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Low Fertility and Economic Growth

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Low fertility in many countries is leading to pronounced changes in population age structure. Currently many populations, particularly in the industrialized world, are heavily concentrated in the working ages. In the coming decades the working-age population will decline while the population of retirees will increase. The objective of this paper is to explore the economic implications of these demographic changes in economies where intergenerational transfers are pervasive and investment in human and physical capital is influenced by fertility and population age structure. When completed,the paper will: (1) provide a brief overview of why population age structure affects economic growth; (2) discuss approaches to measuring standards of living at the aggregate level; (3) provides estimates of the effects of population age structure on standards of living in different countries; and (4) discuss the implications for policy. The analysis will draw heavily on national transfer accounts, which provide comprehensive estimates of economic flows that characterize the generational economy.

# Introduction

Fertility is low in the West and in East Asia and population decline and population aging is a virtual certainty. There seems to be little doubt that countries in Latin America and South and Southeast Asia will follow a path that is at least broadly similar to that of the countries further along in the demographic transition. Recent evidence supports the view that very low fertility, a TFR less than 1.3, may be ending in Europe. East Asia is somewhat distinctive among low fertility countries as fertility has not recovered to the extent observed in Europe (Goldstein et al. 2009). China is a very interesting case because public policy continues to be strongly antinatalist although fertility has dropped to well below replacement. Moreover, in 13 of China’s 31 administrative units (special municipalities, autonomous regions, and provinces) the TFR was 1.3 or below in 2000 (NBS and EWC 2007). The combined 2008 population of these provinces exceed 500 million – a substantially larger population than either the US or the EU population (NBS 2010).

Low fertility has broad and important implications many of which are poorly understood. Low fertility is beginning to lead to depopulation in some countries and can be expected to lead to much smaller populations in the future. The trend in the number of children provides a simple leading indicator of what we might expect. Given the UN low fertility scenario, which is possibly a little pessimistic, the population 0-14 2050 will be one-third of the peak level in Germany, China, and Japan. The situation is quite different in some other countries, like the United States where the total number of children isn’t declining at all. Many environmentalists consider the prospect of population decline to be a favorable development. There may be economic and political implications, however, that point in a different direction.

Low fertility is also the main reason why populations are aging. The implications of changes in population age structure, particularly the economic implications, have been much more extensively studied. Of course, many important questions remain to be addressed. For the most part this paper will not deal directly with the issue of optimal fertility. Rather we will be concerned primarily with how fertility affects important aggregate economic measures, e.g., income and consumption.

The purpose of this paper is to examine some of the macroeconomic implications of changes in population age structure. The goal is to answer the following question: “Have fertility rates dropped to such low levels that standards of living are threatened to a significant degree?” Answering this question does not tell us whether fertility is too high, too low, or just right.

In addressing this question we draw on a new set of economic accounts, National Transfer Accounts, which document economic flows to and across ages at the aggregate level in a manner consistent with National Income and Product Accounts. Research teams in more than 35 countries on six continents are currently collaborating in the construction of NTA. Relatively complete accounts have been completed for 23 countries. More detailed information about NTA is available at [www.ntaccounts.org](http://www.ntaccounts.org). The theoretical foundations of the accounts build on Lee (1993a, b) and some details of the accounts and some preliminary results are reported in Lee, Lee, and Mason and Mason, Lee, et al. A comprehensive analysis of the 23 countries will be published in 2011 (Lee and Mason forthcoming).

# Support ratios

The support ratio and its relationship to economic growth have drawn considerable attention in the literature on the demographic effects of age structure (Bloom, Canning, et al; Kelley and Schmidt; Lee, Mason). For the moment let’s confine ourselves to the simple relationship between the support ratio and per capita income leaving consumption to be addressed later. The simple income and growth identities are:

 

Where gr[] is the instantaneous growth rate of the variable in brackets.

The first term on the right-hand-side, income per worker, captures differences in the productivity of the work force that influence labor income and also non-labor income per worker that varies because of asset income and net transfers from the rest of the world. The second term on the right-hand-side, the support ratio, captures the extent to which the population is concentrated in the working-age rather than in the “dependent” ages.

The support ratio is important because of the basic economic lifecycle that characterizes all contemporary societies. During the early years of life and the later years of life, humans produce a great deal less through their labor than they consume. In the middle of the lifecycle, humans produce a great deal more than they consume. Other considerations aside, populations with heavy concentrations at the surplus ages, a high support ratio, have an obvious advantage in realizing high per capita income. Likewise, populations in which the lifecycle surplus population is growing relative to the lifecycle deficit population will experience more rapidly growth in per capita income – other things equal. Given growth in income per worker, a change in the growth rate of the support ratio yields a one-for-one change in the growth rate of income per capita.

The support ratio is determined by the interaction between the economic lifecycle and population age structure, and, hence, its value reflects variation in both the economic lifecycle. The support ratio is calculated by using age profiles of per capita consumption, , and labor income, from a base year *t0* to weight historical and projected population data,:

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The results presented here use NTA estimates of labor income and consumption for each of 23 countries. The numerator (*L*), the effective number of producers, is constructed by weighting the population at each age by an index that is an estimate of age-specific variation in labor income. The measure incorporates age variation in labor force participation, unemployment rates, hours worked, and wages. The index is constructed by dividing per capita age-specific labor income by the mean labor income of those 30-49 (the simple average of the age-specific values) to control for country differences in the level of labor productivity.

The denominator, the effective number of consumers (*N*), is constructing by weighting the population at each age by an index that represents age-specific variation in per capita consumption. The consumption profile includes both public and private consumption and reflects a variety of factors – biological needs, tastes, responses to interest rates, political institutions, and so forth. The index is constructed by dividing per capita age-specific consumption by mean labor income of those 30-49, as above, to control for country differences in the level of labor productivity. The profile is further adjusted so that mean consumption for those 30-49 is set to 60% of mean labor income of those 30-49. The value of 60% is approximately the value that holds for the 23 countries in our sample. This procedure controls for country differences in saving and asset income. Note that proportional changes in the support ratio, i.e., the rate of growth of the support ratio, are not affected by the scaling of consumption and labor income profiles. Comparisons in the level of the support ratio are affected as is our intention.

The age profiles used to construct support ratios are broadly similar across countries. The evidence supports the assertion made above that all contemporary societies have a period of “dependency” at both the end and the beginning of life. There are also important differences across countries as is conveyed by Figure 1 which shows the profiles of labor income and consumption for the six highest income and the six lowest income countries in our pool (Lee and Mason 2011 forthcoming). Labor income rises a bit later in the highest income countries and peaks at a later age than in the lowest income countries. In high income countries, labor income drops much more sharply and is substantially lower at older ages than labor income in low income countries. Two differences in the consumption profiles are striking. The first is that child consumption is substantially higher in high income than in low income countries, in part, because of greater spending on health and education in high income countries. The second differences is that consumption at older ages increases very sharply in the high income countries because of spending on health care and long-term care. In low income countries, consumption is very flat across adult ages.



