International Institute for
Applied Systems Analysis
Schlossplatz 1
A-2361 Laxenburg, Austria

Tel: +43 2236 807 342
Fax: +43 2236 71313
E-mail: publications@iiasa.ac.at
Web: www.iiasa.ac.at

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Global and Regional Population Growth if European Demographic Transition Patterns Had Been Universal

Vegard Skirbekk (skirbekk@iiasa.ac.at)
Marcin Stonawski (stonaw@iiasa.ac.at)
Guido Alfani (guido.alfani@unibocconi.it)

Approved by

Wolfgang Lutz
Program Director, World Population Program

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Abstract

This study provides simulations showing what global and regional population sizes would be if the rest of the world would have experienced similar population growth patterns as what was observed in Europe during the demographic transition. In 1820-2010, slower growth was observed in Europe & North America where population increased by 4.6 times to a level of 1,088 million. The population of Asia increased from 720 million to 4,165 million. However, the biggest change from 1820 to 2010 was observed in regions that had relatively small populations in 1820 – Latin America (which increased by 38 times to 597 million) and Africa (which increased by 14 times to 1,031 million). Our simulations show that if the French pattern of population growth had been followed (French population size increasing by 2.5 1820-2010), the global population would have merely doubled during the demographic transition (increasing to 2.02 times its original size) over the 1820-2010 period. All regions would have had a significantly lower population size: Europe & North America would have increased to 474 million and Asia to 1,453 million, while Africa would have grown to 150 million, which is just 15% of its current population. Projections suggest that population implications of following the in the coming decades would have been much lower – e.g., if Nigeria would have followed the French population growth trajectory, it would grow to 72 million in 2100, while UN median variant projections suggest it would reach 914 million people by 2100.

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About the Authors

Vegard Skirbekk is Project Director of the Age and Cohort Change Project (ACC) with the World Population Program at the International Institute for Applied Systems Analysis (IIASA, VID/ÖAW, WU), Wittgenstein Centre for Demography and Global Human Capital.

Marcin Stonawski is Deputy Project Director of the Age and Cohort Change Project (ACC) with the World Population Program at the International Institute for Applied Systems Analysis (IIASA, VID/ÖAW, WU), Wittgenstein Centre for Demography and Global Human Capital.

Guido Alfani is an Associate Professor in the Department of Policy Analysis and Public Management at Bocconi University.

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1 Introduction

During the demographic transition which in Europe tended to take place from the early 19th to the end of the 20th century, the population in European countries and its overseas offshoots increased by a factor five or less, which is low compared to the increase now taking place in most other regions of the world. This study provides simulations showing what global and regional population sizes would be if the rest of the world would experience similar population growth patterns as what was observed in Europe.

European[1] culture distinguished itself through choices that led to the *European marriage pattern*, characterized by late marriage, significant shares not marrying, low levels of extramarital childbearing and comparatively low fertility (Hajnal 1965; Van de Walle 1986; Clark 2008). One important consequence was the relatively low population growth characterizing the cultures, religions and ethno-linguistic groups where the European marriage pattern was dominant.

2 Defining the Period of the Demographic Transition

Until recent centuries, high levels of fertility did not lead to rapid population growth, due to high mortality rates. This balance implied population growth at extremely low levels, with sometimes zero or negative growth. Population growth, resulting from the excess of births over deaths, occurs where death rates decline faster than birth rates. The process of demographic transition began in Western Europe around 1800, but much later in other regions– and it is still underway in many parts of the world today (Rathke & Sarferaz 2010; Lee 2003; Coale 1973).

We define the demographic transition as the movement from a long term situation where birth and death rates are high (c. 35-40) to a steady state of low birth and mortality rates (c. 10-15). Defining the onset of this process is difficult. The European Fertility Project (EFP) defined the onset of the fertility transition as a 10% decline in the index of marital fertility, which never again reached pre-transitional levels. As we consider the demographic transition to consist of the movement of *both* birth and death rates, we identify the start of the demographic transition. We choose as

[1] In this article, when the European case is discussed, it is referring to Western Europe (i.e., west of the "Hajnal" line), and not the entire continent.

1820, a year where sustained mortality decline had not been observed in almost any country and population growth had been slow - population levels observed then can therefore represent population size before the onset of the demographic transition. Most scholars place the initiation of sustained mortality decline around this period or later (e.g. Lee 2003, 170). We acknowledge that this does not take into account that some countries had a much later onset of the demographic transition. However, as population growth was modest prior to the demographic transition, this would have relatively little effect on the initial demographic values.

For "end point" values, we use both 2010 values (to assess the population growth to date) as well as population size in 2100 (medium variant UN population projections, UNPD World Population Prospects - The 2012 Revision) as proxies for a population size at advanced stages of or at the end of the demographic transition. We acknowledge that many countries would have completed the demographic transition long before these years, which would not affect the results to a large degree. We also note that some nations are projected to not have completed the demographic transition by the year 2100 – a longer projection period is likely to have revealed that the differences in population growth between nations are greater, still.

3 The Demographic Transition Multiplier

The demographic transition multiplier (DTM) is a simple measure of the change in population over the period of the demographic transition. For country *j*, the DTM is:

$$DTM_j = \frac{Pop_{j,t}}{Pop_{j,t-T_{dt}}}$$

Where $Pop_{j,t}$ is population at time *t* (post-transition) and T_{dt} is the duration of the transition. Therefore $Pop_{j,t-T_{dt}}$ is population at the start of the transition.. The size of the DTM depends on the relative growth of the population from time *t* to time $t - T_{dt}$.

The components of the DTM are births (*B*), deaths (*D*) and net migration (*NM*):

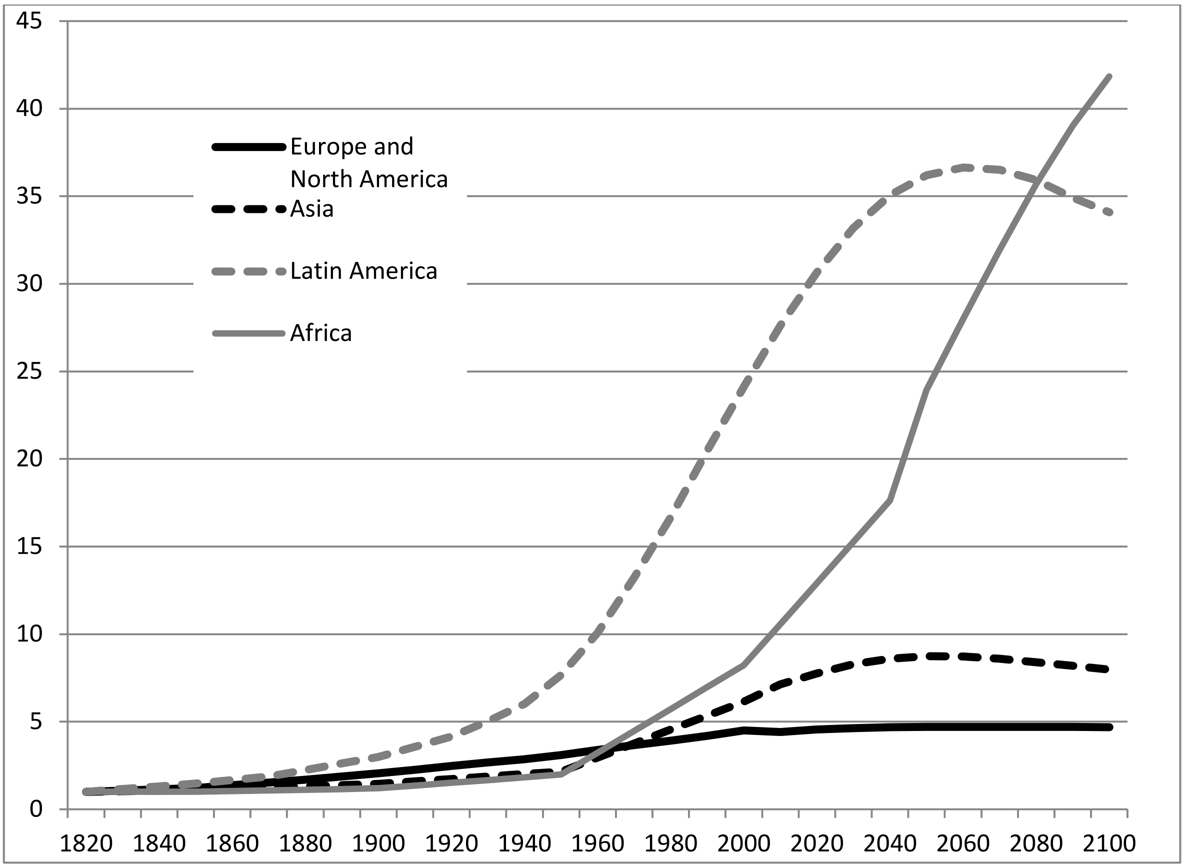
$$DTM_j = \frac{\sum_{i=1}^{T_{dt}}(B_{j,i} - D_{j,i} + NM_{j,i}) + Pop_{j,t-T_{dt}}}{Pop_{j,t-T_{dt}}}$$

The DTM is a measure of two stock variables, population before and after the demographic transition. Its scale will be purely determined by the flow of births, deaths and net migrants. However, as many nations lack historic data, we are for some nations not able to observe the entire demographic transition window. We then provide data for the part of the demographic transition that we can observe. With a base year set in 1820 we are able to observe most of the demographic transition for almost all countries/regions. For some countries we only have 1950 as the base year. We provide two end points, 2010 (as it is of interest to observe the DTM close to now) and 2100 (a period when the demographic transition is expected to have completed for most nations.

The DTM is a result of a number of complicated factors. First, greater levels of mortality and spikes in the death rate, like those caused in many countries by the two World Wars or by the Spanish Influenza pandemic, could reduce the DTM; similarly, low and rapidly declining fertility would lower the DTM. Sudden decreases in mortality as, say, resulting from the spread of medical innovations could increase the DTM if not offset by declines in fertility. Our definition of the DTM also includes demographic growth through migration. Migration would lower the DTM of the sending country and increase the DTM of the receiving country.

Figure 1 shows the very different developments over time in the DTM. Here the population for Africa, Latin-America, Europe and Asia is considered (population is set to 1 in 1820). The European and North American[2] population expands somewhat more rapidly than the African and Asian populations until the mid 20th century and then stabilizes at a level slightly below 5. However, the European demographic transition resulted in small effects on overall population size compared to the situation in Asia, Latin-America and Africa where the DTM is estimated to reach DTM levels of 8, 34 and 42, respectively by 2100.

Figure 1. Population increase 1820-2100 in Asia, Africa, and Europe and North America. (population set to 1 in 1820). Source: Maddison (2010), UN (1973; 2013), UN medium variant assumptions.



The demographic transitions taking place in many parts of Asia, Latin-America and Africa will result in much larger DTMs than observed in historical Europe and European offshoots. Asian and African population growth is in excess of that

[2] Europe and North America is considered together in order to account for the fact that large scale migration from Europe to North America took place during the demographic transition. Therefore it seems more realistic to consider these world regions as one entity.

documented in the major Western European nations. Moreover, the population growth currently taking place in Africa is natural population growth and will therefore have different socioeconomic effects than one fuelled by migration, which is usually dominated by people in their prime working ages. In contrast to migration-fuelled growth, natural population growth can only occur when births outnumber deaths. In which case, natural population growth is characterized by either a rise in fertility relative to mortality or decline in mortality relative to fertility (Dyson & Murphy 1985).

Although the DTM's parsimony is attractive from a methodological standpoint, care needs to be taken in its interpretation. For instance, a country may have a high DTM because land is abundant and there are few effective immigration restrictions. As aforementioned, migration will act to decrease the dependency ratio in the short run and subsequently allow greater spending on education and investment (less transfer payments to those not working and greater resources per child).

4 European Demographic Exceptionalism in Terms of Net Fertility

The 2SNRR (2 Sex Net Reproduction Rate) is a measure of how many children of both sexes survive to mid-reproductive ages under varying fertility and mortality conditions (Keilman et al. 2013). The use of the 2SNRR allows one to compare the European demographic transition with those of other world regions. It also focuses on 2SNRR variations between cultural, socio-economic and geographically differentiated subgroups of present and historical populations around the world.

