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Population–Environment Interactions: European Migration, Population Composition and Climate Change

Sarah Harper

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Abstract The paper addresses the collision of two twenty-first Century transitions—the unprecedented change in the size, composition, density and distribution of the human population, and rapid change in the earth's natural environment, in part a response to the above. It argues that it is important to consider these aspects of population change and environment together in order to understand the reality of any mitigation that may be made. Following a review of research which is beginning to address not only the environmental impact of population growth, but also of changes in density, distribution and composition, the paper turns to explore the interaction of population composition and density with environmental change through addressing interactions between migration, ageing populations and climate change. It considers a key population question facing the EU, that of the demographic deficit, and addresses how the mitigating role of migration will be affected by future climate change. It thus considers whether migration is a valid policy approach in the context of Europe's demographic deficit and the impact of climate change on this relationship.

Keywords Migration · Population · Climate change · Ageing

1 Introduction

The twenty-first Century is experiencing two significant transitions—a dramatic and historically unprecedented change in the size, composition, density and distribution of the human population, and rapid change in the earth's natural environment, in part a response to the above. This century is likely to see the global population grow from its current 7 billion to reach 10 billion, a threefold increase in just one hundred years. At the same time, and in part a response to this rapid population growth a second transition has occurred—global climate change. It is increasingly being acknowledged that the growing numbers of people, and the industrialised urbanised, high consumption lives they lead, has contributed to—or even some would argue caused—the planet's climate to change with rapid environmental effects.

S. Harper (✉)
University of Oxford, Oxford, UK
e-mail: sarah.harper@ageing.ox.ac.uk

This change in the size, composition, density and distribution of the human population, has arisen due to the *demographic transition*, which commenced in Europe sometime after 1750, in Asia and Latin America during the twentieth Century, and now there are indications that Africa will transition during the twenty-first Century. Why the demographic transition occurred when it did, where it did and how it did is strongly debated, but while the details may be contested the general story is clear—a humans economically develop so mortality falls, then sometime later fertility falls, and in the gap between the two trends population increases. According to the UN maximum world population will reach between 15 billion (high variant) and 6 billion (low variant), with 10 billion as the medium variant by 2100. The high variant 15 billion is generally recognised to place significant strain on the earth's resources, while the medium variant of 10 billion will require a significant increase in the requirement for food, water, energy and minerals. In addition, this population increase will not be homogeneously spread across the globe. The Less and Least Developed Regions countries will account for 97 % of the growth to 2050. Asia will comprise 55 % of the world population by 2050 at 5 billion, Africa is projected to double in size by 2050 from 1,022 to 2,192 million, while Europe will decline from 738 to 719 million.

The classic demographic transition is typically associated with economic development, and is perceived as comprising four main stages (Bongaarts and Feeney 1998; Bucht 1996; Cliquet 1991; Lutz and Goldstein 2004; Van de Kaa 1987; Vaupel and Lundström 1994). In stage 1 populations experience high death rates from disease, famine, malnutrition, lack of clean water and sanitation, there is no impetus, or even the thought to reduce fertility—these populations have high births and death rates, and a relatively small but often fluctuating population size—for example England pre 1780, and current day Ethiopia. Stage 2 sees improvements in public heath, sanitation, clean water and food, and mortality, especially infant and child mortality, falls. There is, however, still high fertility rates, resulting in a rapidly expanding population size—for example nineteenth Century England and current day Sudan. In stage 3 rapidly falling total fertility rates occur alongside low mortality rates. There is a still expanding but slowing population size such as England in the early twentieth century and Uruguay. Stage 4 sees low mortality and fertility, a high but relatively stable population—current day UK and Canada for example.

Key to the demographic transition is changes in fertility rates. Generally described, Total Fertility Rate (TFR) is the number of live children born to women of child bearing age. In technical terms the Total Fertility Rate of a population is the average number of children that would be born to a woman over her lifetime if she were to experience the exact current age-specific fertility rates across her lifetime, and if she were to survive to the end of her reproductive life.

The actual drivers of fertility fall have been long debated but broadly fall into three positions. One theory is that fertility falls in response to a fall in infant mortality. Economists describe this as the increase in child survival rates reduces the fertility required to achieve a desired number of surviving children. A second position is that high fertility is a response to un-met need for family planning, and it is only through the introduction of modern family planning methods that women will start to reduce the number of births they have. The third broad hypothesis is that fertility fall is driven by education. Educating girls in particular, encourages later marriage and gives them access to the labour market, which reduces the number of births, but also and crucially, it changes the "mind set" of the women and their communities and enables them to recognise the range of alternative choices they can make. Indeed one of the greatest contemporary demographers, Jack Caldwell, identified "ideational change" as the biggest factor in falling fertility (Caldwell 1980).

