EXAMINING THE ROLE OF INTERNATIONAL MIGRATION IN GLOBAL POPULATION PROJECTIONS

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Summary

Advances in projecting international migration have been hindered by a lack of adequate data. Consequently, international projection-making agencies commonly use simplistic assumptions of net-migration measures derived as residuals from demographic accounting. However, past net migration can be often volatile and introduce bias when projecting populations (Rogers, 1990). This paper presents sets of global population projections to 2060, focusing on two alternative assumptions of international migration. Assumptions on rates of other demographic factors, namely fertility and mortality, are held constant allowing an examination of the role of international migration in global population projections models.

In the first projection, we set the future net number of migrants by age and sex in each country to mirror that of the United Nations. In the second projection, we use a set of estimated 5-year bilateral migration flows by sex developed from the flows from stocks methodology of Abel (2013) and Abel & Sander (2014). The sex-specific bilateral flow table estimates are disaggregated by age using a parametric assumption for emigration schedules, and then summed over rows and columns to obtain immigration and emigration rates by age and sex. These estimates are used as base data in a bi-regional projection model, where immigration and emigration rates are assumed to remain constant up to 2060.

Our results highlight differences in the future level of populations around the globe and numbers of migrant flows between a net migration projection model and a bi-regional projection model.

Keywords: international migration flows, global population projections, bi-regional projection model

1.1 Introduction

International migration is an important driver of demographic growth in many countries (Lee, 2011). In recent decades, migration often has had a significant effect on population change in more developed regions. In some of these nations,

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migration is beginning to account for over half of population growth (National Research Council, 2000). The rise in influence of migration on demographic change is likely to spread to more countries as fertility and mortality rates continue to fall in the developing world.

Migration is widely considered as the largest source of uncertainty in demographic projections (Bongaarts & Bulatao, 2000). Unlike other demographic components, there does not exist an acknowledged underlying transition theory to enable effective future levels of long run international migration flows to be forecast. In addition, migration flows can be volatile since short term changes in economic, social or political factors can often play and important role. These factors are complex process themselves, where no single force can explain the history of observed past migration. The exploration of these relationships at a global level has been hindered by the lack of data of comparable migration. Most countries in the world do not produce estimates on the number of international migrants entering or leaving their borders. Those that do, tend to be in developed nations where data are collected under multiple definitions (Kelly, 1987; Nowok, Kupiszewska, & Poulain, 2006).

With no viable alternative, global population projection models have been based on net migration numbers derived by the United Nations based on demographic accounting and, in some cases, scaled annual flows derived from migration records where they exist. The use of net migration as a measure of geographical mobility has long been known to be problematic. In what Rogers (1990) describes as the uni-regional fallacy, the use of net migration measures leads to bias and inconsistency in demographic projections. These features are introduced as a net migration measure confounds changing migration propensities with a changing (future) population. Moreover, they obscure regularities in the age profiles of migration and thereby further misspecify the spatial dynamics generating observed settlement patterns.

This paper considers an alternative, multi-regional type approach, to projecting global population where both immigration and emigration terms are specified in the projection model. Input data for these terms are based upon new estimates of global migration flows using an adaptation of the methodology of Abel (2013) and Abel & Sander (2014) to obtain bilateral migrant flow tables from existing bilateral migrant stock tables. In Section 2 we outline the basic mathematics behind a few possible models of global population projections. In Section 3 we provide details of the baseline migration data and future assumptions on global migration required as inputs into the projection models. In Section 4 comparisons for different migration specifications on the future level of populations and number of migrants are illustrated. Finally, in Section 5 the results are discussed.

1.2 Migration in Global Projection Models

In a global population projection model, with complete geographic coverage, there exists various ways to specify international migration. In each case there must be a consideration for a closed system, i.e. there cannot be non-zero global net

migration total or total outflows from all countries must equate to the total inflows. In this section we illustrate a couple of approaches to project population for all countries.

The simplest option to incorporate international migration into population projection models, beyond ignoring all migration, is to use a measure on the net migration for each country. Two distinct migration measures are available in this uni-regional setting.