The European relatively low net fertility is well documented (Coale & Watkins 1986; Chesnais 1992) and stands in stark contrast with other parts of the world that experienced far greater 2SNRR levels (e.g., Kuwait had a 2SNRR of 6.8 surviving children in the mid-1960s). In spite of the fact that the demographic transition took place over a longer time period in Europe, it tended to result in lower demographic transition multipliers (population size at the end over the population size at the beginning of the demographic transition) in European nations than in non-European nations.

From the 19th until the later part of the 20th century, mortality reductions led to an increase in the 2SNRR in Europe, rising from around 2 to around 3 children. There were seldom more than three children surviving to mid-reproductive age.

This is relatively modest in an international setting. Figures 2a-c present TFR (Total fertility rates – a measure of gross fertility) and 2SNRR during the demographic transition in European countries where relevant data is available from the 19th century, while Figures 2d-f show the cases of three non-European countries (where 2SNRR levels rose to much higher levels) (Source: (Sardon 1991; Chesnais 1992; UN 2013).

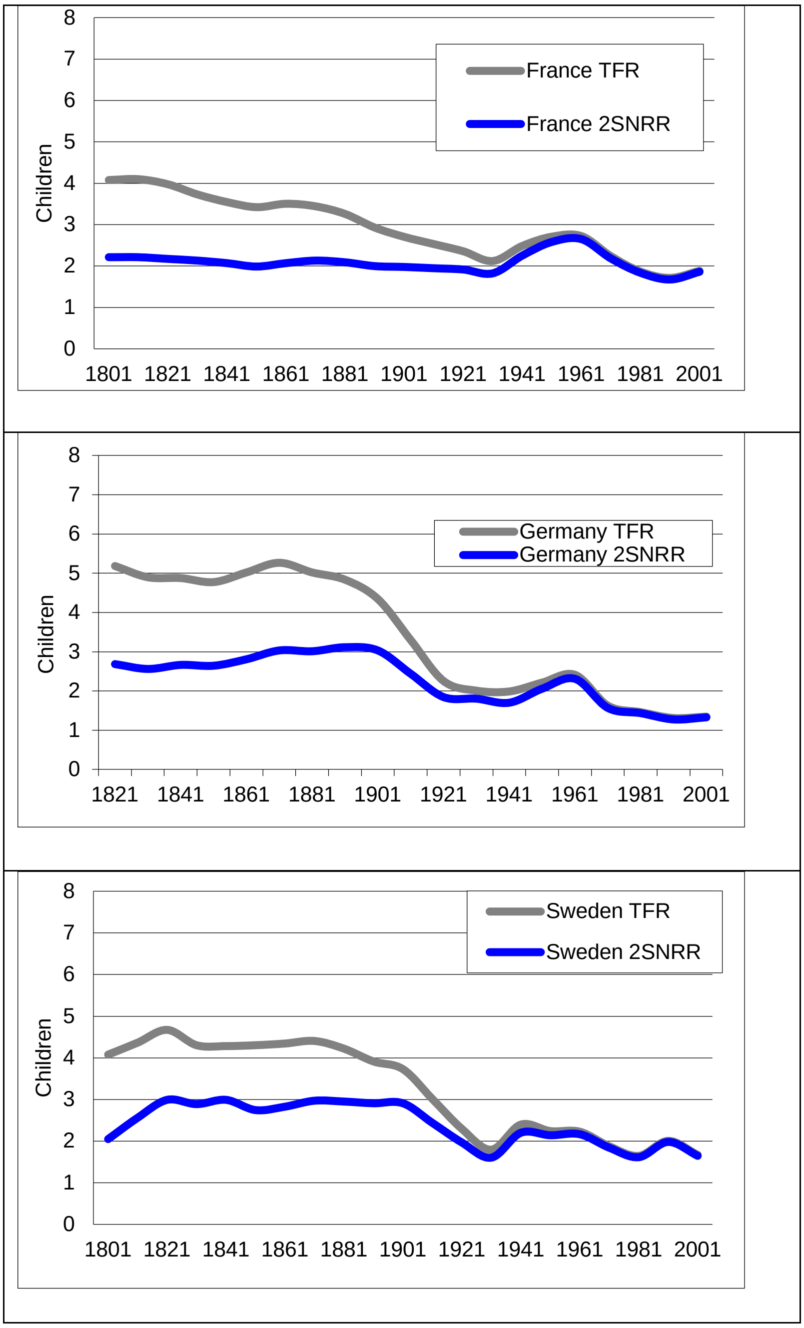
This stands in contrast with the demographic transition in most other world regions where, during the period of mortality decline, net fertility increased to high levels, causing rapid population growth in a short period of time and generally greater levels of overall population increase during the demographic transition.

The first country to experience sustained mortality and fertility decline was France, where 2SNRR remained at around 2 children throughout the demographic transition from 1801 until the present. 2SNRR never rose above 2.3 children before the baby boom in the post-war period. In other words, this was not a demographic transition where a lag between mortality decline and fertility decline led to high net fertility. Similar observations have been made in other European countries. For all European countries for which we have data, the highest 2SNRR observed is around 3 children. For England, Wrigley et al. (1997) present data from the late 16th century which also suggests that there were relatively large fluctuations in net fertility, never exceeding three surviving children. This makes the European situation unique compared to the transition from other world regions for which we have data. Sardon (1991) shows that for 15 European countries with available data, 11 experienced below replacement net fertility already for the generations born 1901-1906. Also, "European offshoots" may have been early to display low 2SNRR levels, at least for some subgroups. For instance, Sanderson (1987) shows that urban white women born 1846-55 in Northeast USA had only 1.8 surviving children at ages 45-54 in the year 1900.

For the European countries, the gradual decline in TFR was matched by an increase in longevity and thereby a stability of the 2SNRR. This was for example the case of Sweden, where there is slight growth in the 2SNRR from levels around 2 children to only around 3 children as mortality declined.

Several studies suggests that non-European societies were dominated by "natural fertility" levels, where women bore on average up to 7-8 children and long term slow growth rates reveal that only slightly above 2 survived (Cleland 2001; UN 1973). Conditions with scarce food and resources, changing temperatures and rainfall, low hygiene and recurring famines led to an environment where the long term net fertility averaged slightly above 2, with population growth rates being less than 0.02% (UN 1973)). The European fertility decline was initiated in 1880-1920 (Coale & Watkins 1986) and gross fertility levels for most European countries reached about 2 children around the 1970s, covering a time span of 50-100 years. In Asia, the drop was faster; e.g., Singapore and the Republic of Korea took 25-30 years to go from natural to replacement fertility, while in countries such as China, Thailand and Mauritius it took 40-45 years.

Figures 2a-c. TFR and 2SNRR from France, Germany and Sweden, 1801/21-2001. Source: (Sardon 1991; Chesnais 1992; UN 2013).



Figures 2d-f. TFR and 2SNRR from Kuwait, Indonesia and China, 1950-2010 (source: UN (2013).

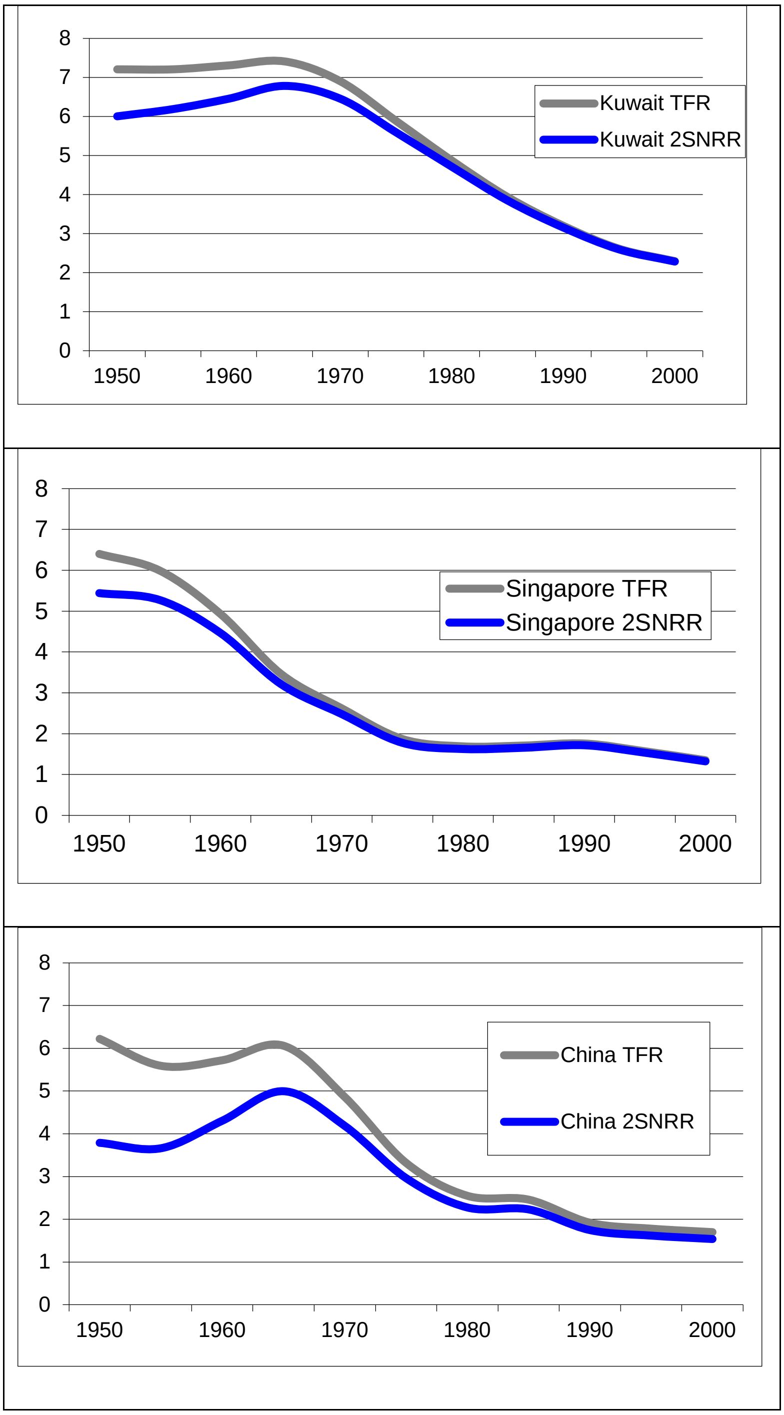
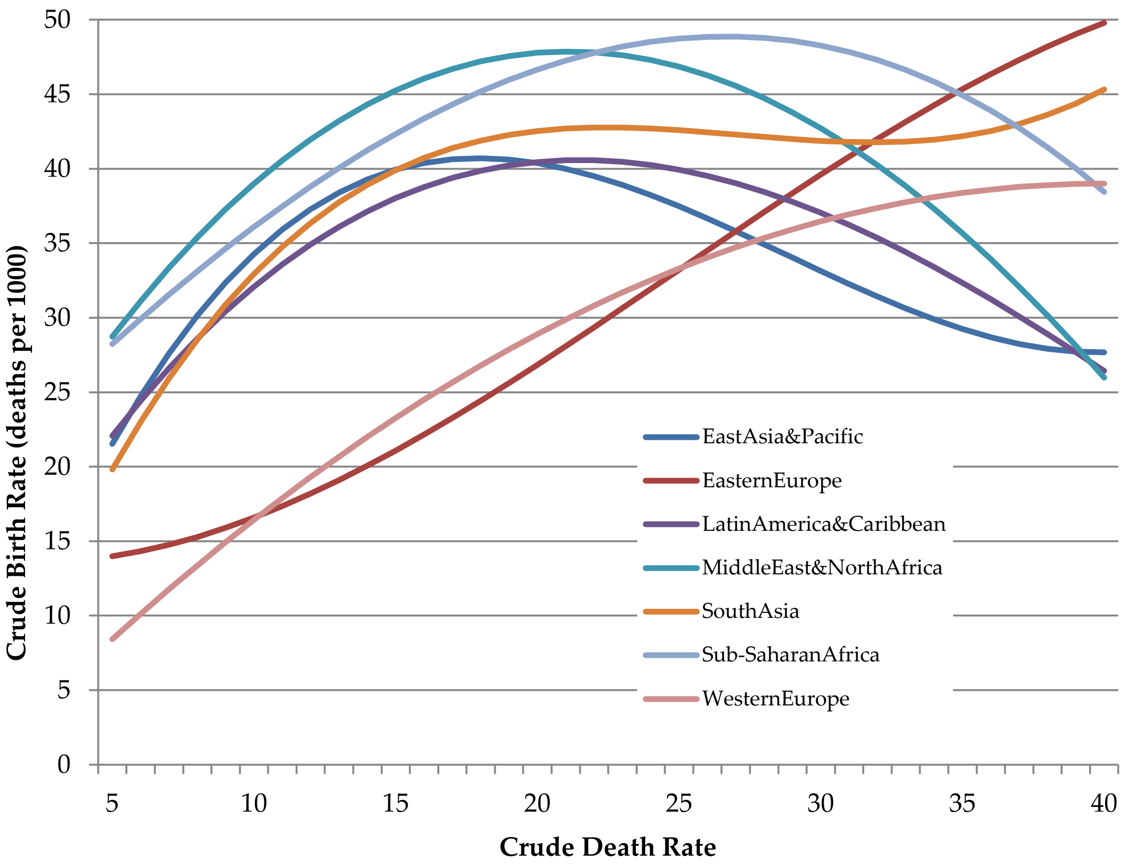


Figure 3 plots empirical observations of population growth by world regions. Two clear patterns emerge from the data. The European, or early demographic transition pattern, involves a tandem decline of birth and death rates with low population growth. The non-European or late demographic transition pattern, however, stands in stark contrast. Here, fertility, as measured by the crude birth rate, does not decline in tandem with the crude death rate. Births stay high and population growth rates reach around 3.5% on average.