Two thirds of the world's countries are now at or below replacement level—crudely defined as 2.1. These are diverse including Hong Kong the lowest at 0.99, Poland, Germany, Barbados,

Thailand, Viet Nam, Mauritius, Iran, Chile, Tunisia, the US and Myanmar. A further fifty-eight are low medium – that is with a TFR of 2.1-3—these include Ireland, New Zealand, Indonesia, Argentina, Sri Lanka, Bangladesh, Mexico, Venezuela, Botswana, Egypt, Samoa, and India. Eighteen are at high medium 3-4.1—including Zimbabwe, Bolivia and Pakistan. Forty-eight remain high—4.1 and above—most but not all are in sub-Saharan Africa, and most are classified by the UN as Least Developed Countries.

The highest is Niger with over 7 children per reproductive women. For while TFRs across the globe are generally falling, the case of Sub Saharan Africa remains of concern. The medium UN scenario is that TFR in Africa will fall to near replacement by 2050. If this occurs then the African population will increase from 1bn now to 2bn by 2050 and 3.5bn by the end of the century. However TFR still remains above 4 in many countries. As a consequence if TFR reduction stalls and remains at its current 5.5 for the region, then SSA's population will reach just under 3bn (2,720 million) by 2050 and 14.5 bn (14,520 million) by 2100, leading to a maximum world population of over 24 billion by the century's end. It is thus important that the drivers of fertility reduction are understood so that African women can be able to choose the family size they desire. This is not only because a population of 24 billion would place considerable burden on the planet's resources, but because African governments increasingly recognise that such high birth rates are reducing the potential for development, and African women are themselves calling for measures which will improve their own well-being and those of their existing children.

Clearly different regions of the world are experiencing different demographic scenarios. While Africa still faces rapid population growth, Europe faces population decline. It is important, however, to consider not only changes in population size, but also other significant population changes of the twenty-first century those of *density, distribution* and *composition*. This century will also see a continuous and rapid growth in the *density* of human population, as an increasing percentage live in cities and other urban areas, projected to reach 75 % by 2050. This will also be reflected in the changing *distribution* of people, with a reduction in rural residents, alongside the overall increase in those living in Asia and Africa, and a fall in European and North American populations. The age *composition* of the population will also change as median ages rise, and there is a proportionate shift from younger to older people across the globe.

2 Population and Environment

As we discussed above, the demographic transition thus not only leads to falling fertility and mortality and thus ultimately alters population size, but also to associated developments in density (urbanisation), distribution (migration) and composition (age-structural change or population ageing). It is now clear that it is important to consider these aspects of population change and environment together in order to understand the reality of any mitigation that may be made. There are calls for a need to incorporate a more nuanced understanding of population size, age structure, household size and composition, migration and urbanization into climate change scenarios that provide the basis for policy decision-making and strategy development for climate change mitigation and adaptation (Young et al. 2009; Jiang and Hardee 2011; McNeill 2006; Stephenson et al. 2010).

There is a growing literature on environmental interactions with population size. This suggests, for example, that slowing population growth could provide over one quarter of the emissions reductions suggested to be necessary by 2050 to avoid dangerous climate change (O'Neill et al. 2010; O'Neill 2009). In relation to distribution, there is evidence that environ-

mental changes, including climate change, may result in migration (Feng et al. 2010). Several authors have predicted that as environmental changes increase, migratory pressures will also increase (IPCC 2007a). Recent papers, however, have emphasised that the environmental refugee scenario may be overstated and that environmentally related migration is complex and related to the temporality and kind of environmental change (Adepoju et al. 2010; Warner 2010; Bardsley and Hugo 2010 Tacoli 2009; Barnett and Weber 2010; Skeldon 2009; Fielding 2011; Bohra-Mishra and Massey 2010; Barbieri et al. 2010). The majority of people in environmentally disadvantaged regions will not have the resources to make permanent long distance relocations. There is general agreement, that the response to sudden climatic events will result in short term temporary moves. As Tacoli (2009) points out much of the earlier literature following on from the IPCC 2007 report overlooked the fact that migration requires financial resources and social support, both of which may decline with climate change, which may thus result in fewer rather than more people being able to move. However, there is a clear renewal of interest in the contemporary migration–environment nexus, and additional work is needed to reembed the environment more firmly within migration theories (Piguet 2013). Black et al. (2011) for example suggests that the environment drives migration through mechanisms characterised as the availability and reliability of ecosystem services and exposure to hazard, and the effect of the environment is therefore highly dependent on economic, political, social and demographic context. Environmental change has the potential to affect directly the hazardousness of place, and also affects migration indirectly, in particular through economic drivers, by changing livelihoods for example, and political drivers, through affecting conflicts over resources.

