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Intrinsic and Age Structure Component of World Population Growth

Aalok Ranjan Chaurasia

Manju Singh

MLC Foundation

'Shyam' Institute

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Abstract

This paper decomposes the natural population growth rate in the world, in its more developed, less developed and the least developed regions and in 201 countries during 1950–2020 into an intrinsic component which is determined by prevailing fertility and mortality levels and an age structure component which is determined by the population age structure effect on the birth rate and the death rate. The paper reveals that there has been a shift in the main drivers of population growth from fertility and mortality to population age composition through its effect on the birth rate and the death rate. Given the increasing dominance of the age structure component of population growth, the paper calls for explicit provision of addressing age structure component of population growth in population policies directed towards population stabilisation.

Key words

Natural population growth rate, Decomposition, Intrinsic component, Age structure component, World, Regions, Countries

Intrinsic and Age Structure Components of World Population Growth, 1950–2020

1. Introduction

The word population is estimated to have increased from around 2.5 billion in 1950 to almost 7.8 billion in 2020 (United Nations 2019a) with significant variation across regions and countries. Population growth has been the most rapid in the least developed countries but the slowest in the more developed countries of the world. The population of the least developed countries increased from 0.195 billion in 1950 to more than 1.057 billion in 2020. By contrast, the population of the more developed countries increased from around 0.815 billion to almost 1.274 billion. The population of the less developed countries, on the other hand, increased from around 1.526 billion to around 5.464 billion. There has also been substantial variation in population growth across 201 countries and areas for which estimates have been prepared by the United Nations Population Division.

In relative terms, world population more than tripled between 1950 and 2020. Against this global average, population of the least developed countries multiplied by more than 5.4 times; population of the less developed countries multiplied by more than 3.5 times whereas, the population of more developed countries multiplied by only about 1.6 times. In 1950, the least developed countries of the world accounted for less than 8 per cent of the world population. This proportion increased to more than 13 per cent in 2020. The population of more developed countries accounted for around 32 per cent of the world population in 1950 but this proportion decreased to around 16 per cent in 2020. The share of the population of the less developed countries, on the other hand, increased from around 60 per cent in 1950 to more than 70 per cent in 2020.

Annual addition to the world population is estimated to have peaked during 1986–1987 when almost 93 million people were added to the world population. After 1986–87, the annual addition to the world population is decreasing albeit slowly as more than 81 million people are estimated to have been added to the world population during 2019–2020 compared to the annual addition of less than 48 million during 1950–1951 was less than 48 million. It is only in the more developed countries of the world where the annual addition to the population during 2019–2020 was less than that during 1950–1951. In the least developed countries, annual addition to the population increased by around six times between 1950–1951 and 2019–2020, whereas the annual addition in the population of the least developed countries increased from 35 million to 55 million during this period.

There has been a high degree of volatility in the trend in the world population growth rate which increased from 1.78 per cent during 1950–1955 to more than 2.05 per cent during 1965–1970 over a period of 15 years but then decreased to 1.77 per cent during 1975–1980 in a period of 10 years. During the next 10 years period, 1975–1980 through 1985–1990, the world population growth rate remained virtually stagnant with a small increase during 1985–1990. During the next 10 years, the world population growth rate decreased rapidly from 1.79 per cent during 1980–85 to 1.34 per cent during 1995–2000 but the decrease in the world population growth rate slowed down during the period 1995–2000 and 2015–2020. During 2015–2020, the world population is estimated to have increased at the rate of around 1.09 per cent per year.

At the global level, population growth during a given period is equal to the difference between the number of births and the number of deaths during the period. If the number of births exceeds the number of deaths, population increases. If the number of births is less than the number of deaths during the period, population decreases. If the number of births is equal to the number of deaths, there is no change in population. At regional or country level, population growth is also influenced by the number of immigrants minus the number of outmigrants. The pace of population growth is the most popularly measured in terms of population growth rate which is the sum of the difference between the birth rate and the death rate or the rate of natural increase (RNI) and the net migration rate (NMR) or the difference between the immigration rate and the emigration rate. At the global level, there is no in- or out-migration so that population growth rate is equal to the rate of natural increase (RNI). Population growth rate is also equal to the rate of natural increase (RNI) in countries and in regions where the net migration rate is zero.

The primary determinant of the birth rate is the actual birth performance of the population or population fertility which is determined by the fertility of women in the reproductive age group or in the age group 15-49 years but the birth rate is conditioned by population age and sex composition. The birth rate, therefore, has two components – one determined by population fertility and the other by population age and sex composition. A similar argument suggests that the death rate also has two components – one determined by population risk of death or population mortality and the other population age and sex composition. Population fertility and population mortality constitute the intrinsic component of natural population growth while the difference between natural population growth and its intrinsic component constitute natural population growth attributed to population age and sex structure. The distinction between intrinsic component and structure component is important as the structure component is the legacy of the past population fertility and mortality dynamics (Preston et al, 2001). From the policy perspective, it is helpful to know the relative contribution of the intrinsic component and the structure component to natural population growth. For example, the need to reduce population fertility and mortality in a country would be less pressing if the intrinsic component accounts for only 50 per cent of the natural population growth while the structure component accounts for the remaining 50 per cent than if intrinsic component accounts for 90 per cent while structure component accounts for only 10 per cent of natural population growth. An understanding of the relative role played by the change in population fertility, population mortality, and the change in population age and sex structure in deciding the natural population growth helps in understanding why a country may sustain a positive natural population growth despite having a negative intrinsic component.

The structure component of natural population growth has been related with the concept of population momentum which has historically been studied in the context of fertility transition. In its narrow perspective, population momentum is the tendency for the population to grow beyond the time the replacement level fertility is achieved (Preston et al, 2001). Population momentum was first studied by Vincent (1945) who termed it the growth potential of the population and, subsequently, by Bourgeois-Pichat (1971) who called it the inertia of population. The term momentum was first used by Keyfitz (1971). It is usually measured in relative terms as the ratio of the size of the long-run stationary population to the size of the population when the replacement fertility is first attained (Espenshade and Tannen, 2015). Population momentum can be both greater than or less than its limiting value of 1. When the momentum factor is greater than 1, population continues to grow even after attaining replacement fertility. When the momentum factor is less than 1, a decreasing population may continue to decrease even if the intrinsic component of natural population growth is positive. When the momentum factor is equal to 1, natural population growth is determined solely by its intrinsic component (Preston and Guillot 1997).

Population momentum, however, is not limited to fertility transition only. It has been argued to be one of the most misunderstood phenomena in demography (Preston et al, 2001). In its more general conceptualisation, population momentum reflects the influence that population age and sex structure has on natural population growth (Gendell, 1984). In this broad conceptualisation, natural population growth has two components – an intrinsic component determined by population fertility and population mortality and a structure component determined by population age and sex structure. Decomposing natural population growth into its intrinsic and structure components is important. This decomposition demonstrates that natural population growth may be substantially different from the intrinsic component of growth.

In this paper, we decompose natural growth of the world population and population of its more developed, less developed, and the least developed regions and 201 countries into the intrinsic component determined by population fertility and population mortality and structure component determined by population age and sex structure during 1950 through 2020 based on the estimates prepared by the United Nations Population Division. The paper also decomposes the change in the natural population growth rate or the rate of natural increase into the change in population fertility, change in population mortality and the change in population age and sex structure. The analysis highlights the importance of population age and sex structure as in deciding the world population growth that merits appropriate policy response.

The paper is organised as follows. The next section of the paper describes the analytical framework developed to decompose the change in the rate of natural increase into the change in the increasing rate of natural increase and the change attributed to the transition in population age composition. The third section describes the data used. The paper is based on the population estimates prepared by the United Nations Population Division which permit inter-country comparison as they are based on a standard methodology. The fourth section presents a comparative perspective of population growth in the world, in its three regions and 201 countries during 1950 through 2020. The fifth section presents results of the decomposition analysis. This section also highlights how intrinsic population growth and momentum population growth has contributed to the world population growth during the last 70 years. The last section summarises the findings of the analysis and discusses its implications for future population growth.

2. Decomposition of the Rate of Natural Increase

Let g denotes the population growth rate, b birth rate, d death rate, i immigration rate and o emigration rate for any population. Then,

$$g = b - d + i - o = r + n \tag{1}$$

where r is the rate of natural increase and n is the net migration rate. At the global level, there is no in-migration or out-migration, so that.

$$g = b - d = r \tag{2}$$

Equation (2) also holds for those countries and regions also where there is either no in- or out-migration or the net migration rate is 0.

The rate of natural increase, r, is commonly used as an indicator of population transition. The demographic transition theory (Notestein, 1945) says that as population moves from the pre-transition phase, characterised by high birth rate and high death rate, to the post-transition phase, characterised by low birth rate and low death rate, the population size increases, and its age composition changes. In the pre-transition phase, birth and death rates are high and the rate of natural increase is low. In the post-transition phase, birth and death rates are low and the rate of natural increase is again low. The decrease in birth and death rates characterises population transition. There is, usually, a time gap between the onset of the decrease in the death rate, d, and the onset of the decrease in the birth rate, b, so that, with population transition, r first accelerates and then decelerates, and the rate of natural increase follows a reverse V-shape trajectory. The decrease in both birth rate and death rate is also conditioned by the change in population age and sex structure.

If b_i denotes the birth rate in age i and w_i denotes the proportion of the population in age i, then, b can be calculated as

$$b = \frac{\sum_{i=1}^{o} w_i b_i}{\sum_{i=1}^{n} w_i} \quad (3)$$

where o is the highest age and

$$\sum_{i=1}^{n} w_i = 1$$

Equation (3) suggests that birth rate has two components – one determined by age-specific birth rates or the birth rate independent of population age and sex structure (b_a) and the other determined by the age and sex structure of the population (a_b) irrespective of age-specific birth rates. The birth rate independent of population age and sex structure (b_a) may be estimated as the age-standardised birth rate based on age-specific birth rates and the rectangular population of one person per age as the standard (Wunsch, 2006). In other words,

$$b_a = \frac{1}{o} * \sum_{i=1}^{o} b_i \quad (4)$$

so that

$$b = b_a \times \left(\frac{b}{b_a}\right) = b_a \times a_b \quad (5)$$

a_b is the age and sex structure effects on b given b_a. If a_b>1, population age and sex structure inflates b given b_a. If a_b<1, population age and sex structure deflates b given b_a. If a_b=1, b=b_a.

Arguing in the same manner, the death rate, d, can be calculated as

$$d = \frac{\sum_{i=1}^{o} w_i d_i}{\sum_{i=1}^{o} w_i} \quad (6)$$

And the death rate independent of population age and sex structure (da) can be calculated as

$$d_a = \frac{1}{o} * \sum_{i=1}^{o} d_i \quad (7)$$

so that

$$d = d_a \times \left(\frac{d}{d_a}\right) = d_a \times a_d \quad (8)$$

a_d is the age and sex structure effects on d given d_a. If a_d>1, population age and sex structure inflates d given d_a. If a_d<1, population age and sex structure deflates d given d_a. If a_d=1, d=d_a.

Equation (2) may now be written as

$$r = b - d = b_a \times a_b - d_a \times a_d \quad (9)$$

We know that the logarithmic mean (Carlson, 1972) of b and d, L_{bd} is equal to

$$L_{bd} = \frac{b-d}{\ln{(b/d)}} \quad (10)$$

or

$$r = b - d = L_{bd} * \ln\left(\frac{b}{d}\right) = \{L_{bd} * \ln(b)\} + \{-L_{bd} * \ln(d)\}$$

$$r = [L_{bd} \times \ln(b_a)] + [-L_{bd} \times \ln(d_a)] + [L_{bd} \times \ln a_b] + [-L_{bd} \times \ln a_b]$$

$$= (r_{ba} + r_{da}) + (r_{ab} + r_{ad}) = r_i + r_a \quad (11)$$

Here r_i is determined by b_a and d_a and, therefore, may be termed as the intrinsic component of r. On the other hand, r_a is determined by a_b and a_d and may be termed as the population age and sex structure component of r. The intrinsic component is determined by the current fertility and mortality dynamics while the population age and sex structure component is determined by past fertility and mortality dynamics.

If s denotes the stationary birth rate which is equal to the stationary death rate, then equations (5) and (8) may also be written as

$$b = s \times \left(\frac{b_a}{s}\right) \times \left(\frac{b}{b_a}\right) = s \times b_s \times a_b \tag{12}$$

and

$$d = s \times \left(\frac{d_a}{s}\right) \times \left(\frac{d}{d_a}\right) = s \times d_s \times a_d \tag{13}$$

The stationary birth rate or the stationary death rate is determined purely by the level of mortality in the population.

The change in r between two points in time, $t_2 > t_1$ may now be decomposed as

$$\nabla r = r^2 - r^1 = (b^2 - b^1) - (d^2 - d^1) = \nabla b - \nabla d \tag{14}$$

If L_b is the logarithmic mean of b^2 and b^1, then

$$\nabla b = b^2 - b^1 = \frac{b^2 - b^1}{\ln\left(\frac{b^2}{b^1}\right)} \times \ln\left(\frac{b^2}{b^1}\right) = L_b \times ln\left(\frac{s^2 \times b_s^2 \times a_b^2}{s^1 \times b_s^1 \times a_b^1}\right)$$

$$\nabla b = L_b \times \left[ln\left(\frac{s^2}{s^1}\right) + ln\left(\frac{b_s^2}{b_s^1}\right) + ln\left(\frac{a_b^2}{a_b^1}\right)\right] \tag{15}$$

Similarly, if L_d is the logarithmic mean of d^2 and d^1, then

$$\nabla d = L_d \left[ln\left(\frac{s^2}{s^1}\right) + ln\left(\frac{d_s^2}{d_s^1}\right) + ln\left(\frac{a_d^2}{a_d^1}\right)\right] \tag{16}$$

Substituting from (14) and (15) into (13) and rearranging, we get

$$\nabla r = \left\{(L_b - L_d) \times ln\left(\frac{s^2}{s^1}\right)\right\} + \left\{L_b \times ln\left(\frac{b_s^2}{b_s^1}\right)\right\} + \left\{-L_d \times ln\left(\frac{d_s^2}{d_s^1}\right)\right\} + \left\{L_b \times ln\left(\frac{a_b^2}{a_b^1}\right)\right\} + \left\{-L_d \times ln\left(\frac{a_d^2}{a_d^1}\right)\right\}$$

$$\nabla r = \partial s + \partial b_a + \partial d_a + \partial a_b + \partial a_d = \partial s + \partial r_i + \partial r_a \tag{17}$$

$$\partial s = (L_b - L_d) \times ln\left(\frac{s^2}{s^1}\right)$$

$$\partial b_a = L_b \times ln\left(\frac{b_s^2}{b_s^1}\right)$$

$$\partial d_a = -L_d \times ln\left(\frac{d_s^2}{d_s^1}\right)$$

$$\partial a_b = L_b \times ln\left(\frac{a_b^2}{a_b^1}\right)$$

$$\partial a_d = -L_d \times ln\left(\frac{a_d^2}{a_d^1}\right)$$

$$\partial r_i = \partial b_a + \partial d_a = L_b \times ln\left(\frac{b_s^2}{b_s^1}\right) - L_d \times ln\left(\frac{d_m^2}{d_m^1}\right)$$

$$\partial r_a = \partial a_b + \partial a_d = L_b \times ln\left(\frac{a_b^2}{a_b^1}\right) - L_d \times ln\left(\frac{a_d^2}{a_d^1}\right)$$

Equations (11) and (17) constitute the analytical framework of the present analysis.

3. Data

The analysis is based on the 2019 revision of the estimates of total population, population growth rate, rate of natural increase, birth rate, death rate, age-specific fertility rates and age-specific death rate prepared by the United Nations (United Nations, 2019a). These estimates are based on standard methodology and assumptions which permit inter-country comparison (United Nations, 2019b). These estimates are available for 201 countries and areas of the world which have been grouped into: 1) more developed; 2) less developed; and 3) the least developed region for statistical purposes only. It does not express any judgment on the part of the United Nations about the stage of development reached by any country or area (United Nations, 2019a). According to this classification, more developed region comprises of 49 countries; less developed region 106 countries; and the least developed region 46 countries. The least developed countries, however, are classified following specific classification criteria and the list of the countries is updated regularly (United Nations, 1999). The classification of a country into more developed, less developed and the least developed regions, although, meant for statistical purposes only, is, however, relevant for the present analysis as the pattern of population growth during the 70 years between 1950-2000 has been found to be significantly different in the three regions.

4. World Population Growth 1950-2020

The rate of natural increase, *r*, in the world has not been uniform during the 70 years under reference. It increased during 1950-1955 through 1965-1970 to peak to more than 2 per cent per year during 1965-70 (Figure 1). During 1975-1980 through 1985-1990, *r* remained virtually stagnant and, after 1985-1990, it decreased, first rapidly and then slowly to 1.09 per cent per year during 2015-2020. As the result, world population increased from about 2536 million in 1950 to around 7795 million in 2020 or an addition of more than 5000 million people in the 70 years.

The rate of natural increase has been different in different development regions. In the more developed region, *r* decreased from around 1.18 per cent per year during 1950-1955 to less than 0.05 per cent per year during 2015-2020. In the less developed region, *r* increased up to 1965-1970 and then decreased with the decrease stagnating during 1975-1980 through 1985-1990. In the least developed countries, *r* increased up to 1980-1985 and then decreased with the decrease gaining some momentum after 2005-2010. In all the three development regions, the decrease in *r* has not been consistent as it increased for some times during the period under reference. In the more developed region, *r* doubled during 2005-2010 compared to that during 2000-2005. In the less developed region, it increased during 1955-1960 through 1970-1975 whereas in the least developed region, it increased during the period 1950-55 through 1980-85.