Figure 1 The economic lifecycles of rich and poor countries and hunter-gatherers: consumption and labor income. Source: Lee and Mason (2011 forthcoming) “Lifecycles, support systems, and generational flows: Patterns and change”

Note: Data for hunter-gatherer profiles are from Kaplan (1994) and Howell (2010); for method of construction, see text. The profiles for the bottom and top quartile of 23 NTA economies are unweighted averages of the profiles for the six poorest and six richest economies. The bottom quartile group consists of China, India, Indonesia, Kenya, Nigeria, and the Philippines. The top quartile group comprises Austria, Finland, Germany, Japan, Spain, and the US. Values are scaled by average labor income for ages 30–49.

The support ratios for 23 populations for 1950-2050 are presented in Figure 2. In all cases except Taiwan, the support ratios are constructed using the medium fertility scenario from the 2008 UN World Population Prospects. The population data for Taiwan are from the NTA websites and original sources are provided there. The upper left panel shows the supports ratios for all countries but without identifying individual countries. The individual countries are identifies in the regional panels.

## Trends in the support ratio

The support ratio, with few exceptions, has followed a similar pattern in all countries. Starting from 1950 the support ratio declined. In the West this occurred because the baby boom led to a rise in the share of young dependents, while in the developing world reductions in infant and child mortality led to an increase in the share of young dependents. This initial decline in the support ratio did not occur in Japan, which experienced a very short-lived post-World War II baby boom.

## The First dividend

The support ratio began to rise due to fertility decline in many countries starting in the late 1960s and early 1970s. The increase began in East Asia (Japan aside), Latin America (except Uruguay), South and Southeast Asia, and the West (except Spain and Sweden) between 1964 and 1975. That the rise in the support ratio occurred almost simultaneously in so many countries is an interesting feature of Figure 2. The duration of this phase has varied considerably across regions, however. In East Asia, the support ratio rose for 42 years, on average, as compared with 49 years in Latin America and 60 years in South and Southeast Asia. The first dividend phase was shorter in the West lasting 30 years on average.

The percentage increase in the support ratio during this period was also substantially less in the West than elsewhere. On average, from trough to peak, the support ratio increase by 12% in Western countries. In East Asia, the increase was 37%, in Latin America 28%, and in South and Southeast Asia 34%. The annual boost to economic growth during this period was 0.7% in East Asia and 0.5% in Latin America and South and Southeast Asia. In the West, economic growth was higher by 0.4% per annum.

The African case is quite distinctive from the rest of the world. The dividend phase has been substantially delayed – although the support ratio reached its minimum much earlier in Kenya than in Nigeria. Neither country will have experienced its peak support ratio by 2050, the end of the projection period. The average gain for Africa of 43% is the highest of any region reflecting the very low support ratios (0.53) reached in Kenya in 1980. The next lowest value in our series is 0.64 for Taiwan in 1967. Whether the support ratios of other African countries are similar to Kenya’s or to Nigeria’s is not known at this time although estimates are being constructed for three other African countries – Mozambique, Senegal, and South Africa.

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Figure 2. Support ratios, 1950-2050, 23 NTA populations.

Figure 3 plots the annual growth rate of the support ratio, in percent, against the duration of the first dividend period, in years. Western countries (and Uruguay) are clustered much closer to the origin than the rest of the world reflecting the shorter durations and smaller annual increases of the first dividend phase. If we look outside the West, the dividend phase was longer and had a larger annual effect on economic growth. The longest dividend phases are found in South and Southeast Asia (67 years) and Africa (61 years). Note however, that the estimates are truncated and the projected support ratio is still increasing in 2050 in Kenya and Nigeria. The annual increase for Africa is about 0.6% per year and for South and Southeast Asia about 0.4% per year. The duration in of the dividend phase was short in Latin America (47 years) and especially East Asia (42 years). The annual growth rate of the support ratio was 0.54% in Latin American and 0.75% in East Asia. The isoquants shown in Figure 3 can be used to judge the total increase in the support ratio during the dividend phase. The total gains in the support ratio are particularly high in East Asia, exceeding 40% in South Korea and Taiwan, in Thailand, and in Kenya. The total gain in Japan, 26%, is less than in other East Asian countries, but considerably greater than in rich Western countries.

Figure 3. The average annual growth rate of the support ratio, in percent, and the duration of the first dividend phase of the age transition, 23 countries. Note: Isoquants mark the total increase in the support ratio over the first dividend phase – 10%, 25%, and 40%.

## Population aging

The support peaked and began to decline in four of the twenty-three NTA economies in the 1990s. Japan reached its maximum in 1994, Finland and Germany in 1995, and Austria in 1996. The peak support ratio for the other East Asian and Western countries occurs between 2003 and 2011 (Spain) or 2012 (China). In short, among the countries of the West and in East Asia population aging as measured by the support ratio has begun or will soon begin (Table 1).

For the most part, the declines in the support ratio in aging societies have been moderate to this point. The greatest declines have been in Japan, a drop of 7.5%, and Finland, a decline of 6.2%. The support ratio declined by 0.45 percent per year in Japan and by 0.40 percent per year in Finland during the last decade and a half.

Population aging will continue during the next forty years with steady declines in the support ratio in all of the East Asian and Western economies. In East Asia, the annual decline from the peak to 2050 is estimated about 0.5 percent per year while among Western countries the annual decline is a little less than 0.4 percent per year. Those experiencing the most severe rates of decline are South Korea (0.52), Taiwan (0.62), Slovenia (0.53) and Spain (0.57). The United States is projected to experience the smallest rate of decline of 0.22 percent per year.

Population aging as indicated by a declining support ratio will begin in another decade or two in most Latin American and South and Southeast Asia countries. For the five Latin American countries in our sample, the support ratio will begin to decline after 2024. In South and Southeast Asia, the decline begins after 2032. This group of countries is quite diverse, however, with population aging beginning quite early in Thailand (2010) and with a considerable delay in India (2041) and the Philippines (2048).

Among these countries Brazil is projected to experience the most severe decline at an annual rate of 0.45 percent per year. The effects of aging will be quite modest in Uruguay and East and Southeast Asian countries aside from Thailand.