Countries that experience higher 2SNRR levels will experience greater population growth. Cleland (2001) notes that the European population and its overseas offshoots increased from 200 to 750 million from 1800 to 1950, implying an annual average growth rate of about 0.8 % and a demographic transition multiplier of 3.75 for this period.

In countries such as Angola, Somalia, Cameroon, Palestinian Occupied Territories and Afghanistan, sustained fertility decline had by 2010 not yet been initiated in spite of substantial mortality declines. For the 27 countries with a TFR that rounds up to 6 or more children in the 2000s, mortality is in many cases relatively low – e.g., the Palestinian Occupied Territories has a mortality similar to the Baltic EU member states with an e(0) of 72.3, but a TFR which is 4 times higher, in spite of the fact that mortality decline was initiated more than 50 years ago. In Yemen, where e(0) is above 60 years, TFR remained at above 6 from 2000 till 2005, with a mortality decline lasting for about 35 years.

Figure 3. Trends in birth and death rates over the demographic transition for selected world regions.



5 Causes of the Demographic Transition

A number of factors have been argued to be causing the early timing of the demographic transition in Europe, ranging from ideological change and the enlightenment, improved hygiene, housing conditions, economic determinants and the industrial revolution, the spread of education, cultural norms (such as abstinence and late marriage) that decreased fertility, diffusion of low fertility norms from elite groups to the public and changes in contextual and institutional regulations and settings (Coale 1973; Chesnais 1992; Cervellati & Schupp 2005; Lee 2003).

Many of the changes that were related to the timing of the demographic transition in Europe may have taken place also in other world regions at a similar time as Europe. Naturally, different types of society-changing inventions, ranging from Egyptian water irrigation systems, Chinese gunpowder, Arabic Numerals, or Indian Astronomy have emerged in different parts of the world (Krebs 2004; Huff 2011; Xing 2013) and it has been argued that even by the nineteenth century some non-European areas, and in particular China, were not as backward as is usually implied (Goody 2006). Possibly, also the *demographic transition* could potentially have taken place in other world regions during the same period or even earlier than Europe. Also, China has a long historic tradition of reducing fertility from natural levels, using natural fertility limitation techniques (Zhao 2006). The sustained decline in family size towards replacement levels and below did originate in Europe (Notestein 1945), but it could have been possible that it originated independently elsewhere – and the trajectories observed in Europe could have been replicated elsewhere. An additional argument in favour of this view comes from Goody, who suggested that differences in household structures and systems of household formation across the wider Eurasian area have been overstated: both considering issues of measurement/categorization (with European and Asian families being more similar than what may be suggested by the straight application of specific categories, like Hajnal's distinction between "stem" and "joint" systems of family formation), and regarding the impact that different "structures" are traditionally credited to have on demographic and economic processes, including fertility control - see later (Goody 1996).

At the individual level, high education has been found to have similar effects across different ethnic groups within countries – and the effects are often found to be similar for higher fertility subpopulations, e.g., in the US black women with higher education have been found to have slightly lower fertility than their white counterparts (Maralani 2013) and the fertility of higher educated women in many poorer countries is often resemble fertility levels of better educated women in richer nations (Skirbekk 2008; Jejeebhoy 1995). Likewise, it is potentially possible that factors such as income growth, industrialization, urbanization, institutional development, and social change that drove the demographic transition could have taken place at the same time elsewhere or in Europe. In fact, relative living standards in Europe and Asia recently became a much-debated topic in world economic history, between those who suggest that as late as the eighteenth century, in the two areas living standards were about on par (Pomeranz 2000; Lee and Feng 1999) and those who stick to the idea that western European living standards had surpassed the Asian well before the beginning of the industrial revolution (Broadberry and Gupta 2006; Allen et al. 2011) - although not to such a degree as was commonly implied in the past. Medical improvements, better nutrition and the spread of more effective contraceptive techniques and preferences for fewer children could have also have spread earlier from Europe (Caldwell 2001; Livi-Bacci 2012). In effect, at least some key determinants of the demographic transition could plausibly have taken place in many regions of the world at an earlier time than they actually did.

5.1 Speed of Mortality Decline as a Driver of Low Net Fertility

The low 2SNRR of Europe may in part be explained by the relatively slow increase in life expectancy which gave couples the ability to more accurately predict the number of survivors under changing mortality conditions. Non-western countries tended to undergo the mortality decline at a much faster pace and at later periods compared to the Western nations: e.g., in Sweden life expectancy at birth rose from 45 years to 70 years over a period of about 90 years (from 1860 to 1950), while in Indonesia the same increase in life expectancy took only about 40 years (from 1965 to 2005).

The synthesis of historical evidence for Europe, China, Japan and India by Wilson and Airey (1999) suggests that long-term stability was achieved in these larger societies limiting total fertility to the range of 4 to 6 births, retaining stable populations at life expectancy at birth of 25 to 40 years. Furthermore, with an average of 4-5 children, Europeans had a lower pre-demographic transition fertility rate due to restrained fertility behavior. This lower initial level meant that they only had to reduce their fertility by slightly more than half to reach replacement fertility. In most other world regions, gross fertility tended to be in the range of 6-8 children; thus, a stronger reduction in gross fertility was needed to attain replacement fertility under conditions of low mortality.

When mortality declines rapidly, parental estimates of how many surviving children are likely to result from a given net fertility are often incorrect. Estimates of ideal size for countries early in the demographic transition, as evidenced from questionnaires suggest that the ideal family size was seldom above 3, 4, or 5 children (Mauldin 1965), and when mortality falls, gross fertility would need to decrease if ideals are to be realized.

The slow European mortality decline, taking more than a century to double life expectancy, coincided with low levels of net fertility increases. The same level of mortality decline that took a century and a half in European countries transpired in less than half that time in many countries from other world regions, such as in Asia. For instance, in Vietnam, the growth in life expectancy from about 40 to more than 70 years took place in about 45 years, while in France it took more than 100 years (Notestein (1953), Coale (1986), Davis (1963), UN (2013)).

Mortality decline is a necessary but not sufficent condition for lowering fertility. Mortality decline implies that unless gross fertility is lowered, more children will result in greater demand for parental resources and time. The willingness and capacity to lower fertility is also crucial for childbearing restrictions (Jejeebhoy 1995; Coale & Watkins 1986; Van de Walle 1986).

France was characterized by being an early transition country, and it was also a country that experienced early ideological and societal change causing the changes in family size and the decline in fertility. The enlightenment, the French revolution, religious critique, changing social structures and new attitudes towards fatalism were among the factors leading to lower fertility (Weir 1984; Shorter 1973).

A number of researchers have proposed explanatory frameworks that include improved survival as one of several determinants as well as cultural, technological and labour market changes along with urbanization and the availability of more effective prevention (making sexual abstinence unnecessary for lowered fertility, see e.g., (Mason 1997).

5.2 Education Lowered Fertility of the Europeans Historically

Education is strongly negatively related to fertility in the historical context of Europe (e.g., (Bongaarts & Watkins 1996; Chesnais 1992; Cochrane 1979; Skirbekk 2008). In several European nations, education levels increased for relatively broad sections of society from an early stage, following cultural and ideological long term changes including the Enlightement and the general societal spread towards high literacy levels (Green 1979; Maynes 1985; Ramirez & Boli 1987).

Education levels in European countries were relatively high from an early stage, with education levels observed in the early 19th century in countries such as Germany, England and France, that are still not matched in several countries in the world by turn of the 21st century (KC et al. 2010; Morrisson & Murtin 2009).

High European historical educaiton is likely to be a key reason why Europe had relatively low fertility historially. Skirbekk (2008) provides a broad meta-analysis of available data sets on historical differentials by level of education and/or social status from 1300 to the present. His analysis illustrates that position in a social hierarchy was positively associated with the level of fertility in the pre-demographic transition era. Over time, however, this positive effect of social status on fertility weakened, particularly in the latter half of the 20th century. Female education has been negatively associated with fertility for as long as education has been measured. Particularly in developing countries that are still in the midst of the fertility transition, the negative association is very strong. For instance, in Ethiopia, for example, the DHS data show that women without formal education have more than six children on average whereas women with secondary or higher education have only two children, a key reason why in Addis Abbeba, the total fertility rate has fallen to 1.8 (2010).

Increasing education levels are widely considered key cause of fertility decline during the demographic transition (Basu 2002; Martin & Juarez 1995; Cleland 2002). Education tends to be associated with a delay in the onset of childbearing and lower fertility outcomes. A close examination of the mechanisms at work suggests that these effects are causal and not solely driven by selection into schooling (e.g., those who would have fewer children in any case attain a higher education). Education has been found to depress fertility preferences, raise female autonomy, increase contraceptive practice, raise the opportunity costs of having children, and postpone the timing of childbearing (Jejeebhoy 1995; Gustafsson 2001; Kravdal 2002). In many developing countries age at marriage is another important intermediate variable in the relationship. There is strong evidence that early basic education is associated with later age at marriage. In Vietnam, for instance, a year of additional schooling reduces the probability of an arranged marriage by about 14 percentage points (Smith et al. 2009).

As mentioned above, in low fertility industrialized countries the differentials tend to be smaller but the association with female education is still clearly negative in most cases. This also seems related to the timing of the onset of childbearing. Education could also have self-reinforcing effects on fertility timing, where increasing levels of education create a race where one needs to have more and more schooling in order to be "on par" or better than others of the same sex-cohort group (Lutz et al. 2006; Skirbekk & KC 2012). This can imply that education results in fertility being increasingly postponed for each successive generation, since education levels gradually increase and more years of schooling are needed to reach a given percentile in the educational distribution. Several natural experiments suggest causal effects from educational extensions to a delay in the age of fertility in early adulthood. This phenomenon has been identified in very different contexts where school reforms have taken place, for instance in Norway and Turkey (Monstad et al. 2008; Kýrdar et al. 2011).

5.3 Abstinence and Low Net Reproduction

A central feature of the European marriage pattern was that considerable proportions of the population showed abstinence from sex and reproduction during much of reproductive life. The depressed fertility of the Europeans was caused by sexual abstinence through late marriage (in some cases not until the late 20s) and the fact that considerable portions of the populations never married, resulting in populations foregoing at least a quarter of their natural fertility (Hajnal 1965; Coale & Watkins 1986; Clark 2008; Wrigley et al. 1997). During the Middle Ages, late age to marriage was not a requirement of formal regulations (according to the Medieval Catholic Church, marriage could happen as soon as sexual maturity was reached) so the average age at marriage was mostly determined by social customs.