In terms of composition changes, there is evidence that the age structure of the population impacts upon consumption patterns and thus predicted CO2 emissions (Zagheni 2011). O'Neill et al. (2012), for example, produce evidence for how CO2 emissions from the use of fossil fuels are affected by demographic factors such as population growth or decline, ageing, urbanisation, and changes in household size. Liddle (2010, 2011, 2013) takes the analysis a step further and by analyzing panels consisting of poor, middle, and rich countries, shows those environmental impact relationships vary across development levels. Alternatively Menz and Welsch (2012) take a cohort approach suggesting that shifts in both the age and the cohort composition have contributed to rising carbon emissions in OECD countries.

The question of density changes in population and climate converge around the city. It has been argued that many cities will need to adapt to mitigate the impact of short and long term climate change. However, most urban dwellers are left vulnerable in cities with limited infrastructure and services needed to mitigate climate change-related risks, and with inadequate political and institutional systems. The existing vulnerability of African cities, for example, with their fast growing populations and weak management, means any environmental change is likely to have significant consequences (Parnell and Walawege 2011). A further steam of research has considered the impact of urbanisation on CO2 emissions, concluding that there is a small but significant effect (Krey et al. 2012; O'Neill et al. 2012) which may be related to increased consumption (Satterthwaite 2009).

3 Migration, Population Composition and Environmental Impact

As a case example, the second half of the paper turns to consider the interaction of population composition and density with environmental change through addressing interactions between migration, ageing populations and climate change. It explores a key population question facing the EU, that of the demographic deficit and addresses how the mitigating role of

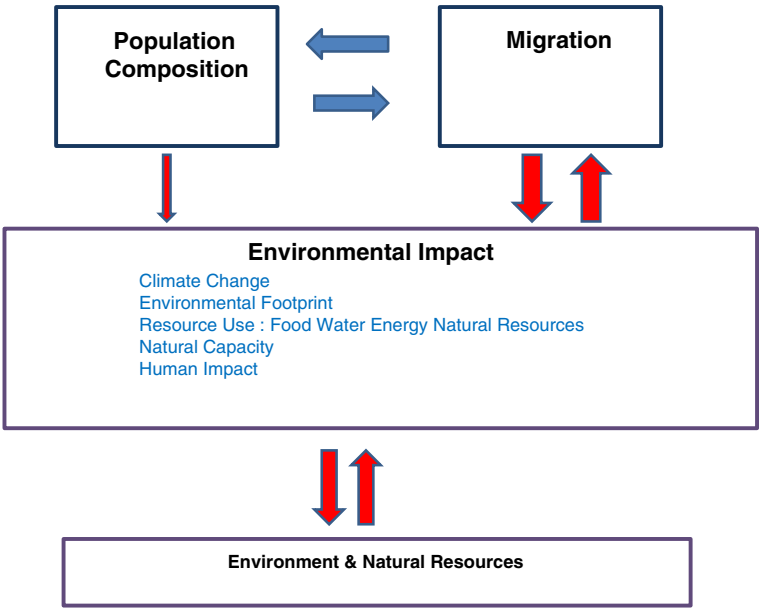

Fig. 1 Migration, population composition and environmental impact

migration will be affected by future climate change. It thus considers whether migration is a valid policy approach in the context of Europe's demographic deficit and the impact of climate change on this relationship.

While there is a growing body of research independently addressing migration and ageing populations and migration and climate change independently, the question of migration, ageing populations and climate change has been neglected (Harper 2011a,b). For example, there is little knowledge of age-related migration under conditions of environmental change, (Raskin et al. 2002; MEA 2005) and the literature on environmental refugees has generally ignored age specific relationships.

The paper employs the model developed in Harper (2011a) as an analytical framework to guide the exploration of these questions (Fig. 1).

3.1 Europe's Changing Population Composition

Europe, as all countries in the Developed Regions of the world, has gone through considerable population ageing over the past century. This age-structural transition from predominantly young to predominantly older populations emerges at the end of the classic demographic transition (Bloom et al. 2003; Pool 2005). Taking an age structural change perspective allows us to view population change in terms of a shift between providers and dependents—the dependency ratio—and how this will typically move from a large percentage of young to large percentage of old dependents during the demographic transition[1]. The Elderly Dependency

[1] These ratios comprise Elderly Dependency Ratios (EDR), the number of persons of working age (aged 15–64) per person aged 65 or over; Youth Dependency Ratios (YDR), the number of persons of working age (aged 15–64) per person aged 15 or under; and Total Dependency Ratios, number of those 15–64 with those outside this age range. It must of course be noted that these accepted broad age categories are in practice a mere proxy for productivity/non-productivity.