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| Table 1. Support ratios for aging populations. |
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|  | Support Ratios | Maximum value |  | Decline to 2010 [1] |  | Decline to 2050 [1] |
| Country | 2010 | 2050 | Support ratio | Year |   | Duration | Decline (%) | Annual decline (%) |   | Duration | Decline (%) | Annual decline (%) |
| Kenya | 0.63 | 0.79 | 0.79 | 2050 |  | - | - | - |  | - | - | - |
| Nigeria | 0.69 | 0.93 | 0.93 | 2050 |  | - | - | - |  | - | - | - |
| *Africa* | 0.66 | 0.86 | 0.86 | 2050 |   | - | - | - |   | - | - | - |
| China | 0.94 | 0.80 | 0.94 | 2012 |  | - | - | - |  | 38 | 14.6 | 0.36 |
| Japan | 0.78 | 0.60 | 0.85 | 1994 |  | 16 | 7.5 | 0.45 |  | 56 | 28.6 | 0.45 |
| South Korea | 0.94 | 0.71 | 0.94 | 2008 |  | 2 | 0.1 | 0.06 |  | 42 | 24.2 | 0.52 |
| Taiwan | 0.92 | 0.67 | 0.92 | 2010 |  | - | - | - |  | 40 | 28.0 | 0.62 |
| *East Asia* | 0.89 | 0.70 | 0.91 | 2006 |   | 5 | 1.9 | 0.13 |   | 44 | 23.8 | 0.49 |
| Brazil | 0.84 | 0.78 | 0.88 | 2026 |  | - | - | - |  | 24 | 11.3 | 0.45 |
| Chile | 0.94 | 0.85 | 0.95 | 2016 |  | - | - | - |  | 34 | 10.1 | 0.28 |
| Costa Rica | 0.93 | 0.87 | 0.96 | 2022 |  | - | - | - |  | 28 | 8.7 | 0.30 |
| Mexico | 0.95 | 0.94 | 1.00 | 2027 |  | - | - | - |  | 23 | 6.3 | 0.27 |
| Uruguay | 0.85 | 0.85 | 0.87 | 2028 |  | - | - | - |  | 22 | 2.9 | 0.13 |
| *Latin America* | 0.90 | 0.86 | 0.93 | 2024 |   | - | - | - |   | 26 | 7.9 | 0.28 |
| India | 0.88 | 0.96 | 0.97 | 2041 |  | - | - | - |  | 9 | 1.3 | 0.14 |
| Indonesia | 0.97 | 0.99 | 1.03 | 2030 |  | - | - | - |  | 20 | 3.2 | 0.16 |
| Philippines | 0.83 | 0.94 | 0.94 | 2048 |  | - | - | - |  | 2 | 0.0 | 0.01 |
| Thailand | 0.97 | 0.85 | 0.97 | 2010 |  | - | - | - |  | 40 | 12.2 | 0.29 |
| *S & SE Asia* | 0.91 | 0.94 | 0.98 | 2032 |   | - | - | - |   | 18 | 4.2 | 0.15 |
| Austria | 0.90 | 0.70 | 0.91 | 1996 |  | 14 | 1.2 | 0.08 |  | 54 | 22.3 | 0.37 |
| Finland | 0.82 | 0.71 | 0.88 | 1995 |  | 15 | 6.2 | 0.40 |  | 55 | 19.3 | 0.32 |
| Germany | 0.83 | 0.63 | 0.85 | 1995 |  | 15 | 3.2 | 0.21 |  | 55 | 26.0 | 0.42 |
| Hungary | 0.86 | 0.73 | 0.86 | 2009 |  | 1 | 0.0 | 0.03 |  | 41 | 15.8 | 0.36 |
| Slovenia | 0.76 | 0.56 | 0.76 | 2006 |  | 4 | 0.7 | 0.19 |  | 44 | 26.1 | 0.53 |
| Spain | 0.90 | 0.67 | 0.90 | 2011 |  | - | - | - |  | 39 | 25.0 | 0.57 |
| Sweden | 0.78 | 0.69 | 0.80 | 2003 |  | 7 | 1.9 | 0.27 |  | 47 | 13.8 | 0.28 |
| US | 0.89 | 0.81 | 0.90 | 2003 |  | 7 | 1.1 | 0.15 |  | 47 | 10.7 | 0.22 |
| *Europe & US* | 0.84 | 0.69 | 0.86 | 2002 |   | 8 | 1.8 | 0.16 |   | 48 | 19.9 | 0.38 |

Note. [1] Values are reported only for populations with declining support ratios.

## The support ratio and country differences in the lifecycle

The dynamics of the support ratio are so important that they tend to mask the influences of the lifecycle on differences across countries. In the absence of dramatic new developments in the demography, e.g., a surge in fertility or a reversal in mortality decline, the dynamics will become less important over time. By 2050, as noted above every country but those in Africa is projected to be aging and many are expected to be well along in this process. Despite the broad similarities in the demography of countries around the world, a striking feature of Figure 2 is the considerable divergence in the support ratios seen there. In fact, the variance in the support ratio has been increasing sharply since the 1970s. One explanation for this, explored below, is that the projected differences in age structure in the future are actually quite substantial. The second explanation, explored in this section, is that differences in the economic lifecycle at older ages are becoming increasingly important as populations become concentrated there. This divergence would become increasingly important as countries age.

The influence of the economic lifecycle on the support ratio can be assessed by allowing the economic lifecycle to vary while controlling for population age structure. The results of such an exercise are reported in Figure 4. The reported support ratios are calculated by using the economic lifecycle of each country, replacement level fertility, and two mortality schedules. In one case, we use each country’s estimates survival rates by age for 1995-2000. In the second case we use the 1995-2000 survival rates for Japan. Japan is selected because it had the highest life expectancy of any country in our sample.

The values have two interpretations. One is the support ratio given a steady-state rate of population growth of zero. The second is the expected value for a synthetic cohort of the ratio of lifetime labor income to consumption based on prevailing survival rates and age schedules of labor income and consumption.

The range in the values is quite substantial. The replacement rate support ratio for Indonesia, at one extreme, is 0.98 while in Slovenia, at the other extreme, the value is only 0.614. Other things equal the lifecycle for Indonesia would accommodate consumption higher by more than 50% than the lifecycle in Slovenia at replacement fertility. If we consider the replacement rate support ratios using survival rates for Japan, the basic pattern remains unchanged. The Slovenia support ratio would be somewhat lower at 0.948 and the Slovenia support ratio would be lower by 0.614. On average the support ratio is reduced for the 22 countries shown here from 0.825 to 0.791 given Japan’s survival rates. This is a 4 percent decline in the support ratio due to the difference in life expectancy between Japan and the other countries. Another indicator of the relatively modest impact of higher life expectancy on the support ratio is that the variance in the support ratio is reduced by less the 5% by controlling for differences in survival. The remainder is due to differences in the age profiles of consumption and labor income or the interaction of the profiles with survival rates.

The bottom line here is that differences in the lifecycle can have quite an important effect on the support ratio. This should not come as a great surprise given that a frequently suggested and intuitive solution to a decline in the support ratio is to increase the age at retirement. The standard way of summarizing the consumption and labor income profiles is using their mean ages. A convenient empirical relationship is that there is a roughly linear relationship between the difference between the mean age of consumption and the mean age of earning and the support ratio. Using the replacement rate support ratio and Japan survival rates, we see that on average an increase in the difference between the mean age of consumption and the mean age of earning by 1 year will reduce the support ratio by 0.03 or by about 4 percent of the mean support ratio for the sample.