Recent research suggests that the Black Death in the mid-fourteenth century might have played a key role in the establishment of the European marriage pattern, especially in northern Europe (De Moor and Van Zanden 2010). What is sure, is that by the late medieval times, the age to marriage was used to restrict fertility, in Europe, especially in periods of lower resource production, leading to an average woman bearing 4-5 children. Iceland is an extreme example of this, as premarital sex was illegal and marriage was only permitted to those with the economic means to sustain themselves. In Iceland, the death penalty for pre-marital sexual relations (even if the woman agreed) was the law during some periods prior to the demographic transition unless the couple was about to get married with the permission of the male guardian of the woman’s family (Gunnarson 1980).

In other areas of Europe the doctrine of the medieval Catholic Church was much softer regarding premarital sex. Young men were required to at least respect the virginity of their fiancée up until marriage, but there was a considerable degree of ambiguity on the matter (Alfani 2013, Gaudemet 1987). Juridically, a man who "seduced" a woman of good moral standing and then refused to marry her was culpable of "rape", even if the woman had agreed to sexual intercourse. The penaly usually consisted in a fine, but the real aim of the lay tribunals was to induce the man to accept a marriage which often resulted in the cancelation of the fine (Lombardi 2008). From the sixteenth century, the Reformation led to significant changes in both the formal and the informal norms regulating premarital sex.

After the Reformation both the Protestant churches and the Roman Catholic Church tried to limitate premarital or extramarital sex, including between the betrothed

(Goody 2000). The strategy followed was to present premarital sex as a sin, promising severe otherwordly penalties to the sinners. In Catholic Europe, after the reform of marriage introduced by the Council of Trent (1545-63) young women could no longer claim that they presumed a marriage was established by the simple occurrence of sexual intercourse, a fact which made premarital sexuality an increasingly risky affair, and increased the incentives to stay sexually celibate ahead of marriage. In Protestant Europe, lay tribunals progressively introduced harsher penalties, including inprisonment (for both sexes) as well as the usual fines (Lombardi 2008).

Overall, control of extramarital sex was effective in Europe; both in Catholic and Protestant areas the incidence of births out of wedlock was minimal. During the eighteenth century, it was about 2-4 per cent in England, 3 in Scandinavia, and just one per cent in southwestern Europe (Italy, France and Spain). This being said, a significant proportion of first births were in fact due to premarital sex: it has been estimated that in eighteenth-century France, Germany and England, 10-30 per cent of the firstborn had been conceived before marriage (Livi Bacci 2000). Clearly, the post-Reformation campaigns had not entirely eliminated premarital sexuality (Lombardi 2008) - but they had possibly been much more successful in reducing other forms of extramarital sex. Seemingly everywhere across the continent the age of marriage was an effective regulator of fertility, one which changed in time reflecting availability of resources. Consequently, a substantial number of Europeans may have given up sex for much of their adult lives (some entirely) to avoid penalties, to increase resource availability per capita and to lower the mortality for their families.

Other factors may have also contributed to the uniquely low European fertility patterns. European patterns of breastfeeding may have depressed fertility to the extent that it contributed to longer spacing between children (Wilson 1986). It has also been argued that Europeans place a greater emphasis on nuclear family structures rather than extended families, causing individuals to postpone childbirth before they have the resources to form a new household, effectively resulting in older ages at marriage – although the evidence is not always clear (Laslett & Harrison 1963; Smith 1993).

Even if it seems to be an established fact that net reproduction rates in pre-transitional Europe were fairly low, it should be noticed that possibly the differences with other areas of the world, in particular in Asia, are overstated. For example, in the case of China it has been argued that, although age to marriage was generally lower than in western Europe, intra-marital fertility was also lower (Lee and Feng 1999). It has been hypothesized that this might be due to a lower propensity to sexual intercourse in arranged marriages compared to consensus-based unions (Kok et al. 2006; De Moor and Van Zanden 2010). The practice of infanticide possibly contributed to further reduce net reproduction rates in these areas.

5.4 Diffusion of Low Fertility from Elite Groups

Status was generally associated with high fertility historically, but in Europe this relationship reversed early in the demographic transition (Bardet 1983). Fertility decline is likely to have been initiated by certain economic groups (the richer), certain religious groups (e.g., Jews who travelled and mixed with members of other religions), as well as certain educational groups (the more literate and educated) (Jejeebhoy 1995; Skirbekk 2008); presumably this process matched to a large degree the pattern of spread of contraception. However, mortality was also lower among these groups from the onset of the demographic transition (Jones & Cameron 1984; Antonovsky 1967), and hence the net fertility decrease among elite groups was lower than the reduction in gross fertility relative to the rest of the population. Skirbekk (2008) estimates that the average variation before 1750 was 36.8% higher than among the lowest social class observed, but that this relation gradually diminshed as mortality and fertility fell. In effect, gross fertility differentials can be large even if net fertility differentials are smaller and net fertility differentials during the demographic transition may be lower than what studies often suggest (e.g., L. Jones, Schoonbroodt, and Tertilt 2008; Bardet 1983).

For instance, Innes (1938) suggests that for Britain 1891, wives of agricultural labourers had on average 6.7 children, while wives of professional, clerical, and higher white collar workers had 5.0 children. However, this 25% higher fertility could be reduced if mortality differentials up to the mid-reproductive period werer adjusted for, as upper classes had lower mortality (Antonovsky 1967; Livi Bacci 1991). Mortality reducing measures included improved health behaviours, which tended to be first used by the upper social strata (Jones & Cameron 1984).

5.5 Economic Determinants

The growing economic costs of having children versus working drove down fertility earlier in many settings (Gustafsson 2001). One study based on the Bangladeshi setting concluded that the growing costs of raising children and the greater opportunity costs could be more important in reducing fertility than other factors, such as mortality decline and cultural change (Shenk et al. 2013). The growing consumption losses expected from childbearing during the demographic transition can increase - as children start working at an increasingly high age, and expected losses in terms of childbearing due to income increases (Lee 2003; Gustafsson 2001). These kinds of models see fertility decline as a response to consumers' demand for children compared to other goods (Becker 1967; Schultz 1997).

In the case of western European, changes in the relative costs of children during the demographic transition are usually explained with the new needs of an economic system which was being deeply transformed by the industrial revolution. However, the causal connection between the process of economic modernization and the demographic transition is notoriously difficult to assess, so that the two are better understood as closely interacting processes, rather than as one (industrial revolution) "causing" the other (demographic transition) (Livi Bacci 2000; 2012). In fact, the historical experience of the nineteenth and twentieth centuries shows a wide variety of possible differential chronologies for the two processes. On the one hand, regarding demographic change, in many areas of the developing world the demographic transition started well before any significant economic modernization had occurred. Even in Europe, this was the case of France which is credited with being the first country to start the transition - being at the time a mostly agrarian society while England, the first industrial country, experienced a relatively late fertility decline (Livi Bacci 2000; 2012). On the other hand, specialists of the industrial revolution pointed out that in some late-comers the industrialization process started in absence of many concomitant transformations (cultural, institutional and social) characterizing the European experience (Landes 2003). Overall, this literature strenghtens the idea that the European demographic transition had unique characteristics, due to its complex interaction with other largely independent processes.

As a final point, apart from raising the cost of children, the concomitant industrial revolution could have contributed to shape the European demographic transition by triggering other processes, like urbanization and changes in family structures/family formation, which reduced the final DTM.

5.6 Contextual Settings

Voigtländer and Voth (2011) suggest that cultural and technological innovation in Europe drove increases in pastoralism, which brought about a rise in female employment (partly as female labour was less costly than male labour), which in turn depressed female fertility. The rise in less labour intensive pastoralism is suggested to have partly resulted from the population decline during the Black Death in 14th century Europe. Increased prevalence of work in husbandry may have led to delayed marriages and decreased fertility outcomes as it enhanced female employment opportunities. More generally, De Moor and Van Zanden (2010) suggest that the shock caused by the Black Death to the labour market increased female participation into it and led to more balanced roles and power distribution between the genders (as well as favouring the establishment of the European marriage pattern; see above). This is also related to the spread of life-cycle service: landlords took in large shares of young female and male cohorts, giving them housing and food while they worked. Especially in northwestern Europe, a large proportion of 15-24 year olds were servants. Kussmaul (1981) estimates that in seventeenth- and eighteenth-century England they accounted for 10-12 per cent of the total population. Focusing on the age group 15-24, Reher estimates that overall 30-55 per cent of the young persons were servants in northern Europe, while in southern Europe the figure falls to 5-20 per cent (Reher 1998, 206) e. Kussmaul (1981) also estimates that two thirds of servants married immediately before or after the end of their contracts. Consequently, as already Hajnal (1982) had noticed, the incidence of service was inversely related to age to marriage and fertility.

Fertility limitation may in turn have contributed to early industrialization (as the capital-labour ratio was skewed towards the latter), which raised the opportunity costs of female childbearing and depressed fertility outcomes (Voigtländer & Voth 2006).

Other contextual settings that might contribute to explain early fertility decline in Europe include social and ideological change in France, from the Enlightenment period to the French Revolution, with the diffusion of behaviours (like *coitus interrupts*, an early contraceptive method) that the Napoleonic Wars later spread to much of the continent (Weir 1984; González-Bailón and Murphy 2013). However, the causal connection between the Revolution and the spread of the use of contraception – and consequently, the causal connection between secularization and fertility decline – has also been questioned by some scholars, as possibly both phenomena reflected a general wave of cultural change in France, investing at about the same time the rural masses and the urban elites (Bardet and Dupâquier 1986). The latter view could be better able to explain the quick fertility decline occurred in France, compared with interpretations involving slow downward spread of ideas or practices first developed by a urban, secularized and ideologically advanced elite.

6 Projections and Conclusion

We have illustrated Europe's unique population history in a historic and international perspective. The demographic transition multiplier captures net population increase over the demographic transition, and this measure differs considerably across nations. While the DTM in Europe and North America was around five or less, DTM levels in other parts of the world are much greater. In the following section, we estimate what the regional and global demographic implications of having a European DTM could have been. The European choice of population behaviour has far reaching consequences in terms of global and regional population growth, including effects on greenhouse gas emissions, resource use, poverty and income distributions, culture and society. It is plausible that the demographic experiences that took place in Europe and European offshoots could have been replicated in other parts of the world if social, institutional, economic and cultural factors that were present in Europe had been adopted.

Figures 7a-d and Table 1 show the demographic patterns that took place until 2010 and projections until 2100 ("Baseline" scenario) along with counterfactual growth trajectories assuming European and North American growth patterns would have been followed in other world regions ("European World" scenario). Further, we include projections of what the world would look like if it had followed the French demographic transition - which had the lowest DTM level ("French World" scenario).

In 1820 almost 69% of world's population lived in Asia, 22.5% in Europe and North America, whereas the share of African population was around 7% and Latin American 1.5%. Until 2010, the proportional amount of Asia's population decreased to the level of 60%, and Europe's to around 16%. Concurrently, Africa and Latin America reached 15% and 8.6% respectively. The UN projects that until the end of the century, the share of the African population will grow dramatically and reach 38.6%, at a deficit of Europe, Asia and Latin Africa which will be diminished to 10.6%, 43.5% and 6.8% in 2100.

