Population change and Economic Growth in the Western World, 1850-1990

By
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In this paper we analyze the relationship between population change and economic growth in the Western world between 1850 and 1990. More specifically we focus on how shifts in the economic growth rate during this period are connected to changes in population age structure. Our analysis addresses three questions that have been brought forward in recent discussions about the determinants of economic growth.

The first question relates to the finding that differences in age structure may explain a substantial part of the variation in economic growth rates between for example Eastern Asia, South Asia and Africa [Bloom, 2000 #11; Bloom, 2000 #13]. Is it possible to give a similar explanation to the 20th-century acceleration of economic growth in the Western World?

The second question builds on Lindh & Malmberg's (1999) study of age effect on economic growth in the OECD in the post-war period. Lindh & Malmberg show that during this period increases in the middle aged population have a positive effect on economic growth rates whereas increases in the old age group
depress economic growth. Is this type of age effects to be found in a study that also includes the 1850 to 1950 period?

The third question concerns the role of population density in economic development. In a standard Solow model with capital and labor population density is a non-issue. However, in traditional Malthusian models increasing population density will have a depressing effect on per capita income whereas models focusing on the role played by specialization on productivity can predict that increasing density will lead to higher per capita income. The question addressed here is if a density sensitive specification is thrown out by long term growth data in preference for a density-neutral specification?

The paper is organized as follows. In the first section a short review of the recent literature on demographic effects on economic growth is provided. The next section presents a model of age structure change during the demographic transition and in the third section the relevance of this age transition model for the Western world is assessed. The fourth section discusses possible specifications of age effect models and in the fifth section data and estimation results are presented. Section six concludes.

Population change and growth—A review

If [Malthus, 1798 #203] commonly is given as the first reference for demographics effect in general then [Smith, 1776 #192] deserves to be the first when it comes to discussing the effects of population on economic growth. Smith's dictum that "the division of labour is limited by the extent of the market" has, for more than two hundred years provided a conundrum for economists trying to sort out the determinants of economic development.
The major problem has, of course, been to combine the opposing insights of Adam Smith and Thomas Malthus. The solution opted for by most economists has been to primarily base their analysis on Malthus at the cost of losing much of the ability to model productivity growth. This is, for example, the case with the Solow model which, essentially, is a neo-malthusian model. Both Malthus and Solow, thus, sees technological change as an exogenous force whereas Adam Smith regards technological change in the form of a more detailed division of labor as an endogenous process.

Depending on whether Malthus or Smith is taken as a starting point the conclusion as to how population growth will affect economic development will, of course, differ. A number of economists have opted for Smith instead of Malthus [Simon, 1977 #186; Boserup, 1981 #149; Simon, 1986 #188; Kremer, 1993 #175; Malmberg, 1994 #48] and others have tried steer a middle course [Kelley, 1972 #166; Kelley, 1974 #168; Kelley, 1995 #171; Becker, 1999 #146]. But most models have taken a more neo-malthusian standpoint [Coale, 1958 #154; Kelley, 1973 #167; Brander, 1994 #150; Sarel, 1994 #185; Bloom, 1997 #147, Lindh, 1999 #181]. The difference here is that the Smithians see increasing population density as a possible bonus for productivity whereas the neo-malthusians consider population growth to have a negative effect on per capita income because of capital dilution effects.