Figure 4. Support ratio versus the difference between the mean age of consumption and the mean of earning for 22 countries given replacement level fertility and the current survival schedule for Japan.

From Figure 4 we can see that the difference in the mean ages varies from about -3 years in Nigeria and Indonesia to +4.6 years in Austria. But of more direct interest to policy are the means of the two profiles. The mean of earnings varies from 40 in Austria to 49 in Nigeria while the mean age of consumption varies from 43 in Slovenia to 47 in Brazil and the United States (see Table 2). The standard deviation of the mean age of consumption is 1.45 years and for earning is 1.92 years. Judging purely from the cross-sectional differences a one standard deviation increase in the mean age of earning would raise the support ratio by about 0.06.

Perhaps a more appropriate comparison is to look at countries with similar levels of development. Consider only the rich industrialized countries. In Japan and the US the mean age of earning exceeds 45. In comparison, the mean age of earning in Germany, Spain, and Finland is under 43 years, in Austria and South Korea is about 42 years, and in Slovenia is under 41 years. So raising the mean age of earning in these European economies to the level found in Japan and US would yield very significant gains in the support ratio – about 0.1 in Austria and somewhat more in Slovenia, for example.

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| Table 2 . Mean ages of consumption and labor income, support ratios given replacement fertility and own survival schedule or survival schedule for Japan.  |
|  | Own survival schedule |  | Japan survival schedule |  |
| Country | AC | AYl | Ac-Ayl | Support ratio | AC | AYl | Ac-Ayl | Support ratio |
| Slovenia | 39.9 | 40.5 | -0.6 | 0.652 | 42.7 | 40.7 | 2.0 | 0.614 |
| Japan | 45.8 | 45.1 | 0.7 | 0.719 | 45.8 | 45.1 | 0.7 | 0.719 |
| Sweden | 44.4 | 43.9 | 0.5 | 0.729 | 45.9 | 44.0 | 2.0 | 0.703 |
| Germany | 44.3 | 42.6 | 1.8 | 0.751 | 46.1 | 42.7 | 3.5 | 0.72 |
| Kenya | 37.6 | 40.5 | -2.9 | 0.751 | 44.4 | 42.1 | 2.3 | 0.713 |
| Spain | 42.5 | 42.8 | -0.3 | 0.757 | 43.4 | 42.8 | 0.5 | 0.744 |
| Brazil | 43.7 | 43.3 | 0.3 | 0.775 | 47.1 | 44.1 | 3.0 | 0.732 |
| Finland | 42.6 | 42.6 | 0.0 | 0.778 | 44.8 | 42.8 | 2.0 | 0.744 |
| Austria | 42.8 | 39.7 | 3.1 | 0.802 | 44.4 | 39.8 | 4.6 | 0.773 |
| S. Korea | 39.7 | 41.7 | -2.0 | 0.806 | 42.1 | 42.1 | 0.0 | 0.773 |
| US | 46.2 | 45.3 | 1.0 | 0.81 | 47.4 | 45.5 | 1.9 | 0.793 |
| Hungary | 40.4 | 42.5 | -2.0 | 0.811 | 45.1 | 43.0 | 2.0 | 0.738 |
| China | 40.0 | 42.0 | -2.0 | 0.838 | 43.3 | 42.8 | 0.5 | 0.793 |
| Costa Rica | 44.7 | 43.7 | 0.9 | 0.857 | 45.7 | 43.9 | 1.8 | 0.841 |
| Uruguay | 41.9 | 43.8 | -1.9 | 0.859 | 44.3 | 44.2 | 0.1 | 0.822 |
| Thailand | 39.1 | 41.6 | -2.5 | 0.866 | 43.5 | 42.5 | 1.0 | 0.817 |
| Chile | 43.2 | 43.2 | 0.0 | 0.87 | 45.0 | 43.6 | 1.4 | 0.843 |
| India | 40.1 | 43.0 | -3.0 | 0.921 | 45.9 | 44.4 | 1.5 | 0.844 |
| Philippines | 40.2 | 44.0 | -3.9 | 0.935 | 44.5 | 45.1 | -0.5 | 0.875 |
| Mexico | 42.4 | 43.7 | -1.2 | 0.936 | 44.2 | 44.2 | 0.1 | 0.913 |
| Nigeria | 38.0 | 46.8 | -8.8 | 0.955 | 46.2 | 49.4 | -3.1 | 0.944 |
| Indonesia | 38.3 | 43.4 | -5.1 | 0.982 | 42.5 | 45.2 | -2.7 | 0.948 |
|  |  |  |  |  |  |  |  |  |
| Averages | 41.7 | 43.0 | -1.27 | 0.825 | 44.7 | 43.6 | 1.1 | 0.791 |

In the rich industrialized countries the mean age of consumption is highest in the US at over 47 years and lowest in Slovenia, Spain at 43 years and South Korea at 42 years. If the mean age of consumption in the US were to decline to the South Korean value, the support ratio would increase by about 0.15 a gain of about 20%. This is a crude approximation but gives a rough idea of the impact of alternative consumption and labor income profiles.

# Maximum support ratio

The support ratio in steady-state, represented in continuous form, is:

 

Where *n* is the population growth rate,  is expected years lived at age x,  is the age profile of labor income, and is the age profile of consumption. Taking the derivative of the ln of the support ratio with respect to the population growth rate yields:

 

The partial effect of an increase in the population growth rate on the log support ratio is the difference between the mean age of consumers weighted by their consumption () and the mean age of producers weighted by their labor income (). The maximum support ratio is realized when the mean ages are equal. If the mean age of consumers exceeds the mean age of producers, an increase in the population growth rate or in fertility will lead to a higher support ratio. If the mean age of effective producers exceeds the mean age of effective consumers, an increase in the population growth rate or the fertility rate leads to a decline in the support ratio.

Two sets of results are reported below. In one set, which we emphasize in the discussion, the own-survival rates are used. In the second set of results, the Japan survival rates are used. We use a discrete formulation and solve iteratively for the population growth rate that equalizes the mean ages of effective consumers and producers. The corresponding total fertility rate and support ratios are reported, as well.

A relatively old population is advantageous in countries in which dependency is relatively high at young ages and relatively low at young ages. Conditions that would favor an old population would be high spending and low labor income for children and/or low consumption and high labor income for the elderly. Nigeria is something of an extreme case in this regard because labor income is very low for children and very high for older ages. The consumption profile is similar to what we find for other countries, relatively flat. In any case the economic lifecycle in Nigeria is at a maximum when the mean ages of consumption and labor income are greater than 50, a benchmark no other country reaches. Given the current survival schedule in Nigeria, such an old population can be realized only if the fertility rate is very low (1.3) and population is experiencing rapid decline (-3.1% per year).