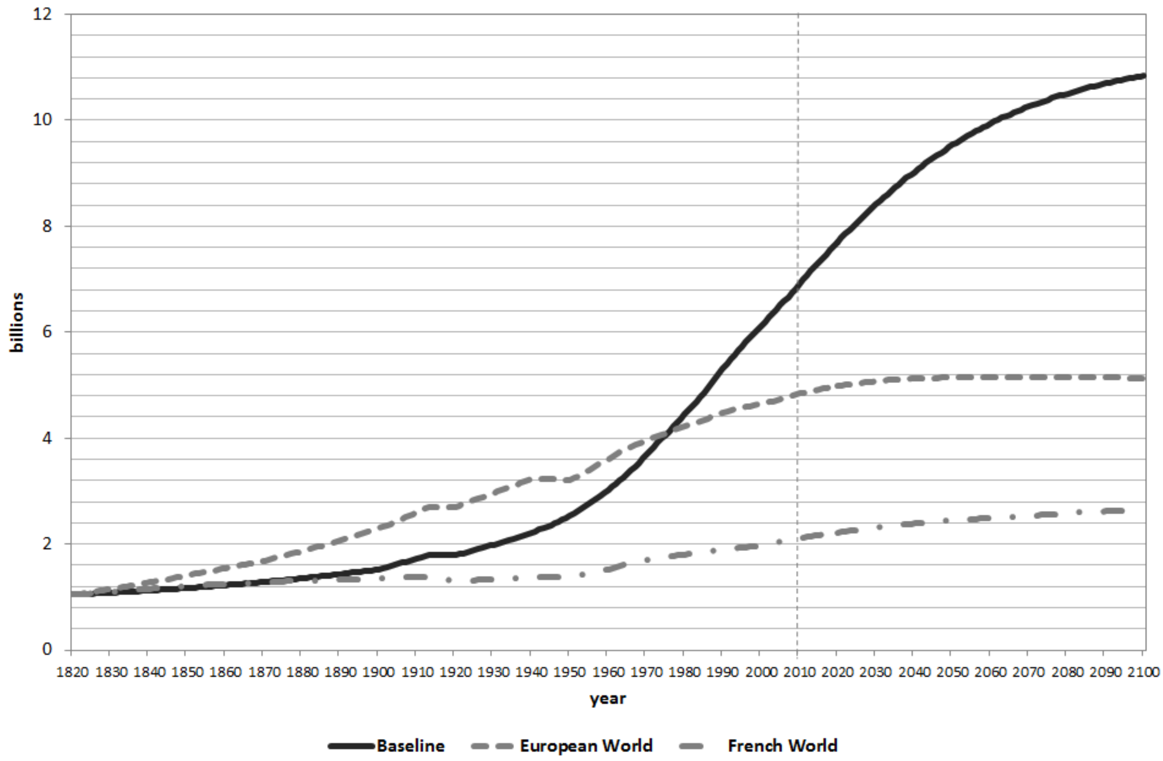
Scenario	Year	Europe & Northern America	Asia	Africa	Latin America	Australia & New Zealand	Global Population
-	1820	234,457	717,890	74,236	15,695	434	1,042,713
Baseline	2010	1,087,785	4,165,440	1,031,084	596,191	26,773	6,907,273
	2100	1,152,924	4,711,514	4,184,577	736,228	47,684	10,832,927
European World	2010	1,087,785	3,330,713	344,424	72,820	2,014	4,837,757
	2100	1,152,924	3,530,162	365,049	77,181	2,134	5,127,450
French World	2010	474,398	1,452,570	150,208	31,758	878	2,109,813
	2100	593,152	1,816,186	187,809	39,708	1,098	2,637,953

Table 1. Population size in 1820, 2010 and 2100 by region and scenario.

During the period 1820-2010, the global population increased from around 1 billion to 6.9 billion and according to the UN experts it will reach the level of 10.8 billion people in 2100. Whereas, if the pace of population growth in the whole world had been on the level observed in Europe (Scenario 2), the global population would have increased to 4.8 billion in 2010, 70% of what it is today. By 2100 the world population would be 47%.

The French trajectory of population change would have seen the world's population increase to 2.1 billion in 2010 and to only 2.6 billion in 2100, less than a quarter of the current medium variant scenario (Scenario 3). The different global population trends by scenario are shown in Figure 7a.

Figure 7a. Total World Population in billions 1820-2100, by three scenarios.



In 1820-2010, the population of Asia increased from 720 million to 4,165 million (fig. 7b). Slower growth was observed in Europe & North America where population increased by 4.6 times to a level of 1,088 million. However, the biggest change from 1820 to 2010 was observed in regions that had relatively small populations in 1820 – Latin America (which increased by 38 times to 597 million) and Africa (which increased by 14 times to 1,031 million).

Figure 7c shows the alternative population change in regions under the scenario of the European and North American growth patterns. According to this scenario, all regions would have grown by a factor of 4.6. In 2010, Asia would have reached only 3,330 million people, Africa 344 million and Latin America 73 million people.

If the French pattern of population growth had been followed, see Figure 7d, the global population would have merely doubled during the demographic transition (increasing to 2.02 times its original size) over the 1820-2010 period. All regions would have had a significantly lower population size: Europe & North America would have increased to 474 million and Asia to 1,453 million, while Africa would have grown to 150 million, which is just 15% of its current population.

We also provide in Table 2 the DTM by country, using 1820 or 1950 as the base year and 2010 and 2100 (UN median variant assumptions) as the end year. DTM estimates are given for the case if it would follow UN median variant trajectory, the European or the French population growth trajectory. Several of the countries lack data from 1820, and for these cases we use the population size in 1950 as the base year. In effect, these DTM estimates cover most or a significant share of the period demographic transition – and thereby provide a realistic DTM for many nations.

Table 3 provides population size estimates for 2010 or 2100 for all nations using either 1950 or (when data is available) 1820 as a base year. In terms of estimates for the national population would have been. Using 1950 as a base year, we do not capture the entire demographic transition for many nations, but a large part of it, in particular for poorer nations (who tended to be in relatively early stages of the demographic transition at this point in time). In terms of the DTM, it is 4.9 (for the European trajectory) or 2.5 (for the French trajectory) if the base year was 1820. If the base year is 1950, the DTM is 1.6 for the European trajectory and 1.9 for the French trajectory.

The implications of differences in population growth patterns are large. If Nigeria would have followed the French population trajectory, it would grow from 38 million in 1950 to 72 million in 2100, while the UN projections suggest it would reach 914 million people by 2100. If Brazil would have followed the European population growth trajectory it would have grown from 5 million in 1820 to 22 million by 2100, rather than the projected growth to 194 million individuals. If India would have followed the European population trajectory since 1820, it would have grown from 209 million to 529 million rather than 1547 million by 2100.

In sum, this study demonstrates global and regional population growth effects of specific cultural and societal characteristics that affect patterns of net fertility over the demographic transition. Population growth is more influenced by cultural variation causing uneven growth rather than by any universal population growth trajectories over the demographic transition. We highlight how culture can have large effects on population change, and thereby represent a central mechanism contributing to population growth related outcomes, such as environmental outcomes.

Figure 7b. Population size of Europe & Northern America in 1820-2100, by scenario.

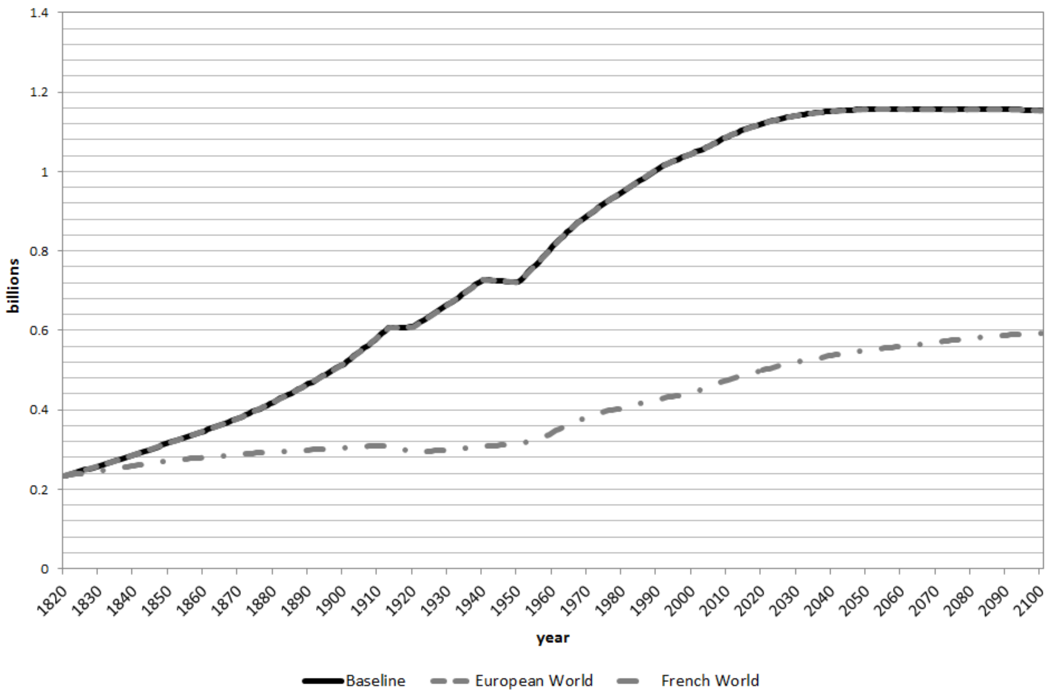


Figure 7c. Population size of Asia in 1820-2100, by scenario.

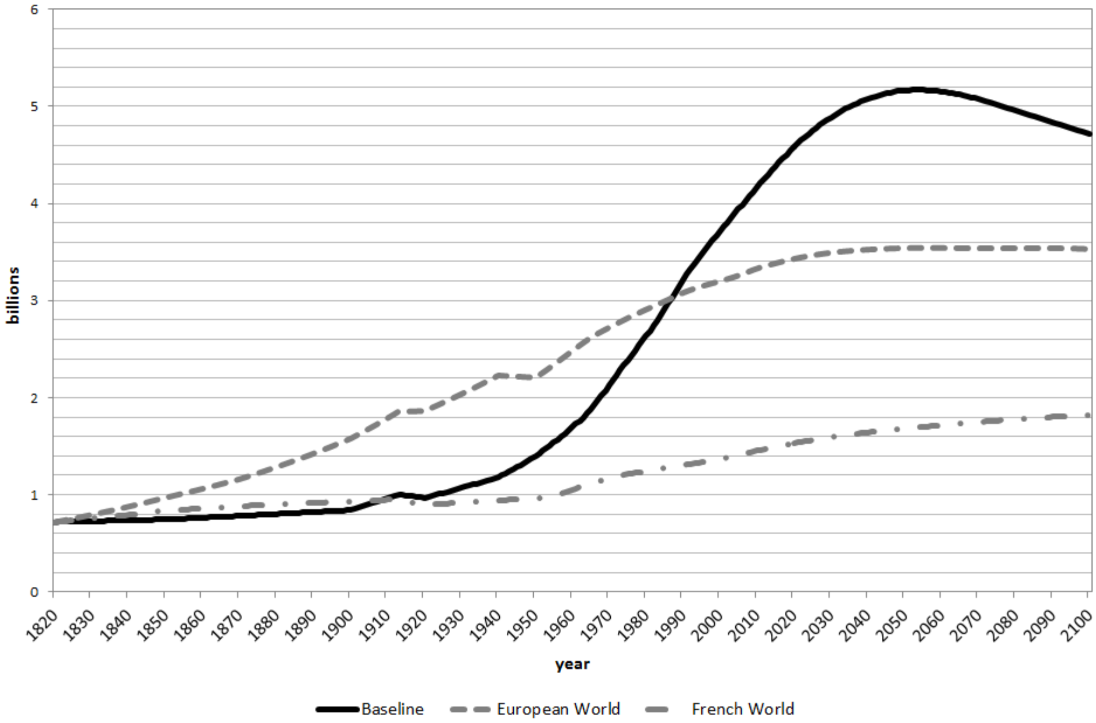
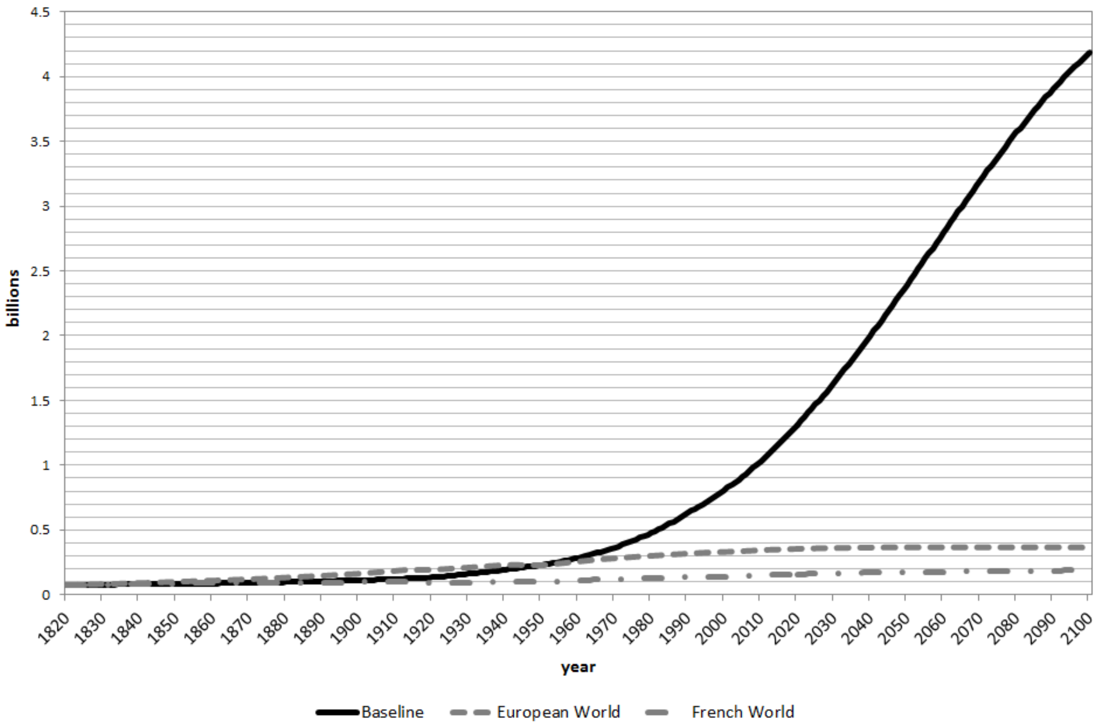


Figure 7d. Population size of Africa in 1820-2100, by scenario.



