Understanding global demographic convergence since 1950

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Introduction and background

Is the world converging to a single demographic regime? Or are groups of countries following distinct paths through the process of demographic transition? The answers to these questions are pivotal to our understanding of the nature and mechanisms of population change. They are also key elements for deriving the assumptions underlying population projections. Following an exploratory investigation by Wilson (2001), interest in global demographic convergence has continued through the last decade. More attention has been given to mortality (Bloom and Canning 2007; Clark 2010; Goesling and Firebaugh 2004; Mayer-Foulkes 2003; McMichael et al. 2004; Moser et al. 2005; Neumayer 2004). The focus on mortality may arise in part because life expectancy is one component in the calculation of the widely used human development index, proposed by the United Nations, and is often used in other calculations of the quality of life (Becker et al 2005; Gidwitz et al. 2010; Kenny 2005; Konya and Guisan 2008; Mayer-Foulkes 2010; Molina 2010; Neumayer 2003). It is also the case that studying life expectancy (an increasing variable with no logical limit) is a natural extension of economists' interest in convergence in income. Fertility change, and its implications, has also been examined through the lens of convergence, (Lee and Reher 2011; Reher 2004, 2007; Wilson 2004; and especially Dorius 2008). However, convergence in total fertility (the main variable of interest) is potentially more difficult to interpret than life expectancy, as the TFR is a decreasing variable with a logical limit, zero, and a *de facto* lower limit to date of around one. Thus convergence in fertility must, of its nature, be an asymptotic process.

Perhaps the most intriguing aspect of much of the work on convergence is the ambiguous nature of the conclusions. In mortality it seems that convergence was modest at any time, and has been replaced by divergence since the 1980s (Moser et al. 2005), and in fertility the only definite statistical evidence for convergence is found after 1990 (Dorius 2008). However, the limited degree of convergence that emerges from sophisticated analyses seems to run contrary to the more mundane evidence from simple time-trends in total fertility or life expectancy, which suggests that both the health and fertility transitions are in full swing. In this brief note my aim is to consider the implications of the studies of convergence published over the last 10 years and to sketch out a context within which I believe analysis of convergence, and the ambiguous statistical evidence for it, can best be viewed. I address mortality and fertility in turn, though some of the methodological points are relevant to both. Rather than repeat the calculations made by the various scholars who have studied convergence, this paper takes a different slant, examining the trajectories over time that

various world regions have followed. When presented in this way, the data suggest that five distinct regional histories can be traced in mortality, and three in fertility, and that global convergence has moved more rapidly and unambiguously in fertility than in mortality. In common with most analyses in the literature, here I use the comprehensive estimates of life expectancy and total fertility since 1950 made by the United Nations Population Division as part of their biennial population projections (United Nations 2009).

In answering the basic questions posed at the outset, demographers are able to draw on an extensive literature, theoretical, methodological and empirical, within economics, where convergence lies at the heart of modern economic growth theory (Barro and Sala-i-Martin 1992, 2004). The classic methods used in economics refer to two distinct but related measures: beta- and sigma-convergence. Beta convergence is said to occur when countries that are laggards in the demographic transition (i.e. with lower life expectancy or higher fertility at the start of a time period) show more movement towards convergence than those further along the process of transition. Sigma-convergence occurs if the variance of the variable under study, usually life expectancy or total fertility, diminishes over time. In addition to these core indicators, scholars have also used a wide range of other measures of dispersion to search for evidence of convergence. A potentially valuable dimension for demography is the attention given in economics to “convergence clubs”, groups of countries that show common trends, even if they differ from more general patterns of convergence. This interest in diverse experiences has led to the hunt for multiple equilibria, sometimes referred to as “twin peaks” when only two distinct distributions are expected (Quah 1996, 1997). The method of choice for the study of convergence in the presence of multimodality has been “kernel density estimates” proposed by Silverman (1981). Bloom and Canning (2007) have provided an example of the potential of this method for studying health transition, though as yet no systematic study of fertility in this way has been published. In short, the researcher interested in studying convergence has no lack of statistical tools fit for the purpose.

Mortality

When considering the progress of the health transition, we see that the world is not a single demographic system. Rather, it is cut by deep faults into a number of blocs, each with its own distinctive trajectory of life expectancy. I have chosen here to divide the nations of the world into five groups: the USSR and its successor states, the rest of the developed world (i.e. the rest of Europe, North America, Japan and Australasia), Southern Africa (i.e. South Africa and its English-speaking neighbours), the rest of Sub-Saharan Africa (i.e. East, Middle and West Africa) and finally, the rest of the developing world. More sub-divisions could easily be proposed, whose mortality history differs in some degree from the rest of the world. However, I have chosen here to apply Occam's razor with some determination, and present what I see as two mainstream (and converging) stories (for the developed and developing world) and three clearly different time tracks. I suggest that this five-way grouping captures the most significant dimensions of global mortality change that are relevant to the issue of convergence.