Austria represents the other polar extreme among our NTA countries where a mean age of less than 40 maximizes the support ratio. In no other country is the maximum realized when the mean age of effective consumers and effective producers below 40. Austria has very high labor income among young adults and an early age at retirement. The result is that the support ratio would be maximized with a TFR of 2.6 and a population growth rate of 0.8% per year.

In many countries, the fertility that maximizes the support ratio is close to replacement. In 16 of the 22 countries, a total fertility rate between 1.8 and 2.2 produces the maximum support ratio. Only in Germany and Austria does a TFR above 2.2 lead to a higher support ratio. Three low income countries besides Nigeria have SR-maximizing total fertility rates below 1.8. These are Indonesia, the Philippines, and Thailand – all countries with relatively low consumption and high labor income among the elderly.

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| Table 3. Maximum support ratio and corresponding mean ages, TFR, and population growth rates conditional on age profiles of consumption and labor income, own survival rates for 2010.  |
| Region | Country | Ac | Ayl | TFR | Support ratio | Pop growth rate (%) |
| Africa | Kenya | 41.6 | 41.6 | 2.0 | 0.76 | -0.820 |
| Africa | Nigeria | 51.6 | 51.6 | 1.3 | 1.10 | -3.121 |
| E Asia | China | 43.0 | 43.0 | 2.0 | 0.84 | -0.610 |
| E Asia | Japan | 44.9 | 44.9 | 2.2 | 0.72 | 0.133 |
| E Asia | South Korea | 42.6 | 42.6 | 1.8 | 0.81 | -0.554 |
| Europe/US | Austria | 38.7 | 38.7 | 2.6 | 0.81 | 0.753 |
| Europe/US | Finland | 42.6 | 42.6 | 2.1 | 0.78 | 0.000 |
| Europe/US | Germany | 42.1 | 42.1 | 2.4 | 0.75 | 0.414 |
| Europe/US | Hungary | 43.1 | 43.1 | 1.8 | 0.82 | -0.534 |
| Europe/US | Slovenia | 40.7 | 40.7 | 2.0 | 0.65 | -0.136 |
| Europe/US | Spain | 42.9 | 42.9 | 2.0 | 0.76 | -0.061 |
| Europe/US | Sweden | 43.8 | 43.8 | 2.1 | 0.73 | 0.091 |
| Europe/US | US | 44.9 | 44.9 | 2.2 | 0.81 | 0.229 |
| Latin America | Brazil | 43.2 | 43.2 | 2.2 | 0.78 | 0.085 |
| Latin America | Chile | 43.2 | 43.2 | 2.1 | 0.87 | 0.003 |
| Latin America | Costa Rica | 43.3 | 43.3 | 2.2 | 0.86 | 0.261 |
| Latin America | Mexico | 44.4 | 44.4 | 1.9 | 0.94 | -0.386 |
| Latin America | Uruguay | 44.5 | 44.5 | 1.8 | 0.86 | -0.483 |
| SSE Asia | India | 44.7 | 44.7 | 1.9 | 0.94 | -0.998 |
| SSE Asia | Indonesia | 47.4 | 47.4 | 1.3 | 1.04 | -2.021 |
| SSE Asia | Philippines | 46.4 | 46.4 | 1.5 | 0.96 | -1.295 |
| SSE Asia | Thailand | 42.7 | 42.7 | 1.7 | 0.88 | -0.734 |

If we turn our attention to the calculations employing survival rates for Japan, we see that again an old population is favored in Nigeria and a young population in Austria. In only two countries is substantial population decline an advantage – Nigeria and Indonesia, both of which realize their SR maximum with a rate of population decline of almost -1% per year. In the Philippines very modest population decline is favorable. In four countries, Kenya, Austria, Germany, and Brazil, a population growth rate in excess of 0.5% per year maximizes the support ratio. In the remaining 16 countries a population growth between 0.0 and 0.5% per year maximizes the support ratio. The TFRs range as high as 2.6 in Germany and as low as 1.6 in Indonesia and Nigeria. In most countries, a TFR modestly greater than replacement leads to the maximum support ratio.

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| Table 4 . Maximum support ratio and corresponding mean ages, TFR, and population growth rates conditional on age profiles of consumption and labor income, Japan survival rates for 2010.  |
| Region | Country | Ac | Ayl | TFR | Support ratio | Pop growth rate (%) |
| Africa | Kenya | 41.3 | 41.3 | 2.4 | 0.72 | 0.553 |
| Africa | Nigeria | 50.8 | 50.8 | 1.6 | 0.96 | -0.844 |
| E Asia | China | 42.6 | 42.6 | 2.3 | 0.79 | 0.132 |
| E Asia | Japan | 44.9 | 44.9 | 2.2 | 0.72 | 0.133 |
| E Asia | South Korea | 42.1 | 42.1 | 2.1 | 0.77 | -0.004 |
| Europe/US | Austria | 38.4 | 38.4 | 2.4 | 0.79 | 1.045 |
| Europe/US | Finland | 42.3 | 42.3 | 2.3 | 0.75 | 0.404 |
| Europe/US | Germany | 41.7 | 41.7 | 2.6 | 0.73 | 0.751 |
| Europe/US | Hungary | 42.5 | 42.5 | 2.4 | 0.74 | 0.436 |
| Europe/US | Slovenia | 40.3 | 40.3 | 2.3 | 0.62 | 0.378 |
| Europe/US | Spain | 42.7 | 42.7 | 2.2 | 0.74 | 0.120 |
| Europe/US | Sweden | 43.4 | 43.4 | 2.3 | 0.71 | 0.347 |
| Europe/US | US | 44.8 | 44.8 | 2.3 | 0.80 | 0.435 |
| Latin America | Brazil | 43.0 | 43.0 | 2.4 | 0.74 | 0.700 |
| Latin America | Chile | 42.9 | 42.9 | 2.3 | 0.85 | 0.361 |
| Latin America | Costa Rica | 43.1 | 43.1 | 2.4 | 0.84 | 0.473 |
| Latin America | Mexico | 44.1 | 44.1 | 2.1 | 0.91 | 0.025 |
| Latin America | Uruguay | 44.1 | 44.1 | 2.1 | 0.82 | 0.029 |
| SSE Asia | India | 43.8 | 43.8 | 2.3 | 0.85 | 0.383 |
| SSE Asia | Indonesia | 47.3 | 47.3 | 1.6 | 0.96 | -0.865 |
| SSE Asia | Philippines | 45.4 | 45.4 | 2.0 | 0.88 | -0.144 |
| SSE Asia | Thailand | 42.1 | 42.1 | 2.2 | 0.82 | 0.254 |

The high fertility countries in our data, Nigeria and Kenya, have TFRs that are substantially above the level that will maximize the support ratio while the low fertility countries, Austria, Germany, Hungary, Japan, and South Korea, have fertility rates that are well below the level that maximizes the support ratio. But how great would be the gain if these countries moved to the SR-maximizing level of fertility?