Country	Index			
	2010/1820	2100/1820	2010/1950	2100/1950
Afghanistan	8.7	18.1	3.8	8.0
Albania	7.2	5.1	2.6	1.8
Algeria	13.8	20.4	4.2	6.2
Andorra	-	-	12.6	14.7
Angola	-	-	4.7	23.5
Anguilla	-	-	2.7	2.3
Antigua and Barbuda	-	-	1.9	2.5
Argentina	75.6	94.4	2.4	2.9
Armenia	7.2	4.9	2.2	1.5
Aruba	-	-	2.7	2.3
Australia	67.1	124.2	2.7	5.1
Austria	2.5	2.8	1.2	1.4
Azerbaijan	10.3	9.6	3.1	2.9
Bahamas	-	-	4.6	6.4
Bahrain	-	-	10.8	13.1
Bangladesh	-	-	4.0	4.8
Barbados	-	-	1.3	1.5
Belarus	4.0	2.4	1.2	0.7
Belgium	3.2	3.7	1.3	1.5
Belize	-	-	4.5	10.1
Benin	-	-	4.2	14.6
Bhutan	-	-	4.1	4.9
Bolivia (Plurinational State of)	9.2	17.7	3.7	7.2
Bosnia and Herzegovina	-	-	1.4	0.9
Botswana	-	-	4.8	7.3
Brazil	43.3	43.2	3.6	3.6
British Virgin Islands	-	-	3.7	4.5
Brunei Darussalam	-	-	8.3	10.4
Bulgaria	3.4	1.6	1.0	0.5
Burkina Faso	-	-	3.6	17.6
Burundi	-	-	4.0	24.4
Cambodia	6.9	11.3	3.2	5.3
Cameroon	-	-	4.6	18.4
Canada	41.8	62.4	2.5	3.7
Cape Verde	-	-	2.7	3.1
Caribbean Netherlands	-	-	2.5	3.0
Cayman Islands	-	-	8.7	9.5
Central African Republic	-	-	3.3	8.9
Chad	-	-	4.7	25.3
Channel Islands	-	-	1.6	1.6
Chile	22.2	24.4	2.8	3.1
China	3.6	2.8	2.5	2.0
China, Hong Kong SAR	352.5	343.8	3.6	3.5
China, Macao SAR	-	-	2.7	4.2

Country	Index			
	2010/1820	2100/1820	2010/1950	2100/1950
Colombia	38.5	49.9	3.9	5.0
Comoros	-	-	4.4	16.2
Congo	-	-	5.1	26.4
Costa Rica	74.1	84.4	4.8	5.5
Côte d'Ivoire	-	-	7.2	29.0
Croatia	-	-	1.1	0.7
Cuba	18.6	9.0	1.9	0.9
Curaçao	-	-	1.5	1.6
Cyprus	-	-	2.2	2.3
Czech Republic	-	-	1.2	1.2
Dem. People's Republic of Korea	5.6	5.8	2.3	2.4
Democratic Republic of the Congo	-	-	5.1	21.5
Denmark	4.8	6.1	1.3	1.6
Djibouti	-	-	13.5	21.0
Dominica	-	-	1.4	1.3
Dominican Republic	112.5	139.5	4.2	5.2
Ecuador	30.0	48.8	4.3	7.1
Egypt	18.6	32.2	3.6	6.3
El Salvador	25.1	22.3	2.8	2.5
Equatorial Guinea	-	-	3.1	10.7
Eritrea	1.8	6.9	5.0	19.1
Estonia	3.9	2.9	1.2	0.9
Ethiopia	-	-	4.8	13.4
Faeroe Islands	-	-	1.6	1.7
Falkland Islands (Malvinas)	-	-	1.3	1.2
Finland	4.6	4.9	1.3	1.4
France	2.0	2.5	1.5	1.9
French Guiana	-	-	9.1	26.4
Gabon	-	-	3.3	10.3
Gambia	-	-	6.2	31.0
Georgia	4.1	2.8	1.2	0.9
Germany	3.3	2.3	1.2	0.8
Ghana	-	-	4.9	11.5
Gibraltar	-	-	1.4	1.1
Greece	4.8	4.1	1.5	1.2
Grenada	-	-	1.4	1.0
Guadeloupe	-	-	2.2	2.1
Guatemala	24.1	78.1	4.6	14.8
Guinea	-	-	3.5	11.6
Guinea-Bissau	-	-	3.1	10.9
Guyana	-	-	1.9	1.5
Haiti	13.7	20.5	3.1	4.6
Holy See	-	-	0.9	0.9
Honduras	56.5	115.8	5.1	10.5

Country	Index			
	2010/1820	2100/1820	2010/1950	2100/1950
Hungary	2.4	1.8	1.1	0.8
Iceland	-	-	2.2	2.9
India	5.8	7.4	3.2	4.1
Indonesia	13.4	17.6	3.3	4.3
Iran (Islamic Republic of)	11.4	14.4	4.3	5.5
Iraq	28.3	97.3	5.4	18.6
Ireland	0.6	0.9	1.5	2.3
Isle of Man	-	-	1.5	1.8
Israel	-	-	5.9	11.9
Italy	3.0	2.7	1.3	1.2
Jamaica	6.8	5.1	2.0	1.5
Japan	4.1	2.7	1.5	1.0
Jordan	29.7	59.6	14.4	28.8
Kazakhstan	7.8	10.3	2.4	3.1
Kenya	-	-	6.7	26.4
Kuwait	-	-	19.6	52.3
Kyrgyzstan	10.1	16.8	3.1	5.1
Lao People's Democratic Republic	13.6	23.7	3.8	6.6
Latvia	3.5	2.5	1.1	0.7
Lebanon	13.1	12.4	3.3	3.1
Lesotho	-	-	2.7	4.3
Liberia	-	-	4.3	17.1
Libya	11.2	14.2	5.4	6.9
Liechtenstein	-	-	2.6	3.4
Lithuania	3.9	2.7	1.2	0.8
Luxembourg	-	-	1.7	2.4
Madagascar	12.5	62.5	5.2	25.7
Malawi	-	-	5.2	29.5
Malaysia	98.5	147.7	4.6	6.9
Maldives	-	-	4.4	6.4
Mali	-	-	3.0	21.7
Malta	-	-	1.4	1.1
Martinique	-	-	1.8	1.5
Mauritania	-	-	5.5	18.8
Mauritius	-	-	2.5	2.0
Mayotte	-	-	13.5	43.3
Mexico	17.9	21.2	4.2	4.9
Monaco	-	-	1.8	3.5
Mongolia	4.4	6.4	3.5	5.0
Montenegro	-	-	1.6	1.1
Montserrat	-	-	0.4	0.4
Morocco	11.8	15.9	3.5	4.8
Mozambique	11.4	53.4	3.7	17.4
Myanmar	14.8	13.5	3.0	2.7

Country	Index			
	2010/1820	2100/1820	2010/1950	2100/1950
Namibia	-	-	4.5	8.8
Nepal	6.9	8.9	3.3	4.2
Netherlands	7.1	6.8	1.7	1.6
New Zealand	43.7	61.9	2.3	3.2
Nicaragua	31.3	42.5	4.5	6.1
Niger	-	-	6.2	79.6
Nigeria	-	-	4.2	24.1
Norway	5.0	7.8	1.5	2.3
Oman	8.8	12.0	6.1	8.4
Other non-specified areas	11.6	7.1	3.1	1.9
Pakistan	-	-	4.6	7.0
Panama	-	-	4.3	7.3
Paraguay	45.2	82.8	4.4	8.0
Peru	22.2	30.2	3.8	5.2
Philippines	42.9	86.3	5.0	10.1
Poland	3.7	2.5	1.5	1.1
Portugal	3.2	2.3	1.3	0.9
Puerto Rico	15.0	11.5	1.7	1.3
Qatar	-	-	70.0	79.5
Republic of Korea	5.2	4.3	2.5	2.1
Republic of Moldova	5.0	2.4	1.5	0.7
Réunion	-	-	3.4	4.6
Romania	3.4	2.0	1.3	0.8
Russian Federation	4.6	3.3	1.4	1.0
Rwanda	-	-	5.0	16.6
Saint Helena	-	-	0.9	0.8
Saint Kitts and Nevis	-	-	1.1	1.4
Saint Lucia	-	-	2.1	2.1
Saint Vincent and the Grenadines	-	-	1.6	1.4
San Marino	-	-	2.4	2.3
Sao Tome and Principe	-	-	3.0	9.5
Saudi Arabia	13.0	17.8	8.7	11.9
Senegal	-	-	5.2	23.5
Serbia	-	-	1.4	0.6
Seychelles	-	-	2.5	2.4
Sierra Leone	-	-	3.0	7.1
Singapore	169.3	201.3	5.0	5.9
Sint Maarten (Dutch part)	-	-	28.4	36.6
Slovakia	-	-	1.6	1.1
Slovenia	-	-	1.4	1.2
Somalia	9.6	54.0	4.3	23.8
South Africa	33.2	41.4	3.8	4.7
South Sudan	-	-	3.8	15.2
Spain	3.8	3.4	1.6	1.5

Country	Index			
	2010/1820	2100/1820	2010/1950	2100/1950
Sri Lanka	17.1	17.9	2.6	2.7
State of Palestine	12.1	38.8	4.3	13.8
Sudan	6.9	22.5	6.2	20.3
Suriname	-	-	2.4	2.7
Swaziland	-	-	4.4	7.9
Sweden	3.6	5.6	1.3	2.1
Switzerland	3.9	6.5	1.7	2.7
Syrian Arab Republic	16.1	30.0	6.3	11.8
Tajikistan	16.3	45.7	5.0	13.9
TFYR Macedonia	-	-	1.7	1.1
Thailand	14.2	8.7	3.2	2.0
Timor-Leste	-	-	2.5	7.5
Togo	-	-	4.5	17.7
Trinidad and Tobago	22.1	13.2	2.1	1.2
Tunisia	12.2	13.2	3.4	3.7
Turkey	7.2	8.6	3.4	4.1
Turkmenistan	13.7	15.7	4.2	4.8
Turks and Caicos Islands	-	-	6.1	7.4
Uganda	-	-	6.6	39.7
Ukraine	4.1	2.2	1.2	0.7
United Arab Emirates	-	-	121.3	197.7
United Kingdom	2.9	3.6	1.2	1.5
United Republic of Tanzania	-	-	5.9	36.0
United States of America	31.3	46.3	2.0	2.9
United States Virgin Islands	-	-	4.0	4.0
Uruguay	61.3	59.8	1.5	1.5
Uzbekistan	14.5	16.0	4.4	4.9
Venezuela (Bolivarian Republic of)	40.5	59.6	5.7	8.4
Viet Nam	13.6	12.2	3.6	3.2
Western Sahara	-	-	37.4	56.9
Yemen	8.8	16.3	4.9	9.0
Zambia	-	-	5.6	52.4
Zimbabwe	-	-	4.8	11.9

Table 2. DTM index for up to 210 countries, population estimates/projections for 2010 or 2100 (base year 1820 or 1950). Source: UN (2013) median variant projections, Maddison (2010).