Ratio (EDR) has been taken by some to measure the move of a country to that of an aged population, suggesting that 14 % EDR achieves this. Alternatively, the shift within the Total Dependency Ratio (TDR) has been used, with the move from a high Youth Dependency Ration (YDR) to a high EDR determining when a population reached demographic maturity (Harper 2006). By this measure Europe became mature in 2000, Asia is predicted to reach maturity by 2045.

A population with a large percentage of young productive adults has the potential to produce a *demographic dividend.* This usually occurs late in the demographic transition when a series of large birth cohorts are followed by a set of far smaller ones as total fertility rates fall, resulting in a decrease in young dependents, and thus a fall in the YDR. This is accompanied by a substantial increase in the available labour force, and the potential for high savings rates particularly as the consumption needs of large numbers of dependent children is reduced. In addition it enables families to concentrate their resources on fewer children, with higher survival probabilities increasing the expected return to investments in children and furthermore releases capital for investment in production (Bloom et al. 2003; Holzmann 2005). Greater per capita output and economic growth through an enhanced labour force and high investment rates produces the "demographic dividend." In addition, society is able to increase its aggregate per capita income level before the time the population becomes mature, and to accumulate assets which can be can be drawn upon to help finance the consumption needs of an elderly population (Heller 2006).

Alternatively, a population with a large percentage of older dependent adults leads to the so-called *demographic deficit*. The next decade will see a rapid shift towards increased EDRs in most industrialised countries. The EU-25 Elderly Dependency Ratio is set to double and reach 51 % by 2050, as the working-age population (15–64 years), decreases by 48 million between now and 2050, and the EU-25 will change from having four to only two persons of working age for each citizen aged 65 and above (European Commission 2006). The demographic deficit is perceived to herald negative implications for both nations and regions It is argued that this results in demographic decline leading to a fall in economic activity; and in demographic ageing resulting in economic burden due to increased requirement for pensions and health care (Lee and Mason 2010).

3.2 Declining Population

There is an assumption that declining populations can have dramatic negative effects, via declining demand, on economic growth and employment (Chesnais 1998; Fina-Sanglas 2000). This "can have negative psychological effects on investors, affect some strategic activities such as the building industry, slow down the growth of many other markets and favour a "rentist economy" to the detriment of the "productive economy" (Fina-Sanglas 2000). However this is contested by those who argue that in a modern, industrial economy aggregate demand depends on aggregate incomes rather than on the number of people, and furthermore that in a modern, open economy the extent of the markets does not depend on the number of domestic consumers, though the magnitude of this effect is questioned (Holzmann 2002). Others argue that structural changes in the age composition of a population will affect both the structure of consumption and employment. Feyrer (2007), for example, found that the relative size of the age group 40 and 49 is particularly associated with productivity growth, while Lindh and Malmberg (1999) found that this was related to the size of the 50–64 age group. Fougere and Merette (1999) introduce the idea that as the aggregate cost of schooling falls when there are fewer young people, more intensive training of the young becomes affordable and may lead to subsequent productivity growth. Others argue that the demand for

employment will shift from one sector to another as the population shifts from young to old. However, as Van Groezen et al. (2005) points out, population ageing also shifts demand in the economy to labour intensive services where the potential for productivity growth may be less. Poot (2008) suggests that since labour mobility (geographic, occupational, industrial, or job to job) is inversely related to age, population ageing may also lower productivity growth through slowing down structural adjustment in the economy. There is also an extensive literature which debates the current and future productivity of older workers, with a now general acceptance that future cohorts of older men and women, with higher levels of education, skills and training, will be able to maintain high levels of productivity given supportive and conducive working environments (Harper 2010; Bloom et al. 2010).

3.3 Population Ageing

The impact of population ageing on the capacity of societies to finance pensions and long term health and social care is also strongly debated, though it is generally accepted that this will depend both on the growth of labour productivity and on the employment rate. Average annual growth in the EU between 2004 and 2010 was 2.4 %, projected to fall to 1.2 % by 2030 due to the reduction in the working age population.: "even if the objective of 70 % in the overall rate of employment as set out in the Lisbon Strategy is reached, the total number of persons in work is set to decrease by 30 million between the end of the decade and 2050" (EU 2006:6). It is argued that the EU will have to increase its productivity to compensate for this (European Commission 2006) in order to pay for the demands of the ageing population. There is, however, considerable evidence from both Europe and beyond (Harper and Leeson 2010; Bloom and Canning 2004) of the extensive downward transfers made by older people to their adult children and grandchildren, which to an extent counter the transfers made via public transfer systems such as pensions. Indeed, Harper and Leeson (2010) argue that while public welfare wipes out most upward transfers to older people, it has far less effect on private family downward transfers from older people.