A note on the precise definitions of the five regions is needed here. The United Nations' estimates do not present a USSR grouping, so it was reconstructed from its successors' histories. I have chosen to focus on the USSR and the Post-Soviet states, even though during the Communist era many other countries in Eastern and Central Europe also saw life expectancy stagnate. However, in the two decades since the collapse of the Berlin Wall most have begun to converge fairly rapidly with Western Europe. Only the Post-Soviet States remain so strikingly divergent from the mainstream of health improvement. I also use a slightly different definition of Southern Africa from the United Nations, including Zimbabwe, whereas the UN places that country in Eastern Africa. I made the switch because Zimbabwe's trajectories in both life expectancy and total fertility manifestly have more in common with its neighbours to the south than those to its north. With Zimbabwe added, the Southern Africa group contains the countries where the reduction in life expectancy occasioned by the spread of HIV/AIDS is greatest.

The five groups of nations are of very different size. The smallest, Southern Africa, amounted to only 18 million people in 1950, rising to 71 million by 2010; it is now growing at around one per cent a year. The USSR's population at the start of the UN's data in 1950 was 181 million, and that of its successor states 283 million (and declining) at the end of the study period. East, Middle and West Africa had a population a little below that of the USSR to begin with (156 million) but reached almost 750 million in 2010; it is growing at around 2.5 per cent per year. The "Other Developed" category had 656 million in 1950 and 1,031

million by 2010, and is growing at 0.35 per cent per year. This leaves the rest of the world, by far the largest group, with 1,517 million in 1950 and 4,773 million in 2010 (i.e. between 60 and 70 per cent of the global total). It is growing at around 1.25 per cent a year.

In creating the five regions used in the mortality analysis each country's life expectancy is taken into account *pro rata* to its population. Thus the estimates presented here are weighted averages of the components nations in each region. Appendix 1 gives more detailed information on the population of each region over time.

Figures 1 and 2 present life expectancy at birth in each five-year period since 1950 for females and males for the five world regions, along with the highest life expectancy for any individual country in each period in the UN's data (see Appendix 2). The two graphs show essentially the same broad features, though a number of differences emerge in the details. The Other Developed and Other Developing trends correspond to the mainstream health transition; both rise steadily and, albeit slowly, are converging. Since the gains in life expectancy in recent decades have been close to linear for both groupings, as a rough and ready indicator of convergence, we can compare the slopes of the two lines. If we consider only the values after 1970 (the rise in life expectancy for the Other Developing category through the 1960s was uniquely rapid), the female life expectancies would converge in about 65 years, while for males it would take a little over 90 years. This extrapolation is not intended, of course, to be a forecast; the future is sure to hold many surprises. However, the simple comparison of trends does provide an indication of the relatively sedate pace at which the mainstream of health transition is advancing. Yet this is the good news in Figures 1 and 2, because in none of the three other groupings is there any evidence that convergence is underway at all.

Looking first at Africa we can see that the gap in life expectancy between EMW Africa and the Other Developed category has remained roughly constant. In 1950-55 the gap was 28.4 years for males (64.1 versus 35.7) and 30.3 years for females (68.6 versus 38.3); by 2005-10 the gap was 25.6 for males (76.1-50.5) and 29.3 for females (81.9-52.7). At this rate, the gap between the majority of Sub-Saharan Africa and the developed world would not close for centuries; for Southern Africa the situation is even worse. After four decades when the gains in life expectancy roughly paralleled the rest of the developing world, the last 20 years have seen the most striking, sustained reversal yet observed in life expectancy, as HIV/AIDS spread to epidemic proportions.