This question is answered by calculating the steady-state support ratio given the current age-specific fertility rates and age profiles for labor income and consumption for each country and the Japan survival rates. The percentage difference between that support ratio and the maximum attainable support ratio is plotted against the current TFR in Figure 5. As would be expected we see a U-shaped curve that is relatively flat in the 1.5 to 3 TFR range. For most countries in this range, the gain from moving to the maximum is an increase in the support ratio by about 2% or less. Brazil is an exception and could realize an increase in the support ratio of over 5% by moving to the SR-maximizing fertility rate. Outside this fertility range the gains are greater. Five of the low fertility countries, including Brazil, could increase their support ratio by 5-7%. Two low fertility countries, Germany and Austria, could gain around 12%. Among the high fertility countries, Nigeria’s support ratio could rise by a considerable 30% while Kenya’s gain would be about 10% by moving to the maximum value.

Figure 5. Percentage difference between the steady state support ratio given the current fertility rate and the maximum support ratio conditioned on the current age profiles of consumption and labor income and current Japanese survival rates.

These numbers may strike many as being surprisingly small as compared with earlier studies of the effects of age structure. The reason is that these are steady-state results that do not reflect the large transitory effects of changes in age structure.

# Maximizing Consumption

Public discourse about the economic effects of population age structure emphasizes the support ratio, or related measures, almost exclusively. As most economists appreciate, however, variation in fertility and population growth has other important effects on economic growth and standards of living that are not captured by the support ratio.

It is well known in the Solow growth model (Solow 1956) that more rapid population growth requires that a higher proportion of output be set aside to equip the increasing workforce. In order to maintain golden rule growth, more rapid population growth rates lead to higher saving rates and lower per capita consumption. The effect of population growth on per capita aggregate consumption is:

 

where *c* is per capita aggregate consumption and *K* is capital per capita. This equation describes the “capital-dilution effect”: more rapid population growth dilutes the capital per person. But a given level of per capita consumption can go with any number of different age patterns of consumption, supported by different patterns of intergenerational transfers and lifecycle saving. Importantly an increase in the population growth rate can lead to an increase in lifetime consumption across steady states even when simple per capita consumption, *c,* *falls*.

Let *C(n*) be the present value of survival-weighted lifecycle consumption. More rapid population growth (and a younger population) can either raise *C* or reduce it, depending upon the specific age patterns of consumption and intergenerational transfers. Arthur and McNicoll (1978) showed that across golden rule paths

 

That is, there are two effects on lifecycle consumption when the population growth rate differs. First, there is an effect that is equivalent to the change in the support ratio. Second, there is the standard capital dilution effect, *−K*.

The golden rule case is obviously a very strong assumption to make. It is an attractive assumption because it leads to elegant and simple results. But more importantly it leads to valuable insights about the economic consequences of population aging. If fertility declines to low levels the support ratio will decline, as emphasized above, but capital deepening will also occur lead to higher wages. The fertility rate that maximizes the support ratio is higher than the fertility rate that maximizes lifetime consumption.

In several of our earlier studies we treated capital as endogenous and the outcome of the lifecycle demand for wealth and the policy environment that governed transfers to children and the elderly. One of the conclusions of this research is that the demand for capital rises over the demographic transition as spending on children declines, the duration of retirement increases, and the population becomes increasingly concentrated at older, wealthier ages. A second important conclusion is that the nature of the transfer system has very important implications for the extent to which population aging leads to capital accumulation. Heavy reliance on either public or private transfers to fund the gap between consumption and labor income undermines the demand for capital in aging societies.

The approaches to funding the lifecycle deficit (consumption less labor income) of the elderly varies widely from country to country. The support system for the elderly, the means by which their lifecycle deficit is funded, can be effectively described as consisting of three components: public transfers, private transfers, and asset-based reallocations. Depending on the country, the elderly benefit from public pension programs, publicly funded health care and long-term care, and other cash and in-kind transfer programs. Of course, depending upon the particulars of the tax system, the elderly help fund these programs. Private transfers are dominated by intrahousehold flows between the elderly and co-resident family members. The third source of support for the elderly is their assets: personal savings, stocks and bonds, a business or farm, and owner-occupied housing, to name important examples.

To document how the old-age support system varies across societies, we compare public transfers, private transfers, and asset-based reallocations as a “share” of the lifecycle deficit of those 65 and older.[[1]](#endnote-1) The shares are conveniently represented by a triangle graph that nevertheless requires some explanation (Figure 6). Each of the three vertices of the triangle represents exclusive reliance on one of the three funding sources, with the other two being zero. Any movement toward one of these vertices represents an increase in the share of that source. Along the sides of the triangle, one source is zero while the other two vary. Movement along one of the gridlines implies that one source is constant at one third or two thirds of the lifecycle deficit while the other two vary. Points lying outside the triangle indicate that one or more of the components are negative. This occurs frequently because net private transfers to the elderly are often negative; that is, the elderly provide more to their descendants than they receive from them.



Figure 6. Funding sources for persons 65 and older, measured as shares of the lifecycle deficit: 17 economies around 2000. Source: Mason and Lee forthcoming.

Net familial transfers are an important source of support for the elderly in only a few Asian economies: South Korea, Taiwan, and Thailand. In Taiwan and Thailand, net family transfers represent about one third of the lifecycle deficit of the elderly, and in South Korea net family transfers account for roughly 20%. In many countries (Chile, Costa Rica, Japan, the Philippines, Slovenia, Spain, and Sweden), net familial transfers are close to zero or negative. In a few countries (Brazil, Mexico, the US, and Uruguay) the elderly provide substantially more support to their descendants than they receive.

Net public transfers vary widely in importance. In the Philippines and Thailand, net public transfers are essentially zero, with the elderly paying as much in taxes as they are receive in benefits. Net public transfers fund roughly one third of the old-age deficit in Mexico, South Korea, Taiwan, and the US; one half in Uruguay; and two thirds in Costa Rica, Japan, and Spain. Well over two thirds of the old-age deficits are funded by public transfers in Austria, Chile, Slovenia, and Sweden. In Brazil, net public transfers are about one third larger than the lifecycle deficit, and the excess is transferred to younger family members.

The elderly in Mexico, the Philippines, Thailand, and the US rely most heavily on assets. In Taiwan, where familial transfers are dominant, the elderly rely on assets to a much smaller degree. In Austria, Brazil, Chile, Slovenia, and Sweden, where public transfers dominate, assets play a very limited role.

There are interesting regional patterns in the support system. Public transfer systems are most important in Europe and Latin America and least important in developing Asia. Among industrialized economies, public transfers to the elderly are less important in Japan and the US than in European economies.

The values in Figure 6 are averaged across all persons 65 and older and conceal important differences between younger and older elderly. The elderly in almost every economy rely less on assets at older than at younger ages. They fill this resource gap with public transfers in the US and European economies, but with familial transfers in Asia and Latin America. Among the oldest old in both Latin America and Asia, familial transfers are very important, but at no age are they important in the US or Europe.