For each country, future population can be projected by multiplying current population levels by birth, death and net migration rates. To ensure a closed global system, a restriction of a global zero sum of net migrants in each age group, during each projected time period must be set. As Rogers (1990) showed, using a rate of net migration leads to bias and inconsistency future projections if there is non-zero migration. This due to the incorrect population at risk, being applied to the net migration rate where the net migration rate encompasses not only moves out the population, but also moves in from all other countries. It is perhaps for this reason that the United Nations uses an alternative specification of for net migration based on counts of gross flows, where again a constraint for zero sum of net migrants is maintained in all future time periods.

Age-specific migration rates exhibit a strong age-specific regularities and temporal stabilities (Rogers & Castro, 1981). The use of migrant counts rather than rates is likely to lead to distorted age schedules for migration in future time periods. For example, consider a country with a high fertility rate and net emigration such. As the numbers of population in peak migration ages (early 20's) in future projection periods grows, the proportional age-specific rate of migrants leaving will fall as the total amount of age-specific amount of migrants leaving is fixed. One possible solution to avoid the pitfalls of net migration in global population projection models is to move away from the uni-regional perspective and used a model with age specific immigration and emigration rates in each country.

In a bi-regional projection model the immigration rate for a given country is calculated based on the population at risk, i.e. the population of the rest of the world. The emigration rate out of country is based on the resident population at the time. A constraint is commonly set to ensure a closed global system of migrants in each age groupd. Where the balance in immigration and emigration numbers in future projected periods is not maintained, a small adjustment is typically made to scale up or down immigration or emigration counts.

### 1.3 Baseline Migration Data

Until recently, the migration estimates to run global bi-regional projection model have not been available. However, global bilateral migrant stock data published by the World Bank (Özden, Parsons, Schiff, & Walmsley, 2011) and the United Nations Population Division (2012) estimates of global bilateral migrant flows have been derived by Abel (2013) and Abel & Sander (2014) that are constrained to match the changes in migrant stocks. What follows in this section is a brief

overview of the flows-from-stock method of Abel (2013) and Abel & Sander (2014) which is then applied to produce global bilateral migrant flow tables by sex. The results of these estimates for the 2005-10 period are shown alongside further assumptions to obtain age specific immigration and emigration rates required for a bi-regional projection model.

1.3.1 Origin-Destination-Sex Dimension

As migration flow data is often incomplete and not comparable across nations, Abel & Sander (2014) estimates the number of movements by linking changes in bilateral migrant stock data over time. Figure 1 illustrates the methodology to obtain bilateral flows from changes in the stock tables for people born in a hypothetical Country A.

Figure 1: Hypothetical Example of Flows-From-Stock Methodology of Abel & Sander (2014) for People Born in Country A.
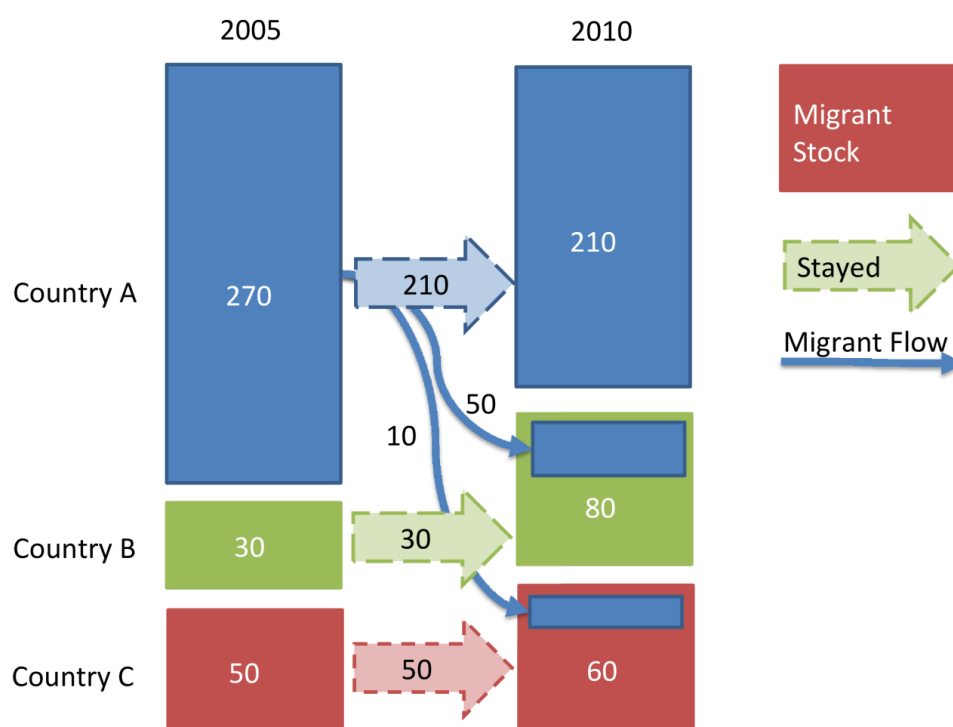
In the example, the location of people born in Country A is given in 2005 and 2010. As we assume no births and deaths in this example, the stock of migrants across all (of the possible 3) locations in both years are equal (270 + 30 + 50 = 210 + 80 + 60 = 350). The number of people born in Country A and living in Country A (blue field) decreases from 270 in 2005 to 210 in 2010. The number of people born in A and living in Country B (green field) increases from 30 to 80 and the number of people living in Country C (red field) also increases from 50 to 60. The