4 Migration and the Demographic Deficit

For many decades, Europe has attempted to compensate for its demographic deficit by facilitating immigration. This is seen as having the potential to prevent population decline, maintain the size of the labour force and thus the support ratio, and slow down structural population ageing. The impact of this has both short and long term implications. There is a direct impact of migration on future fertility increases, on population size, and on labour replacement through increasing the working age population. However, while immigration to Europe will in the short term achieve immediate increases in total fertility rates, population growth and labour market contribution, these are unlikely to achieve full replacement level, to be unsustainable over the longer term, and indeed may eventually contribute to a worsening of the demographic deficit, as the total fertility rates of the immigrant population falls and they age in place. In addition, and importantly, there are also the indirect effects of migration on innovation, economic growth, employment and welfare.

4.1 Migration and Fertility

Immigration raises the number of births in the host country in the short term (Andersson 2004; Andersson and Scott 2005). First generation immigrant women usually have higher levels

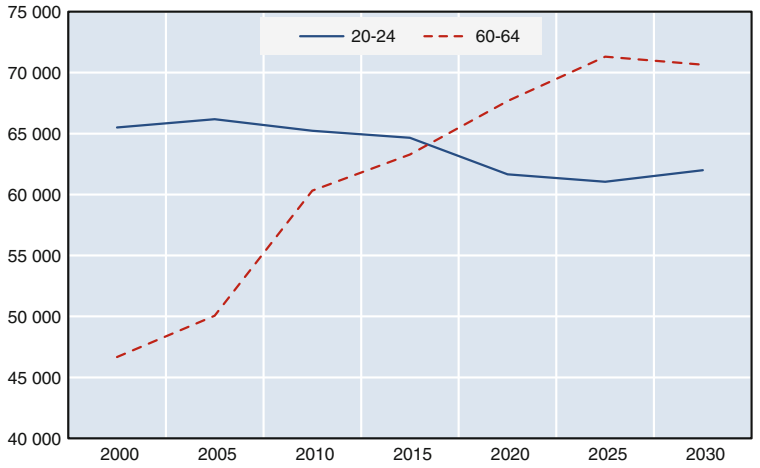

Fig. 2 Observed and projected size of the incoming (20–24) and outgoing (60–64) working-age cohorts in OECD countries, 2000–2030. *Source* UN World population 2008. Excludes Mexico and Turkey, Reproduced from IOM (2010)

of period fertility than host country women, though this effect appears to diminish by the second generation (Genereux 2007; Sobotka 2008) . This initial high fertility is related both to immigrants often lower levels of education and income, and high rates of intermarriage which are conducive to higher fertility, as well as the culture, norms and values in the region of origin which may also promote higher fertility. However, following this initial high level, migrant fertility rates decline to reach levels close to the host country rate within a period of time between one decade and a single generation (Kulu 2005; Toulemon 2004). It has been argued that this subsequent fall in fertility may be related to assimilation into the host community or non-assimilation with adoption of socio-economic and cultural norms (Coleman 2006). Or that national welfare policies, employment patterns and other institutional factors facilitate an adjustment of migrants' fertility to 'local' fertility patterns (Sobotka 2008).

4.2 Migration and Age-Structural Transition

There is clear interest in the direct impact of migration on the working age population and on the potential support ratio. It is projected that if migration rates stay largely at their current levels, the working-age population in OECD countries will rise between 2010 and 2020 by only 1.9 % compared to the 8.6 % growth seen between 2000 and 2010 (IOM 2010). Indeed, for almost half of OECD countries, the outgoing cohorts will be larger than the incoming ones by 2015 (Fig. 2).