An inviting interpretation of the declining reliance on assets is that the elderly spend down their assets as they age, but this interpretation appears to be wrong in almost every society. With rare exceptions, the elderly are not dissaving (Chapter 9). The older elderly have less wealth because they had low labor income during their working years, which they earned further in the past, and they were never able to accumulate as much wealth as younger elderly. This cohort effect is particularly strong in the rapidly growing economies of East Asia. In some countries, such as the US, the relative importance of asset-based reallocations is declining because of large increases in in-kind transfers for health and long-term care late in life.

In the results presented here we abstract from the endogenous nature of the demand for capital and take it as given, the outcome of public policy. We then use a similar approach to the one taken above to calculate the fertility and population growth rates that satisfies equation and, hence, maximizes lifetime consumption.

The results presented in Table 5 with K/C equal to 4.0 and the Japanese survival rates. In all cases but one, the consumption maximizing population growth rate is negative. It ranges as low as -2.3% per annum in Indonesia and -2.0% per annum in Nigeria. In Europe and the US, the consumption maximizing population growth rate varies from 0.1% in Austria to -0.5% in the United States and -0.7% in Spain. The consumption maximizing population growth rates in East Asia are somewhat lower ranging from -0.7% in Japan to -1.0% in South Korea. With the exception of Austria, the consumption maximizing fertility is below replacement.

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| Table 5. Summary measures given fertility rate that maximizes lifetime consumption, given age-profiles of consumption and labor income and current Japanese survival rates; K/C = 4.0.  |
| Country | AC | Ayl | TFR | Support ratio | Population growth rate (%) |
| Kenya | 46.7 | 42.7 | 1.8 | 0.71 | -0.4 |
| Nigeria | 56.9 | 52.9 | 1.2 | 0.94 | -2.0 |
| China | 48.5 | 44.5 | 1.7 | 0.78 | -0.9 |
| Japan | 50.1 | 46.1 | 1.7 | 0.71 | -0.7 |
| S Korea | 47.6 | 43.6 | 1.6 | 0.76 | -1.0 |
| Austria | 43.6 | 39.6 | 2.2 | 0.78 | 0.1 |
| Finland | 47.4 | 43.4 | 1.8 | 0.74 | -0.4 |
| Germany | 46.8 | 42.8 | 2.0 | 0.72 | -0.1 |
| Hungary | 47.6 | 43.6 | 1.8 | 0.73 | -0.4 |
| Slovenia | 45.1 | 41.1 | 1.9 | 0.61 | -0.4 |
| Spain | 47.8 | 43.8 | 1.7 | 0.73 | -0.7 |
| Sweden | 48.5 | 44.5 | 1.9 | 0.70 | -0.4 |
| US | 50.3 | 46.3 | 1.8 | 0.78 | -0.5 |
| Brazil | 48.5 | 44.5 | 1.9 | 0.73 | -0.2 |
| Chile | 48.7 | 44.7 | 1.7 | 0.83 | -0.7 |
| Costa Rica | 49.0 | 45.0 | 1.8 | 0.83 | -0.6 |
| Mexico | 50.4 | 46.4 | 1.5 | 0.89 | -1.1 |
| Uruguay | 49.6 | 45.6 | 1.6 | 0.81 | -0.9 |
| India | 49.7 | 45.7 | 1.8 | 0.83 | -0.7 |
| Indonesia | 55.0 | 51.0 | 1.1 | 0.94 | -2.3 |
| Philippines | 51.5 | 47.5 | 1.5 | 0.86 | -1.2 |
| Thailand | 47.6 | 43.6 | 1.7 | 0.80 | -0.7 |

The key point here is that adverse economic effects of low fertility seem to be exaggerated IF countries do not rely excessively on transfer systems to meet the material needs that occur at the end of life. Analysis of the support ratio implies that moderate population growth is desirable although moderate population decline involves little cost. Once we move beyond the simplest of economic models, the evidence indicates that modest rates of population decline, less than one percent per year, do not have adverse economic effects. Under some circumstances, a very old population and rapid population decline can be advantageous from a consumption maximizing perspective. These cases are of less interest because the countries involved are still relatively young, and their age profiles of consumption and labor income may change very substantially before they begin to experience substantial aging.

References

Arrondel, L., and A. Masson. 2006. Altruism, exchange or indirect reciprocity: What do the data on family transfers show? Chapter 14 in S.-C. Kolm and J.M. Ythier (eds.), *Handbook of the economics of giving, altruism and reciprocity*, Vol. 2, pp. 971–1053. Amsterdam and New York: Elsevier.

Arthur, B.W., and G. McNicoll. 1978. Samuelson, population and intergenerational transfers. *International Economic Review* 19(1): 241–46.

Autor, D.H., F. Levy, and R.J. Murnane. 2003. The skill content of recent technological change: An empirical exploration. *Quarterly Journal of Economics* 118(4): 1279–1334.

Barro, R.J. 1974. Are government bonds net wealth? *Journal of Political Economy* 28(6): 1095–1117.

Becker, G., and R. Barro. 1988. A reformulation of the economic theory of fertility. *Quarterly Journal of Economics* 103(1): 1–25.

Becker, G.S., and K.M. Murphy. 1988. The family and the state. *Journal of Law & Economics* 31(1): 1–18.

Becker, G.S., K.M. Murphy, and R. Tamura. 1990. Human capital, fertility, and economic growth. *Journal of Political Economy* 98(5): S12–S37.

Bommier, A., and R. Lee. 2003. Overlapping generations models with realistic demography. *Journal of Population Economics* 16(1): 135–60.

Bommier, A., R. Lee, T. Miller, and S. Zuber. 2010. Who wins and who loses? Public transfer accounts for US generations born 1850–2090. *Population and Development Review* 36(1): 1–26.

Cigno, A. 2000. Self-enforcing family constitutions: Implications for saving, fertility and intergenerational transfers. In A. Mason and G. Tapinos (eds.), *Sharing the wealth: Demographic change and economic transfers between generations,* pp. 232–55. Oxford: Oxford University Press.

Cox, D. 1987. Motives for private transfers. *Journal of Political Economy* 95(3): 508–46.

Goldstein, Joshua R., Tomas Sobotka, and Aiva Jasilioniene, 2009, “The End of ‘Lowest-Low’ Fertility?” *Population and Development Review* 35(4) 663-699.

Howell, N. 2010. *Life histories of the Dobe !Kung.* Berkeley: University of California Press.

Kaplan, H. 1994. Evolutionary and wealth flows theories of fertility: Empirical tests and new models. *Population and Development Review* 20(4): 753–91.