Figure 2: Estimated migrant flows (in millions) between regions for 2005-10. Males (left) and Females (right).
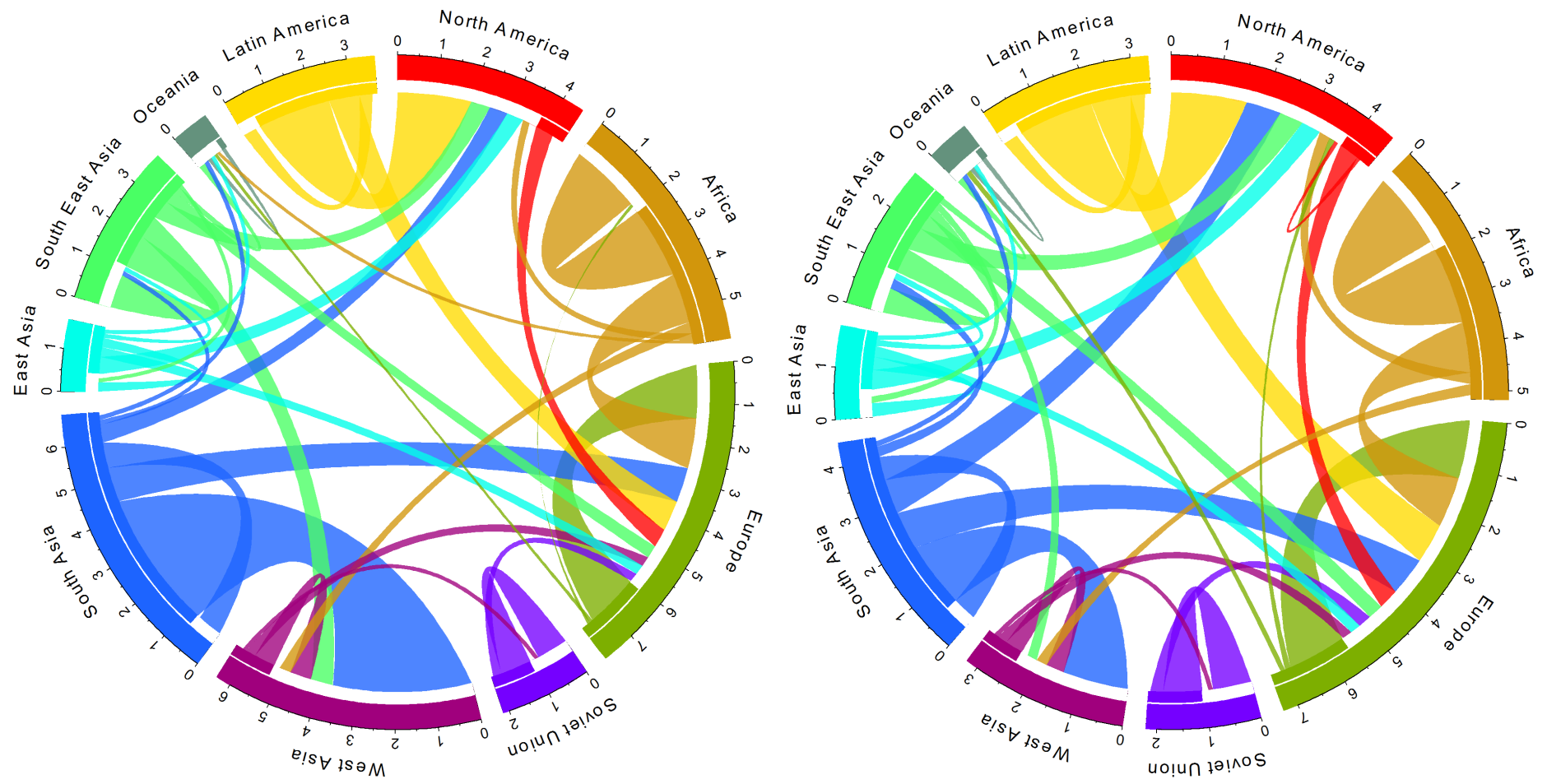
estimate of the minimum number of migrant flow required to match the differences in the stocks of people born in Country A is calculated. In doing so the number of stayers, those who remain in their country of residence between 2005 and 2010, are set to their maximum possible number. In this simplified example, 210 people born in A stay in A, 30 stay in B and 50 stay in C. The remaining flows required to match the stocks and number of stayers are estimated using an iterative proportional fitting algorithm. This results in conditional maximum likelihood estimates of 50 moves from Country A to Country B and 10 moves from Country A to Country C, whilst maintaining the observed stocks in 2005 and 2010.