It is, however, agreed that viewing direct labour replacement as the prime importance of migration is inappropriate given the huge numbers of immigrants which would be required under such calculations. Holzmann (2005) for example, forecasts for Europe and Russia combined, a migration of 3.3 million is needed annually until 2025 and 4.1 million annually between 2025 and 2050. A more realistic approach is to focus on the wider impacts, such as the role of immigration and economic activity in slowing down the negative economic consequences of structural ageing (Bijak et al. 2007; OECD 2010). This is particularly important in very low fertility countries, such as Italy where significant and continuous immigration may slow population ageing (Dalla Zuanna 2006)

4.3 Migration and Fiscal Contribution

It is now recognised that migration can affect public finances. In particular, migration can reduce the sustainability gap by increasing the tax base, even if the migrants' contributions to the present budget are negative (Brücker 2002a). A study by Bonin et al. (2000) on the intergenerational fiscal imbalance induced by ageing in Germany, concludes, for example, that an active migration policy favouring high-skilled immigrants may considerably enlarge the positive impact of immigration on the tax burden of native residents and decrease the fiscal burden of future resident generations. A key question is whether immigrants are more or less likely than natives to use the provision of the welfare state (Barrett and McCarthy 2007; Borjas and Hilton 1996; Brücker et al. 2002) and/or whether immigrants assimilate into or out of the welfare state (Borjas and Trejo 1991; Hansen and Lofstrom 2003).

Generational accounting assesses the intertemporal sustainability of public finances by calculating both the expected taxes and expenditures of public finances, based on long-term projections of the underlying fiscal and demographic variables. The conclusions from several studies are that given the young migrant age structure and the strong long term propensity to return to the host country, many European countries will benefit overall. For example, in the German case (Bonin et al. 2000) there is a large fiscal gain for the host population in admitting migrants, with the authors projecting between a 30 and 40 % decrease in the net tax burden depending on the range of migration flows. This, they suggest, arises from the migrant age structure which denotes little demand on public sector finances, and the future potential cohort size of their descendants, who will share the future tax burden of the country, with some negative effect if the migrants grow old in Germany. Yet Rendall's (2004) study of the UK suggests that almost half of overseas-born immigrants to the UK emigrate again within five years. This process of return migration among UK's overseas-born immigrants will lower the UK's old-age dependency ratio in at least the immediate future.

A generational accounting approach has also been taken in studies which calculate the net present value of the fiscal contribution of migrants (Bonin et al. 2000; Brücker 2002a; Storesletten 2000). As Brücker points out for Germany, given that it can be expected that future migrants will arrive with higher human capital endowments through education and training, the net contribution per migrant to the public budget will increase. However, Feld (2005) and McDonald and Kippen (2001) caution that there are considerable diversity in nations labour markets and welfare regimes which means individual national effects will apply.

A more broad study of the UK is that undertaken by Dustmann et al. (2010). Using a dynamic model (Storesletten 2000) they assess the fiscal consequences of migration to the UK from the Central and Eastern European countries that joined the European Union in May 2004 (A8 countries). This showed that those migrants with a least one year of residence, and thus legally entitled to benefits, are 59 % less likely than natives to receive state benefits or tax credits and 57 % less likely to live in social housing. Even if A8 immigrants had the same demographic characteristics as natives, they would still be 13 % less likely to receive benefits and 29 % less likely to live in social housing. They also conclude that A8 immigrants made a positive contribution to the public finances despite the fact that the UK has been running a budget deficit over the last few years. This is because they have a higher labour force participation rate, pay proportionately more in indirect taxes and make much less use of benefits and public services. The conclusion that overall migrants make a net contribution in the UK is reached in several other studies: Home Office (Gott and Johnson 2002); IPPR (Sriskandarajah et al. 2005).

4.4 Migration, GDP and Economic Growth

An important broader question is the macroeconomic consequences of population ageing. Several studies have indicated a negative impact of age-structural transitions on economic growth (Holzmann 2005; IMF 2003; Martins et al. 2005). Conversely, there is some evidence that immigration can improve competitiveness and productivity. Several studies have highlighted the role of migrants in encouraging new investment, improving efficiency and increasing innovation and entrepreneurship, although there are clear regional and temporal differences (Poot et al. 1988; Poot 2008; Quispe-Agnoli and Zavodny 2002; Saiz 2003). It is argued, for example, that growing social or ethnic diversity due to immigration encourages innovation and entrepreneurship through increasing creativity (Audretsch and Keilbach 2004). This may also be related to the slower labour force growth associated with an ageing population which then leads to a higher relative price of labour and therefore provides a greater incentive to innovate (Romer 1990). Borjas (2001) argues that immigrants are more responsive to regional wage differentials and therefore help the labour market to attain an efficient allocation. Blanchflower and Shadforth (2009) in their analysis of the consequences of migration from Eastern Europe on the UK economy suggest that immigration may have slowed wage inflation through the "fear of unemployment" mechanism.