Kaplan, H., M. Gurven, J. Winking, P.L. Hooper, and J. Stieglitz. 2010. Learning, menopause, and the human adaptive complex. *Annals of the New York Academy of Sciences*, special issue, *The biodemography of reproductive aging,* 1204: 30–42.

Laferrere, A., and F.-C. Wolff. 2006. Microeconomic models of family transfers. Chapter 13 in S.-C. Kolm and J.M. Ythier (eds.), *Handbook of the economics of giving, altruism and reciprocity*, Vol. 2, pp. 889–969. Amsterdam and London: Elsevier.

———. 1994a. The formal demography of population aging, transfers, and the economic life cycle. In L. Martin and S. Preston (eds.), *The demography of aging,* pp. 8–49.Washington, D.C.: National Academy Press.

Lee, R. (with the assistance of T. Miller). 1994b. Population age structure, intergenerational transfers, and wealth: A new approach, with applications to the U.S. *Journal of Human Resources,* special issue edited by P. Gertler, *The family and intergenerational relations,* 29(4): 1027–63.

Lee, R., and A. Mason. 2010. Some macroeconomic aspects of global population aging. *Demography* 47 (Suppl): S151–S172.

Lee, R and Mason, A., lead authors and editors, *Population Aging and the General Economy: A Global Perspective (Cheltenham, UK: Edward Elgar).*

Lee, R., S.-H. Lee, and A. Mason. 2008. Charting the economic lifecycle. In A. Prskawetz, D.E. Bloom, and W. Lutz (eds.), *Population aging, human capital accumulation, and productivity growth.* Supplement to *Population and Development Review* 34: 208–37.

 Mason, A., and R. Lee. 2007. Transfers, capital, and consumption over the demographic transition. In R. Clark, N. Ogawa, and A. Mason (eds.), *Population aging, intergenerational transfers and the macroeconomy*, pp. 128–62. Cheltenham, UK: Edward Elgar.

Mason, A., R. Lee, A.-C. Tung, M.S. Lai, and T. Miller. 2009. Population aging and intergenerational transfers: Introducing age into national income accounts. In D.A. Wise (ed.), *Developments in the economics of aging,* pp. 89–122. National Bureau of Economic Research Conference Report. Chicago: University of Chicago Press.

Mason, A., and R. Lee, forthcoming. “Gopulation aging and the generational economy: Key findings,” in Lee, R and Mason, A., lead authors and editors, *Population Aging and the General Economy: A Global Perspective (Cheltenham, UK: Edward Elgar).*

National Bureau of Statistics of China and East-West Center, 2007, Fertility Estimates for Provinces of China, 1975-2000.

National Bureau of Statistics of China, 2010. China Statistical Yearbook 2009.

Razin, A., and E. Sadka. 1995. *Population economics*. Cambridge, MA: The MIT Press.

Samuelson, P. 1958. An exact consumption-loan model of interest with or without the social contrivance of money. *Journal of Political Economy* 66(6): 467–82.

———. 1975. The optimum growth rate for population. *International Economic Review* 16(3): 531–38.

Sanchez-Romero, M. 2009. Demographic transition and rapid economic growth: The case of Taiwan. Unpublished manuscript, Department of Demography, University of California, Berkeley.

Skirbekk, V. 2008. Age and productivity capacity: Descriptions, causes and policy options. *Ageing Horizons* 8: 4–12.

Solow, R.M. 1956. A contribution to the theory of economic growth. *Quarterly Journal of Economics* 70(1): 65–94.

Tobin, J. 1967. Life cycle saving and balanced economic growth. In W. Fellner et al*.* (eds.), *Ten economic studies in the tradition of Irving Fisher,* pp.231–56. Wiley: New York.

Weil, D. 1997. The economics of population aging. Chapter 17 in M. Rosenzweig and O. Stark (eds.), *Handbook of population and family economics*, Vol. 1, Part 2, pp. 967–1014. Amsterdam and New York: Elsevier.

Willis, R. 1987. Externalities and population. In D.G. Johnson and R.D. Lee (eds.), *Population growth and economic development: Issues and evidence*, pp.661–702. Madison: University of Wisconsin Press.

———. 1988. Life cycles, institutions and population growth: A theory of the equilibrium interest rate in an overlapping-generations model. In R. Lee, W.B. Arthur, and G. Rodgers (eds.), *Economics of changing age distributions in developed countries*, pp.106–38. Oxford: Oxford University Press.

———. 1994. Economic analysis of fertility: Micro-foundations and aggregate implications. In K.L. Kiessling and H. Landberg (eds.), *Population and economic development and the environment*, pp. 139–72. Oxford: Oxford University Press.

Yaari, M. 1965. Uncertain lifetime, life insurance, and the theory of the consumer. *The* *Review of Economic Studies* 32(2): 137–50.

1. The shares must sum to 1 by definition, but they need not be positive. Negative transfer shares indicate that the elderly are giving more than they are receiving. If the elderly are saving all of their asset income plus some of their labor income, the share for asset-based reallocations will be negative; but we do not observe this outcome for any country.

References

Barro, R.J. 1974. Are government bonds net worth? *Journal of Political Economy* 82(6): 1095–1117.

Becker, G. 1960. An economic analysis of fertility. In *Demographic and economic change in developed countries,* pp. 209–40. Princeton: Princeton University Press for National Bureau of Economic Research.

Feldstein, M. 1974. Social security, induced retirement, and aggregate capital accumulation. *Journal of Political Economy* 82(5): 905–26.

Gruber, J., and D.A. Wise. 1999. *Social security and retirement around the world.* Chicago: University of Chicago Press.

———. 2001. An international perspective on policies for an aging society. NBER Working Papers No. W8103. Boston: National Bureau of Economic Research.

Lee, R. 2003a. Demographic change, welfare, and intergenerational transfers: A global overview. *GENUS*. 59(3–4): 43–70.

———. 2003b. The demographic transition: Three centuries of fundamental change. *Journal of Economic Perspectives* 17(4): 167–90.

Lee, R., and A. Mason. 2010. Fertility, human capital, and economic growth over the demographic transition. *European Journal of Population* 26(2): 159–82.

Mason, A, and R. Lee. 2007. Transfers, capital, and consumption over the demographic transition. In R. Clark, A. Mason, and N. Ogawa (eds.), *Population aging, intergenerational transfers and the macroeconomy,* pp. 128–62. Cheltenham, UK, and Northampton, MA: Elgar Press**.**

Ogawa, N., A. Mason, A. Chawla, and R. Matsukura. 2010. Japan’s unprecedented aging and changing intergenerational transfers. In T. Ito and A.K. Rose (eds.), *The economic consequences of demographic change in East Asia*, pp. 131–60. NBER–EASE Vol. 19. Boston: National Bureau of Economic Research.

UN [United Nations] Population Division. 2009. World population prospects: The 2008 revision. Population database. <http://esa.un.org/unpp/index.asp?panel=2> (accessed 3 October 2010). [↑](#endnote-ref-1)