We produce a comparable set of global migration flows by simultaneously replicating the estimation procedure in Figure 1 for 196 countries twice, once for male stock data and once for female stock data provided by United Nations Population Division (2012). Alterations are made to the migrant stock counts to control for births and deaths during the period, as given in the World Population Prospects of United Nations Population Division (2011). Estimated migrant flow tables have net migration levels in each country that are almost identical to those in the World Population Prospect for the 2005-10 period, due to the demographic accounting method presented in Abel & Sander (2014). Estimates themselves represent the minimum number of migrant transition flows required to match the stock tables at the beginning and end of the period.

In order to briefly illustrate the patterns estimated in the two bilateral migration tables we plot in Figure 2 a representation of the data after aggregating the 196 country specific flows into 10 world regions using the *circlize* package (Gu, 2013) in R. In each side of the figure, the origins and destinations are represented by the circle's segments. Flows have the same colour as their origin and the width at the base of the flow ribbon indicates their size. The direction of the flow is shown by the gap between ribbon and region, where ribbons are attached to their flows origin, and the gap denotes the destination. Tick marks show each region's gross migration in millions.

The two plots show patterns that broadly follow conventional thinking on current international migration flows. The size and direction of flows appear to be similar between the sexes, with the exception of larger flows moving from South Asia to West Asia (mainly oil rich Gulf States). The underlying estimates provide a set of immigration and emigration rates for each country, by sex, to be utilised in a global population projection model, such as the bi-regional model shown in the previous section. However, in order to obtain projections disaggregated by age, a further step is required.

1.3.2. Age Dimension

As there was no information on migrant stock populations by age, we were unable to estimate any age-specific flows using the flows-from-stock methodology outlined above. In order to derive estimates by age groups, required for bi-regional projection models, we relied upon the seven parameter age schedule of Rogers & Castro (1981) to disaggregate each estimated flow in our bilateral table. Rogers & Castro (1981) discussed a set of fundamental parameters obtained by fitting their schedule to multiple sets of internal migration data.

The migration schedule formed by the fundamental parameter of Rogers & Castro (1981) is plotted in the solid black line of Figure 3, where the estimates from the schedule have been scaled to fix the area under the curve to be unity. In order to account for differences between internal and our international migration application we altered some parameter values, depending on the country of origin. For flows from less developed countries outside the OECD (Organisation for Economic Co-operation and Development) and GCC (Gulf Cooperation Council) countries, we applied a migration schedule with a larger labour force peak, as shown in Figure 3. Flows that originated from OECD and GCC countries were assumed to follow a migration age schedule with a later peak. This schedule, shown in the middle blue line in Figure 3 is based on the parameter set given in the middle column of Table 1 and then scaled to set the sum of the age-specific rates to sum to unity. The alterative schedule reflects an assumption of moves after longer periods of education and/or later entry into the education market in these countries, while allowing return migration of temporary workers from OECD and GCC countries at older ages.