The rate of natural increase, *r*, has varied widely across 201 countries and areas of the world currently and in the past. During the 1950-1955, there was no country or area in the world where *r* was negative whereas it was at least 20 per 1000 population per year in 110 countries. During 2015-2020, *r* was negative in 23 countries and areas. However, there were still 55 countries and areas where *r* was at least 20 per 1000 population per year (Figure 2). The inter-country diversity in *r* is reflected from the inter-country coefficient of variation which shows an inconsistent trend during the period under reference. The inter-country coefficient of in *r* decreased from 0.400 during 1950-1955 to ___ during 1955-1960 but increased to 0.883 during 2015-2020 implying that countries and areas of the world have diverged, instead converged, over time terms of the natural population growth. The population growth in the three development regions and 201 countries and areas has also been influenced by the net migration rate determined by the rate of immigration and the rate of emigration.

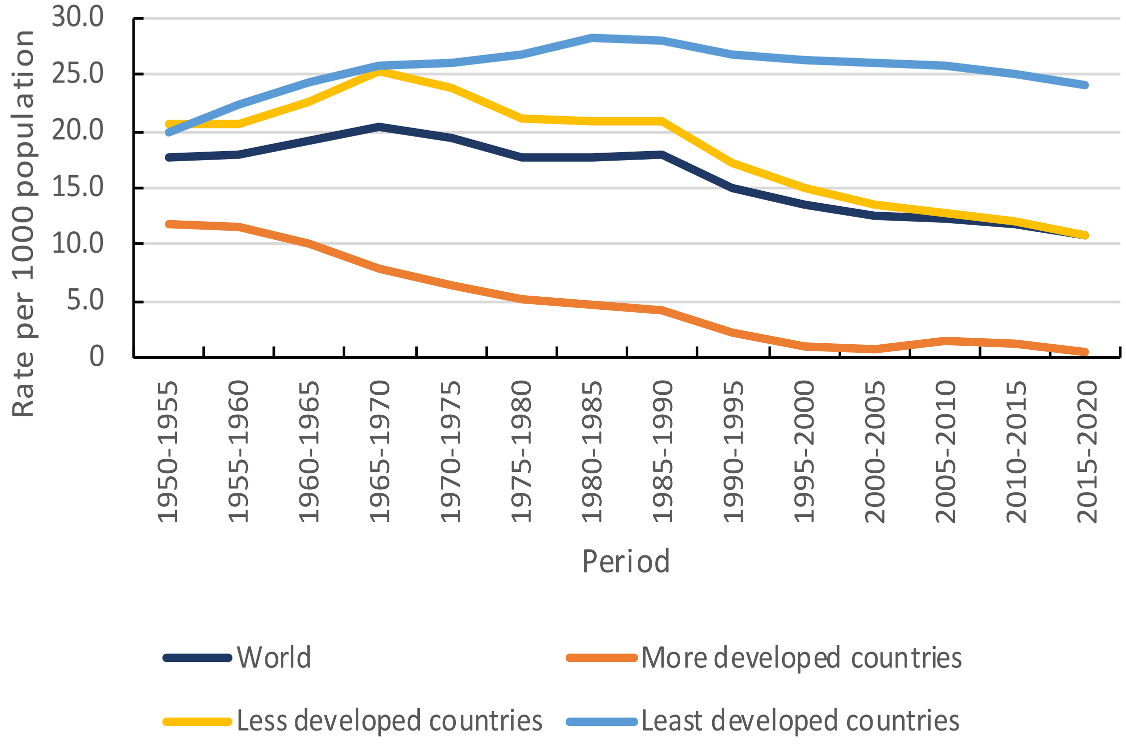

Figure 1: Rate of natural increase per 1000 population in the World and major regions, 1950-2020
Source: United Nations (2019)

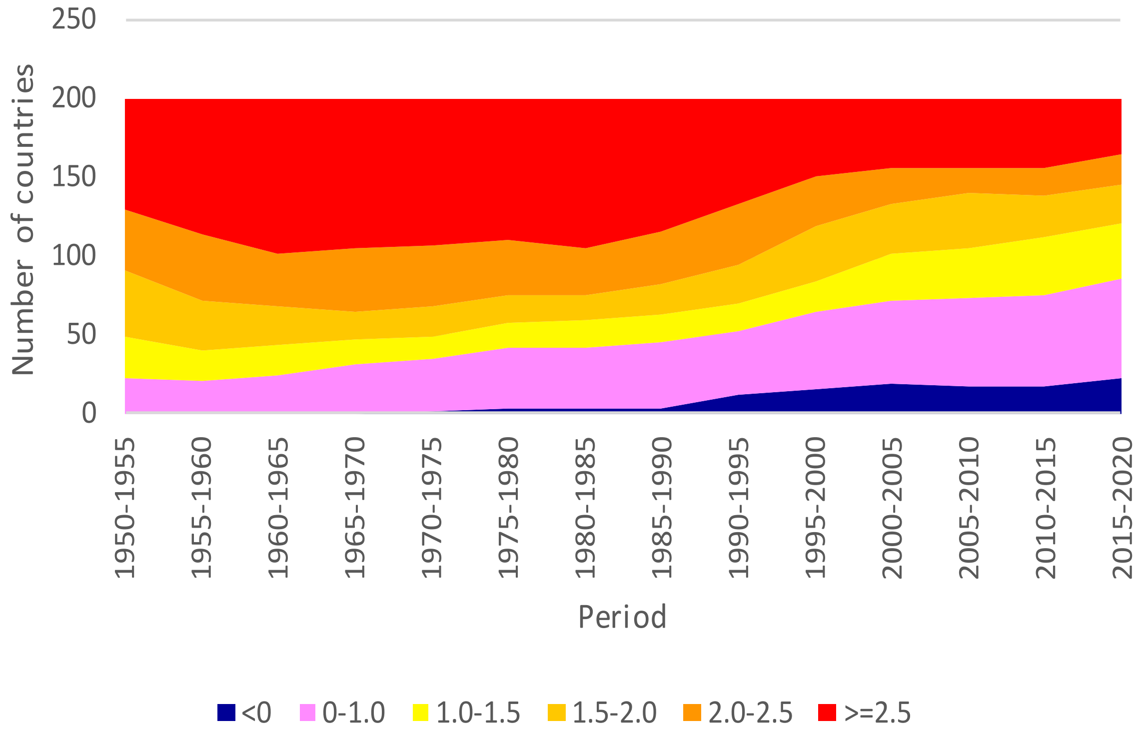

Figure 2: Inter-country variation in the rate of natural increase, 1950-2020
Source: United Nations (2019).

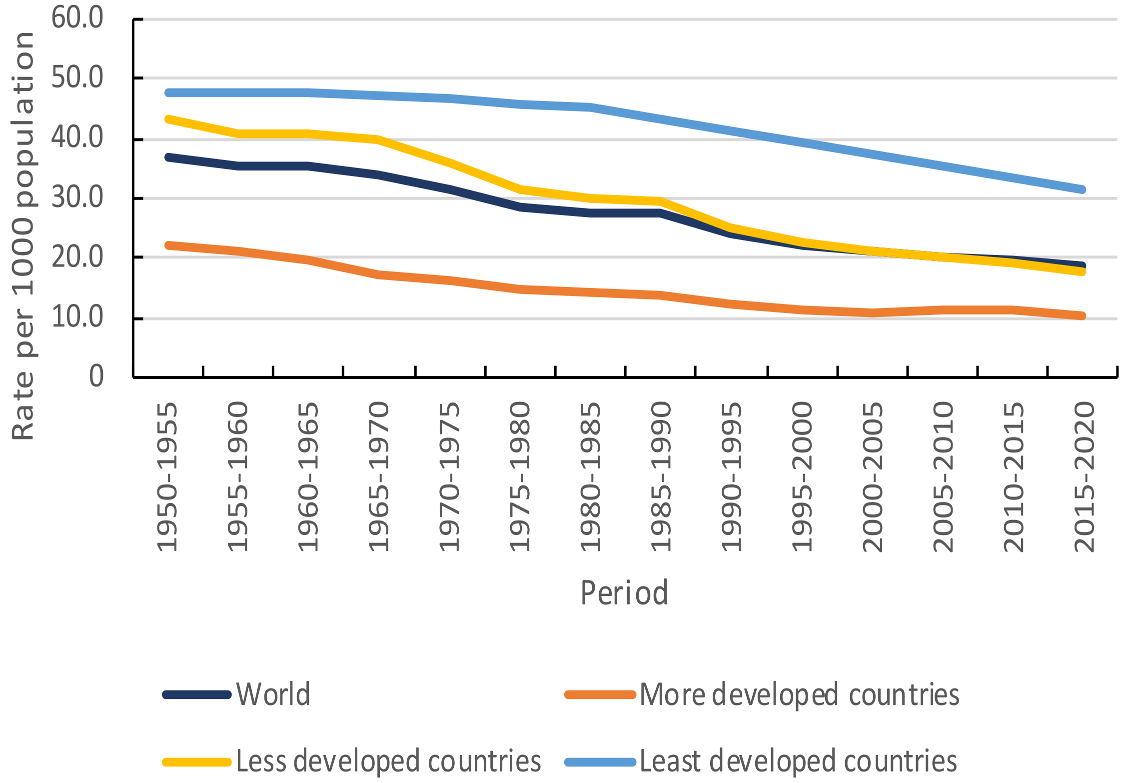

Figure 3: Birth rate (per 1000 population) in the world and its major regions, 1950-2020
Source: United Nations (2019).

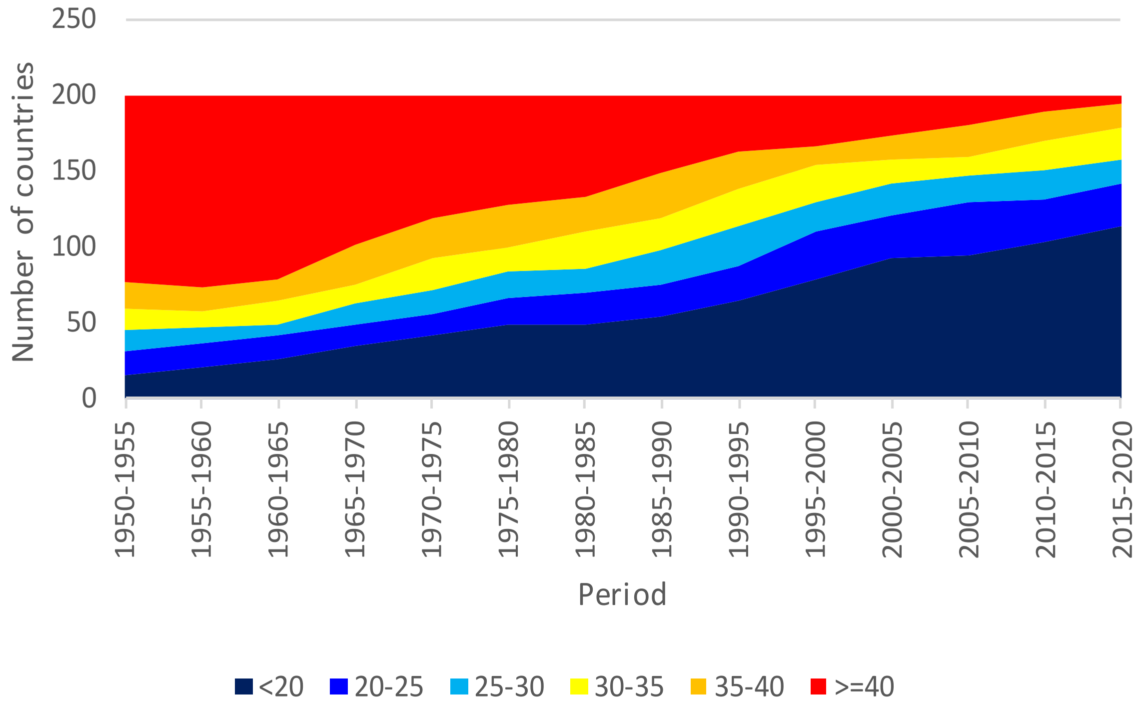

Figure 4: Inter-country variation in birth rate (per 1000 population), 1950-2020
Source: United Nations (2019)

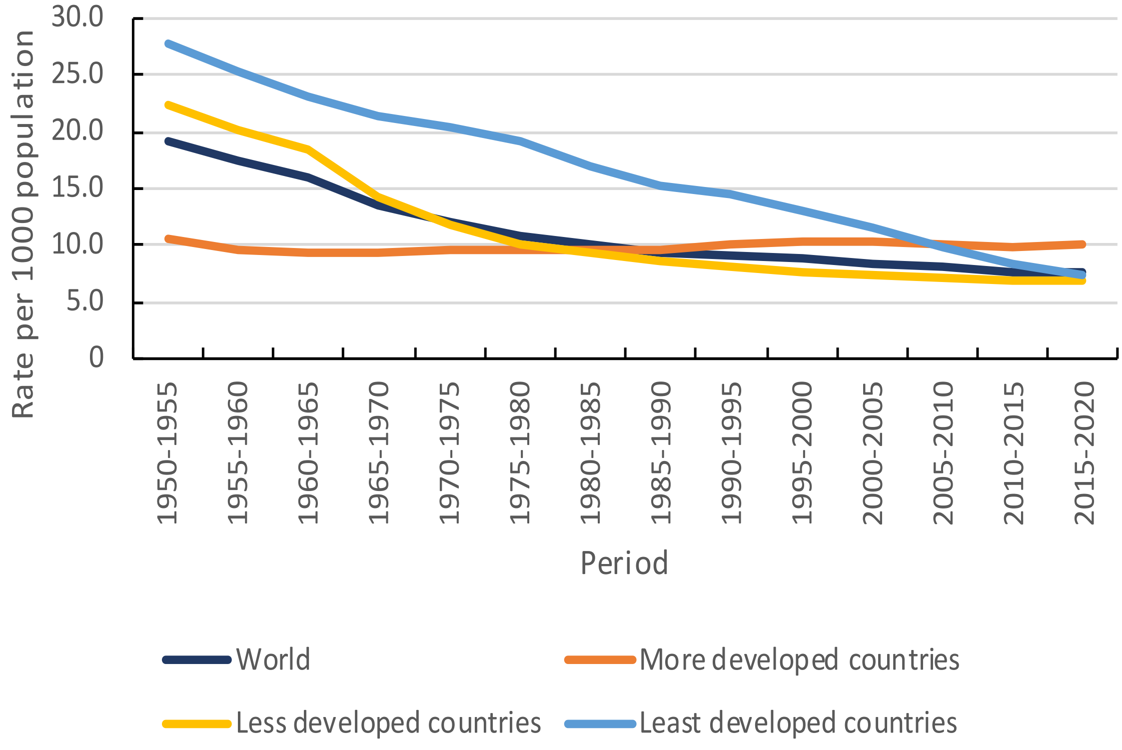

Figure 5: Death rate (per 1000 population) in the world and its major regions, 1950-2020
Source: United Nations (2019)

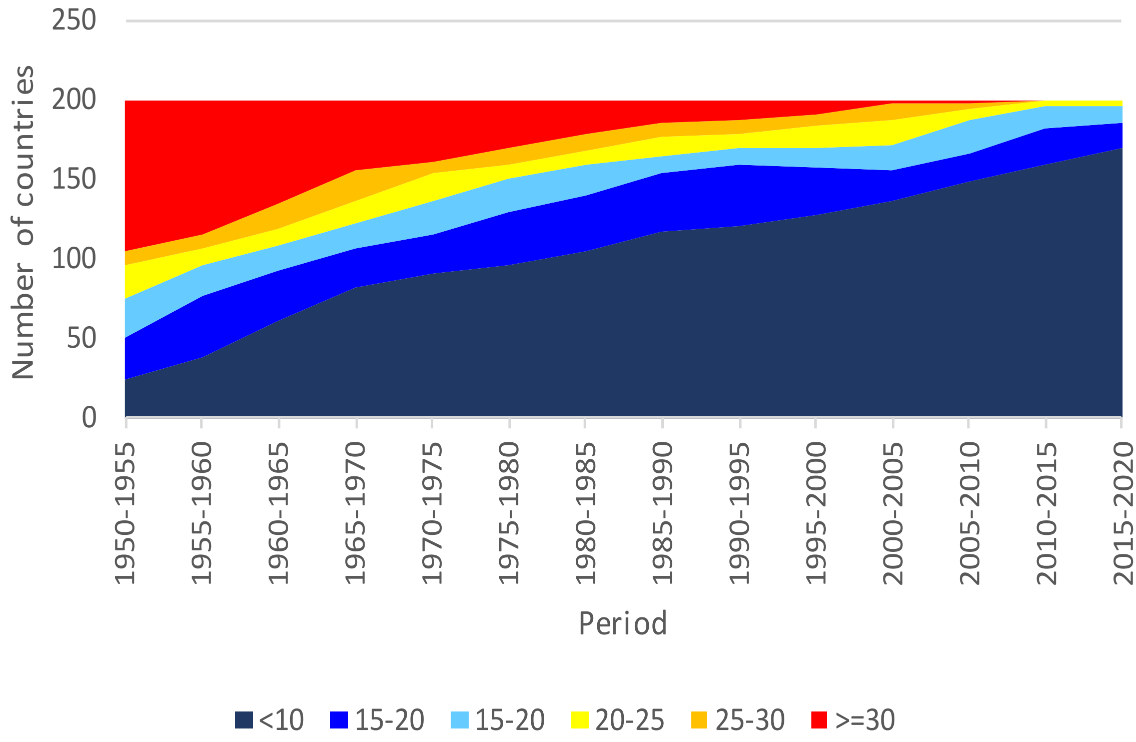

Figure 4: Inter-country variation in death rate (per 1000 population), 1950-2020
Source: United Nations (2019)

The birth rate, *b*, in the world, decreased from 36.9 births per 1000 population during 1950–1955 to 18.5 births per 1000 population during 2015–2020. The decrease was not uniform and there was near stagnation in *b* during 1980–85 through 1985–90. The birth rate, *b*, decreased in all the three development regions, although the pace of decrease has been different in different regions. In the more developed region, the birth rate increased during 2000–2005 through 2010–2015 but decreased subsequently. On the other hand, the decrease in the birth rate in the least developed countries accelerated after 1980–1985 whereas the decrease in the less developed countries appears to have slowed down after 1985–1990. However, during 2015–2020, the birth rate in the less developed countries was lower than the world average (Figure 4). The gap in the birth rate between the more developed region and the least developed region of the world, however, remains quite substantial even during 2015–2020.