The last fifteen years have seen some progress in this debate thanks to the insight that population age structure must be brought into the picture if we are to understand how population change affect economic growth. As long as economic growth was related only to population growth in general it proved very difficult to get clear-cut correlations between demographic variables and measures of economic growth. On one hand, the long run correlation favored a positive correlation between population growth and economic development. On the other hand, no such positive correlation could be demonstrated in short-term data.
However, beginning with [Brander, 1994 #150] and followed up by [Bloom, 2000 #230; Bloom, 2000 #229; Bloom, 1997 #147] and [Williamson, 1998 #193] the solution to this problem has been shown to distinguish between the growth of dependent age groups and growth in the working age groups. When this simple adjustment is made the puzzle is solved in that growth of the dependent age groups has a negative effect on economic growth whereas growth in the working age population has a positive effect on per capita growth rates. A question that still lingers on, though, is if this empirical pattern really fits with a neo-malthusian model. One argument here is that the positive effect of growth in the working age population is due to the difference between per capita growth rates and growth rates in GDP per worker. Another, more plausible argument, is that these model captures a positive savings effect of increases in the working age population. A third argument would be that growth of the working age population would stimulate a more developed division of labor—which means improved technology (see [Kögel, 2000 #174]). This argument, however, is not neo-malthusian.

Another line of argument has been taken up by [Lindh, 1999 #181]. Here the population is not only divided into dependent and working age groups but the working age population is further subdivided into young adults and middle age adults. With these more detailed age data it can be argued that shifts in the age structure will affect not only the physical stock of capital—through the savings rate—but also the stock of human capital—because of the accumulation of experience over working life. In the OECD data Lindh and Malmberg find strong support for this model. A large middle-aged population is associated with high per worker growth rates also when differences in investment rates are controlled for. Similar results have also been presented by [McMillan, 1990 #182; Andersson, 1998 #145; Persson, 1998 #184].

A more Smithian approach was taken by [Malmberg, 1994 #48] who analysed age effects on Swedish economic and total factor productivity growth using a
model based on Romer (1990). Malmberg did indeed find a positive effect on productivity not only by increasing shares of middle-aged but also by a larger size of the middle-aged population. This scale effect cannot be directly interpreted in favor of a Smithian view, but it hints at the possibility that market size may have positive growth effects. The question is however if it is possible to discriminate between the neo-malthusian and Smithian views when one uses models with an age decomposition of the population. The reason is that increasing population shares of an age group are strongly correlated with an increasing share of the same group.

In this area it is clear that the last ten years represent a major break-through. The population-neutralist view that became popular in the 1980s when no apparent correlation between population growth and economic growth could be demonstrated is now about to give way to the contention that "Population does matter" [Birdsall, 2000 #231].

The age transition in the Western world

Traditionally, interest in the demographic transition has focused on the effects of changing death and birth rates on population growth. Population growth is slow during the high mortality, high fertility phase. It accelerates when mortality rates go down and then slows down again when fertility falls. Less attention have been given to the age structure effects of the transition. This is surprising given the fact that the social and economic effect of the age transition must be considered to be substantial. We all know that the economic behavior of human beings changes radically over the lifecycle. Therefore, we shouldn't expect that, for example, an increase in the number of children should have the same effect as an increase in the number of middle aged.
What are then the effects of the demographic transition on age structure. One way to answer this question is to introduce the typical patterns of mortality and fertility change during the transition into a standard population forecast model of the cohort type. This will allow us to simulate the age structure changes that we are to expect during the transition. Later the results of such a simulation may be compared to the actual historical patterns that we can observe in the data.

Our starting point is that the population under study is in a long-run steady-state with a stable age structure. This implies that the age structure has been fully adapted to the prevailing mortality and fertility pattern of the population. Due to the high mortality the age structure of this initial population is triangular, see figure 1. Now assume that this population during fifty years experiences a mortality decline that reduces the death rate from 40 per thousand to 10 per thousand and that mortality thereafter remains constant. The assumed changes in the death rate are illustrated in figure 2.

In accordance with the stylized facts of the demographic transition we assume, further, that the fertility pattern is unchanged during the first fifty years. The number of children born then falls back to the same level as before the transition started. The assumed fertility pattern during the first fifty years is shown in figure 3. After the reduction in fertility the number of children born is assumed to be constant. That is, we abstract from the birth fluctuations that in general characterize the post-transition period.