Figure 3: Standardised Rogers-Castro Curves for Parameter Values in Table 1
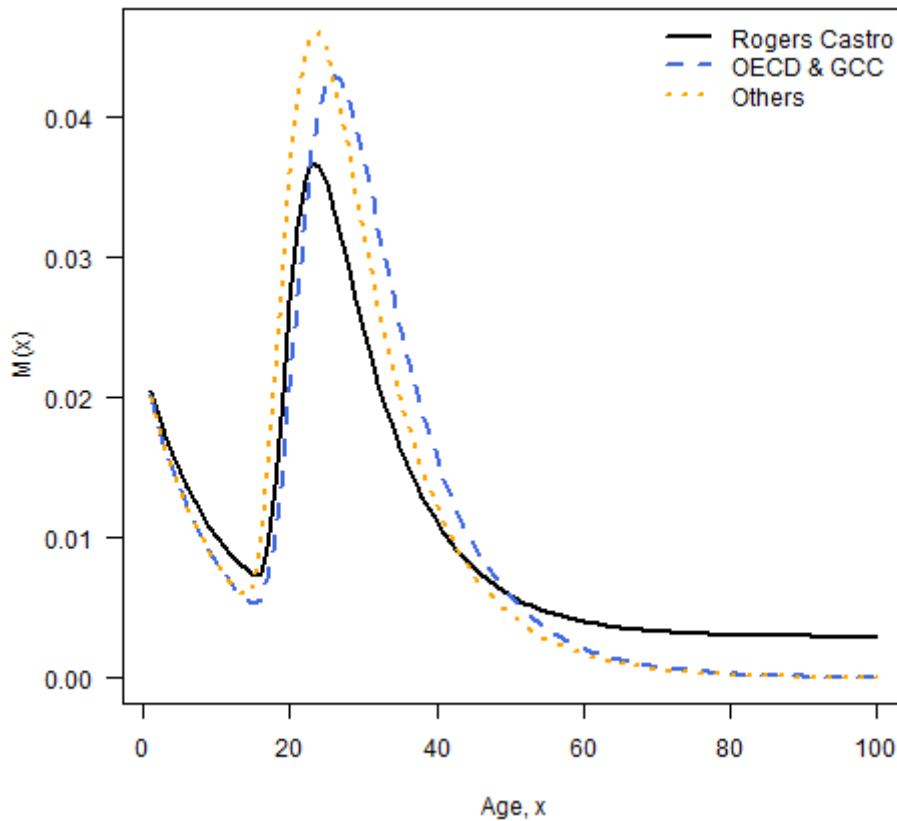
Given the origin specific age-schedules, where the sum of the age-specific migration rates summed to unity, we multiplied through age specific rates at each 5 year interval to each origin-destination-sex (m_{ijs}) table;

$$m_{ijxs} = m_{ijs}M(x)$$

This resulted in an array of origin-destination migration flow table by sex and age covering the 5 year time period between 2005 and 2010.

1.3.3 Future Assumptions

Migration is widely considered as the most difficult demographic component to predict. Unlike other demographic components, are no acknowledged underlying transition theory to enable effective future levels of long run migration flows to be estimated. As a result, most agencies making long run population projections use some form of naive forecast for migration, where all future values are set to their least observed values.

The United Nations Population Division (2011) World Population Prospects assume a naive forecast of net migration up until 2050. Under their normal migration assumption, the future path of international migration is set on the basis of past net migration counts which are disaggregated by age using a standardised Rogers-Castro schedule. Exceptions in the overall level from the naive forecast are made for some selected countries where consideration of the policy stance of future international migration flows are made. After 2050, it is assumed that net migration will gradually decline and reach zero by 2100.