Figure 1: Life expectancy for females, world regions and maximum national value, 1950-55 to 2005-10

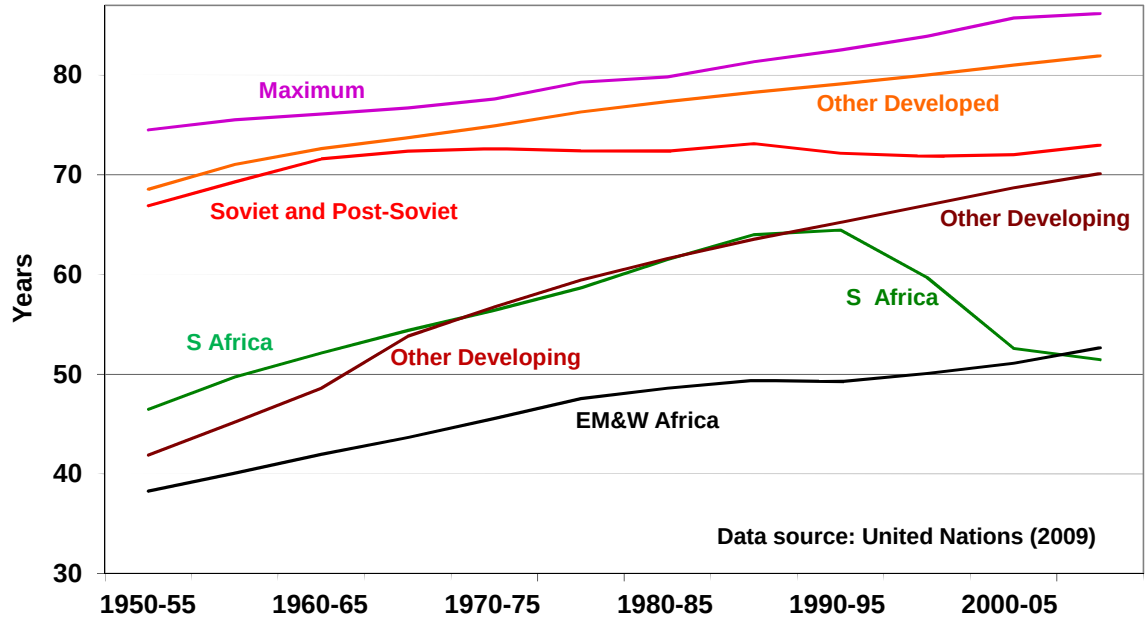
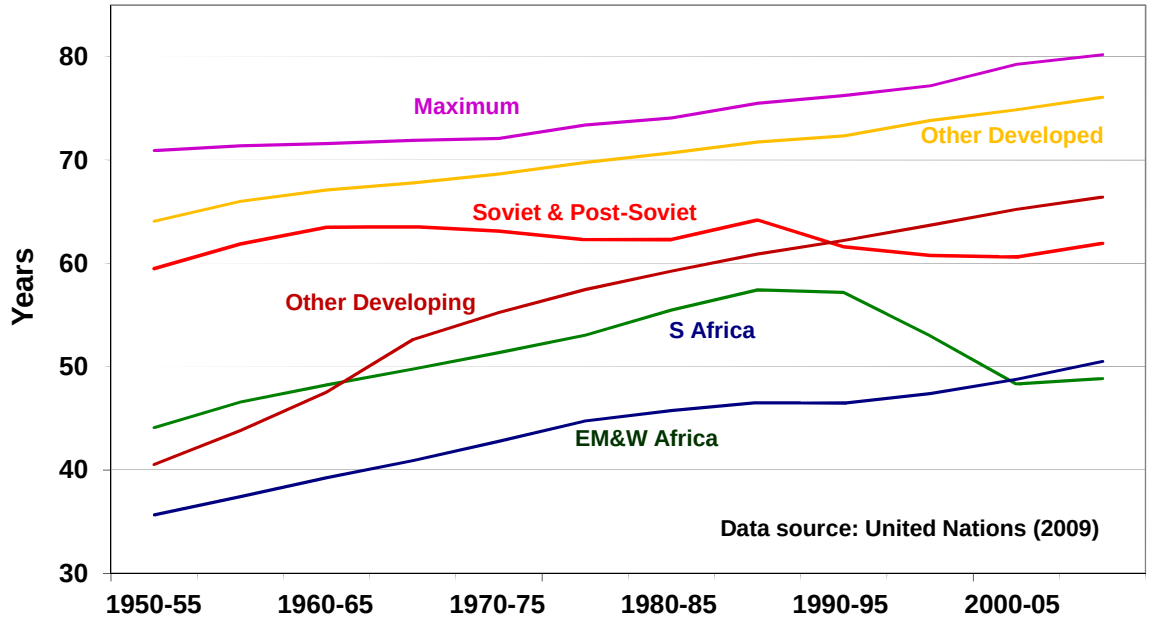


Figure 2: Life expectancy for males, world regions and maximum national value, 1950-55 to 2005-10



For Southern Africa hope may lie in the future, if antiviral medication becomes generally available, extending the lives of people living with HIV, but the recent past speaks only of divergence rather than convergence. In consequence of the mortality reversals in Southern Africa and limited gains elsewhere in Sub-Saharan Africa, by 2005-10 countries in these regions made up the overwhelming majority of those anywhere in the world with high mortality. Taking the two sexes together, there are 40 countries in the world where life expectancy falls short of 60 years; 39 are in Sub-Saharan Africa, accompanied only by Afghanistan, the lowest of all at 43.8.