Country	Baseline				European growth trajectory		French growth trajectory		European growth trajectory		French growth trajectory	
					starting year 1820				*starting year 1950*			
	1820	1950	2010	2100	2010	2100	2010	2100	2010	2100	2010	2100
Afghanistan	3,280	7,451	28,398	59,249	15,218	16,129	6,637	8,298	11,240	11,913	11,262	14,081
Albania	437	1,214	3,150	2,217	2,027	2,149	884	1,106	1,832	1,942	1,836	2,295
Algeria	2,689	8,872	37,063	54,887	12,476	13,223	5,441	6,803	13,384	14,186	13,411	16,768
Andorra	-	6	78	91	-	-	-	-	9	10	9	12
Angola	-	4,148	19,549	97,337	-	-	-	-	6,257	6,631	6,269	7,839
Anguilla	-	5	14	12	-	-	-	-	8	8	8	10
Antigua and Barbuda	-	46	87	114	-	-	-	-	70	74	70	88
Argentina	534	17,150	40,374	50,436	2,478	2,626	1,080	1,351	25,872	27,421	25,924	32,413
Armenia	413	1,354	2,963	2,023	1,918	2,032	836	1,046	2,042	2,164	2,046	2,558
Aruba	-	38	102	86	-	-	-	-	57	61	58	72
Australia	334	8,177	22,404	41,497	1,550	1,642	676	845	12,336	13,074	12,360	15,455
Austria	3,369	6,938	8,402	9,587	15,631	16,567	6,817	8,523	10,466	11,093	10,487	13,112
Azerbaijan	880	2,896	9,095	8,433	4,083	4,327	1,781	2,226	4,369	4,630	4,377	5,473
Bahamas	-	79	360	504	-	-	-	-	119	126	120	149
Bahrain	-	116	1,252	1,520	-	-	-	-	174	185	175	219
Bangladesh	-	37,895	151,125	182,238	-	-	-	-	57,165	60,589	57,280	71,618
Barbados	-	211	280	316	-	-	-	-	318	337	319	399
Belarus	2,355	7,745	9,491	5,601	10,927	11,581	4,765	5,958	11,684	12,383	11,707	14,638
Belgium	3,434	8,628	10,941	12,594	15,932	16,886	6,948	8,688	13,016	13,796	13,042	16,307
Belize	-	69	309	693	-	-	-	-	104	110	104	130
Benin	-	2,255	9,510	32,944	-	-	-	-	3,402	3,606	3,409	4,262
Bhutan	-	177	717	870	-	-	-	-	267	283	267	334
Bolivia	-	2,714	10,157	19,510	-	-	-	-	4,094	4,339	4,102	5,129
Bosnia and Herzegovina	-	2,661	3,846	2,374	-	-	-	-	4,015	4,255	4,023	5,030
Botswana	-	413	1,969	3,025	-	-	-	-	622	660	624	780
Brazil	4,507	53,975	195,210	194,533	20,911	22,163	9,119	11,402	81,423	86,298	81,585	102,008
British Virgin Islands	-	7	27	33	-	-	-	-	11	12	11	14
Brunei Darussalam	-	48	401	501	-	-	-	-	72	77	73	91
Bulgaria	2,187	7,251	7,389	3,533	10,147	10,754	4,425	5,533	10,938	11,593	10,960	13,704
Burkina Faso	-	4,284	15,540	75,274	-	-	-	-	6,463	6,850	6,476	8,097
Burundi	-	2,309	9,233	56,285	-	-	-	-	3,483	3,692	3,490	4,364

Country	Baseline				European growth trajectory *starting year 1820*		French growth trajectory *starting year 1820*		European growth trajectory *starting year 1950*		French growth trajectory *starting year 1950*	
	1820	1950	2010	2100	2010	2100	2010	2100	2010	2100	2010	2100
Cambodia	2,090	4,433	14,365	23,587	9,697	10,277	4,229	5,287	6,687	7,087	6,700	8,378
Cameroon	-	4,466	20,624	82,393	-	-	-	-	6,738	7,141	6,751	8,441
Canada	816	13,737	34,126	50,882	3,786	4,013	1,651	2,064	20,723	21,964	20,764	25,962
Cape Verde	-	178	488	552	-	-	-	-	269	285	269	337
Caribbean Netherlands	-	7	18	22	-	-	-	-	11	11	11	13
Cayman Islands	-	6	56	61	-	-	-	-	10	10	10	12
Central African Republic	-	1,327	4,350	11,851	-	-	-	-	2,001	2,121	2,005	2,507
Chad	-	2,502	11,721	63,286	-	-	-	-	3,775	4,001	3,782	4,729
Channel Islands	-	102	160	165	-	-	-	-	154	163	155	193
Chile	771	6,082	17,151	18,843	3,579	3,794	1,561	1,952	9,175	9,724	9,193	11,494
China	381,000	543,776	1,359,821	1,085,631	1,767,682	1,873,534	770,911	963,890	820,305	869,426	821,945	1,027,699
China, Hong Kong SAR	20	1,974	7,050	6,876	93	98	40	51	2,978	3,156	2,984	3,731
China, Macao SAR	-	196	535	818	-	-	-	-	296	314	297	371
Colombia	1,206	12,000	46,445	60,223	5,595	5,930	2,440	3,051	18,102	19,186	18,138	22,678
Comoros	-	156	683	2,538	-	-	-	-	236	250	236	295
Congo	-	808	4,112	21,322	-	-	-	-	1,218	1,291	1,221	1,527
Costa Rica	63	966	4,670	5,316	292	310	127	159	1,457	1,545	1,460	1,826
Côte d'Ivoire	-	2,630	18,977	76,180	-	-	-	-	3,968	4,205	3,976	4,971
Croatia	-	3,850	4,338	2,768	-	-	-	-	5,808	6,156	5,820	7,277
Cuba	605	5,920	11,282	5,458	2,807	2,975	1,224	1,531	8,931	9,465	8,948	11,188
Curaçao	-	100	148	159	-	-	-	-	151	160	151	189
Cyprus	-	494	1,104	1,156	-	-	-	-	745	790	747	934
Cyprus	-	494	1,104	1,156	-	-	-	-	745	790	747	934
Czech Republic	-	8,876	10,554	11,086	-	-	-	-	13,390	14,192	13,417	16,776
Dem. People's Republic of Korea	4,345	10,549	24,501	25,000	20,159	21,366	8,792	10,992	15,914	16,867	15,946	19,938
Democratic Republic of the Congo	-	12,184	62,191	262,134	-	-	-	-	18,379	19,480	18,416	23,026
Denmark	1,155	4,268	5,551	6,992	5,359	5,680	2,337	2,922	6,439	6,824	6,452	8,067
Djibouti	-	62	834	1,300	-	-	-	-	94	99	94	117
Dominica	-	51	71	64	-	-	-	-	77	82	77	97
Dominican Republic	89	2,380	10,017	12,414	413	438	180	225	3,590	3,805	3,598	4,498
Ecuador	500	3,452	15,001	24,410	2,320	2,459	1,012	1,265	5,208	5,520	5,219	6,525

Country	Baseline				European growth trajectory		French growth trajectory		European growth trajectory		French growth trajectory	
					starting year 1820				*starting year 1950*			
	1820	1950	2010	2100	2010	2100	2010	2100	2010	2100	2010	2100
Egypt	4,194	21,514	78,076	135,200	19,458	20,624	8,486	10,610	32,455	34,398	32,520	40,660
El Salvador	248	2,200	6,218	5,542	1,151	1,220	502	627	3,319	3,517	3,325	4,158
Equatorial Guinea	-	226	696	2,419	-	-	-	-	340	361	341	426
Eritrea	3,154	1,141	5,741	21,761	14,633	15,510	6,382	7,979	1,722	1,825	1,725	2,157
Estonia	334	1,101	1,299	959	1,550	1,643	676	845	1,661	1,760	1,664	2,081
Ethiopia	-	18,128	87,095	243,416	-	-	-	-	27,347	28,984	27,401	34,261
Faeroe Islands	-	32	50	53	-	-	-	-	48	50	48	60
Falkland Islands (Malvinas)	-	2	3	3	-	-	-	-	3	4	3	4
Finland	1,169	4,008	5,368	5,762	5,424	5,748	2,365	2,957	6,047	6,409	6,059	7,575
France	31,250	41,832	63,231	79,059	144,987	153,669	63,231	79,059	63,105	66,884	63,231	79,059
French Guiana	-	25	231	674	-	-	-	-	38	41	39	48
Gabon	-	473	1,556	4,884	-	-	-	-	714	757	715	895
Gambia	-	271	1,681	8,423	-	-	-	-	409	434	410	513
Georgia	1,072	3,527	4,389	3,026	4,974	5,272	2,169	2,712	5,321	5,639	5,331	6,666
Germany	24,905	70,094	83,017	56,902	115,549	122,468	50,392	63,007	105,739	112,071	105,950	132,472
Ghana	-	4,981	24,263	57,210	-	-	-	-	7,514	7,964	7,529	9,414
Gibraltar	-	20	29	23	-	-	-	-	31	33	31	39
Greece	2,312	7,566	11,110	9,365	10,727	11,369	4,678	5,849	11,414	12,097	11,436	14,299
Grenada	-	77	105	77	-	-	-	-	116	123	116	145
Guadeloupe	-	210	459	448	-	-	-	-	317	336	317	397
Guatemala	595	3,146	14,342	46,462	2,761	2,926	1,204	1,505	4,746	5,030	4,755	5,946
Guinea	-	3,094	10,876	35,768	-	-	-	-	4,667	4,946	4,676	5,847
Guinea-Bissau	-	518	1,587	5,628	-	-	-	-	782	828	783	979
Guyana	-	407	786	604	-	-	-	-	613	650	615	768
Haiti	723	3,221	9,896	14,799	3,354	3,555	1,463	1,829	4,859	5,150	4,869	6,088
Holy See	-	1	1	1	-	-	-	-	1	1	1	2
Honduras	135	1,487	7,621	15,627	626	664	273	342	2,244	2,378	2,248	2,811
Hungary	4,146	9,338	10,015	7,661	19,236	20,388	8,389	10,489	14,086	14,930	14,114	17,648
Iceland	-	143	318	413	-	-	-	-	215	228	216	270
India	209,000	376,325	1,205,625	1,546,833	969,674	1,027,739	422,888	528,748	567,700	601,694	568,834	711,228
Indonesia	17,927	72,592	240,676	315,296	83,174	88,154	36,273	45,353	109,508	116,065	109,727	137,194