Immigration also increases the size of the local economy, which can potentially lead to more competition and efficiency. In addition, international migration can indirectly affect regional competitiveness through the trade and international linkages that result from a country's diasporas remaining in touch with their country and region of birth. Poot (2008), for example, suggests that immigration has a positive effect on trade between the source country of the immigrants and the host country, as immigrants tend to have a preference for the products from their home countries, and furthermore can reduce transaction costs of bilateral trade with their home countries either through individual characteristics such as business contacts or through more generic traits such as language. Other studies have suggested that immigration may result in a negative trade balance, for while immigrants expand exports to their native country, they also stimulate imports from this country (Ching and Chen 2000; Wagner et al. 2002).

5 The Role of Climate Change

There is thus general consensus in the literature that migration is a valid policy approach in the context of a demographic deficit, which will not prevent age-structural transition, but may alleviate it (Coleman 2002; Espenshade et al. 1982; Espenshade 2001; Feld 2000; Lesthaeghe 2000; Pollard 1973; Saczuk 2003). Migration can at very high levels, avert future decline in the total population (UN 2000) and in the population of working age (Coleman 2004, 2008). Immigration to Europe will in the short term achieve immediate increases in total fertility rates, population growth and labour market contribution. The impact on innovation, economic growth, employment in general, and welfare are more complex. Migrant workers fill both the demand for highly skilled workers and the gap in unskilled employment, increasingly in the care and service sector (Leeson 2010). The evidence is that migrants contribute to public welfare such as pensions and health care but usually do not draw on them, at least immediately.

It is thus essential that Europe continues to attract key skills over the coming decades, and thus encourages enterprises that will attract such workers. Yet, future projections also suggest that Europe's ability to attract skilled migrants will decline as it competes with North

America, Oceania and Asia. As Holzmann (2005) points out, the European share of global WAP has fallen from around 25 % in 1950 to 14 % in 1995, projected to fall to 9 % in 2025 and 6 % by 2050. In 2010 the WAP comprised 70 % of Europe's population, with older and younger dependents equal in size, and representing a total dependency ratio (TDR) of 46:100 workers. This will increase to 73:100 workers by 2050. These projections predict that the proportion of global migrants to North America and Developed Oceania increases from 50 to 80 % by 2025, to the detriment of European flows. This is based on the assumption that these regions will prove to be more attractive destinations for skilled migrants who increasingly will be able to select where they place their skills. Similar views have also been espoused for Asia, in particular China, and the more economically advanced parts of Latin America and Africa. However, these projections fail to take into account future scenarios in which different regions of the world will not only have different economic profiles, but increasingly different degrees of challenging environments within which to live (See Harper 2010, 2011a,b for a fuller discussion of this).

In particular, it is already accepted that the challenges which climate change may bring will impact upon sustainable economic development in a number of regions, specifically those in the South, potentially causing significant problems in areas as diverse as health, water supply, agriculture, infrastructure damages and financial and other economic services (IPCC 2007a,b,c; Shalizi and Lecocq 2010). Climate shocks have already had large impacts on economic growth in many Asian and Central American countries, (IMF 2003) and it is recognised that an increase in the frequency and magnitude of such shocks due to climate change will reduce their chances of getting out of them or magnify the national consequences for economic growth (Shalizi and Lecocq 2010).

Seven of the cities recently identified as the top 50 in terms of their current and future importance to global business are at high risk from climate change related extreme temperature and weather systems. Maplecroft's Climate Change Vulnerability Index (CCVI), which evaluates exposure to climate related natural hazards and the sensitivity of populations, highlights the vulnerability of Dhaka, Bangladesh, (ranked 1st), Manila, the Philippines (2), Bangkok, Thailand (3), Yangon, Myanmar (4), Jakarta, Indonesia (5), Ho Chi Minh City, Viet Nam (6) and Kolkata, India (7). The top 10 cities exposed in term of population are Kolkata, Mumbai, Dhaka, Guangzhou, Ho Chi Minh City, Shanghai, Bangkok, Rangoon, Miami and Hai Pho'ng.

Coastal cities will be especially significant here as their potential for economic growth are reduced through the impact of climate change and they are significant hubs for skilled migration. (Huq et al. 2007). Hare et al. (2011) project that sea-level rise and increased water temperatures will accelerate beach and coastal erosion and cause degradation of natural coastal defences, which would impact negatively on water supply, fisheries productivity and tourism industries in many small island countries and other regions. For example, sea-level rise of 0.5 m has been projected to result in the total number of people exposed to flooding risk in 136 port cities globally increasing by more than threefold to around 150 million people. Sea-level rise of a few metres could result in widespread loss of coastal and deltaic areas such as Bangladesh, the Nile, Yangtze and Mekong Delta regions (Hare et al. 2011). Hare et al. (2011) report that on an asset base, the most vulnerable cities were found to be Miami, Guangdong, Greater New York, Kolkata, Shanghai, Mumbai, Tianjin, Tokyo, Hong Kong and Bangkok (Nicholls et al. 2008). Similarly, in another study of port cities, Kolkata, Mumbai, Dhaka, Guangzhou, Ho Chi Minh City, Shanghai, Bangkok, Rangoon and Hai Phong were identified as the top cities in terms of population exposure to climate extremes in particular flooding and heat.