The experience of the USSR and Post-Soviet States is also deeply unsettling for any notion of an inevitable health transition, with no sign of any convergent dynamic since the 1960s, and a stagnating life expectancy moving them ever further away from the leaders in health transition. It is easy to forget now, after decades of decline, that in the late-1950s and 1960s the European parts of the Soviet Union enjoyed life expectancy comparable with many countries in Western Europe. The turn-around for males is especially striking. In 1960-65, for example, Ukraine had a male life expectancy of 67.4, similar to that in France (67.2). By 2005-10 French males had an almost 15-year advantage over their Ukrainian counterparts (77.6 versus 62.8). Russia was never quite so advanced in the health transition as Ukraine, but in 1960-65 life expectancy for males was 64.1; a value it has not equalled since.

In contrast with the situation 50 years ago, today the Post-Soviet States find themselves closer to the opposite end of the spectrum of life expectancies. By 2005-10 male life expectancy for Russia was 58.45; 42 of the 49 countries falling below this value were in Sub-Saharan Africa, the others being Afghanistan, Cambodia, East Timor, Haiti, Kazakhstan, Myanmar and Papua New Guinea. At just 61.9, the overall male life expectancy for the Post-Soviet States is now well below that for the Other Developing group of nations (66.4), while female e(0) remains somewhat ahead (73.0 versus 70.1).

How does the consideration of Figures 1 and 2 help us interpret measures of convergence in mortality? Clearly, we cannot speak of truly global convergence, but the fact that by far the most populous grouping of countries, the Other Developing category, is converging with the rich world suggests that there is reason to see convergence as a general (though not universal) process. However, it is also clear that understanding the exceptions is a key requirement for any assessment of convergence. In this regard, the experience of EMW Africa is especially significant, as it now constitutes a much larger fraction of the world's population (10 per cent) than the Post-Soviet States (4 per cent) or Southern Africa (1 per

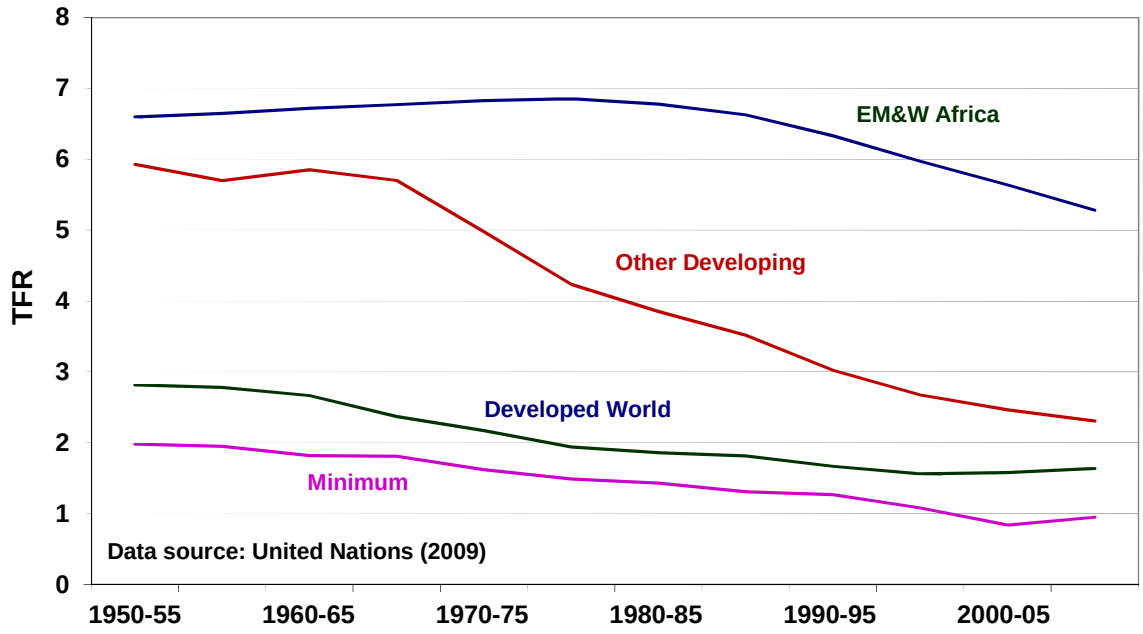
cent). Given that the life expectancy gap between EMW Africa and the Other Developed stayed roughly constant, this means that the low tail of the distribution of life expectancy remained as far away as ever from the high end. Moreover, the percentage of the world's population living in EMW Africa has been growing. In such a situation, many statistical indices will indicate at best a weak degree of convergence, even if the majority of countries are closing the gap on the global leaders. Thus, even before the stagnation of life expectancy in the USSR and the onset of the HIV/AIDS crisis in Southern Africa, we can expect at best tentative statistical evidence of convergence, with divergence predominating more recently.