Given these assumptions the initially stable age structure will develop as shown in figure 4-7. The first fifty years will, as can be seen in figure 4, be characterized by a large increase in the number of children. To some this effect of declining mortality may seem surprising. In high-mortality regimes, however, children are a very vulnerable group. Old people are also a vulnerable group but
in high-mortality populations the number of old people is low. In the short run a
reduction in mortality, therefore, primarily saves the lives of young children.

Figure 4 also shows that although we have assumed that the age-specific fertility
rates are constant, there is an accelerated growth in number of children. The
reason is that improved child survival will, in time, lead to an increase in the
fertile population which, with unchanged fertility patterns, will lead to an
increase in the number of children born. Fifty years after the start of the
mortality decline the age structure of the simulated population has, therefore,
acquired a shape typically found in for example present-day African
populations. When confronted with an age structure like this one might,
erroneously, see it as the result of increasing fertility. In our model, however, the
fertility pattern is unchanged. Instead it is a mortality decline that has led to this
skewed age distribution.

Figure 5 shows how this skewed age structure is affected by a fertility decline.
According to our assumptions the number of births are reduced in two steps.
First down to a level of 125000 births per decade, then after another decade
down to the initial level of 100000 births per decade. With this reduction of
fertility a bulge is introduced into the age structure consisting of the cohorts
born just before the fertility decline. As these cohorts age this bulge will move
across the age distribution from the young adult age groups, over the middle age
group to the old age, see figure 6 and figure 7.

Figure 8 contains the same data as figure 4-7 but here the focus is on changes in
the size of the different age groups. From this graph it is evident that population
growth during the first phase of the demographic transition is concentrated to the
youngest age group. In time the young adult group also starts to grow rapidly
and in the phase that follows immediately after the fertility decline this is the
group with the fastest growth. Soon enough, however, the size of the young
adult group has reached its maximum and, instead, it is the middle-aged group
that for a time experience the fastest absolute growth. When the transition bulge
moves into old age this phase of growth in the working age population comes to
an end. And henceforth population growth becomes concentrated to the oldest
age groups.

When these graphs are examined it should be remembered that once the number
of births has returned to the 100 000 level there is no further change in either
mortality or fertility are assumed. Every change in the model age distribution
from seventy years after the start of the mortality decline and onwards are
instead momentum effects not influenced by current changes in mortality and
fertility. It is, therefore, difficult to argue that the absolute increase in the older
age groups that can be observed after the fertility decline is caused by
contemporary social and economic circumstances. Instead these changes are due
to the autonomous process of cohort aging in a population where the size of
different age groups are far away from their long-run equilibrium values. This is
important if one wants to discuss the direction of causality between population
change and economic growth. If it is possible to demonstrate a correlation
between changes in the adult population and changes in the rate of economic
growth it is unlikely that this correlation is due to a causal effect of economic
growth on the size and composition of the adult population.

Figure 9 shows for 14 Western countries how the 0-19, 20-39, 49-59, and 60+
age groups have developed between 1850 and 1990. If these graphs of observed
data are compared to figure 8 where the development of the simulated
population is presented it is easy to see that a large group of countries has had a
development that is similar to the model population.
Belgium, for example experiences an expanding child- and youth population between 1860 to 1910 and an expanding young adult population between 1880 and 1930. Growth in the middle aged population is high in the first half of the 20th century whereas the old age population starts to expand after 1920. A similar pattern is found in Denmark, Germany, Great Britain, Italy, Norway, Sweden, and Switzerland. The exact timing of the different phases differs however with a peak of the youngest age group around 1910 for Germany, Great Britain, and Switzerland, around 1920 for the Nordic countries, and in 1930 for Italy.

In the non-European Anglo-Saxon countries and in the Netherlands the pattern is somewhat different given that the expansion of the youngest age group continues more or less unbroken until about 1970. These countries do experience a dampening in the growth of the youngest cohort during the inter-war year—in the US it does in fact decline. However, the post-war baby boom in these countries is so strong and long-lived that it can be seen as the continuation of a high fertility regime.