The birth rate has decreased in all but one country for which estimates have been prepared by the United Nations Population Division but at the pace of decrease has been different. Gabon is the only country where the birth rate during 2015–2020 was higher than the birth rate during 1950–1955. The inter-country coefficient of variation in the birth rate increased from 0.277 during 1950–1955 to 0.495 during 2000–2005 but decreased marginally to 0.481 during 2010–2015 and has remained virtually the same during 2015–2020 which indicates that the countries have diverged over time as far as the trend in the birth rate is concerned. During 1950–1955, the birth rate was at least 35 births per 1000 population in 123 countries whereas there were only 15 countries where the birth rate was less than 15 births per 1000 population. During 2015–2020, the birth rate was less than 20 births per 1000 population in 115 countries. However, there were still 6 countries where the birth rate was more than 35 per 1000 population even during 2015–2020.

On the other hand, the death rate decreased in all but 16 countries. Out of the 16 countries in which death rate during 2015–2020 was higher than the death rate during 1950–1955, 15 are more developed countries and areas. The only other country where the death rate during 2015–2020 was higher than the death rate during 1950–1955 is Puerto Rico. The countries have, however converged over time as regards the trend in the death rate, although there were periods of divergence. The inter-country coefficient of variation in the death rate increased from 0.419 during 1950–1955 to 0.462 during 1970–1975 indicating a diverging trend in the death rate across countries. During 1970–1975 through 2000–2005, there has been only a marginal decrease in the inter-country coefficient of variation in the death rate, although there were spikes during 1975–80 and during 1990–1995 but, after 2000–2005, the inter-country coefficient of variation in the death rate decreased quite rapidly. During 1950–1955, there were only 24 countries and areas in the world where the death rate was less than 10 per 1000 population while the death rate was at least 20 per 1000 population in 88 countries and at least 30 per 1000 population in 17 countries. During 2015–2020, there were only 31 countries where the death rate was more than 10 per 1000 population. However, there were still 2 countries where the death rate was more than 15 deaths per 1000 population during 2015–20. On the other hand, there were 25 countries where the death rate was very low, less than 5 deaths per 1000 population during 2015–2020.

This has, however, not been the case in less and the least developed regions where the death rate, *d*, decreased consistently, albeit at different pace. During 2015–2020, *d* was the lowest in the less developed region of the world but the highest in the more developed region. The increase in *d* in the more developed region may be attributed to the change in population age composition. The high death rate has contributed substantially towards the decrease in the rate of natural increase, *r*, in the more developed region. On the other hand, the young population age composition in both less and the least developed regions has kept the death rate *d* low and the rate of natural increase, *r*, high.

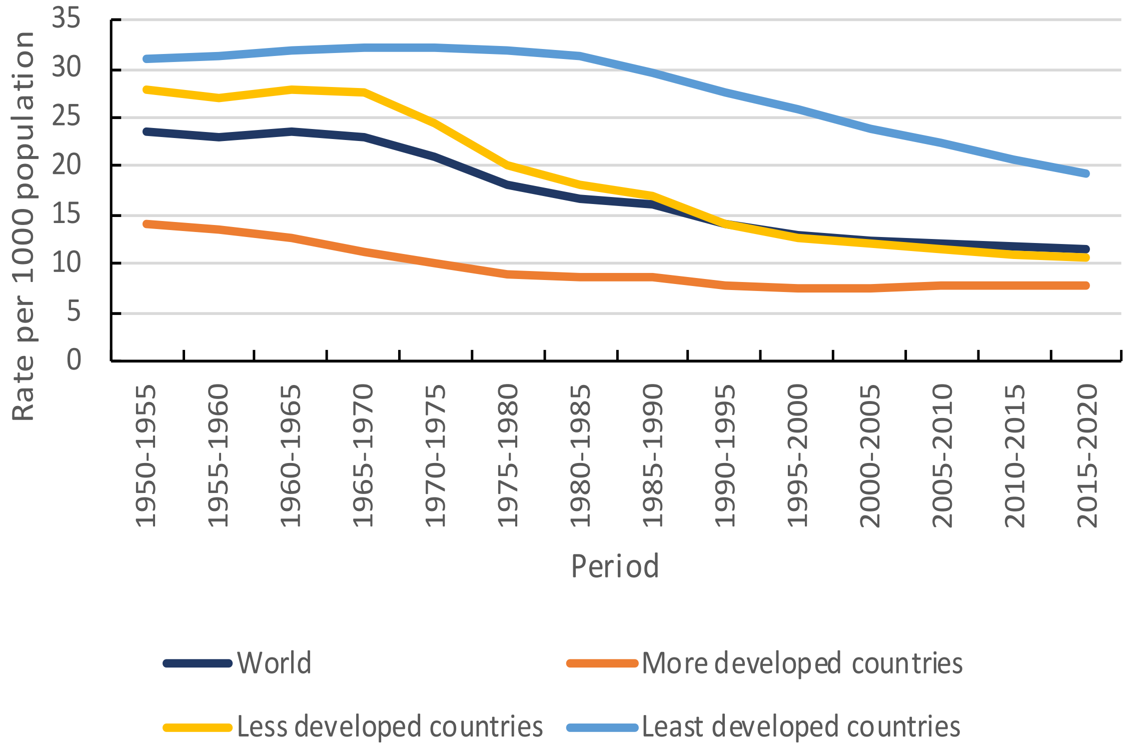

Figure 5: Population fertility (b_f) (per 1000 population) in the world and major regions, 1950-2020
Source: United Nations (2019).

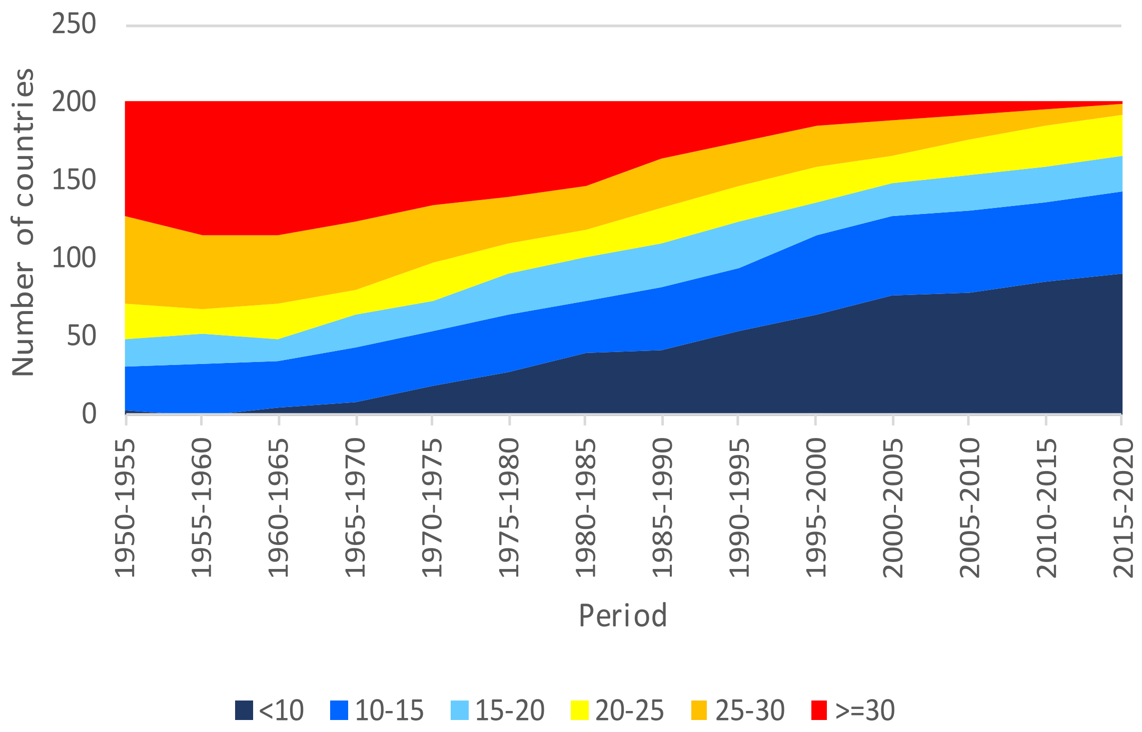

Figure 8: Inter-country variation in birth rate independent of population age composition effect (b_a) (births per 1000 population), 1950-2020
Source: United Nations (2019)

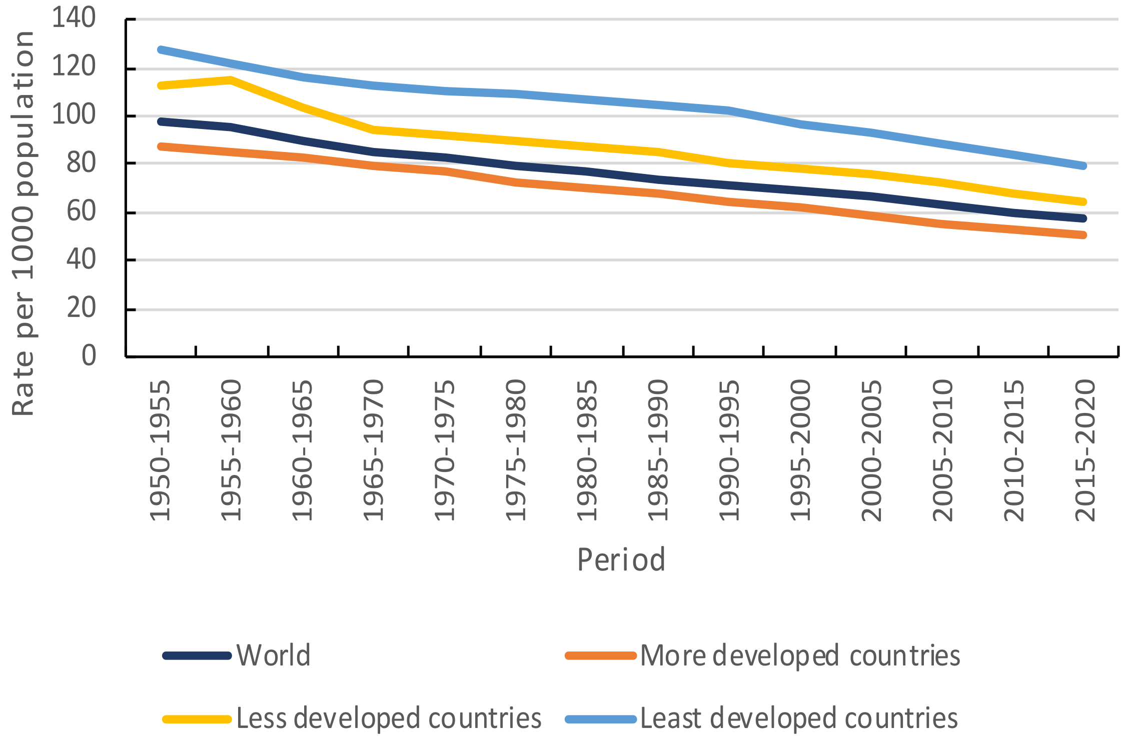

Figure 9: Death rate independent of population age composition effect (d_a) (deaths per 1000 population) in the world and major regions, 1950-2020
Source: United Nations

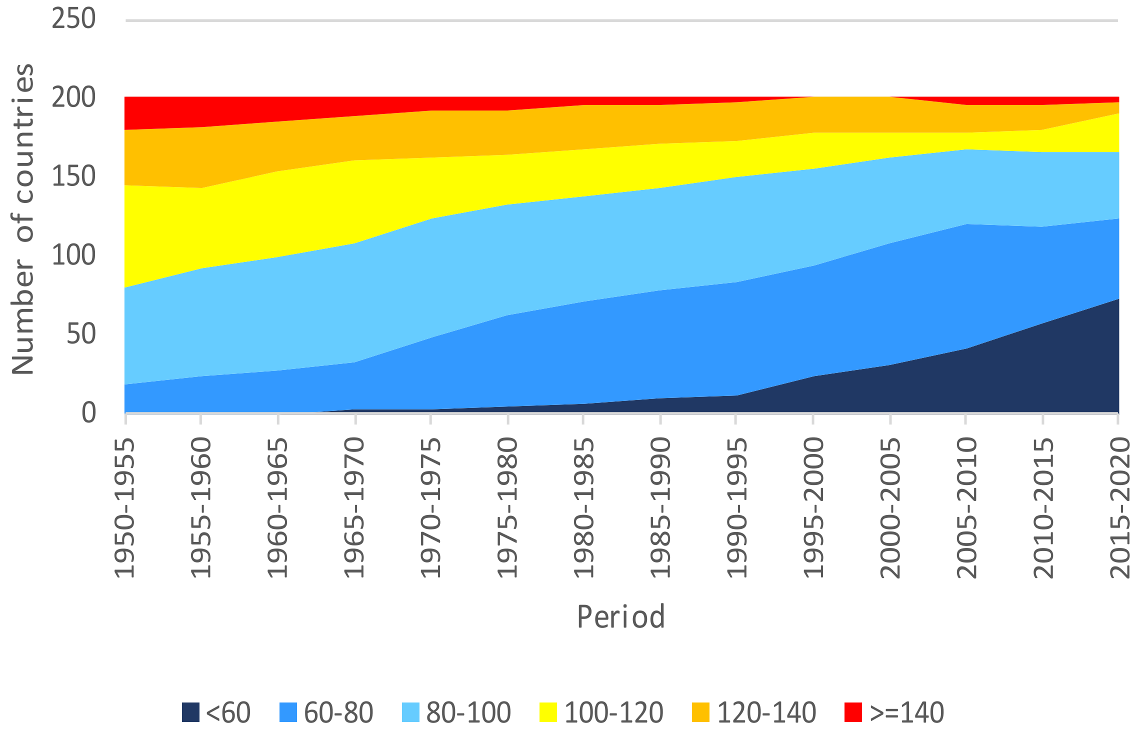

Figure 10: Inter-country variation in death rate independent of population age composition effect (d_a) (deaths per 1000 population), 1950-2020
Source: United Nations (2019)

The population fertility (b_f) or the birth rate independent of the population age and sex structure effect decreased by more than 50 per cent in the world from about 24 births per 1000 population during 1950-55 to about 11 births per 1000 population during 2015-2020 (Figure 7). The decrease in b_f has been the slowest in the more developed region. The b_f in the more developed region was the lowest during 19950-2000 but increased till 2005-2010 and then decreased. However, b_f during 2015-2020 was higher than that during 1995-2000. In the less developed region, b_f decreased rapidly during the period 1965-1970 through 1975-1980 but the decrease slowed down after 1975-1980. After 1990-1995, b_f in the less developed region has become lower than the world average. On the other hand, b_f increased, instead decreased, in the least developed countries during 1950-1955 through 1965-1970. and decreased thereafter.

The trend in population fertility across countries, first diverged and then converged during the last 70 years, although there is no country where the population fertility increased during this period. The inter-country coefficient of variation in b_f increased from 0.294 in 1950-1955 to 0.548 in 2000-2005 but, after 2000-2005, the trend in b_f across countries has tended to converge as the inter-country coefficient of variation in b_f decreased to 0.486 in 2015-2020. However, the inter-country disparity in population fertility during 2015-2020 was still higher than that during 1950-1955. During 1950-1955, there were 152 countries where population fertility was more than 20 births per 1000 population. This number decreased to 34 during 2015-2020. Similarly, there were only 2 countries where b_f was less than 10 births per 1000 population during 1950-1955 whereas there were 91 countries where b_f was less than 10 births per 1000 population during 2015-2020 (Figure 8).

The population mortality or the death rate independent of population age and sex structure effect (d_m) in the world decreased, almost linearly, from almost 98 deaths per 1000 population during 1950-1955 to around 57 deaths per 1000 population during 2015-2020 (Figure 9). The decrease in d_m has also been almost linear in the more developed region and in the least developed region of the world. In the more developed region, d_m decreased from around 87 deaths per 1000 population during 1950-1955 to around 50 deaths per 1000 population during 2015-2020 whereas it decreased from around 127 deaths per 1000 population to around 80 deaths per 1000 population in the least developed region during this period. In the less developed region of the world, however, the trend in d_m has been comparatively volatile as d_m increased, instead decreased, during 1950-1955 through 1955-1960. During the period 1955-1960 through 1965-1970, the decrease in d_m was very rapid in the less developed region but, after 1965-1970, the decrease in d_m in this region has slowed down but has remained almost linear. In the least developed region, the decrease in d_m appears to have slowed down during the period 1960-1965 through 1990-1995, but there has been an acceleration in the decrease in d_m after 1990-1995.