Fertility

Compared with the diverse experience seen in the health transition, the story of fertility decline over recent decades is relatively simple. Figure 3 presents just three regions, rather than the five chosen to portray trends in life expectancy, along with the lowest value of total fertility in any country in each five-year period (see Appendix 2). Because their fertility trends over time are similar, Southern Africa has been included with the rest of the developing world, while the USSR is subsumed into the developed world category. Only the East, Middle and West Africa grouping is presented separately. Before 1970 there was no significant downward trend to fertility in either the EMW Africa group or the rest of the developing world. Until the 1970s the only developing countries to have seen marked fertility decline were exceptional cases (mostly the more economically advanced countries of East Asia and Latin America). In 1965-70 the TFR for the Other Developing grouping was 5.7, against 2.4 for the developed world. The gap between these two groupings (which together constitute the lion's share of the world's population) has shrunk steadily over the four subsequent decades, with the TFRs in 2005-10 being 2.3 and 1.6. In fact, there are reasons to suspect that the gap in fertility may be even smaller. Few developing countries have accurate and complete birth registration, with only intermittent censuses and surveys to use as the basis for estimating trends. So there is inevitably an aspect of estimation involved in assessing recent levels, and The United Nations have tended to overestimate fertility in the recent past (O'Neill et al. 2001). In part this arises because the estimates of past trends are intended to splice smoothly on to future levels; thus fertility decline is seen as having a "smooth landing" rather than an abrupt point of inflection when the assumed long-run level of fertility is reached. Some scholars have also suggested that the UN's estimates of fertility in China are probably too high (Zhang and Zhao 2006). But even if the UN's estimates are correct, and if developing countries reduce fertility at the rate seen over the last four decades

(roughly 1 child less per 12 years) then we can expect the Other Developing and Developed categories to have converged within 10 years. Given that fertility is rising or stable in much of the rich world, but falling in the bulk of developing countries, we may see the gap closed even sooner. Over a slightly longer time frame, we cannot exclude the possibility of a reversed differential, with high fertility in the rich world than in the poor.

Figure 3: Total fertility, world regions and minimum national value, 1950-55 to 2005-10



Already there is considerable overlap between the distributions of fertility in developing and developed countries. Fertility is lower in Iran and North Korea than in the United States, lower in Tunisia and Lebanon than in France, lower in Barbados and Trinidad and Tobago than in the United Kingdom. Given this dramatic narrowing of the gap between fertility in most parts of the world, how are we to interpret the finding in Dorius (2008) that most indices of convergence suggest that there was no global convergence before the 1990s? The answer, as suggested by Dorius, lies in the third trajectory in Figure 3, that of the bulk of Sub-Saharan Africa. Fertility there remained high, and even increased, until 1990. With the high tail of the global fertility distribution fixed in this way, measures of convergence are essentially bound to indicate divergence. Only in the last 20 years, as fertility has fallen in the last large exception to decline, do the global measures indicate convergence. Fertility in EMW Africa is still high (5.25), and 35 of the 39 highest national TFRs are to be found there, but the rate of decline since the late 1980s (roughly one child each 15 years) is not much

slower than that seen for the rest of the developing world as a whole since 1970. It implies that EMW Africa will fall to the current level of the developed world in a little over 50 years.