The absence of an early peak in the size of the youngest age group implies that this group of countries doesn't experience as sharp a rise in the share of the working age population as the European transition countries do. Nonetheless, also in this group with a late peak there is a clear time pattern in the growth of the different age groups. Already in 1900, for example, the US has more than 30 million people in the ages 0-19. It is, however, not until 1950 that the 40-59 group has attained a similar size. And it is only after 1970 that the 60+ group has crossed the 30 millions line.

\[1\] Note that data have been adjusted for changes in borders.
Thus during the 1850 to 1990 period there have been large shifts in the size of different age groups. The general tendency is that the youngest age group dominated before the First World War, working age groups dominated the middle part of the 20th century, whereas the old age group has grown in importance in particular during the last 25 years of the century. If age groups differ in their economic behavior these demographic shifts imply that the macro-economic behavior of these countries may have been influenced. Is this the case? This is the question that we will address in the following section.

Models and data

To analyze the effects of age structure change on economic growth we have combined the demographic data presented above with the growth data assembled by Maddison (1992). The data set has been constructed on the basis of the age structure data available in Mitchell (1992a; 1992bn). For most countries the age data are available at ten-year intervals. In some cases however the interval is shorter or longer. To overcome this problem, Maddison's GDP-data—which are available on an annual basis—has been matched to the years for which Mitchell provides age data. Thereafter, mean annual GDP per capita growth rates have been calculated for the periods between the years for which we have age data. For the most part these are ten-year averages but, as said, in some cases the periods are shorter or longer.

To estimate the effects of a changing age structure two different models have been used. In the first model the age structure is captured by the population shares of the four age groups 0-19, 20-39, 40-59, 60+. When complemented with a measure of initial income this model approximates a Mankiw, Romer, Weil model where age shares act as crucial parameters instead of savings rates
to determine the steady-state level of per capita income. This model, thus, is based on a standard Solow-type model of economic growth.

The second model, instead, tries to implement the idea that population density might influence economic growth. Theoretically, this idea can be traced back to Adam Smith's well-known maxim that "the division of labor is limited by the extent of the market" and in economic geography the productivity effects of agglomeration has traditionally been taken as the main explanation of urbanization. In the 1990s the agglomeration idea has been taken up by economist like Paul Krugman (1991) and recently Becker et al (1999) has tried to formalize this idea in a model of economic growth. Bloom et al. Also use density measures in their growth regressions. Empirically there has also been new studies indicating that manufacturing productivity is positively influenced by city size.

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3 TITLE
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4 Urbanisation and regional productivity in Korean manufacturing
Lee YJ, Zang H

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Productivity and the density of economic activity
Ciccone A, Hall RE

AMERICAN ECONOMIC REVIEW
86: (1) 54-70 MAR 1996
It is not, however, fully clear if and how this type of density effect should be introduced in cross-country regressions. One possibility, though, is to use long time-series of national growth and to estimate the effect of changing density over time instead of estimating the effect of cross-country differences in density. A second question is how the density measure should be constructed. It is not evident that the best thing is to relate population to the land area. For example in a country like Australia large parts of the country are uninhabited and therefore a measure of population per square kilometer would be uninformative. However, since we have access to population and growth data for a 140 years long period population density can be measured by relating the current size of the population to the mean population size over the entire period. In the second model, thus, the mean annual growth rates in per capita income will be related to the size of the 0-19, 20-49, 40-59, and 60+ age group divided by the mean population size of the country over the 1850-1990 period. In addition the model will include initial income and a country dummy.

By measuring population density separately for the different age groups one acknowledges the possibility—put forward by [Becker, 1999 #4]—that the effect of increasing population density depends on the balance between positive and negative effects. The positive effect here is that population growth may increase the inducements for human capital accumulation and the negative effect is diminishing returns given a fixed level of natural resources.