The variation and the trend in population mortality, d_m, across countries have been quite strong (Figure 10). The inter-country coefficient of variation in d_a decreased during the period 1950-1955 through 1965-1970 indicating that the countries converged in terms of population mortality during this period. However, the inter-country coefficient of variation increased during the period 1965-1970 through 2010-2015 with the only exception of the period 1980-1985 which suggests that countries diverged in terms of population mortality during this period. During 2015-2020, there has been a marginal decrease in the inter-country coefficient of variation in population mortality but the inter-country disparity in population mortality remains substantially higher during 2015-2020 as compared to inter-country disparity in population mortality during 1950-1955. In 1950-1955, d_m was at least 120 deaths per 1000 population in 56 countries of the world. By comparison, there were only 10 countries where d_m was at least 120 deaths per 1000 population during 2015-2020. There were, however, 2 countries where d_a was more than 140 deaths per 1000 population even in 2015–2020. On the other hand, there was no country where d_a was less than 60 deaths per 1000 population during 1950–1955 whereas there were 73 countries where d_a was less than 60 deaths per 1000 population during 2015–2020.

The ratio of birth rate, b, and population fertility or birth rate independent of age and sex structure effect, b_f, shows how population age and sex structure affects the birth rate at a given level of population fertility. Similarly, the ratio of death rate, d, and population mortality or death rate independent of age and sex structure effect, d_m, shows how population age and sex structure affects the death rate at a given level of population mortality. The world population age and sex structure has always inflated b, given b_f, throughout the 70 years under reference. During 1950–1955, the population age and sex structure inflated world b_f by almost 57 per cent. During 2015–2020, this inflation was by more than 61 per cent (Figure 11). The trend in the age and sex structure inflation effect has, however, not been uniform. The inflation effect of population age and sex structure on b decreased during 1950–1955 through 1965–1970 and then increased to an all-time high of more than 72 per cent during 1990–1995. After 1990–1995, the inflation effect of population age and sex structure on b has decreased but during 2015–2020, the inflation effect of population age and sex structure on b was higher than that 70 years ago. A similar trend may also be observed in more developed and less developed regions but, in the least developed region, inflation effect of age and sex structure on b has increased since 1975–1980 to almost more than 64 per cent in 2015–2020. Similarly, in all countries, population age and sex structure inflated b, given b_f, during the period under reference. During 1950–1955, the inflation effect of population age and sex structure ranged from a minimum of about 23 per cent to the maximum of almost 120 per cent across countries and areas. During 2015–2020, however, this effect ranged from a minimum of less than 2 per cent to almost 180 per cent indicating that countries and areas have diverged over time as regards the inflation effect of population age and sex structure on b, although there has been a period of convergence also.

On the other hand, age and sex structure effect has deflated the death rate d relative to the population mortality, d_m, very heavily. During 1950–1955, age and sex structure effect deflated world death rate d by more than 80 per cent relative to the population mortality, d_m. This deflating effect of the age and sex structure effect increased to more than 87 per cent during 2010–2015 but then decreased marginally to less than 87 per cent during 2019–2020 (Figure 12). In the more developed region, age and sex structure effect deflated d by almost 88 per cent relative to d_m during 1950–1955 which increased to almost 89 per cent during 1960–1965. However, after 1960–1965, the deflating effect of age and sex structure on the death rate has decreased continuously and, during 2015–2020, it deflated the death rate d by less than 80 per cent relative to d_m. In the less developed countries, the deflating effect of age and sex structure on the death rate d, relative to d_m, increased from around 80 per cent during 1950–1955 to more than 90 per cent during 2005–2010 but then decreased to around 89 per cent during 2015–2020. In the least developed countries, on the other hand, the deflating effect of population age and sex structure on the death rate d increased consistently from around 78 per cent during 1950–1955 to almost 91 per cent during 2015–2020 relative to d_m. Across the countries and areas, the deflating effect of population age and sex structure on d relative to d_m ranged from 93 per cent to 67 per cent during 1950–1955 but from around 97 per cent to 70 per cent during 2015–2020. The countries and areas of the world have also diverged over time in terms of the age and sex structure effect on the death rate as the inter-country coefficient of variation in the deflating effect of population age and sex structure on the death rate d relative to the population mortality, d_m, has increased during 2015–2020 as compared to the inter-country coefficient of variation during 1950–1955.

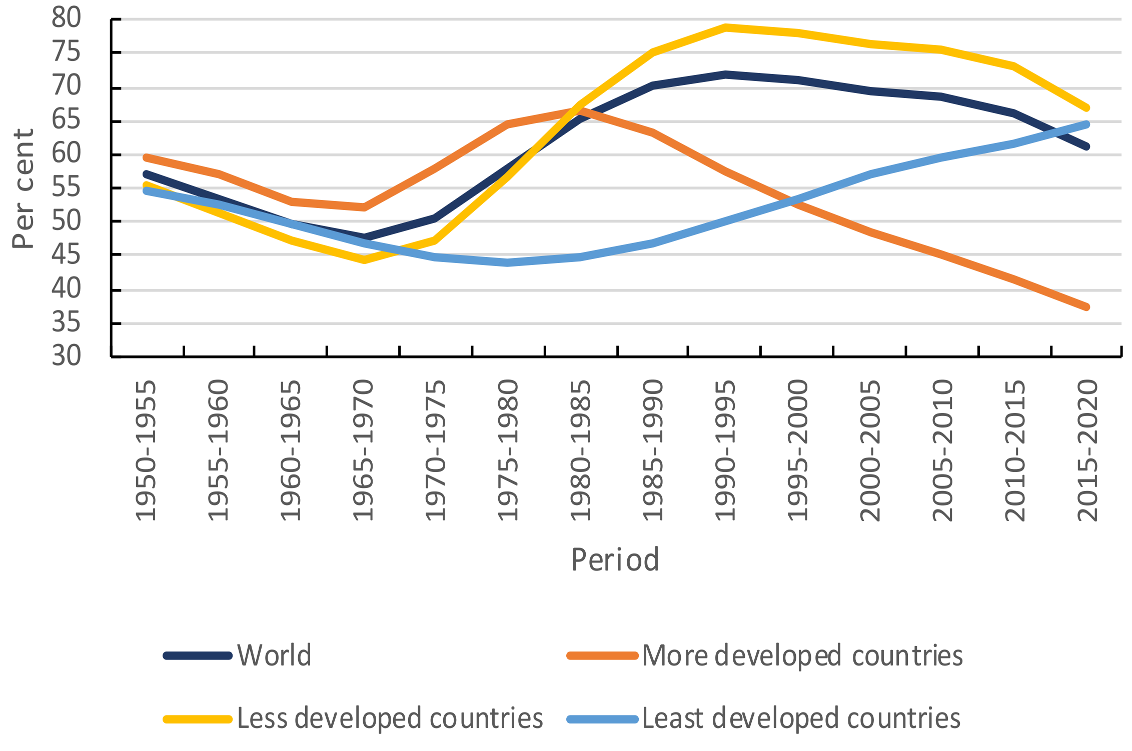

Figure 11: Inflating effect (per cent) of population age and sex structure on birth rate, 1950-1955 through 2015-2020.
Source: Author

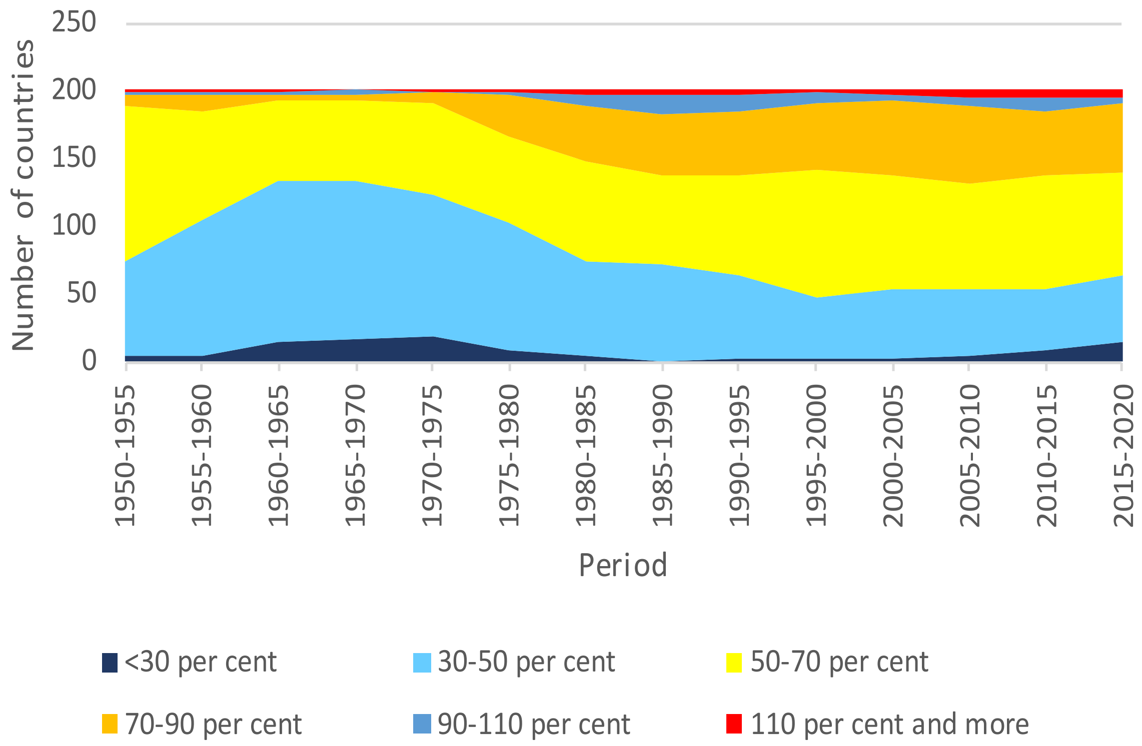

Figure 12: Inflating effect of population age and sex structure on birth rate across countries, 1950-1955 through 2015-2020
Source: Author

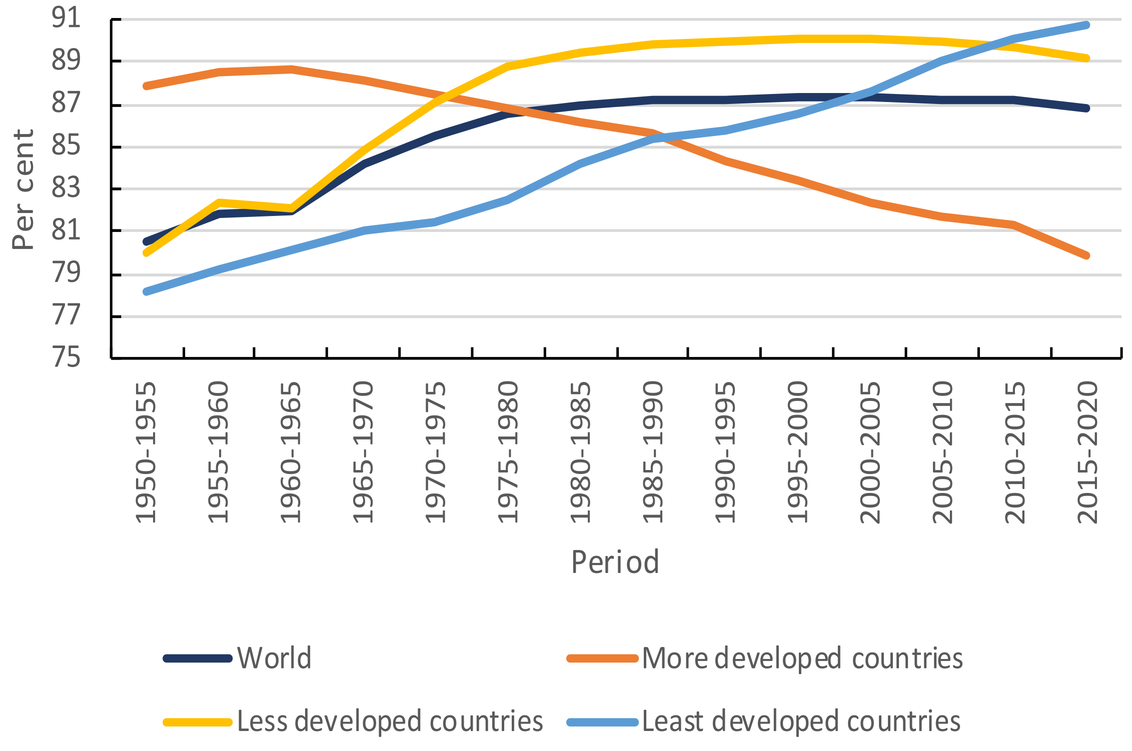

Figure 13: Deflating effect (per cent) of population age and sex structure on death rate, 1950-1955 through 2015-2020
Source: Author

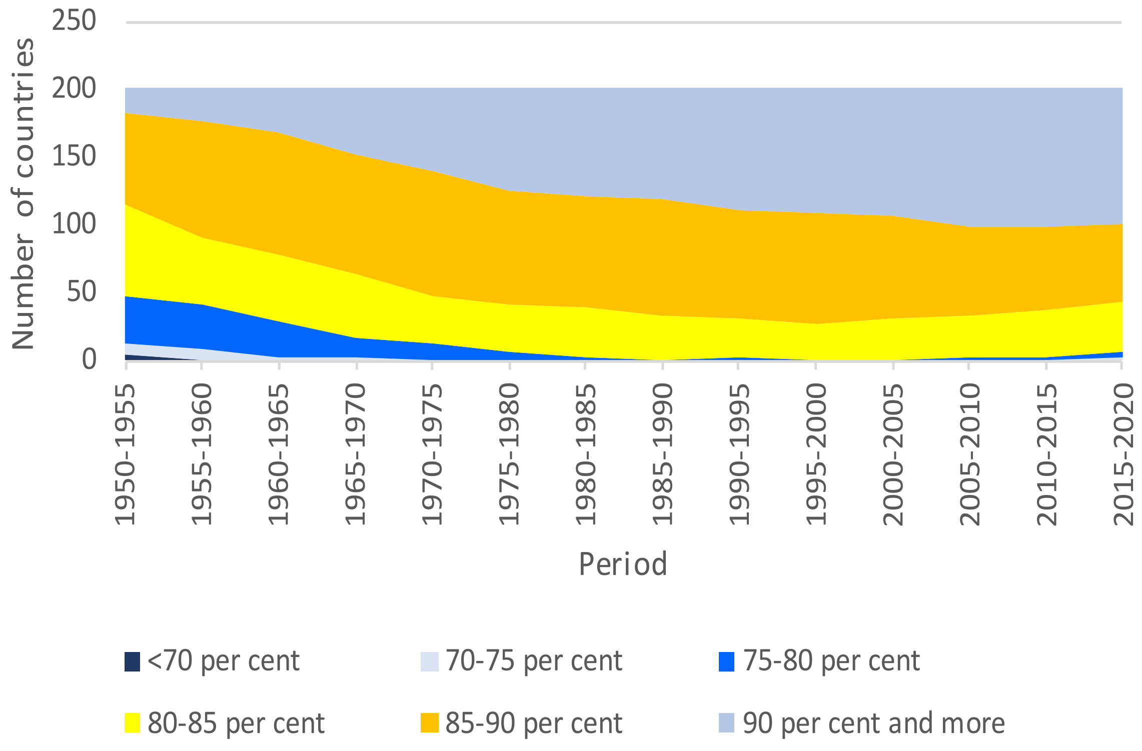

Figure 14: Deflating effect (per cent) of population age and sex structure across countries 1950-1955 through 2015-2020
Source: Author

Decomposition of the Change in the Rate of Natural Increase

The rate of natural increase, r, can be decomposed into the rate of natural increase attributed to population fertility or birth rate independent of age and sex structure effects, r_{ba}, rate of natural increase attributed to population mortality or death rate independent of age and sex structure effects, r_{da}, rate of natural increase attributed to age and sex structure effects on the birth rate, r_{ab}, and rate of natural increase attributed to age and sex structure effects on the death rate, r_{ad} in conjunction with equation (11). This decomposition exercise suggests that r_{ba} always contributed to decrease r whereas r_{da}, r_{ab} and r_{ad} always contributed to increase r in the world and in its more developed, less developed and the least developed regions. The sum of r_{ba} and r_{da} is the intrinsic component of r whereas the sum of r_{ab} and r_{ad} is the age and sex structure component of r. This means that the intrinsic component always contributed to decrease r whereas the age and sex structure component always contributed to increase r. Moreover, the magnitude of the age and sex structure component has always been larger than the magnitude of the intrinsic component so that the rate of natural increase in the world population and the population of its three development regions has always been positive during 1950 through 220.

quite volatile during the 70 years under reference because the change in the intrinsic component and the change in the age component of the rate of natural increase have been different during most of the time. During 1950–1965, the change in the in the intrinsic component was positive which accelerated the increase in the rate of natural increase, but a part of this increase was compensated by the negative change in the age component which resulted in a deceleration in the rate of natural increase (Figure 11). However, during 1960–1970, the intrinsic component and the age component both increased so that the rate of natural increase increased from around 1.91 per cent during 1960–65 to more than 2.05 per cent during 1965–1970. This period was the only period when the world population increased at the rate of more than 2 per cent per year. After 1965–1970, the change in the intrinsic component has been negative throughout the period 1970–2020 but the change in the age component of the rate of natural increase was positive during the period 1970–2010. In other words, during this period, the change in the intrinsic component contributed to slowdown the rate of natural increase whereas the age component contributed to accelerate the rate of natural increase. During 1975–1980, the decrease in the intrinsic component was virtually compensated by the increase in the age component so that the rate of natural increase almost stagnated during the period 1975–1985. On the other hand, the increase in the age component during 1985–1990 was more than the decrease in the intrinsic component in absolute terms so that the rate of natural increase increased from around 1.77 per cent during 1980–85 to 1.79 per cent during 1985–90. The age component of the rate of natural increase started decreasing only after 2005–2010 so that the change in both the intrinsic component and the age component was negative during the period 2010–2020 and, therefore, contributed to slow down the rate of natural increase. In most of the time during the period of 70 years under reference, the intrinsic component, and the age component of the rate of natural increase changed in opposite directions so that the decrease in the rate of natural increase has been slower than the decrease in the intrinsic rate of natural increase. to influence the change in the rate of natural increase.