Country	Baseline				European growth trajectory starting year 1820		French growth trajectory starting year 1820		European growth trajectory starting year 1950		French growth trajectory starting year 1950	
	1820	1950	2010	2100	2010	2100	2010	2100	2010	2100	2010	2100
Iran (Islamic Republic of)	6,560	17,119	74,462	94,324	30,436	32,258	13,273	16,596	25,825	27,371	25,877	32,354
Iraq	1,093	5,719	30,962	106,319	5,071	5,375	2,212	2,765	8,628	9,144	8,645	10,809
Ireland	7,101	2,913	4,468	6,596	32,946	34,919	14,368	17,965	4,395	4,658	4,403	5,506
Isle of Man	-	55	84	98	-	-	-	-	83	88	84	104
Israel	-	1,258	7,420	15,011	-	-	-	-	1,898	2,011	1,901	2,377
Italy	20,176	46,367	60,509	54,598	93,608	99,214	40,824	51,043	69,946	74,134	70,086	87,630
Jamaica	401	1,403	2,741	2,052	1,860	1,972	811	1,014	2,116	2,243	2,121	2,651
Japan	31,000	82,199	127,353	84,471	143,827	152,440	62,725	78,427	124,001	131,426	124,249	155,351
Jordan	217	449	6,455	12,924	1,007	1,067	439	549	677	718	678	848
Kazakhstan	2,041	6,703	15,921	20,938	9,471	10,038	4,130	5,164	10,112	10,717	10,132	12,668
Kenya	-	6,077	40,909	160,423	-	-	-	-	9,167	9,716	9,185	11,485
Kuwait	-	152	2,992	7,960	-	-	-	-	230	243	230	288
Kyrgyzstan	530	1,740	5,334	8,924	2,461	2,608	1,073	1,342	2,625	2,782	2,630	3,288
Lao People's Democratic Republic	470	1,683	6,396	11,153	2,181	2,311	951	1,189	2,539	2,691	2,544	3,181
Latvia	591	1,949	2,091	1,459	2,740	2,904	1,195	1,494	2,940	3,116	2,946	3,683
Lebanon	332	1,335	4,341	4,114	1,540	1,633	672	840	2,013	2,134	2,017	2,522
Lesotho	-	734	2,009	3,183	-	-	-	-	1,107	1,173	1,109	1,387
Liberia	-	930	3,958	15,905	-	-	-	-	1,403	1,487	1,406	1,758
Libya	538	1,113	6,041	7,639	2,496	2,646	1,089	1,361	1,680	1,780	1,683	2,104
Liechtenstein	-	14	36	47	-	-	-	-	21	22	21	26
Lithuania	779	2,567	3,068	2,105	3,613	3,829	1,576	1,970	3,873	4,105	3,881	4,852
Luxembourg	-	296	508	716	-	-	-	-	447	473	447	559
Madagascar	1,683	4,084	21,080	105,128	7,808	8,276	3,405	4,258	6,160	6,529	6,172	7,718
Malawi	-	2,881	15,014	84,986	-	-	-	-	4,346	4,606	4,354	5,444
Malaysia	287	6,110	28,276	42,400	1,332	1,411	581	726	9,217	9,769	9,235	11,547
Maldives	-	74	326	474	-	-	-	-	111	118	111	139
Mali	-	4,638	13,986	100,751	-	-	-	-	6,996	7,415	7,010	8,765
Malta	-	312	425	336	-	-	-	-	471	499	472	590
Martinique	-	222	401	335	-	-	-	-	335	355	336	420
Mauritania	-	660	3,609	12,397	-	-	-	-	996	1,056	998	1,248
Mauritius	-	493	1,231	983	-	-	-	-	744	789	746	932

Country	Baseline				European growth trajectory		French growth trajectory		European growth trajectory		French growth trajectory	
					starting year 1820				*starting year 1950*			
	1820	1950	2010	2100	2010	2100	2010	2100	2010	2100	2010	2100
Mayotte	-	15	204	656	-	-	-	-	23	24	23	29
Mexico	6,587	28,296	117,886	139,795	30,561	32,391	13,328	16,664	42,685	45,241	42,770	53,477
Monaco	-	20	37	70	-	-	-	-	30	32	30	38
Mongolia	619	780	2,713	3,937	2,872	3,044	1,252	1,566	1,177	1,247	1,179	1,475
Montenegro	-	395	620	422	-	-	-	-	595	631	597	746
Montserrat	-	14	5	6	-	-	-	-	20	22	20	26
Morocco	2,689	8,986	31,642	42,726	12,476	13,223	5,441	6,803	13,556	14,367	13,583	16,983
Mozambique	2,096	6,442	23,967	112,018	9,725	10,307	4,241	5,303	9,718	10,300	9,738	12,175
Myanmar	3,506	17,527	51,931	47,413	16,266	17,240	7,094	8,870	26,440	28,024	26,493	33,125
Namibia	-	485	2,179	4,263	-	-	-	-	732	776	734	917
Nepal	3,881	8,140	26,846	34,410	18,006	19,084	7,853	9,819	12,280	13,015	12,304	15,384
Netherlands	2,333	10,027	16,615	15,964	10,824	11,472	4,721	5,902	15,126	16,032	15,156	18,950
New Zealand	100	1,908	4,368	6,187	464	492	202	253	2,878	3,051	2,884	3,606
Nicaragua	186	1,295	5,822	7,902	863	915	376	471	1,954	2,071	1,957	2,447
Niger	-	2,560	15,894	203,781	-	-	-	-	3,861	4,093	3,869	4,838
Nigeria	-	37,860	159,708	913,834	-	-	-	-	57,113	60,533	57,227	71,552
Norway	970	3,265	4,891	7,609	4,500	4,770	1,963	2,454	4,926	5,221	4,936	6,171
Oman	318	456	2,803	3,813	1,475	1,564	643	805	689	730	690	863
Other non-specified areas	2,000	7,562	23,146	14,166	9,279	9,835	4,047	5,060	11,407	12,090	11,430	14,291
Pakistan	-	37,542	173,149	263,320	-	-	-	-	56,634	60,025	56,747	70,952
Panama	-	860	3,678	6,277	-	-	-	-	1,297	1,374	1,299	1,625
Paraguay	143	1,473	6,460	11,841	663	703	289	362	2,222	2,356	2,227	2,784
Peru	1,317	7,632	29,263	39,773	6,110	6,476	2,665	3,332	11,514	12,203	11,537	14,425
Philippines	2,176	18,580	93,444	187,702	10,096	10,700	4,403	5,505	28,029	29,708	28,085	35,116
Poland	10,426	24,824	38,199	26,085	48,372	51,269	21,096	26,377	37,448	39,690	37,523	46,916
Portugal	3,297	8,417	10,590	7,457	15,297	16,213	6,671	8,341	12,697	13,458	12,723	15,907
Puerto Rico	248	2,218	3,710	2,853	1,151	1,220	502	627	3,346	3,546	3,353	4,192
Qatar	-	25	1,750	1,987	-	-	-	-	38	40	38	47
Republic of Korea	9,395	19,211	48,454	40,548	43,589	46,199	19,010	23,768	28,981	30,716	29,039	36,308
Republic of Moldova	713	2,341	3,573	1,702	3,306	3,504	1,442	1,803	3,531	3,743	3,539	4,424
Réunion	-	248	845	1,150	-	-	-	-	374	397	375	469

Country	Baseline				European growth trajectory		French growth trajectory		European growth trajectory		French growth trajectory	
					starting year 1820				*starting year 1950*			
	1820	1950	2010	2100	2010	2100	2010	2100	2010	2100	2010	2100
Romania	6,389	16,236	21,861	12,603	29,642	31,417	12,927	16,163	24,493	25,960	24,542	30,685
Russian Federation	31,088	102,799	143,618	101,882	144,237	152,874	62,904	78,650	155,075	164,362	155,385	194,282
Rwanda	-	2,186	10,837	36,217	-	-	-	-	3,298	3,495	3,305	4,132
Saint Helena	-	5	4	4	-	-	-	-	8	8	8	9
Saint Kitts and Nevis	-	46	52	64	-	-	-	-	69	74	70	87
Saint Lucia	-	83	177	171	-	-	-	-	125	132	125	156
Saint Vincent and the Grenadines	-	67	109	96	-	-	-	-	101	107	101	127
San Marino	-	13	31	29	-	-	-	-	19	20	19	24
Sao Tome and Principe	-	60	178	568	-	-	-	-	91	96	91	113
Saudi Arabia	2,091	3,121	27,258	37,195	9,701	10,282	4,231	5,290	4,709	4,991	4,718	5,899
Senegal	-	2,477	12,951	58,180	-	-	-	-	3,736	3,960	3,744	4,681
Serbia	-	6,732	9,647	4,054	-	-	-	-	10,156	10,764	10,176	12,723
Seychelles	-	36	91	87	-	-	-	-	55	58	55	69
Sierra Leone	-	1,944	5,752	13,890	-	-	-	-	2,933	3,108	2,938	3,674
Singapore	30	1,022	5,079	6,040	139	148	61	76	1,542	1,634	1,545	1,932
Sint Maarten (Dutch part)	-	1	43	55	-	-	-	-	2	2	2	3
Slovakia	-	3,437	5,433	3,892	-	-	-	-	5,184	5,495	5,195	6,495
Slovenia	-	1,473	2,054	1,803	-	-	-	-	2,222	2,355	2,227	2,784
Somalia	1,000	2,264	9,636	53,966	4,640	4,917	2,023	2,530	3,415	3,620	3,422	4,279
South Africa	1,550	13,683	51,452	64,135	7,191	7,622	3,136	3,921	20,642	21,878	20,683	25,860
South Sudan	-	2,583	9,941	39,267	-	-	-	-	3,896	4,130	3,904	4,882
Spain	12,203	28,070	46,182	41,662	56,617	60,007	24,691	30,872	42,344	44,880	42,429	53,050
Sri Lanka	1,213	8,076	20,759	21,729	5,628	5,965	2,454	3,069	12,183	12,912	12,207	15,263
State of Palestine	332	932	4,013	12,866	1,540	1,633	672	840	1,406	1,490	1,409	1,761
Sudan	5,156	5,734	35,652	116,141	23,922	25,354	10,433	13,044	8,650	9,168	8,667	10,837
Suriname	-	215	525	571	-	-	-	-	324	344	325	406
Swaziland	-	273	1,193	2,156	-	-	-	-	412	436	413	516
Sweden	2,573	7,010	9,382	14,468	11,938	12,653	5,206	6,509	10,575	11,208	10,596	13,248
Switzerland	1,986	4,668	7,831	12,822	9,214	9,766	4,018	5,024	7,042	7,464	7,056	8,822
Syrian Arab Republic	1,337	3,413	21,533	40,114	6,203	6,575	2,705	3,382	5,149	5,457	5,159	6,451
Tajikistan	467	1,532	7,627	21,313	2,165	2,295	944	1,181	2,310	2,449	2,315	2,894

Country	Baseline				European growth trajectory		French growth trajectory		European growth trajectory		French growth trajectory	
					starting year 1820				*starting year 1950*			
	1820	1950	2010	2100	2010	2100	2010	2100	2010	2100	2010	2100
TFYR Macedonia	-	1,254	2,102	1,327	-	-	-	-	1,892	2,006	1,896	2,371
Thailand	4,665	20,607	66,402	40,542	21,644	22,940	9,439	11,802	31,087	32,948	31,149	38,946
Timor-Leste	-	433	1,079	3,265	-	-	-	-	654	693	655	819
Togo	-	1,395	6,306	24,659	-	-	-	-	2,105	2,231	2,109	2,637
Trinidad and Tobago	60	646	1,328	790	278	295	121	152	974	1,032	976	1,220
Tunisia	875	3,099	10,632	11,556	4,060	4,303	1,770	2,214	4,674	4,954	4,684	5,856
Turkey	10,074	21,238	72,138	86,465	46,739	49,538	20,384	25,486	32,039	33,958	32,103	40,139
Turkmenistan	367	1,211	5,042	5,766	1,704	1,806	743	929	1,827	1,936	1,830	2,289
Turks and Caicos Islands	-	5	31	37	-	-	-	-	8	8	8	10
Uganda	-	5,158	33,987	204,596	-	-	-	-	7,781	8,247	7,797	9,749
Ukraine	11,215	37,298	46,050	24,629	52,035	55,151	22,693	28,374	56,265	59,634	56,377	70,490
United Arab Emirates	-	70	8,442	13,759	-	-	-	-	105	111	105	132
United Kingdom	21,239	50,616	62,066	77,175	98,540	104,441	42,975	53,732	76,356	80,928	76,509	95,661
United Republic of Tanzania	-	7,650	44,973	275,624	-	-	-	-	11,540	12,231	11,563	14,458
United States of America	9,981	157,813	312,247	462,070	46,305	49,078	20,194	25,250	238,066	252,322	238,542	298,256
United States Virgin Islands	-	27	106	107	-	-	-	-	40	43	41	51
Uruguay	55	2,239	3,372	3,292	255	270	111	139	3,377	3,579	3,384	4,231
Uzbekistan	1,919	6,314	27,769	30,791	8,904	9,437	3,883	4,855	9,525	10,095	9,544	11,933
Venezuela (Bolivarian Republic of)	718	5,094	29,043	42,772	3,331	3,531	1,453	1,816	7,684	8,144	7,699	9,627
Viet Nam	6,551	24,949	89,047	80,122	30,394	32,214	13,255	16,573	37,637	39,891	37,712	47,153
Western Sahara	-	14	515	783	-	-	-	-	21	22	21	26
Yemen	2,593	4,661	22,763	42,181	12,030	12,751	5,247	6,560	7,032	7,453	7,046	8,809
Zambia	-	2,372	13,217	124,302	-	-	-	-	3,579	3,793	3,586	4,484
Zimbabwe	-	2,747	13,077	32,608	-	-	-	-	4,144	4,392	4,152	5,191

Table 3. Population size (in millions) by country for the years 1820, 1950, 2010 and 2100 by scenario.

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