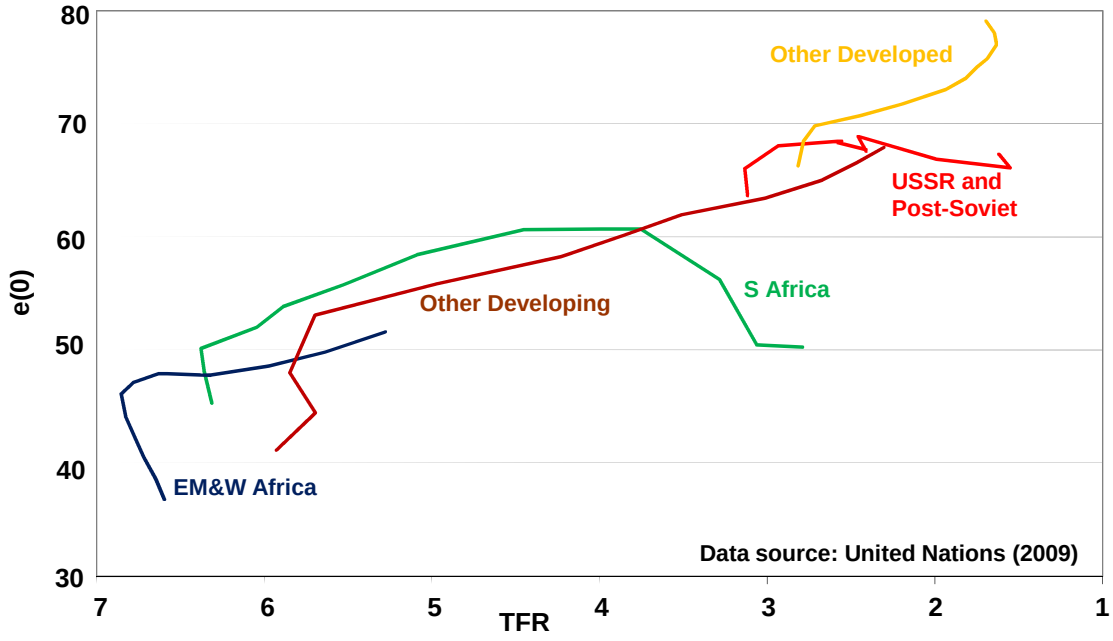
The speed and generality of the fertility decline stand is sharp contrast to the ambiguous picture of convergence seen in mortality. Nowhere do we see departures from the general fertility trends comparable with the stagnation in life expectance in the USSR and Post-Soviet States, let alone the massive drop in life expectancy suffered by Southern Africa. Although there have been pauses and plateaux in national TFRs, both in the historical transition in Europe and the contemporary developing country experience, none has involved the scale of divergence seen in mortality. There seems every reason to view fertility transition as a genuinely global phenomenon (Reher 2004). In this context, it is time for demographers to pay serious attention to the issue of post-transitional fertility in developing countries; much of the developing world is, or soon will be, "post-transitional". Unfortunately, in spite of a great deal of research over many decades, the determinants of post-transitional fertility are far from being well understood. Moreover, the existing literature on both the causes and the implications of very low fertility is overwhelmingly concerned with developed countries, especially Europe. This leaves us facing several fundamental and unanswered questions. How far will fertility fall in the developing world? What can the countries now entering the era of low fertility learn from the experience of Europe, East Asia, and other well established regions of low fertility? How will individuals, families, societies and governments in the developing world adapt to this new fertility regime? These questions have scarcely been posed to date, and never investigated in depth; they set a new research agenda for fertility studies.

Conclusion – A "main sequence" of demographic transition

A famous graph in astronomy, the Hertzsprung-Russell Diagram, plots the colour or spectrum of a star against its magnitude or luminosity. Most stars fall along a diagonal line that is known as the "main sequence", but some types of star (red giants, white dwarves etc.) occupy positions away from the main diagonal. Inspired by this diagram, Figure 4 presents the paths followed over time by the five world regions used to decompose mortality trends; total fertility is plotted on the horizontal (with a reversed scale) and life expectancy on the vertical. The figure conveniently encapsulates the different trends in each region, but removes the dimension of time, showing instead the combination of life expectancy and total fertility found in each five-year period. The mass of the developing world's population, in the Other Developing category, shows an initial rise in life expectancy with no more than a slight fall in