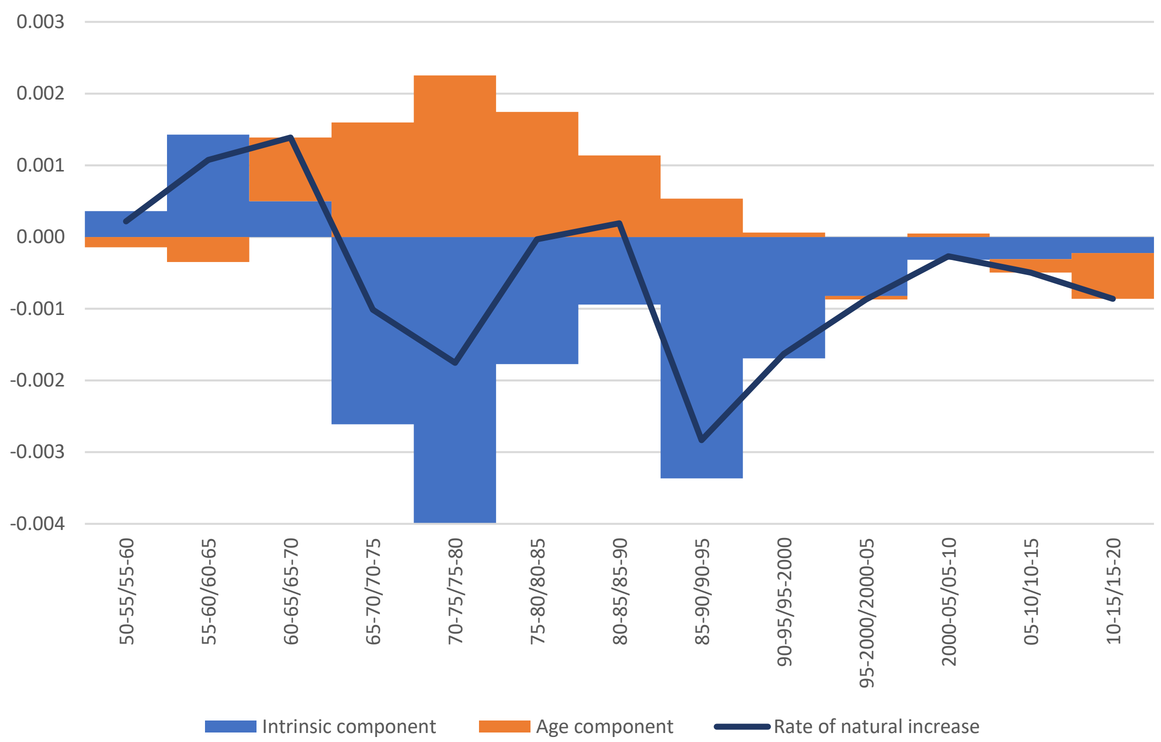

Figure 6: Change in the rate of natural increase and its intrinsic and age components in the world population, 1950-2020
Source: Author

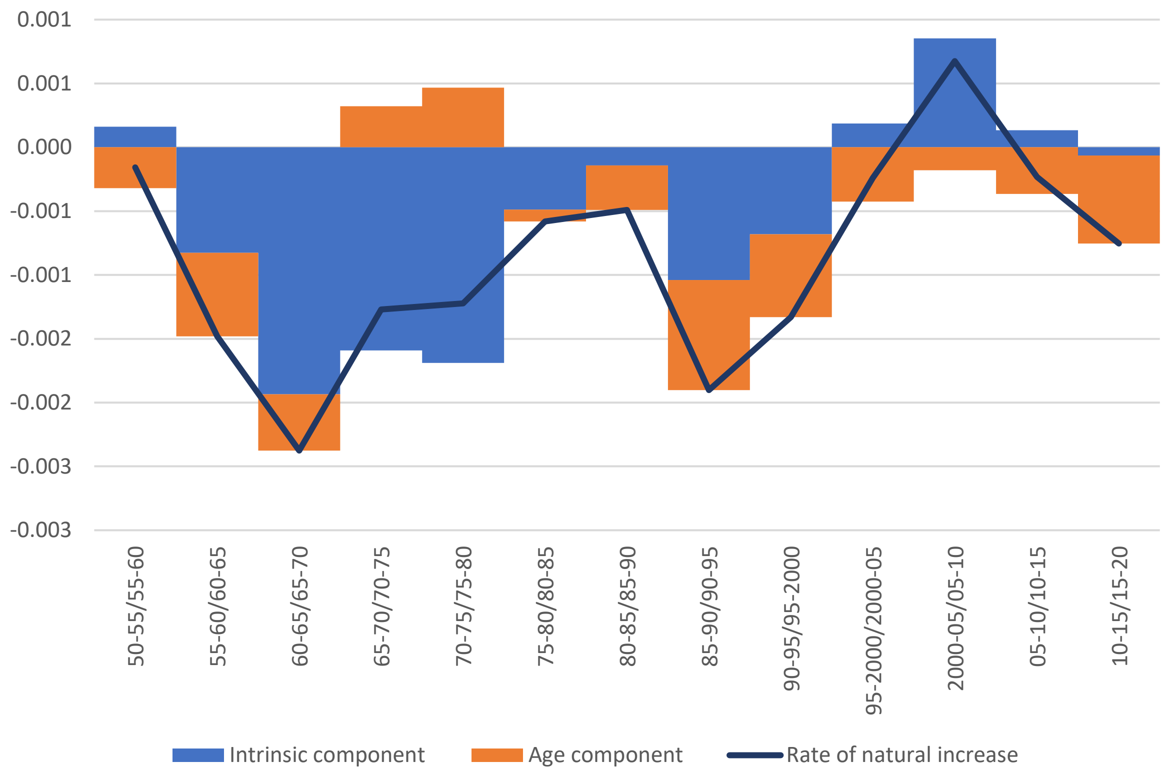

Figure 7: Change in the rate of natural increase and its intrinsic and age components in the population of more developed region, 1950-2020
Source: Author

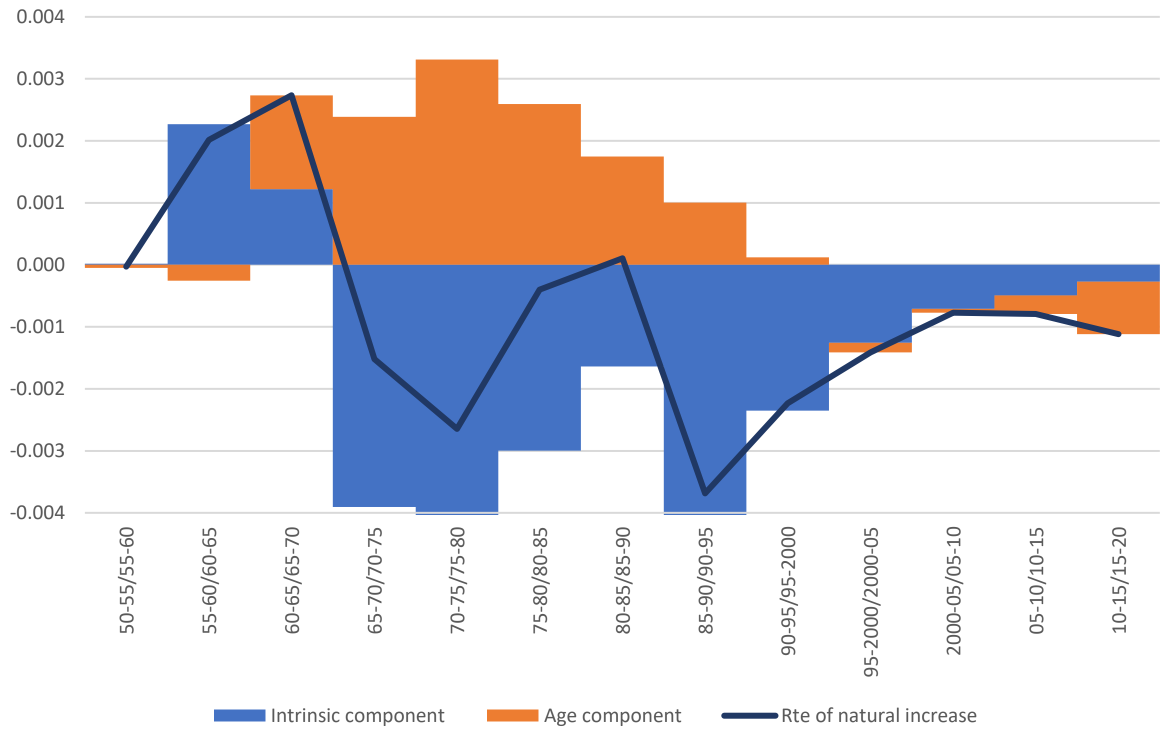

Figure 8: Change in the rate of natural increase and its intrinsic and age components in population of less developed region, 1950-2020

Source: Author

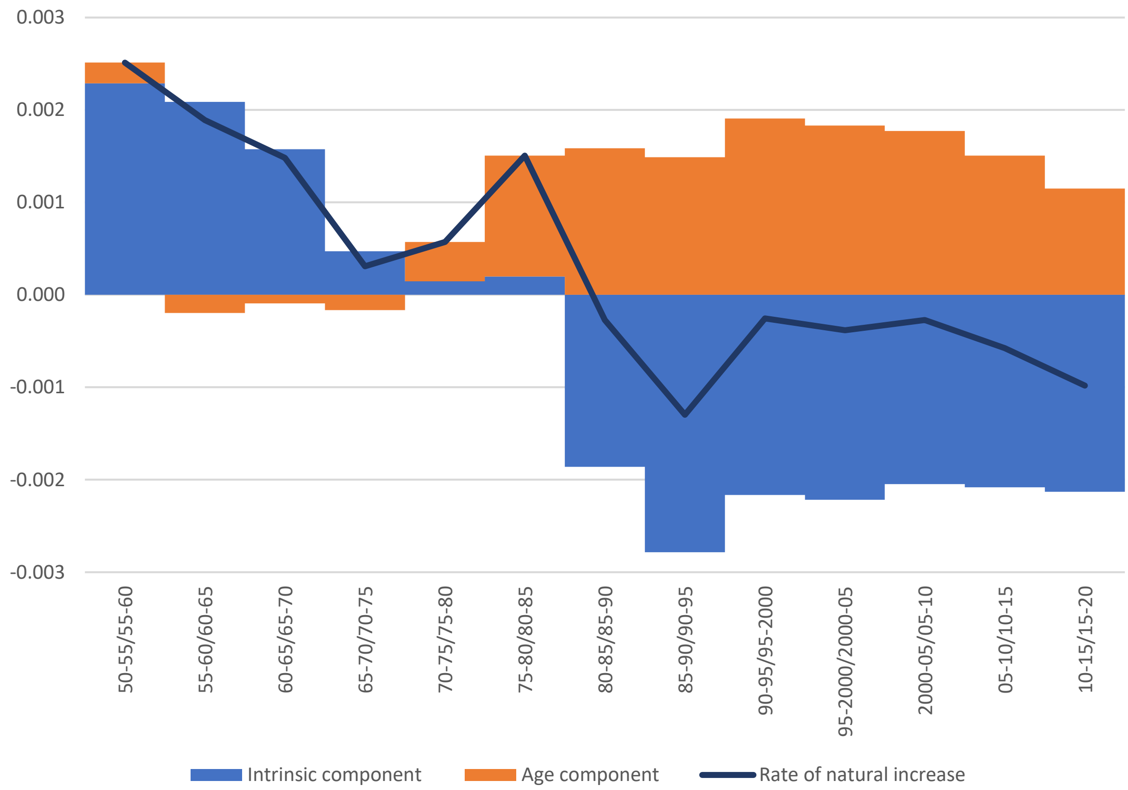

Figure 9: Change in the rate of natural increase and its intrinsic and age components in population of least developed region, 1950-2020

Source: Author

In the more developed region of the world the change in the rate of natural increase has always been negative except for the period 2000–2005/2005–2010. The relative contribution of the change in the intrinsic and age components to the change in the rate of natural increase has, however, been different. The decrease in the rate of natural increase during 1950–1955/1955–1960 has been due to the decrease in the age component as the intrinsic component increased during this period. During 1955–1960/1965–1970, the change in both intrinsic and age component contributed to the decrease in the rate of natural increase, but, during 1965–1970/1975–1980, the decrease in the rate of natural increase was due to the negative change in the intrinsic component as the change in the age component was positive during this period. During 1975–1980/1995–2000, change in both intrinsic and age components accounted for the decrease in the rate of natural increase. During 1995–2000/2000–2005, the decrease in the rate of natural increase was the result of the negative change in the age component as the change in the intrinsic component was positive. During 2000–2005/2005–2010, the magnitude of the positive change in the intrinsic component was larger than the magnitude of the negative change in the age component so that the rate of natural increase increased instead decreased. During 2005–2010/2010–2015, however, the magnitude of the positive change in the intrinsic component was smaller than the magnitude of the negative change in the age component so that the rate of natural increase decreased. Finally, during 2010–2015/2015–2020, the change was negative in both intrinsic and age component which resulted in the decrease in the rate of natural increase, although the negative change in the age component accounted for more than 91 per cent of the negative change in the rate of natural increase during this period.

indicating an increase in the intrinsic rate of natural increase but the change in the age component was negative during this period except for the period 1975–1990 so that the increase in the rate of natural increase during this period was slower than the increase in the intrinsic rate of natural increase. decomposition of the rate of natural increase suggests that the intrinsic rate of natural increase has always been negative, but the momentum rate of natural increase has always positive in the world during the 70 years under reference. and in its three major regions. The intrinsic rate of natural increase decreased throughout the 70 years under reference, but the momentum rate of natural increase increased till 1985–90 and decreased thereafter. Moreover, the momentum rate of natural increase has always been greater than the intrinsic rate of natural increase since 1975–80. During 1950–55, the main driver of world population growth was the intrinsic rate of natural increase which is determined by the fertility and mortality. This scenario virtually reversed during 2015–20 when momentum rate of natural increase accounted for almost 73 per cent of the rate of natural increase. The world population growth is now being driven primarily by the momentum for growth built in the age composition of the population as it affects the birth rate and the death rate. In the more developed countries, population continues to increase despite negative intrinsic rate of natural increase since 1975–80 because of the positive momentum rate of natural increase. In the less developed and the least developed countries of the world also, the momentum for growth built into the age composition of the population has now become the primary driver of population growth.

The intrinsic rate of natural increase can be divided further into intrinsic rate of natural increase attribute to fertility and the intrinsic rate of natural increase attributed to mortality. The intrinsic rate of natural increase in world has always been positive because the intrinsic rate of natural increase attributed to fertility has always been higher than the intrinsic rate of natural increase attributed to mortality. This has also been the case with the less developed and the least developed countries. In the more developed countries, however, the intrinsic rate of natural increase attributed to fertility become lower than the intrinsic rate of natural increase attributed to mortality so that the intrinsic rate of natural increase turned negative in these countries since 1975–80. In these countries, the age independent death rate became higher than the age independent birth rate after 1975. During 2015–20, fertility varied widely across the three groups of countries – around 11 live births per 1000 population in more developed countries to around 17 live births per 1000 population in the less developed and more than 28 live births per 1000 population in the least developed countries. By contrast, the variation in mortality has been substantially narrow – almost 13 deaths per 1000 population in the more developed countries, around 14 deaths per 1000 population in the less developed countries and less than 16 deaths per 1000 population in the least developed countries.

Similarly, the momentum rate of natural increase can be divided further into the momentum rate of natural increase attributed to age composition effect on the birth rate and the momentum rate of natural increase attributed to age composition effect on the death rate. The momentum rate of natural increase attribute to age composition effect on the birth rate has always been positive in the world. It increased up to 1985–90 and then decreased. This means that the age composition effect inflated the age independent birth rate by around 6 per cent during 1950–55. This proportion number increased to more than 13 per cent during 1985–90 but decreased to less than 5 per cent during 2015–20. The momentum rate of natural increase attributed to age composition effect on the death rate, on the other hand, have always been negative. This effect also increased till 1985–90 and then decreased. However, the momentum rate of natural increase attributed to the age composition effect on the death rate has always been a dominating factor in deciding the momentum rate of natural increase. During 1950–55, age composition effect deflated the age independent death rate by around 10 per cent. This proportion increased to more than 45 per cent during 2010–15. Because of the very strong age composition effect, the decrease in the death rate in the world has been substantially faster than the decrease in the age independent death rate.

Both intrinsic rate of natural increase (r_i) and momentum rate of natural increase (r_a) have varied widely across countries currently as well as in the past (Table 4). During 1950–55, there were only two countries – Democratic Republic of Korea and Luxembourg – where the intrinsic rate of natural increase was negative. By 2015–20, the number of countries having a negative intrinsic rate of natural increase increased to 68. On the other hand, there were 15 countries where r_i was at least 25 per 1000 population during 1950–55, but there was no country during 2015–20 where r_i was at least 25 per 1000 population. Niger was the only country in the world where r_i was more than 20 per 1000 population as late as during 2015–20. The inter-country coefficient of variation in r_i has, however, increased very substantially from 0.478 during 1950–55 to 1.551 during 2015–20 which shows that the countries of the world diverged significantly as far as the trend in r_i is concerned.