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Agglomeration and firm performance: economies of scale, localisation, and urbanisation among Swedish export firms
Malmberg A, Malmberg B, Lundequist P
ENVIRONMENT AND PLANNING A
32: (2) 305-321 FEB 2000
Estimation result

Below the estimation results for the density and age share model are presented. One result stands out in both models. The middle age group has throughout a strong positive effect on per capita income growth. This result, thus, corroborates the finding of Lindh & Malmberg (1999) that this is a key group for economic growth. For other age groups the results are not, however, so clear. Contrary to [Bloom, 2000 #11; Bloom, 2000 #13] we do not find a negative effect of youth dependency, and contrary to Lindh & Malmberg (1999) we do not find a negative effect of old age dependency. Moreover, there are indications that in this sample the young adult group has a marked negative effect on per capita income growth rates.

From an econometric point of view these results should be interpreted with care. For this long-term data set, and with the limited number of observations for each country, it cannot be excluded that the age and growth variables are non-stationary and, therefore, the possibility of spurious regression results cannot yet be dismissed. But together with previous similar results on for example OECD data—which have been thoroughly tested—the econometric results suggest that the main pattern of middle aged positive effects on growth survives also over very long horizons and fundamental shifts in economic structures as well as institutions.

An indication of the model’s descriptive power is given in figure 10, which shows observed and age predicted per capita growth rates for the fourteen countries under study. The model used is the one presented in the last column of table 2. From these graphs it is clear that the age model for most countries captures both the rising trend in the growth rates during the 1850 to 1950 period and the downward shift that occurred after the 1960s.
As can be seen from the graphs the age model does not, of course, give a perfect
description of changes in the growth trend. It cannot for example capture the
booms and bust associated with the World Wars. This is, however, not to be
seen as any deficiency in the model. On the contrary any general model of the
normal development of economies that does fit the data in these abnormal
periods must clearly be suspected of spurious results. An interesting feature is,
however, that the age model gives an out-of-sample prediction of increased
growth rates in the 1990s for a number of countries including Australia, Canada,
Finland, Netherlands, Sweden, and the United States.

Taken together, these results indicate that the long-term shifts in the age
structure that are associated with the demographic transition do indeed have an
effect on per capita growth rates. In particular, it seems as if the positive effects
of the age transition on growth rates are associated with the long-term expansion
of the middle-aged population whereas an expansion in the young adult group
has a more mixed result.

From a theoretical point of view, this is not uninteresting. If these effects are
real, they indicate that the Malthusian and Smithian view are not conflicting but
complementary. The Malthusian effect is active when population growth is
concentrated to the young adult group whereas the Smithian effect will become
dominant when population growth shifts towards the middle aged group.

A problem that remains is, however, how this evidence fits with the Bloom et al
results on global data where the whole of the working age population is singled
out as having a positive effect on per capita growth. At least four possibilities
are present. The first is that the pattern is similar in modern global data but is
swamped in regressions that does not subdivide the working age group. The
second possibility is that the negative effect of young adults was stronger during
the early parts of the global industrialization process and has been ameliorated, for example, by a more efficient global capital market. A third possibility is that this effect is due to a mis-specified model. The fourth possibility is that collinearity between the age groups may confound results. Further econometric testing will resolve these questions.

With respect to the density and age share model our conclusion is that the density model is not thrown out by the data. To the contrary, it seems somewhat more robust than the age share model when we introduce initial income, fixed effects and country-specific convergence parameters. It might, therefore, be worthwhile to develop growth models that incorporate both age and density effects.

Our preliminary conclusion is that the hump pattern of age effects on growth peaking at middle age is surprisingly robust even in a fairly shaky data set covering more than 150 years. There are good biological reasons to expect that children, fertile adults and the elderly function differently in the economy. There are also good reasons why the younger and older part of the working age population should have different effects in the economy due to the necessity to accumulate education and experience as well as ordinary wealth over the life cycle. Certainly we would expect that the delimitations of these groups drifts a bit over time, but the basic biological reasons for this partition of the population guarantees a certain robustness in the main features of age distribution effects.