Other potentially economically attractive magnets for skilled migrants, will face increasing vulnerability to other climate induced shocks such as more intense tropical cyclones (Bender et al. 2010; Knutson et al. 2010) which will have an impact on local infrastructure and thus economic growth. A number of regions such as southern USA, parts of Africa, and the Mediterranean basin will face increasing aridity. Even Australia, with its long experience of coping with highly variable climate, may it challenging to adapt to future abrupt climate shifts and intensifying droughts (Risbey 2010).

As the author has explored elsewhere (Harper 2012) other key influences to a locations attractiveness will be local access to both water and food. Significant risks to food and water security are predicted for South Asia (Lal 2010; Mirza 2010), northern Africa (Sissoko et al. 2011; Ben Mohamed 2011; Iglesias et al. 2010) and parts of Russia (Dronin and Kirilenko 2010). In addition, while some regions, such as Australia, USA and the European Mediterranean may have the capacity to mitigate such factors as drought and aridity (Iglesias et al. 2010), others such as the African Mediterranean may not (Shalizi and Lecocq 2010; Sissoko et al. 2011). In relation to food production, as Hare et al. (2011) point out, climate change will induce strong contrasts between world regions, by causing yield increases in some and decreases in others, to an extent that will not be easily solved by international markets (Battisti and Naylor 2009).

5.1 Climate Change and Locational Advantage

The economic literature suggests that European countries will face increasing competition for future global skills from countries of the South. However, this overlooks the probability that according to current climate predictions (IPCC 2007a,b,c), many northern and western European countries will provide relatively environmentally attractive locations in which to live. It is thus likely that Northern and Western Europe in particular will have an locational advantage in being able to attract highly skilled migrants from environmentally challenge locations. Though, southern European, Mediterranean countries, which will face a larger demographic deficit, will not have this advantage, and indeed may well be sources of outmigration if some of the climate scenarios come to pass.

Furthermore, Europe may be at a further advantage in being able to attract those skilled migrants who may decide to leave climate challenged locations. The impact of global ageing on migration trends is that there will be an increased demand for global skills and thus those with skills living in environmentally challenged zones will be able to respond to the growing demand for skilled migrants by the ageing regions. Thus populations facing longer term environmental change will have time to plan and may make more permanent moves. Though, as earlier discussed, this will be only those who have the skills and resources to do so, and if there are the institutional structures in place to allow them to relocate.

6 Conclusion

Most countries of the world, with the exception of small parts of Asia and sub-Saharan Africa, will undergo age structural transitions by 2050. This will result in a fall in the proportion of young dependents and those of working age, and a rise in older dependents. This change in global population composition is occurring however in the context of climate change. The paper has argued that environmentally driven migration will operate through changing the scale, flow and destination of global skilled migration and thus increase the impact on the population composition of both the host and source countries. In terms of scale,

environmentally driven skilled migrants will increase the pool of migrants already attracted by economic opportunities arising from the demographic deficits of the North. . In terms of flow and destination, environmental change may alter the assumption that Asia, and the more economically advanced parts of Latin America and Africa, will prove to be more attractive destinations for skilled migrants, as environmental change may restrain economic growth and thus the economic magnets for attracting skilled migrants. In addition, the migration of skilled workers will under circumstances of environmental change and global ageing, increasingly leave behind vulnerable older people in environmentally challenged zones.

In the EU migration will have some impact in alleviating the so called demographic deficit, in combination with increased productivity and extended working lives. Migrants currently increase national total fertility rates in the short term, especially those from Asia and Africa. In addition, current migrants from Eastern Europe pay proportionately more in indirect taxes and make much less use of benefits and public services and are likely to return to their source countries before becoming old and dependent. Migrant workers fill both the demand for highly skilled workers and the gap in unskilled employment particularly in the growing old age personal care sector. They also contribute to the economy through enhancing GDP by encouraging new investment, improving efficiency and increasing innovation and entrepreneurship, and thus protect it to a degree from the sustainability gap of public finances brought on by population ageing.

Given the structural ageing of most world regions, the EU will have to increase its global skills competitiveness in order to attract the future migrant skills which it will need to sustain its economy. Here future climate change may bring a competitive advantage to the many European counties as it is likely to be environmentally attractive to those with skills and resources looking to migrate away from environmentally challenged areas.

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