The inter-country variation in r_a, on the other hand have shown a mixed trend. The inter-country coefficient of variation in r_a first decreased during the period 1950–55 through 1985–90 but increased consistently since 1985–90. During 1950–55, there were 10 countries in the world where r_a was negative which implies that age composition effects on the birth rate and the death rate contributed to decelerate r given r_i. During 2015–20, however, there were only 8 countries where r_a was negative. In all these countries, r_i was also negative so that r_a contributed to further decrease r given r_i. The trend also suggests that in an increasing proportion of countries, population growth is increasingly being driven by the age composition effects on the birth rate and the death rate or the momentum rate of natural increase while underlying fertility and mortality levels or the intrinsic rate of natural increase is becoming less and less important.

The countries and areas can be divided into 6 groups based on r_i and r_a. During 1950–55, there were 189 countries and areas where both r_i and r_a were positive so that both intrinsic component and momentum component contributed to increase r. This number decreased to 133 during 2015–20 (Table 5). On the other hand, there were two countries – Democratic Republic of Korea and Luxemburg – where r was positive during 1950–55, although r_i was negative. In these countries, population momentum contributed to increase the population. During 2015–20, there were 68 countries where r_i <0, but in 45 countries, r >0 because r_a >0 and r_i < r_a in absolute terms. Moreover, there were 10 countries in 1950–55, where r was positive even though r_a <0 because r_i >0 and r_i > r_a in absolute terms. There was, however, no such country during 2015–20. There was also no country during 1950–55 where r_i <0 but r_a >0 and r_i > r_a in absolute terms so that r <0. There were, however, 15 such countries during 2015–20. Finally, there was no country where both r_i and r_a were negative during 1950–55, but there were 8 such countries during 2015–20. There is also no country, currently or in the past, where r_i >0, r_a <0 and r_i < r_a in absolute terms so that r was negative. In other words, there were 68 countries during 2015–20 where r_i <0 but r <0 in only 23 countries. This means that, in 45 countries of the world, population increased during 2015–20 despite a negative intrinsic rate of natural increase because positive population momentum.

There were 10 countries where the negative population momentum contributed to slow down the intrinsic increase in population as determined by prevailing fertility and mortality. These include Benin (1950–65); Bolivia (1950–55); Cabo Verde (1950–55); Iraq (1950–55); Libya (1950–55); Mayotte (1950–55); Oman (1950–55); Papua New Guinea (1950–55); Somalia (1950–60); and Yemen (Yemen (1950–75). After 1970–75, population momentum was not negative in any country to slow down the increase in population. On the other hand, in recent years, negative population momentum contributed to accelerate the intrinsic decrease in population in 10 countries. These countries include Belarus (1995–2010); Bulgaria (1995–2020); Croatia (2015–20); Hungary (1985–95 and 2015–20); Latvia (1995–2020); Lithuania (2005–20); Romania (2015–20); Russian Federation (1995–2005); Serbia (2015–20); and Ukraine (1995–2020).

The population momentum is the difference between the age composition effect on the birth rate and the age composition effect on the death rate. When the birth rate is higher than the age independent birth rate, the age composition effect on the birth rate tends to accelerate population growth. When the death rate is higher than the age independent death rate, the age composition effect on the death rate tends to decelerate population growth. The population momentum will be negative if either birth rate is less than the age independent birth rate and the death rate is higher than the age independent death rate or birth rate is less than the age independent birth rate and the death rate is less than the age independent death rate but the ratio of birth rate to age independent birth rate is greater than the ratio of the death rate to age independent death rate in absolute terms.

In the 10 countries where population momentum was negative and contributed to slow down population growth during 1950–55, the death rate was higher than the age independent death rate while birth rate was higher than the age independent birth rate in all but two countries. In these countries, negative population momentum was primarily the result of exceptionally high death rate. On the other hand, in 8 countries where negative population momentum contributed to accelerate the decrease in population during 2015–20, the death rate was higher than the age independent death rate in five countries while the birth rate was less than the age independent birth rate in all but one country. In these countries, negative population momentum was primarily the result of exceptionally low birth rate, although in some countries, death rate higher than the age independent death rate also contributed to negative population momentum. However, except for a few exceptions, the population momentum as determined by the age composition effects on the birth rate and the death rate has contributed to accelerate population increase given the intrinsic increase in population throughout the 70 years under reference. In a few countries where intrinsic rate of population increase has turned negative in recent years, the positive population momentum has been responsible for the increase in population. There are, however, only 20 countries where population momentum has been negative, any time during the last 70 years.

Table 6 decomposes the inter–country variance in r into the inter–country variance in r_i and the inter–country variance in r_a. The inter–country variance in r increased up to 2000–05 which indicates that the countries and areas of the world diverged in terms of the rate of natural increase during 1950–2005. The decrease in the inter–country variance in r, after 2000–05, however indicates that the countries and areas of the world are now converging as far as the rate of natural increase is concerned. The inter–country variance in r_i, however, increased up to 1975–80 only whereas the inter–country variance in r_a increased throughout the period under reference. At the same time, the inter–country covariance between r_i and r_a also increased with time. As a result, there has been a decrease in the contribution of inter–country variance in r_i to the inter–country variance in r whereas the contribution of inter–country variance in r_a to inter–country variance in r has increased over time. This observation again confirms that the momentum for growth built in the population age composition is turning to be the primary contributor to world population growth. In an increasing number of countries, underlying fertility and mortality levels are no longer the primary determinants of population growth. Rather, population age composition, as it effects the birth rate and the death rate, is now primarily dominating the population growth trend in most of the countries.

Figure 10: Decomposition of population increase (million) in the world 1950-2020

Source: Author

Figure 11: Decomposition of population increase (million) in more developed countries of the world, 1950-2020

Source: Author

Figure 12: Decomposition of population increase (million) in the less developed countries of the world, 2015-2020

Source: Author

Figure 13: Decomposition of population increase (million) in the least developed countries of the world, 1950-2020

Source: Author

In absolute terms, the world population increased by more than 5258 million during the 70 years between 1950 and 2020. Around 2276 million or 43 per cent of this increase is due to intrinsic increase determined by prevailing fertility and mortality levels whereas momentum increase attributed to age composition effects on the birth rate and the death rate has accounted for an increase of 2982 million or around 57 per cent (Table 7). There has also been a significant change in the relative contribution of intrinsic increase and momentum increase to the natural increase in population over time. During 1950–55, the world population increased by around 237 million and more than 75 per cent of this increase was due to intrinsic increase attributed to the change in the levels of fertility and mortality while momentum increase accounted for less than 25 per cent of the increase. During 2015–20, the world population increased by 415 million, but the contribution of the intrinsic increase decreased to only about 27 whereas the contribution of the momentum increase increased to almost 73 per cent of the total increase.

The relative contribution of intrinsic increase and momentum increase to the natural increase has been different in the three groups of countries. In the more developed countries, population increased by around 459 million during 1950–2020. In-migration from less and the least developed countries accounted for an increase of around 123 million so that the natural increase was around 336 million. Almost 95 per cent of this increase is attributed to population momentum. Since 1975–80, the entire natural increase in these countries has been due to population momentum as fertility and mortality contributed to a decrease, instead increase, in the population. In the less and the least developed countries also, the relative share of intrinsic increase to total natural increase has decreased considerably over time. During 1950–55, the intrinsic increase accounted for almost 84 per cent of the natural increase in the less developed countries and almost 87 per cent in the least developed countries. During 2015–20, by contrast, population momentum accounted for more than 78 per cent of the natural increase in the less developed countries and 58 per cent of natural increase in the least developed countries.

5. Discussions and Conclusions

The present analysis suggests that population momentum or the momentum for growth built in the age composition of the population has played a significant role in the growth of the world population during the 70 years between 1950 and 2020. It reflects how population age composition inflates or deflates the birth rate and the death rate given the age independent birth rate or fertility and the age independent death rate or mortality. It can both accelerate and decelerate the rate of natural increase given the intrinsic rate of natural increase which is determined by prevailing levels of fertility and mortality. When the intrinsic rate of natural increase is positive, a positive population momentum accelerates the rate of natural increase, whereas a negative population momentum decelerates the rate of natural increase. Similarly, when the intrinsic rate of natural increase is negative, a positive momentum decelerates the decrease in population or even accounts for population increase whereas a negative momentum hastens the pace of the decrease in population.

The present analysis suggests that population growth in the world and in its different regions and 201 countries and areas is now increasingly being dominated by the population momentum or age structure effects on the birth rate and the death rate. In the more developed countries of the world, the entire natural population growth since 1975–80 has been the result of population momentum as the intrinsic rate of natural increase in these countries has turned negative since 1975–80. The analysis also suggests that, in 193 of the 201 countries and areas of the world, population momentum now contributes to either accelerate the increase in population or to slow down or revert the decrease in population given the intrinsic population growth. There are only 10 countries where population momentum has contributed to accelerate further the decrease in population relative to the decrease in population determined by the prevailing levels of fertility and mortality during 2015–20. There are 45 countries where natural population growth remains positive despite negative intrinsic rate of natural increase because of the positive population momentum. There are only 15 countries where the positive population momentum was not large enough to compensate for negative intrinsic population growth during 2015–20. Finally, there are only 8 countries where both intrinsic natural population growth was negative and, at the same time, population momentum was also negative so that it further accelerated the decrease in population.

Population momentum has generally been conceptualised, analysed, and discussed in the context of the decrease in fertility, more specifically, what will happen when fertility decreases to the replacement level. The present analysis, however, suggests that there are countries where population momentum has been negative and, therefore, contributed to either slow down the increase in population or to accelerate further the decrease in population. In most of the instances when population momentum was negative, the main reason has been the inflating effect of the population age composition on the death rate. In some countries, the deflating effect of population age composition on the birth rate also contributed to negative population momentum but the inflating effect of population age composition on the death rate has played a dominating role.

The present analysis has implications for population policy. Population dynamics is universally recognised to play a crucial role in realising development goals such as those laid down in the United Nations 2030 Agenda for Sustainable Development (United Nations 2015). It has been argued that harnessing demographic changes for the success and sustainability of development strategies and efforts depends upon effective population policies (United Nations, 2018). The present analysis suggests that, in countries where natural population growth is higher than the intrinsic population growth, reduction in fertility and mortality in the coming years will have only a limited impact on natural population growth as an increasing proportion of natural population growth will be due to population momentum. The scope of population policy in these countries, therefore, needs to be broadened to include appropriate approaches to address momentum population growth in addition to efforts directed towards slowing down intrinsic population growth through reduction in fertility and mortality. Similarly, in countries where population momentum contributes to accelerating the decrease in population given the intrinsic population decrease, population policy must include measures to address negative population momentum in addition to efforts directed towards reversing the decrease in population driven by likely levels of fertility and mortality. This is needed because the approaches required to address population momentum are essentially different from the approaches required to address fertility and mortality. The age composition effects on the birth rate and the death rate are medium term effects. They are determined by the past population dynamics and, therefore, cannot be eliminated by current interventions to modify fertility and mortality. Its impact may, however, be delayed by adopting appropriate reproductive behaviour. It is, therefore, argued that population policies should be explicit about intrinsic population growth determined by fertility and mortality and momentum population growth determined by population age composition so that they can be more effective and relevant in the context of challenges related to economic growth, social inclusion, and environmental protection facing the world as articulated in the United Nations 2030 Agenda for Sustainable Development.

References

Bongaarts J (2007) Population Growth and Policy Options in the Developing World. Paper presented at the Beijing Forum, Beijing, November. New York: Population Council.

Bourgeois-Pichat J (1971) Stable, semi-stable population and growth potential. *Population Studies (Camb)* 25(2): 235-254.

Chaurasia AR (2017) Fertility, mortality and age composition effects of population transition in China and India: 1950-2015. *Comparative Population Studies* 42: 149-189.

Espenshade TJ, Tannen JBC (2015) Population dynamics. Momentum of population growth. In JD Wright (Ed) *International Encyclopedia of Social and Behavioral Sciences*, Second Edition, Volume 18.

Gendell M (1984) The dynamics of population momentum. *Population Today* 12(11): 6–7.

Keyfitz Nathan (1971) On the momentum of population growth. *Demography* 8(1): 71–80.

Notestein FW (1945) Population: the long view. in T Schultz (ed) *Food for the World*. Chicago, University of Chicago Press: 36–57.

Preston SH (1994) *Population and environment: from Rio to Cairo. IUSSP distinguished lecture on population and development*. Liege, Belgium: IUSSP.

Preston SH, Guillot M (1997) Population dynamics in an age of declining fertility. *Genus* 53(3–4): 15–31.

Preston SH, Heuveline P, Guillot M (2001) *Demography. Measuring and Modelling Population Processes*. Oxford, Blackwell Publishers1.

United Nations (1999) *Standard Country or Area Codes for Statistical Use, Revision 4*. New York, Statistics Division. M, No. 49/Rev.4

United Nations (2015) *Transforming Our World. The 2030 Agenda for Sustainable Development*. New York, United Nations.

United Nations (2018) *World Population Policies 2015: Highlights*. New York, Department of Economic and Social Affairs. Population Division. (ST/ESA/SER.A/373).

United Nations (2019a) *World Population Prospects 2019, Online Edition. Rev 1*. New York, Department of Economic and Social Affairs. Population Division. POP/DB/WPP/Rev.2019/POP/F01-1

United Nations (2019b) World Population Prospects 2019. *Methodology of the United Nations Population Estimates and Projections*. New York, Department of Economic and Social Affairs. Population Division.

Vincent P (1945) Potential d'accroissement d'une population. *Journal de la société de statistique de Paris, 1re* Série, Janvier–Février, 86(1–2):16–39.

Table 1: Rate of natural increase, birth rate, death rate, total fertility rate and expectation of life at birth in the world and in more developed, less developed and the least developed countries, 1950–55 through 2015–20.

Period	World	More developed countries	Less developed countries	Least developed countries
Rate of natural increase (per 1000 population)				
1950–55	17.8	11.8	20.7	20.0
1955–60	18.0	11.6	20.7	22.5
1960–65	19.1	10.1	22.7	24.4
1965–70	20.5	7.8	25.4	25.9
1970–75	19.5	6.5	23.9	26.2
1975–80	17.7	5.3	21.2	26.8
1980–85	17.7	4.7	20.8	28.3
1985–90	17.9	4.2	21.0	28.0
1990–95	15.1	2.3	17.3	26.7
1995–2000	13.4	1.0	15.0	26.5
2000–05	12.6	0.7	13.6	26.1
2005–10	12.3	1.4	12.8	25.8
2010–15	11.8	1.2	12.1	25.2
2015–20	10.9	0.4	10.9	24.3
Birth rate (births per 1000 population)				
1950–55	36.9	22.3	43.2	47.8
1955–60	35.4	21.3	40.9	47.8
1960–65	35.2	19.5	41.1	47.6
1965–70	34.0	17.2	39.7	47.3
1970–75	31.5	16.0	35.8	46.7
1975–80	28.5	14.8	31.4	45.9
1980–85	27.7	14.4	30.1	45.2
1985–90	27.4	13.9	29.6	43.3
1990–95	24.2	12.3	25.3	41.3
1995–2000	22.2	11.2	22.8	39.5
2000–05	21.0	11.0	21.1	37.6
2005–10	20.3	11.4	20.1	35.6
2010–15	19.5	11.1	19.1	33.5
2015–20	18.5	10.6	17.9	31.6
Death Rate (deaths per 1000 population)				
1950–55	19.1	10.6	22.5	27.8
1955–60	17.4	9.7	20.2	25.3
1960–65	16.1	9.3	18.4	23.2
1965–70	13.5	9.4	14.3	21.4
1970–75	12.0	9.5	11.9	20.5
1975–80	10.8	9.6	10.1	19.2
1980–85	10.0	9.7	9.2	16.9
1985–90	9.5	9.7	8.6	15.3
1990–95	9.1	10.0	8.1	14.5
1995–2000	8.8	10.2	7.7	13.0

Period	World	More developed countries	Less developed countries	Least developed countries
2000–05	8.5	10.3	7.5	11.5
2005–10	8.0	10.0	7.2	9.8
2010–15	7.7	9.9	7.0	8.3
2015–20	7.5	10.2	7.0	7.4
Total fertility rate				
1950–55	4.97	2.82	6.02	6.53
1955–60	4.90	2.79	5.85	6.60
1960–65	5.02	2.66	6.05	6.70
1965–70	4.93	2.38	5.95	6.76
1970–75	4.47	2.16	5.23	6.75
1975–80	3.86	1.92	4.31	6.67
1980–85	3.59	1.84	3.87	6.53
1985–90	3.44	1.81	3.63	6.17
1990–95	3.01	1.67	3.04	5.75
1995–2000	2.78	1.57	2.74	5.38
2000–05	2.65	1.58	2.57	5.00
2005–10	2.58	1.68	2.46	4.65
2010–15	2.52	1.67	2.38	4.31
2015–20	2.47	1.64	2.33	4.00
Expectation of life at birth (years)				
1950–55	46.96	64.83	42.47	36.27
1955–60	49.37	67.73	44.87	38.76
1960–65	51.18	69.49	46.94	41.02
1965–70	55.43	70.33	52.79	43.16
1970–75	58.09	71.13	56.51	44.22
1975–80	60.27	72.02	59.38	45.80
1980–85	62.07	72.86	61.39	48.83
1985–90	63.71	73.95	63.20	50.76
1990–95	64.56	74.16	64.50	51.50
1995–2000	65.63	74.80	65.67	53.60
2000–05	67.05	75.60	67.07	56.05
2005–10	68.92	76.93	68.71	59.33
2010–15	70.88	78.43	70.51	62.44
2015–20	72.28	79.24	71.95	64.66

Source: United Nations (2019)

Table 2: Inter-country variation in the rate of natural increase, birth rate, death rate, total fertility rate and expectation of life at birth, 1950–55 through 2015–2020.