Further explorations of these effects should, therefore, be a worthwhile effort, not only because of the interest these effects have in themselves when it comes to forecasting. In order to understand how incentive mechanisms and non-age factors really has worked, it is undoubtedly a good idea to abandon sterile
representative individual models and take account of the full effects of shifts in the age distribution in order to avoid drawing faulty conclusions.
References to be added later.
Table 1 Age effects on GDP per capita growth 1850-1990 in 14 Western countries, OLS estimates, Age share model (Standard errors in parentheses)

<table>
<thead>
<tr>
<th>Term</th>
<th>No initial income</th>
<th>Initial income</th>
<th>Country fixed effects</th>
<th>Country fixed effects and country specific convergence parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pop 0-19</td>
<td>0.0075 (0.0183)</td>
<td>0.0077 (0.0188)</td>
<td>0.0072 (0.0213)</td>
<td>0.0424 (0.0249)</td>
</tr>
<tr>
<td>Pop 20-39</td>
<td>-0.0785 (0.0382)</td>
<td>-0.0773 (0.0443)</td>
<td>-0.0393 (0.0479)</td>
<td>0.0029 (0.0487)</td>
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<tr>
<td>Pop 40-59</td>
<td>0.1751 (0.0533)</td>
<td>0.1750 (0.0535)</td>
<td>0.2277 (0.0548)</td>
<td>0.3344 (0.0600)</td>
</tr>
<tr>
<td>Pop 60-</td>
<td>0.0200 (0.0497)</td>
<td>0.0222 (0.0631)</td>
<td>0.1270 (0.0953)</td>
<td>0.3197 (0.1106)</td>
</tr>
<tr>
<td>In initial</td>
<td>-0.0001 (0.0021)</td>
<td>-0.0059 (0.0039)</td>
<td>-0.0175 (0.0050)</td>
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</tr>
<tr>
<td>R-square</td>
<td>0.189</td>
<td>0.189</td>
<td>0.302</td>
<td>0.397</td>
</tr>
<tr>
<td>Adj R-square</td>
<td>0.175</td>
<td>0.170</td>
<td>0.227</td>
<td>0.272</td>
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<tr>
<td>Prob fixed effect (F-test)</td>
<td></td>
<td></td>
<td>0.028</td>
<td>0.031</td>
</tr>
<tr>
<td>Prob country specific convergence (F-test)</td>
<td></td>
<td></td>
<td></td>
<td>0.055</td>
</tr>
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Table 2 Age effects on GDP per capita growth 1850-1990 in 14 Western countries, OLS estimates, Density model (Standard errors in parentheses)

<table>
<thead>
<tr>
<th>Term</th>
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<th>Initial income</th>
<th>Country fixed effects</th>
<th>Country fixed effects and country specific convergence parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0097 (0.0035)</td>
<td>0.0097 (0.0127)</td>
<td>0.0371 (0.0205)</td>
<td>0.1608 (0.0317)</td>
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<tr>
<td>index 0-19</td>
<td>-0.0065 (0.0206)</td>
<td>-0.0091 (0.0206)</td>
<td>-0.0306 (0.0223)</td>
<td>0.0054 (0.0252)</td>
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<tr>
<td>index 20-39</td>
<td>-0.0866 (0.0328)</td>
<td>-0.0782 (0.0329)</td>
<td>-0.0837 (0.0331)</td>
<td>-0.0650 (0.0332)</td>
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<td>index 40-59</td>
<td>0.2009 (0.0446)</td>
<td>0.1978 (0.0444)</td>
<td>0.2331 (0.0455)</td>
<td>0.2710 (0.0453)</td>
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<tr>
<td>index 60-</td>
<td>-0.0562 (0.0415)</td>
<td>-0.0262 (0.0444)</td>
<td>-0.0302 (0.0529)</td>
<td>0.0725 (0.0563)</td>
</tr>
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<td>R-square</td>
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<td>0.204 (0.0025)</td>
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<td>Prob fixed effect (F-test)</td>
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<tr>
<td>Prob country specific convergence (F-test)</td>
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<td></td>
<td>0.0058 (0.0107)</td>
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Table 3: Age effects on GDP per capita growth 1850-1990 in 14 Western countries, OLS estimates, Log density model (Standard errors in parentheses)