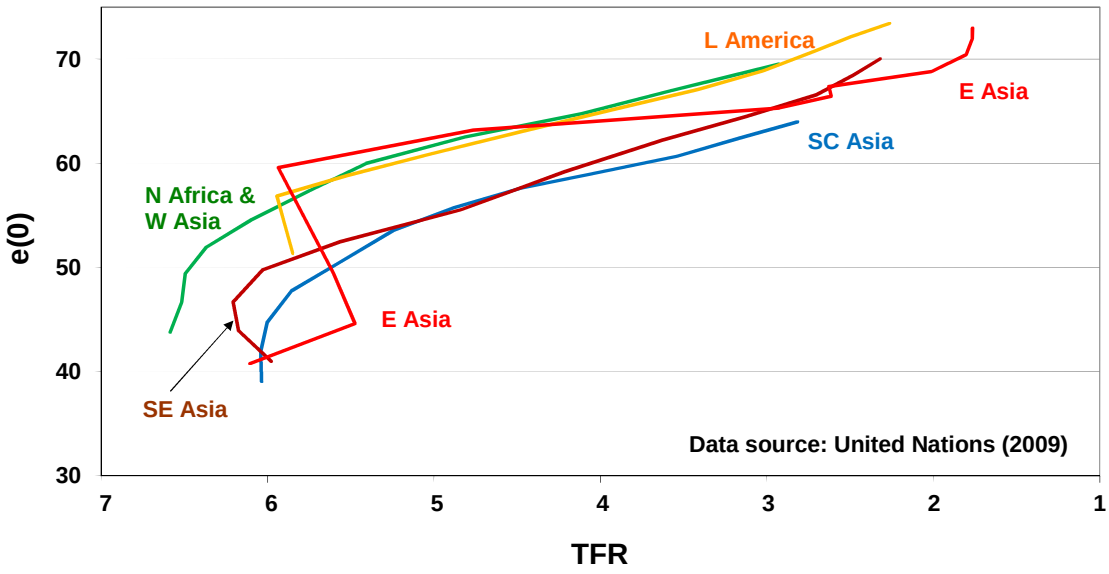
fertility, and then embarks on a long and almost linear track across the diagram, as both mortality and fertility fall. Southern Africa largely parallels the trend of the Other Developing category, but then falls away dramatically. EMW Africa shows an initial rise in both life expectancy and fertility, and then begins its transit across the diagram, though it is still only in the early stages of both the health and fertility transitions. The striking divergence between the Soviet and Post-Soviet experience and that of the remainder of the developed world is also immediately apparent.

Figure 4: Paths of total fertility versus life expectancy (both sexes), world regions, 1950-55 to 2005-10



Of course, the Other Developing grouping is immense and its smoothness could mask a more heterogeneous pattern within smaller aggregations. Figure 5, presenting the five regions of which the Other Developing group is composed, shows that this is not the case; the similarity of trends could scarcely be clearer. The lines for Latin America (including the Caribbean) and the composite of North Africa and West Asia (i.e. mostly the Islamic nations from Morocco to Iran) are so close as to be barely distinguishable for much of the graph, though the Latin America line advances further. Similarly, South-Central Asia (i.e. mostly the Indian Sub-continent) and South-East Asia show a remarkable degree of overlap, though the former has moved less far. Of the five regions, only East Asia (i.e. overwhelmingly China) has a distinctly different time track, with an abrupt initial rise in life expectancy (the effects of the Great Leap Forward famine are somewhat masked because it falls into two quinquennia), followed by its exceptionally rapid fertility decline.

Figure 5: Paths of total fertility versus life expectancy (both sexes), world regions, 1950-5 to 2005-10



In short, figures 4 and 5 suggest that it makes sense to view most demographic change over the past half century as falling along a "main sequence" of demographic transition. The principal differences between the regions of the developing world lie in when they enter this main sequence and how rapidly they move along it. The figures also reiterate the exceptional nature of the HIV/AIDS crisis in Southern Africa and the health crisis in the Soviet and Post-Soviet States. The similarity between the different lines in Figure 5 is a particularly striking finding. The regions are highly diverse in culture and in the level of socio-economic development; they also differ in the date at which fertility transition began and in the tempo of their transitions, yet they follow very similar trajectories. This finding suggests that the health and fertility transitions are more tightly connected than is often appreciated.

This paper has painted the global demographic scene with the very broadest of brushes; consideration of smaller units of aggregations yields a more nuanced picture of change. Yet there is value in reminding ourselves of the powerful similarities that exist in the demographic transition (Dyson 2010). The overwhelming majority of humanity is engaged in a process of demographic convergence. There is good reason to view the fertility transition as a truly global process, with no evidence of significant reversals and only a few countries still to embark upon it. Within a decade or so, we can expect fertility for the large majority of the world's population to be post-transitional. In contrast, the health transition is a slower

transformation and there is disturbing evidence of its fragility, with stagnation and reversals affecting hundreds of millions of people.

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Appendix 1 – Data organisation

All data used in this paper are taken from the United Nations' *World Population Prospects – 2008 Revision* (United Nations 2009). However, the groupings of countries used in the paper differ in some cases from those used by the United Nations. The five groups used here in the analysis of mortality are defined as follows:

USSR and Post-Soviet States: Kazakhstan, Kirghizstan, Tajikistan, Turkmenistan, Uzbekistan (from South-Central Asia); Armenia, Azerbaijan, Georgia (from West Asia); Belarus, Estonia, Latvia, Lithuania, Moldova, Russia, Ukraine (from Europe).