	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020
Rate of natural increase (per cent per year)														
Summary measures of inter-country variation														
Min	0.205	0.290	0.292	0.215	–0.108	–2.098	–0.152	–0.187	–0.305	–0.643	–0.745	–0.591	–0.549	–0.643
Q1	1.522	1.677	1.765	1.641	1.582	1.187	1.220	1.101	0.946	0.742	0.595	0.521	0.439	0.330
Med	2.075	2.332	2.494	2.426	2.436	2.373	2.434	2.358	2.049	1.744	1.493	1.406	1.360	1.176
Q3	2.671	2.903	2.992	2.908	2.853	2.909	2.937	2.888	2.712	2.489	2.362	2.331	2.275	2.174
Max	3.871	3.792	3.888	4.137	4.109	4.229	4.141	4.112	4.086	3.665	3.690	3.802	3.860	3.787
IQR	1.149	1.226	1.227	1.267	1.271	1.723	1.717	1.787	1.767	1.747	1.767	1.810	1.836	1.844
CV	0.400	0.377	0.381	0.413	0.445	0.513	0.509	0.524	0.586	0.663	0.726	0.740	0.763	0.823
	Frequency distribution													
< 0	0	0	0	0	2	4	4	4	13	15	19	17	18	23
0–1.0	23	21	25	32	33	38	38	41	39	50	53	57	58	63
1.0–1.5	26	20	19	16	14	16	17	18	18	19	30	32	36	36
1.5–2.0	42	32	25	17	20	17	17	20	25	36	32	35	27	24
2.0–2.5	39	41	33	40	38	36	30	34	38	31	22	16	18	20
>=2.5	71	87	99	96	94	90	95	84	68	50	45	44	44	35
Birth rate (per 1000 population)														
Summary measures of inter-country variation														
Min	14.5	14.4	13.1	14.1	10.7	10.3	10.4	10.0	9.7	8.0	7.7	8.4	8.4	7.4
Q1	33.0	31.6	30.2	25.1	22.5	20.2	20.1	18.3	16.6	14.3	13.5	12.8	12.1	11.7
Med	43.3	43.1	42.8	39.8	36.6	35.0	32.8	30.1	27.1	23.8	21.2	21.0	19.2	18.0
Q3	47.8	47.6	47.0	45.9	45.2	44.1	42.6	40.5	37.4	34.3	32.4	30.8	29.5	28.3
Max	57.2	57.8	58.3	57.6	56.4	56.4	56.8	55.8	55.2	54.2	52.7	50.8	48.7	46.3
IQR	14.8	16.0	16.8	20.8	22.7	23.9	22.5	22.2	20.8	20.0	18.9	18.0	17.4	16.6
CV	0.277	0.285	0.300	0.334	0.358	0.385	0.396	0.404	0.429	0.469	0.495	0.488	0.481	0.481

	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020
Frequency distribution														
	15	21	26	35	42	49	50	55	65	79	94	95	104	115
	17	16	17	15	15	17	20	21	23	32	28	36	28	28
	14	10	7	13	16	18	16	23	27	20	21	17	20	16
	14	11	15	12	20	17	24	20	24	23	16	12	18	21
	18	16	14	27	26	27	23	30	24	13	15	21	20	15
	123	127	122	99	82	73	68	52	38	34	27	20	11	6
Death rate (per 1000 population)														
Summary measures of inter–country distribution														
Min	6.3	6.0	5.5	4.7	4.6	3.7	2.9	2.3	2.0	2.0	1.7	1.4	1.1	1.2
Q1	12.0	10.6	9.5	8.9	8.2	7.4	6.9	6.8	6.5	6.3	6.0	6.0	6.0	5.8
Med	16.9	14.3	12.4	11.2	10.7	10.2	9.6	9.0	8.6	8.4	8.0	7.7	7.5	7.2
Q3	24.7	21.6	19.8	17.4	15.4	13.6	12.8	11.6	11.5	11.4	10.9	10.0	9.5	9.2
Max	39.2	37.3	36.3	33.6	30.1	61.6	25.2	24.6	47.2	25.4	21.2	20.4	17.5	15.4
IQR	12.8	11.1	10.2	8.5	7.2	6.2	5.9	4.8	5.1	5.0	4.9	4.1	3.5	3.4
CV	0.419	0.438	0.457	0.465	0.462	0.542	0.443	0.440	0.514	0.441	0.438	0.409	0.359	0.345
Frequency distribution														
< 10	24	39	62	83	91	97	106	118	122	128	137	150	161	170
10–12	27	39	32	24	25	33	35	36	38	30	19	18	22	17
12–14	25	18	15	16	22	22	20	12	11	12	17	21	14	10
14–16	21	11	11	14	16	9	8	11	8	14	16	6	3	4
16–18	8	9	16	19	8	10	11	9	9	7	9	4	1	0
>=18	96	85	65	45	39	30	21	15	13	10	3	2	0	0
Total fertility rate														
Summary measures of inter–country distribution														
Min	1.980	1.950	1.810	1.840	1.623	1.408	1.427	1.350	1.260	1.060	0.850	0.980	1.106	1.110
Q1	4.277	4.201	4.273	3.447	2.990	2.548	2.302	2.260	2.050	1.862	1.806	1.821	1.770	1.740
Med	6.000	6.138	6.180	5.945	5.495	5.000	4.370	3.780	3.272	2.950	2.610	2.490	2.380	2.250

	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020
Q3	6.700	6.764	6.804	6.713	6.675	6.550	6.349	5.900	5.250	4.637	4.332	4.034	3.789	3.584
Max	8.000	8.150	8.200	8.250	8.500	8.600	8.800	8.800	8.200	7.700	7.650	7.550	7.350	6.950
IQR	2.423	2.563	2.531	3.266	3.685	4.002	4.048	3.640	3.200	2.775	2.526	2.213	2.019	1.844
CV	0.301	0.304	0.316	0.351	0.389	0.435	0.461	0.470	0.488	0.519	0.536	0.516	0.491	0.468
Frequency distribution														
<2.0	1	2	3	3	10	24	29	34	46	59	67	69	70	80
2.0–2.5	11	15	12	21	23	25	28	27	22	21	29	32	41	43
2.5–3.0	17	14	18	18	18	13	11	10	19	27	26	28	19	15
3.0–3.5	9	8	9	9	9	10	10	20	18	17	10	9	16	9
3.5–4.0	8	8	7	9	6	8	16	12	11	8	13	12	6	14
>=4.0	155	154	152	141	135	121	107	98	85	69	56	51	49	40
Expectation of life at birth (Years)														
Summary measures of inter-country distribution														
Min	27.0	28.0	28.6	30.8	34.2	14.5	39.5	39.7	21.8	37.6	42.0	43.1	48.2	52.7
Q1	40.3	42.9	45.8	48.6	51.2	53.4	54.9	58.6	58.2	59.3	60.9	64.5	66.0	67.5
Med	50.7	53.4	57.3	60.3	62.5	64.3	66.3	67.8	68.7	69.5	71.2	72.5	73.1	74.2
Q3	60.6	63.6	65.6	67.3	69.1	69.9	70.7	71.8	72.8	74.1	75.1	76.1	77.4	78.5
Max	72.8	73.5	73.5	74.1	74.8	76.3	77.0	78.5	79.4	80.5	81.8	82.7	83.4	84.6
IQR	20.3	20.7	19.8	18.7	17.9	16.5	15.8	13.3	14.7	14.8	14.2	11.6	11.5	11.0
CV	0.240	0.228	0.215	0.198	0.184	0.178	0.158	0.149	0.154	0.151	0.149	0.135	0.116	0.104
Frequency distribution														
< 50	97	89	76	58	48	38	30	25	22	20	14	7	2	0
50–55	22	15	16	25	23	17	21	12	13	16	20	14	7	5
55–60	27	30	20	17	20	24	19	23	21	18	12	18	17	8
60–65	28	26	33	35	28	25	25	21	16	15	21	13	21	26
65–70	22	29	35	33	41	48	42	42	40	37	24	32	24	23
70	5	12	21	33	41	49	64	78	89	95	110	117	130	139
N	201	201	201	201	201	201	201	201	201	201	201	201	201	201

Source: United Nations (2019)

Table 3: Intrinsic rate of natural increase and momentum rate of natural increase in the world and in more developed, less developed and the least developed countries, 1950–55 through 2015–20.

Period	World		More developed countries		Less developed countries		Least developed countries	
	Intrinsic rate of natural increase	Momentum rate of natural increase	Intrinsic rate of natural increase	Momentum rate of natural increase	Intrinsic rate of natural increase	Momentum rate of natural increase	Intrinsic rate of natural increase	Momentum rate of natural increase
1950–1955	13.406	4.418	5.224	6.563	17.374	3.319	17.320	2.693
1955–1960	12.645	5.395	4.843	6.786	15.978	4.685	19.004	3.521
1960–1965	12.887	6.229	3.635	6.513	16.820	5.857	20.138	4.279
1965–1970	12.907	7.596	2.165	5.607	17.084	8.328	20.809	5.089
1970–1975	10.939	8.549	1.176	5.326	13.911	9.981	20.752	5.454
1975–1980	8.122	9.613	−0.100	5.378	9.793	11.451	20.521	6.259
1980–1985	7.458	10.247	−0.388	5.084	8.580	12.264	20.555	7.730
1985–1990	7.301	10.597	−0.438	4.644	8.213	12.739	18.925	9.089
1990–1995	5.038	10.027	−1.283	3.587	5.235	12.031	16.849	9.868
1995–2000	4.082	9.353	−1.816	2.790	3.969	11.066	15.425	11.038
2000–2005	3.736	8.827	−1.740	2.474	3.436	10.187	14.059	12.020
2005–2010	3.666	8.629	−1.165	2.574	3.177	9.672	12.714	13.093
2010–2015	3.363	8.438	−1.412	2.588	2.803	9.256	11.348	13.884
2015–2020	2.967	7.973	−1.871	2.293	2.371	8.569	10.082	14.169

Source: Author’s calculations

Table 4: Inter-country variation in the intrinsic rate of natural increase and the momentum rate of natural increase, 1950-55 through 2015-20.

	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000	2000-05	2005-10	2010-15	2015-20
	Intrinsic rate of natural increase (per 1000 population)													
	Summary measures of inter-country distribution													
Min	-0.524	0.738	0.738	-1.520	-2.473	-30.471	-3.264	-2.998	-4.003	-6.306	-6.471	-4.776	-4.212	-4.275
Q1	9.836	10.518	10.518	8.722	4.785	3.056	2.308	2.121	1.280	0.265	-0.064	-0.245	-0.354	-0.980
Med	16.543	17.874	17.874	17.392	14.257	12.114	10.496	8.386	6.486	5.082	3.715	3.434	3.043	2.397
Q3	20.881	21.784	21.784	21.263	20.077	20.064	18.814	17.032	13.917	12.060	10.380	10.083	9.098	7.961
Max	28.297	27.965	27.965	29.949	30.431	31.332	32.033	30.873	29.030	28.616	27.519	25.655	23.474	20.925
IQR	11.045	11.267	11.267	12.541	15.292	17.008	16.506	14.911	12.637	11.795	10.444	10.328	9.452	8.941
CV	0.478	0.467	0.467	0.491	0.638	0.806	0.803	0.849	0.986	1.177	1.330	1.319	1.362	1.551
	Frequency distribution													
<0.00	2	0	0	1	12	20	24	27	37	46	51	52	54	68
0-10	49	46	46	50	62	68	75	81	87	91	97	97	100	96
10-15	35	33	33	30	34	27	23	32	31	28	19	28	34	29
15-20	56	47	47	49	41	35	39	33	28	24	24	17	11	7
20-25	44	64	64	62	45	43	35	24	15	10	9	6	2	1
25-30	15	11	11	9	6	6	4	3	3	2	1	1	0	0
>=30	0	0	0	0	1	2	1	1	0	0	0	0	0	0
N	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	Momentum rate of natural increase (per 1000 population)													
	Summary measures of inter-country distribution													
Min	-7.499	-2.617	-2.617	-2.729	-1.080	1.293	0.790	-0.063	-0.407	-0.609	-1.031	-1.129	-1.572	-2.458
Q1	2.848	3.564	3.564	4.322	5.190	6.010	6.417	6.778	6.844	6.234	5.670	5.109	4.817	4.504
Med	5.095	6.395	6.395	7.405	8.162	9.331	10.389	10.927	10.868	10.158	9.971	10.310	10.228	9.488
Q3	7.633	9.090	9.090	10.400	11.915	12.708	13.305	13.789	13.362	12.662	12.414	12.738	13.324	13.343
Max	16.204	17.126	17.126	19.490	22.685	21.583	21.683	21.769	22.227	21.922	21.303	21.577	19.643	18.240
IQR	4.785	5.526	5.526	6.078	6.725	6.699	6.888	7.011	6.518	6.427	6.744	7.630	8.507	8.840
CV	0.702	0.590	0.590	0.541	0.495	0.462	0.452	0.444	0.464	0.476	0.492	0.511	0.532	0.572

	1950–55	1955–60	1960–65	1965–70	1970–75	1975–80	1980–85	1985–90	1990–95	1995–2000	2000–05	2005–10	2010–15	2015–20
Frequency distribution														
<0.00	10	3	3	2	1	0	0	1	1	5	5	5	4	8
0–10	162	160	160	141	125	113	95	82	88	94	97	92	92	96
10–15	26	31	31	47	63	65	76	82	82	83	84	85	82	71
15–20	3	7	7	11	11	21	26	34	28	17	13	18	23	26
20–25	0	0	0	0	1	2	4	2	2	2	2	1	0	0
25–30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	201	201	201	201	201	201	201	201	201	201	201	201	201	201

Source: Author's calculations

Table 5: Distribution of countries according to intrinsic rate of natural increase and momentum rate of natural increase, 1950–55 through 2015–20.

Category	1950–55	1955–60	1960–65	1965–70	1970–75	1975–80	1980–85	1985–90	1990–95	1995–2000	2000–05	2005–10	2010–15	2015–20
$r>0$, $r_i>0$, $r_a>0$	189	198	198	197	188	181	177	174	164	155	150	149	147	133
$r>0$, $r_i<0$, $r_a>0$	2	0	1	3	10	16	20	23	24	31	32	35	36	45
$r>0$, $r_i>0$, $r_a<0$	10	3	2	1	1	0	0	0	0	0	0	0	0	0
$r<0$, $r_i<0$, $r_a>0$	0	0	0	0	2	4	4	3	12	10	14	12	14	15
$r<0$, $r_i>0$, $r_a<0$	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$r<0$, $r_i<0$, $r_a<0$	0	0	0	0	0	0	0	1	1	5	5	5	4	8
N	201	201	201	201	201	201	201	201	201	201	201	201	201	201

Source: Author’s calculations

Table 6: Decomposition of inter-country variance in the rate of natural increase into inter-country variation in intrinsic rate of natural increase and momentum rate of natural increase, 1950-55 through 2015-20.

Period	Var(r)	Var(r_i)	Var(r_a)	Cov(r_i,r_a)	Inter-country variation in r attributed to inter-country variation in r_i	Inter-country variation in r attributed to inter-country variation in r_a	Proportion (%) of inter-country variation in r attributed to r_i	Proportion (%) of inter-country variation in r attributed to r_a
1950-55	69.40	53.37	15.14	0.45	53.82	15.59	77.54	22.46
1955-60	71.64	54.14	15.46	1.02	55.16	16.48	76.99	23.01
1960-65	76.55	56.66	17.07	1.41	58.07	18.48	75.86	24.14
1965-70	84.16	62.01	17.65	2.25	64.26	19.90	76.36	23.64
1970-75	92.45	68.91	18.20	2.67	71.58	20.87	77.42	22.58
1975-80	115.81	87.01	18.85	4.98	91.99	23.82	79.43	20.57
1980-85	115.22	78.36	20.70	8.08	86.44	28.78	75.02	24.98
1985-90	112.64	69.65	21.46	10.77	80.42	32.23	71.39	28.61
1990-95	112.50	62.67	21.85	13.99	76.66	35.84	68.14	31.86
1995-2000	113.62	59.24	20.58	16.90	76.14	37.48	67.01	32.99
2000-05	114.74	54.48	20.45	19.90	74.38	40.36	64.83	35.17
2005-10	113.84	46.33	22.33	22.59	68.92	44.92	60.54	39.46
2010-15	112.35	38.78	24.56	24.51	63.28	49.07	56.33	43.67
2015-20	108.11	32.23	26.37	24.76	56.99	51.12	52.71	47.29

Source: Author's calculations

Table 7: Decomposition of the population growth in the world and in more developed, less developed and the least developed countries into intrinsic growth and momentum growth, 1950-55 through 2015-20.