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<thead>
<tr>
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<th>Initial income</th>
<th>Country fixed effects</th>
<th>Country fixed effects and country specific convergence parameters</th>
</tr>
</thead>
<tbody>
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<td>0.0293</td>
<td>0.0534</td>
<td>0.1382</td>
</tr>
<tr>
<td></td>
<td>(0.0034)</td>
<td>(0.0151)</td>
<td>(0.0254)</td>
<td>(0.0345)</td>
</tr>
<tr>
<td>ln index 0-19</td>
<td>-0.0051</td>
<td>-0.0049</td>
<td>-0.0204</td>
<td>-0.0224</td>
</tr>
<tr>
<td></td>
<td>(0.0080)</td>
<td>(0.0083)</td>
<td>(0.0099)</td>
<td>(0.0108)</td>
</tr>
<tr>
<td>ln index 20-39</td>
<td>-0.0257</td>
<td>-0.0260</td>
<td>-0.0295</td>
<td>-0.0344</td>
</tr>
<tr>
<td></td>
<td>(0.0120)</td>
<td>(0.0126)</td>
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<td>(0.0127)</td>
</tr>
<tr>
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<td>0.0306</td>
<td>0.0378</td>
<td>0.0471</td>
</tr>
<tr>
<td></td>
<td>(0.0122)</td>
<td>(0.0123)</td>
<td>(0.0125)</td>
<td>(0.0130)</td>
</tr>
<tr>
<td>ln index 60-</td>
<td>0.0001</td>
<td>0.0000</td>
<td>0.0062</td>
<td>0.0121</td>
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<tr>
<td></td>
<td>(0.0064)</td>
<td>(0.0065)</td>
<td>(0.0084)</td>
<td>(0.0092)</td>
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<tr>
<td>ln initial</td>
<td>0.0001</td>
<td>-0.0030</td>
<td>-0.0136</td>
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<td></td>
<td>(0.0021)</td>
<td>(0.0034)</td>
<td>(0.0045)</td>
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<tr>
<td>R-square</td>
<td>0.177</td>
<td>0.177</td>
<td>0.292</td>
<td>0.379</td>
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<tr>
<td>Adj R-square</td>
<td>0.158</td>
<td>0.153</td>
<td>0.210</td>
<td>0.245</td>
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<tr>
<td>Prob fixed effect (F-test)</td>
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<td></td>
<td>0.0278</td>
<td>0.0718</td>
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<tr>
<td>Prob country specific convergence (F-test)</td>
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<td>0.105</td>
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</table>
Figure 1. Initial population with stable age structure
Figure 2. Mortality rates
Figure 3. Fertility year 0 up to year 50, TFR = 4.08,

Years 50-59 125 000 children are born
In the following decade 100 000 children are born
Figure 4. Evolution of the age distribution from year 0 to 50 after mortality has started to fall, TFR constant=4.08
Figure 5. Evolution of the age distribution 60-80 år after mortality fall and 10-30 years after maximal fertility.
Figure 6. Evolution of the age distribution 70-100 years after mortality fall and 20-50 years after fertility fall.
Figure 7. Evolution of the age distribution 110-150 years after mortality fall and 60-100 years after maximal fertility.
Figure 8. Changes in the age composition during the demographic transition
Australia

Belgium

Canada

Denmark

Finland

France

Germany

- total 0-19
- total 20-39
- total 40-59
- total 60-
Figure 10 Annual growth rates in per capita income, observed and age model predicted
Figure 10 Annual growth rates in per capita income, observed and age model predicted