Southern Africa: In addition to Southern Africa as defined by the UN, I include Zimbabwe.

East, Middle and West Africa: The same as the UN's definition except for Zimbabwe which is moved from East to Southern Africa.

Other Developed: The UN's "More Developed" category minus the European members of the USSR and Post-Soviet States.

Other Developing: The UN's "Less Developed" category minus East, Middle, Southern and West Africa, and minus the Asian members of the USSR and Post-Soviet States.

For the analysis of fertility, the USSR and Post-Soviet States are included in the Developed category, and Southern Africa is included with the Other Developing grouping.

Table A1.1 gives the population in each of the five regions used here from 1950 to 2010, while Table A1.2 presents the same information as percentages of the global total. The life expectancy and total fertility rates presented for each region in the paper are weighted averages, using the mid-interval population of each country in the region as the weights.

Table A1.1: Population (millions) in World Regions, 1950-2010

Year	USSR and Post-Soviet States	Southern Africa	East, Middle and West Africa	Other Developed	Other Developing	World
1950	181.0	18.3	156.0	656.3	1517.8	2529.3
1955	196.8	20.7	173.1	695.1	1677.8	2763.5
1960	214.3	23.5	194.1	734.6	1856.9	3023.4
1965	230.9	26.8	219.1	775.1	2079.7	3331.7
1970	242.8	30.7	249.3	810.3	2352.8	3685.8
1975	254.4	35.3	284.9	843.3	2643.5	4061.4
1980	265.4	40.3	329.0	872.1	2930.9	4437.6
1985	277.4	46.3	379,4	897.2	3246.0	4846.2
1990	288.8	52.4	438.5	925.1	3585.5	5290.5
1995	291.2	59.0	503.4	953.0	3906.6	5713.1
2000	288.2	63.8	576.1	978.0	4209.2	6115.4
2005	284.8	67.5	658.1	1005.8	4496.0	6512.3
2010	283.4	70.6	749.5	1031.4	4773.7	6908.7

Data source: United Nations (2009).

Table A1.2: Percentage of World Population in Regions, 1950-2010

Year	USSR and Post-Soviet States	Southern Africa	East, Middle and West Africa	Other Developed	Other Developing	World
1950	7.2	0.7	6.2	25.9	60.0	100.0
1955	7.1	0.7	6.3	25.2	60.7	100.0
1960	7.1	0.8	6.4	24.3	61.4	100.0
1965	6.9	0.8	6.6	23.3	62.4	100.0
1970	6.6	0.8	6.8	22.0	63.8	100.0
1975	6.3	0.9	7.0	20.8	65.1	100.0
1980	6.0	0.9	7.4	19.7	66.0	100.0
1985	5.7	1.0	7.8	18.5	67.0	100.0
1990	5.5	1.0	8.3	17.5	67.8	100.0
1995	5.1	1.0	8.8	16.7	68.4	100.0
2000	4.7	1.0	9.4	16.0	68.8	100.0
2005	4.4	1.0	10.1	15.4	69.0	100.0
2010	4.1	1.0	10.8	14.9	69.1	100.0

Data source: United Nations (2009).

Appendix A2 – Maximal values in the United Nations' data

Figures 1 and 2 in the paper include lines for the highest life expectancy for females and males in any country in each five-year period in the United Nations' data. Similarly, Figure 3 shows the lowest national total fertility rate in each period. These values are listed in Table A2.1.

Table A2.1: Highest male and female life expectancy and lowest total fertility rate in United Nations' data, 1950-55 to 2005-10

Period	Female life expectancy		Male life expectancy		Total fertility rate	
	Country	e(0)	Country	e(0)	Country	TFR
1950-55	Norway	74.5	Norway	70.9	Luxembourg	1.98
1955-60	Norway	75.5	Netherlands	71.4	Latvia	1.95
1960-65	Iceland	76.1	Sweden	71.6	Hungary	1.82
1965-70	Norway	76.7	Sweden	71.9	Latvia	1.81
1970-75	Norway	77.6	Sweden	72.1	Finland	1.62
1975-80	Iceland	79.3	Iceland	73.4	Luxembourg	1.49
1980-85	Iceland	79.8	Japan	74.1	Denmark	1.43
1985-90	Japan	81.3	Japan	75.5	Hong Kong	1.31
1990-95	Japan	82.5	Japan	76.3	Spain	1.27
1995-2000	Japan	83.9	Hong Kong	77.2	Hong Kong	1.08
2000-05	Japan	85.7	Iceland	79.3	Macao	0.84
2005-10	Japan	86.2	Iceland	80.2	Macao	0.95

Data source: United Nations (2009).