Year	Estimated population (000)	Change due to migration (000)	Population net of migration (000)	Natural increase (000)	Intrinsic increase (000)	Momentum increase (000)
	World					
1950	2536431	0	2536431			
1955	2773020	0	2773020	236589	177949	58640
1960	3034950	0	3034950	261930	183604	78326
1965	3339584	0	3339584	304634	205372	99261
1970	3700437	0	3700437	360854	227163	133690
1975	4079480	0	4079480	379043	212756	166287
1980	4458003	0	4458003	378523	173357	205166
1985	4870922	0	4870922	412918	173945	238973
1990	5327231	0	5327231	456309	186137	270172
1995	5744213	0	5744213	416982	139437	277545
2000	6143494	0	6143494	399281	121302	277979
2005	6541907	0	6541907	398413	118469	279944
2010	6956824	0	6956824	414917	123706	291210
2015	7379797	0	7379797	422973	120544	302430
2020	7794799	0	7794799	415002	112567	302435
Increase 1950-2020				5258368	2276310	2982058
	More developed countries					
1950	814819	0	814819			
1955	864430	146	864284	49465	21924	27541
1960	916344	317	916027	51744	21548	30196
1965	966624	2919	963706	47679	17076	30602
1970	1008452	6560	1001892	38187	10639	27547
1975	1048416	13417	1034999	33107	5986	27120
1980	1083126	20449	1062676	27677	-524	28201

Year	Estimated population (000)	Change due to migration (000)	Population net of migration (000)	Natural increase (000)	Intrinsic increase (000)	Momentum increase (000)
1985	1114763	26840	1087923	25247	−2088	27334
1990	1145508	34463	1111045	23121	−2407	25529
1995	1169481	45564	1123918	12873	−7170	20043
2000	1188359	58955	1129405	5487	−10229	15716
2005	1209215	75658	1133557	4153	−9843	13995
2010	1234768	93196	1141571	8014	−6624	14638
2015	1256622	108319	1148303	6732	−8082	14814
2020	1273304	122575	1150729	2425	−10754	13179
Increase 1950−2020				335910	19453	316457
	Less developed countries					
1950	1526184	0	1526184			
1955	1693104	555	1692549	166365	139678	26687
1960	1878087	1320	1876767	184218	142447	41771
1965	2102238	141	2102098	225330	167128	58202
1970	2385068	−1832	2386901	284803	191466	93337
1975	2685822	−3949	2689770	302869	176341	126528
1980	2984265	−6938	2991203	301433	138957	162476
1985	3312667	−7103	3319771	328567	135255	193312
1990	3675448	−10972	3686420	366649	143716	222933
1995	3995050	−23760	4018809	332390	100786	231604
2000	4297919	−34651	4332569	313760	82819	230941
2005	4588501	−49464	4637965	305396	77022	228374
2010	4885441	−60270	4945711	307746	76099	231647
2015	5182043	−71043	5253086	307375	71447	235929
2020	5464056	−84378	5548434	295348	64008	231340
Increase 1950−2020				4022250	1707169	2315080
	Least developed countries					

Year	Estimated population (000)	Change due to migration (000)	Population net of migration (000)	Natural increase (000)	Intrinsic increase (000)	Momentum increase (000)
1950	195428	0	195428			
1955	215486	−509	215995	20567	17800	2767
1960	240518	−1226	241744	25749	21724	4025
1965	270721	−2414	273135	31391	25889	5501
1970	306917	−3978	310895	37760	30341	7419
1975	345243	−9178	354421	43526	34467	9059
1980	390613	−14590	405202	50781	38913	11868
1985	443491	−23267	466758	61556	44733	16823
1990	506276	−30661	536937	70179	47409	22770
1995	579682	−33994	613675	76738	48394	28344
2000	657216	−43275	700491	86815	50605	36211
2005	744191	−53863	798054	97563	52597	44966
2010	836615	−71355	907970	109916	54152	55764
2015	941131	−88927	1030059	122089	54911	67178
2020	1057438	−105408	1162846	132788	55203	77585
Increase 1950−2020				967418	577137	390282

Source: Author's calculations

Equation (13) is true by definition for every population. This means that the naïve regression approaches may be problematic in analysing the relative importance of the change in the intrinsic rate of natural increase and the momentum rate of natural increase to the change in the rate of natural increase. Alternatively, following Preston (1994), inter-country variance in ∇r can be decomposed as

$$\begin{aligned} Var(\nabla r) = & [Var(\nabla b_a) + Cov(\nabla b_a, \nabla d_a) + Cov(\nabla b_a, \nabla a_b) + Cov(\nabla b_a, \nabla a_d)] + \\ & [Var(\nabla d_a) + Cov(\nabla d_a, \nabla b_a) + Cov(\nabla d_a, \nabla a_b) + Cov(\nabla d_a, \nabla a_d)] + \\ & [Var(\nabla a_b) + Cov(\nabla a_b, \nabla b_a) + Cov(\nabla a_b, \nabla d_a) + Cov(\nabla a_b, \nabla a_d)] + \\ & [Var(\nabla a_d) + Cov(\nabla a_d, \nabla b_a) + Cov(\nabla a_d, \nabla d_a) + Cov(\nabla a_d, \nabla a_b)] \end{aligned} \quad (21)$$

or

$$Var(\nabla r) = A + B + C + D \quad (22)$$

It may be noticed that the values of *A* or *B* or *C* or *D* may be small because either the variance term is small, or some of the covariance terms are negative. This problem may be circumvented by using the absolute value of covariance terms in equations (21). Thus, the relative importance of inter-country variation in the intrinsic rate of natural increase and inter-country variation in the momentum rate of natural increase can be calculated as

$$I_{\nabla b_a} = \frac{A'}{A'+B'+C'+D'} \quad (23)$$

$$I_{\nabla d_a} = \frac{B'}{A'+B'+C'+D'} \quad (24)$$

$$I_{\nabla a_b} = \frac{C'}{A'+B'+C'+D'} \quad (25)$$

$$I_{\nabla a_d} = \frac{D'}{A'+B'+C'+D'} \quad (26)$$

$$I_{\nabla r_i} = I_{\nabla b_a} + I_{\nabla d_a} \quad (27)$$

$$I_{\nabla r_a} = I_{\nabla a_b} + I_{\nabla a_d} \quad (28)$$

where

$$A' = Var(\nabla b_a) + |Cov(\nabla b_a, \nabla d_a)| + |Cov(\nabla b_a, \nabla a_b)| + |Cov(\nabla b_a, \nabla a_d)|, \text{ etc.} \quad (29)$$

It may be noticed that

$$Var(\nabla r) \neq A' + B' + C' + D' \quad (30)$$

Components of Natural Population Growth

The world population growth rate, *r*, decreased from around 1.782 per cent during 1950–1955 to 1.094 during 2015–2020 or a decrease of 0.688 per cent points. This decrease in *r* is associated with a decrease of 0.613 per cent points attributed to the change in stationary birth rate or stationary death rate; a decrease of 0.715 per cent points attributed to the change in population fertility or birth rate independent of age and sex structure effect, b_a; an increase of 0.214 per cent points attributed to the change in population mortality or death rate independent of age and sex structure effect, d_a; an increase of almost 0.02 per cent points attributed to the change in age and sex structure effect on birth rate, a_b; and an increase of 0.406 per cent points attributed to the change in the age and sex structure effect on death rate, a_d. In the more developed region, *r* decreased from 1.179 per cent during 1950–1955 to 0.042 per cent during 2015–2020 as the result of a decrease of 0.108 per cent points attributed to the change in stationary birth or death rate; a decrease of 0.534 per cent points attributed to the change in population fertility; a decrease of 0.326 per cent point attributed to the change in the age structure effect on birth rate; an increase of 0.430 per cent points attributed to change in population mortality; and a decrease of 0.599 per cent points attributed to change in age structure effects on the death rate. However, the net addition to the world population increased from around 237 million during 1950–1955 to more than 415 million during 2015–2020. The increase of around 178 million in the net addition to the world population during 2015–2020 compared to that during 1950–1955 has been the result of an increase of 159 million attributed to change in stationary birth rate or death rate; an increase of 185 million attributed to change in population fertility; a decrease of 55 million attributed to change in population mortality; a decrease of 5 million attribute to change in age structure effect on birth rate; and a decrease of 105 million attributed to change in age structure effect of the death rate.

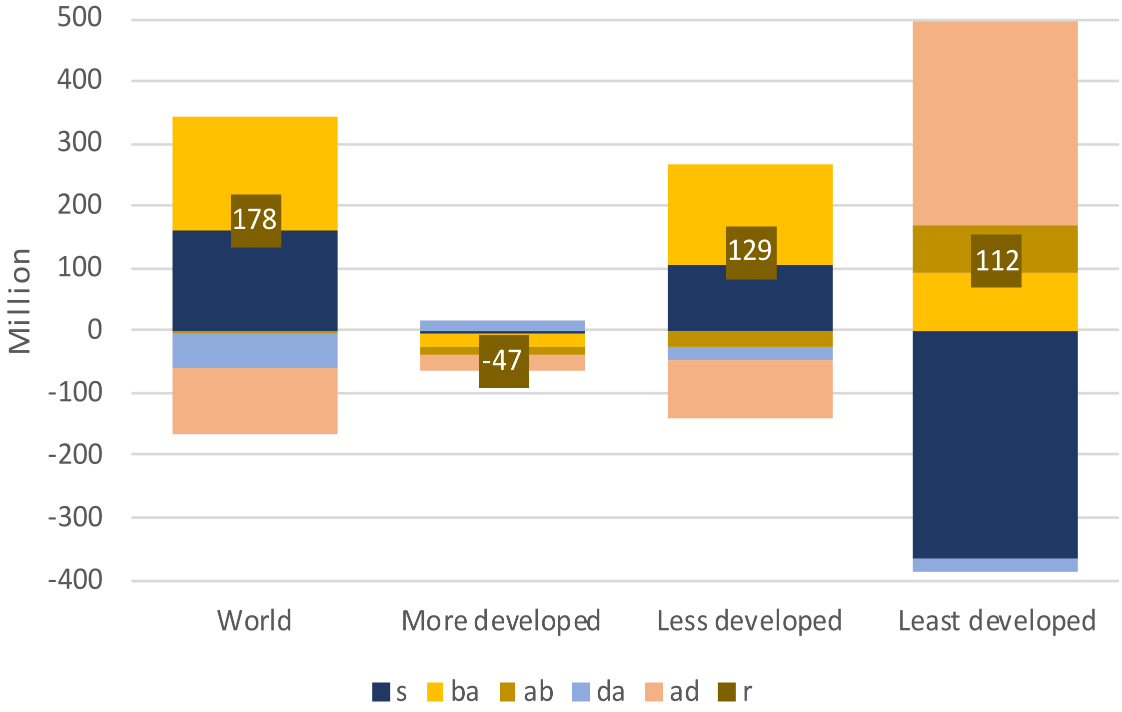

Figure 15: Decomposition of the increase in the net addition to the population during 2015-2020 relative to 1950-1955 in the World, and more developed, less developed, and the least developed regions of the World
Source: Author

The increase in world population during 1950 through 2020 can be decomposed into four components in conjunction with equation (12). This exercise suggests that the world population increased by around 5258 million between 1950 and 2020. The change in population fertility or the age independent birth rate, b_a, resulted in a decrease of 23530 million whereas the change in population mortality or age independent death rate, d_a, resulted in an increase of 16301 million so that the net result of the change in population fertility and population mortality was a decrease of 7229 million in the world population. However, change in the age composition effect on the birth rate, a_b, accounted for an increase of 2452 million whereas change in the age composition effect on death rate, a_d, accounted for an increase of 10036 million so that age composition changes accounted for an increase of 12488 million in the world population (Figure 15). In the more developed region of the world, a natural population growth of 336 million during 1950–2020 has been the result of a decrease of 4062 as the result of the change in population fertility, an increase of 2582 million as the result of the change in population mortality, an increase of 341 million as the result of the change in age structure effect on birth rate, and an increase of 1475 million as the result of the change in the age structure effect on death rate. In the less developed countries, natural population growth during 1950–2020 was 4022 million. Change in population fertility accounted for a decrease of 15955 million, change in population mortality accounted for an increase of 10687 million, and change in age composition effect on birth rate and death rate accounted for an increase of 1709 and 7582 million respectively. Finally, the natural population growth in the least developed countries was 967 million because of a decrease of 3272 million because of change in population fertility; an increase of 2282 million because of change in population mortality; and an increase of 356 million and 1601 million respectively because of the change in the age composition effect on birth rate and death rate.

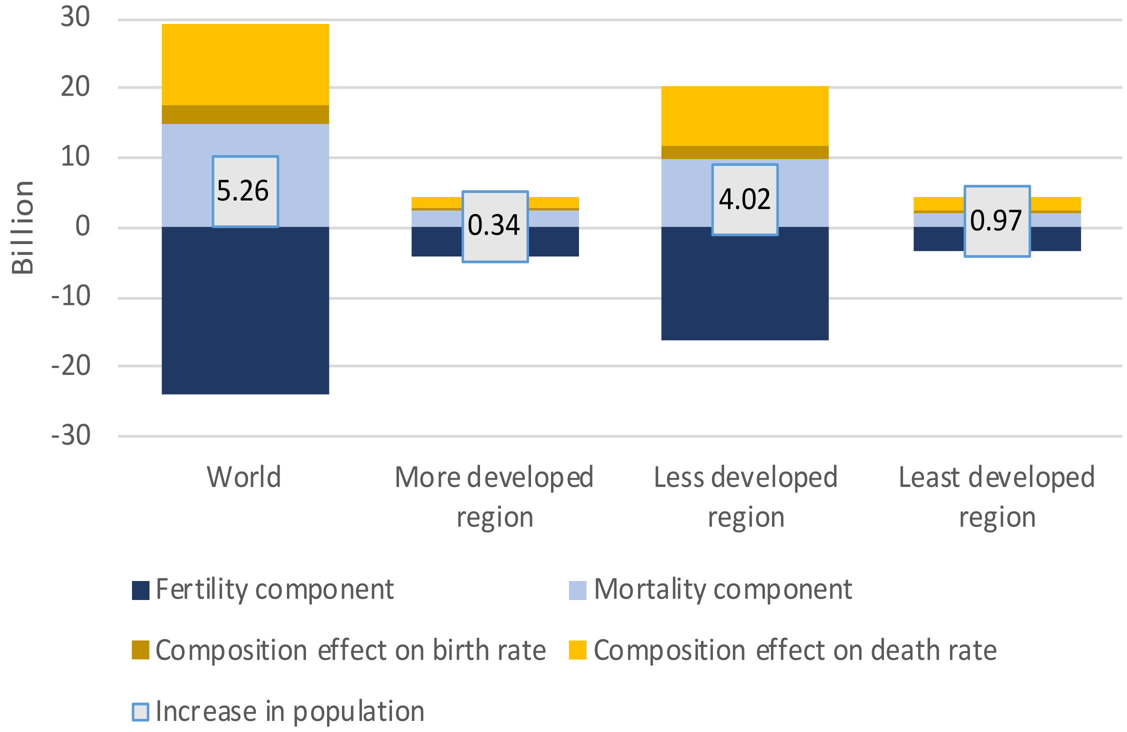

Figure 15: Components of natural population growth (billion) in the world and more developed, less developed and the least developed regions 1950-2020

Source: Author

There are only two exceptions to this global pattern – Mayotte during 1975–1980 through 1980–1985 and in Qatar during 1960–1965 through 1985–1990. However, the age composition component, r_a, has always been positive throughout the period under reference. During 1950–1955 through 1965–1970, there was no country, except Mayotte and Qatar, where r was negative whereas there were 23 countries where r was negative during 2015–2020. The decomposition exercise suggests that the age structure component resulting from the age and sex structure effect on the birth rate and the death rate accounted for an increase in the word population from ___ million in 1950 to __ million in 2020 whereas the intrinsic component accounted for a decrease in the world population from ___ million in 1950 to __ million in 2020 so that world population increased from __ million in 1950 to __ million in 2020. In other words, the increase in the world population during the 70 years between 1950 and 2020 has been due to the inflating effect of population age and sex structure on the birth rate and the deflating effect of population age and sex structure on the death rate. The decrease in the world population attributed to the intrinsic component has, however, not been large enough to compensate for the increase in the world population attributed to the age and sex structure of the population as it affects the birth rate and the death rate.

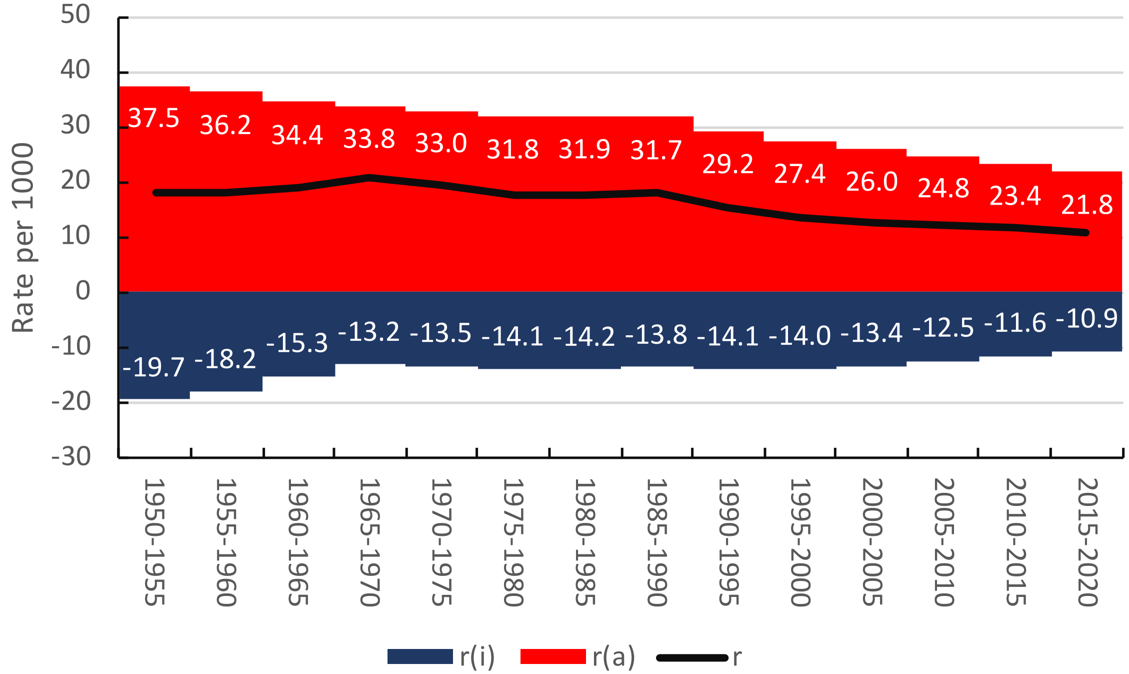

Figure 15: Intrinsic and age structure components of the rate of natural increase (*r*) in the world population 1950-1955 through 2015-2020
Source: Author