For similar reasons we also assume the naive forecast for future immigration and emigration rates for the bi-regional model based on estimated values in 2005-10 with some exceptions. Adjustments in the first two forecast periods, where we considered our estimates in 2005-10 to be unsustainable in the long run were made to 21 immigration rates and 7 emigration rates. The countries where adjustments are applied are listed in Table 2. For most immigration counties this involved a reduction in the 2010-15 migration rates by 20% from the estimated rate in 2005-10, followed by a further reduction of 20% in the 2015-20 period. For emigration counties we increased the 2010-15 and 2015-20 rate by 20%.

Full details on these adjustments and all other assumptions are provided in Sander, Abel, & Riosmena (2014).

Table 3: Countries with Adjustments to Immigration (left) and Emigration (Right) Rates in First Two Projection Periods. For the majority of countries 2005-10 rates were reduced (for immigration) or increased (for emigration) by 20% period on period. For countries in *italics* 2005-10 rates were reduced by 60% period on period.

Immigration			Emigration
Australia	Ireland	*Qatar*	Bahrain
Austria	*Italy*	*Singapore*	Micronesia
Bahrain	Kuwait	*Spain*	Qatar
Burundi	Liberia	Sweden	Samoa
Czech Republic	Luxembourg	Switzerland	Tonga
Greece	Macao	*UAE*	UAE
Iceland	Norway	United Kingdom	Zimbabwe

1.4 Results

The results of the two difference projection models on future migration in each continent are shown in Figure 4 where we plot five lines. The first two represent past data and future levels of net migration as estimated and assumed (respectively) by the United Nations Population Division for the World Population Prospects in 2010 and 2012. Data are taken from the *wpp2010* Sevcikova & Gerland (2013) and *wpp2012* Sevcikova et al. (2013) R packages. As illustrated in the plot, past data in the 2012 edition go back further than 2010. In addition in some continents such as Africa, the past estimates of net migration given in the 2012 edition are markedly different from that of the 2010 edition.

The two dotted blue lines represent the resulting future immigration (positive) and emigration (negative) levels that resulted from the assumed rates in the bi-regional projection model. The bi-regional model projects an increase in the number of emigrants from continents with young populations such as Africa. As the model is based on migration rates it adapts to changes in the population structure. Conversely, the projection model used by the United Nations assumes, in most countries, a constant net level in future projections despite expected changing age structures and population size. In Europe, North America and Oceania the bi-regional model projects a rise in net migration (shown in the solid blue line) as the immigration rate uses the rest of the world population as the population at risk. As this population at risk increases, so does the immigration to countries where we assumed a comparatively high constant rates of immigration. Note, differences between our implied net and the United Nations 2010 net migration in the base year of the projection are due to a small number of countries used in the projection model.

The bi-regional projection model provides substantially different future populations than in the net migration model. In Figure 5 we plot four lines representing various projected populations. The solid black lines are the median forecast of the 2012 World Population Prospects in each continent, which are shown purely for reference. The red line is a hybrid of the mid scenario in our Wittgenstein Centre (WiC) global population projections, where we drop the bi-regional specification and replace it with the same net migration levels as the United Nations (that underlie the black lines in Figure 4) As the level of net migration in this model is identical to that of the United Nations the difference between the red and black line represent differences solely from alternative fertility and mortality forecasts.

