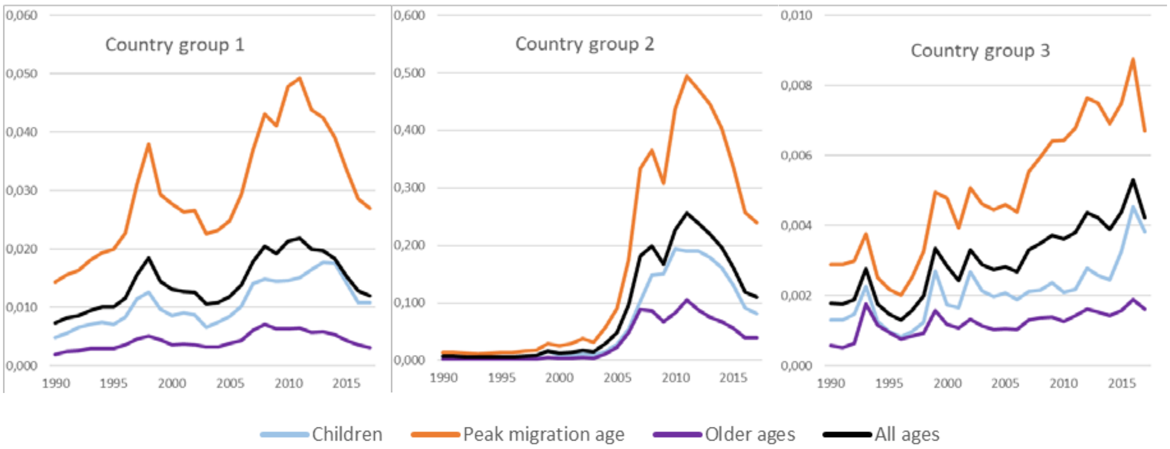


**Figure A1: Registered rates of emigration to Norway from three country groups, for all ages (black lines) and by age groups. Rates are shown as emigrations per thousand inhabitants.**

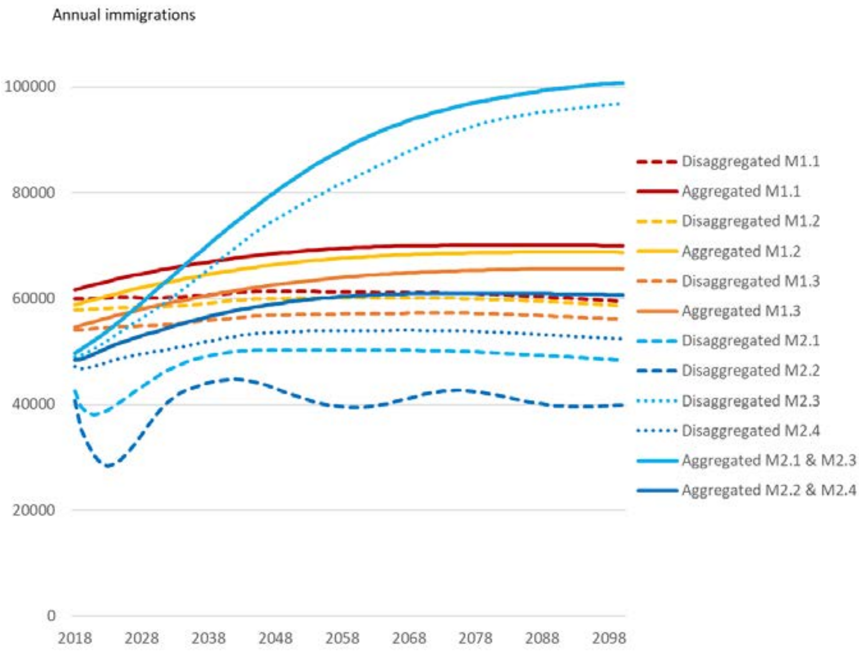


**Figure A2: Projected immigration to Norway 2018-2100 by different methods (displayed in different colors), using disaggregated age groups in origin regions (dotted/dashed lines) or no age disaggregation (solid lines). Sum of the three origin country groups.**


**Figure A3: Difference between immigration projections resulting from aggregated and age-disaggregated methods, by method and country groups. 2018-2100.**

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