Figure 4: Projected Net Migration Levels by Continent (in Millions)
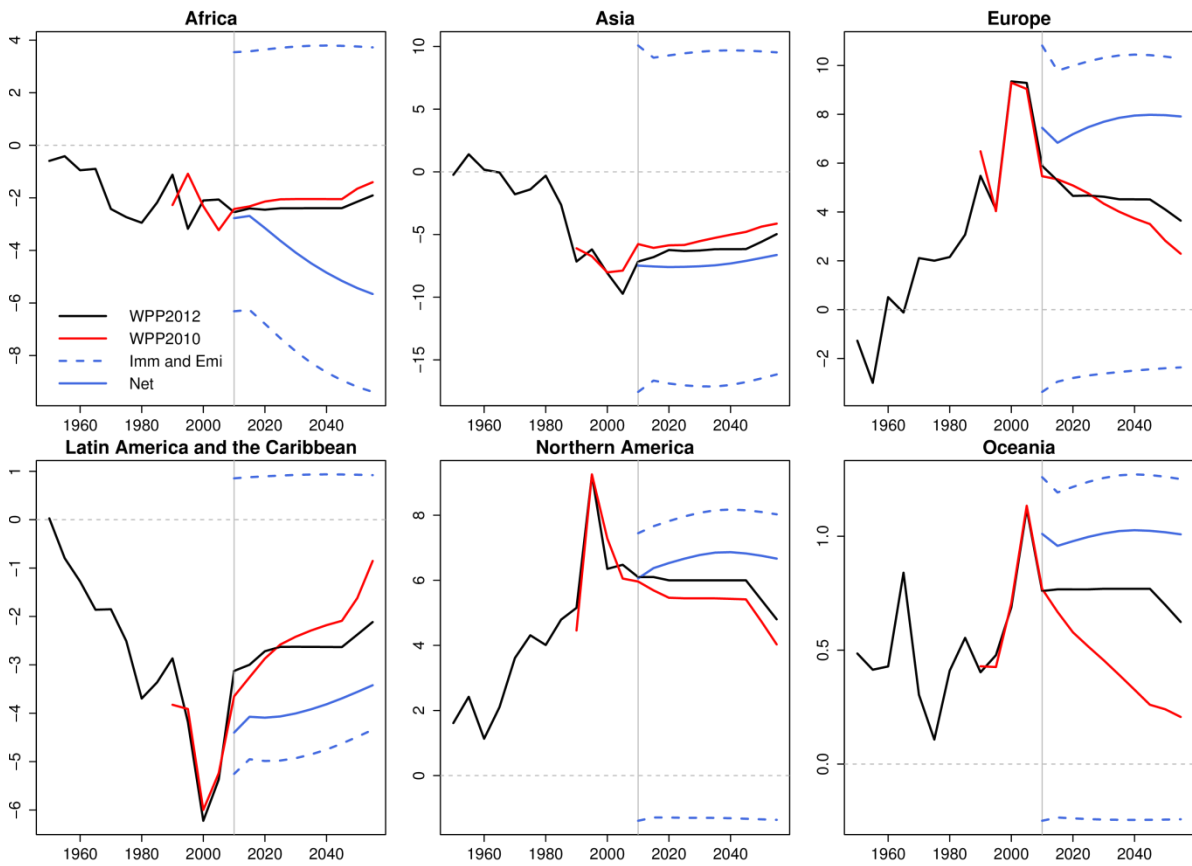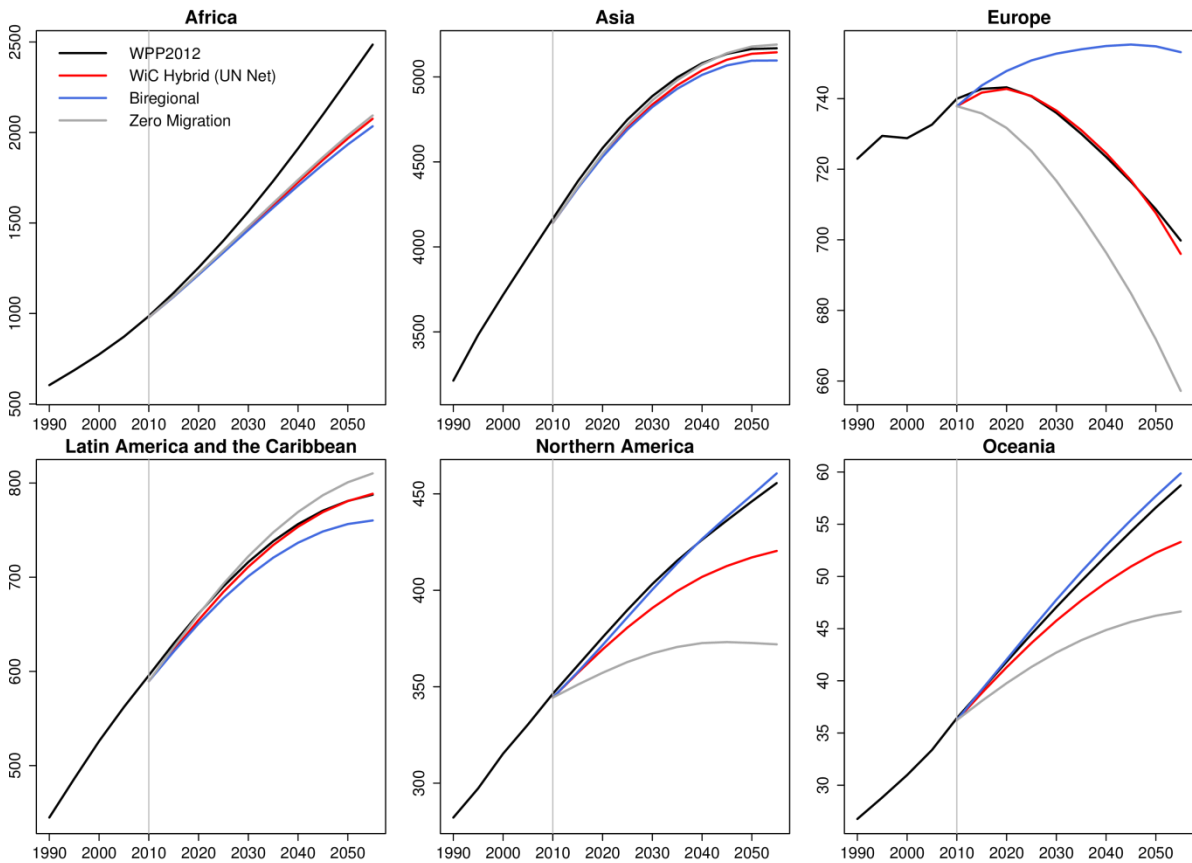

Figure 5: Projected Population by Continent (in Millions)

The solid blue is the original WiC bi-regional projection model. The differences between the red and blue represent the difference in the migration specification within global population projection models. For Europe, North America and Oceania the effect is drastic. The high levels of immigration from the rest of the world in the bi-regional model lead to a continuation of population growth. Under the hybrid model, with the United Nations net migration assumption, the future populations are expected to either fall (Europe) or slow in their increase (North America and Oceania). In the case of these latter two continents the bi-regional specification recovers the lower population, driven by alternative fertility and mortality assumptions, to levels close to those of the United Nations. Unsurprisingly, the impact of migration on the projected populations is largest in continents where fertility and mortality rates are at already stable low levels. This impact is shown by the difference in the principal projections from the populations resulting from the zero migration projection model.

1.5 Summary

At present, the research on migration measures and assumptions in global projection models are relatively unexplored in comparison to other demographic components. This study has made an initial attempt address this issue by investigating the role of an alternative specification, beyond net migration, in a global population projection model.

The bi-regional projection model produces some notable differences in the future levels of migration and resulting population in comparison to the net assumptions used by the United Nations. These differences could be due to two factors. First, in the bi-regional model we used assumptions on future rates. This allows projected immigration and emigration to adjust to changing population structures, where the standardized age schedules in Figure 3 are maintained. Conversely, the United Nations does not have, to our knowledge, have any equivalent dynamics in their projection model to ensure sensible age schedules for future migration rates. Second, in the bi-regional projection model, immigration and emigration rates can respond to changing sizes in their corresponding population at risk. Projection models based on net migration levels do not have any functions to allow for this dynamic response.

Whilst the results in this paper clearly demonstrate the importance of migration specification within global projection model there are a number of possible improvements that could be made. In employing a bi-regional model we have disregarded a lot of (estimated) information in the base data on the origin-destination patterns. These patterns could potentially be used in a full multi-regional projection model at the global level. Further, models fitted to the estimated data might allow for alternative model based forecasts, beyond the naive methods, currently used, as suggested by Cohen, Roig, Reuman, & Gogwilt (2008). Alternative assumptions on the age-schedules used to derive age-specific immigration and emigration rates might also play an important role in the projection model. For instance, there is some evidence to suggest that international migration of children occur at a constant low rate rather than declining at birth as we assumed.

Although it is difficult to claim any one specification of migration in a global population projection model can provide superior, i.e. more accurate forecasts, without some full validation exercises, it is known from work on multi-regional projections in single countries that models which rely on some measure of net migration tend to perform worse (Raymer, Abel, & Rogers, 2012; Wilson & Bell, 2004). As international migration is expected to play an increasingly important role in future demographic change, we have illustrated that an alternative migration specification within a global projection model can have a large impact on future population sizes.

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