Population size, growth, age structure and geographic distribution influence economies because of systematic features of the human lifecycle. Population concentrated in the middle years of life where labor productivity is high directly influences total economic production. “Dependent” populations at young and old ages consume much more than they produce through their labor with implications for living standards. The global economic impact of population reflects national variation in the lifecycle interacting with national differences in demographic change. Here we provide detailed estimates of the lifecycle across 186 countries drawing on National Transfer Accounts and highlight six important effects of population on the global economy. Because the expected global population increase of 40 percent will occur in areas where per capita GDP is low, the impact on GDP growth will be modest. The changing shape of the economic lifecycle, with high consumption and low labor supply at older ages, will heighten the economic effects of population aging. However, we find that the costs of aging are absorbed by prime age adults rather than children or the elderly. Many pressing issues, environmental, health, and economic, are global in nature and inextricably linked to population. Understanding the connections is essential.

The UN’s assessment of world population highlights several important trends. Global population is growing more slowly, but is projected to increase by 3 billion, or 41%, over the remainder of this Century. Aging will be pervasive. Populations in high income economies will decline sharply while those in low income economies will increase substantially (United Nations Department of Economic and Social Affairs: Population Division 2019b). The implications for the global economy, examined in this study, are expected to be very important as well. For decades population growth has fueled GDP growth, but this is likely to end very soon. Slower GDP growth may represent a positive change to the extent that it can reduce environmental strains. Growth in living standards may be slowed in rich economies but not in poor ones. With aging, competition for resources across age groups might be expected to sharpen, but we do not see signs of this occurring. Public finances will be strained requiring higher taxes or smaller public programs. Aging could lead to problems due to higher public debt, but on the positive side might lead to higher levels of capital and productivity.

Six Key Findings (Two findings presented to satisfy page limit)

In the analysis presented here we emphasize the most direct channels by which population change impacts the economy and set aside more indirect channels that are less straightforward. We touch lightly on capital but not on human capital. We emphasize labor but not the changing role of women in the workplace. We discuss the impact of population aging on the economic security of seniors but do not explicitly model how policy reform might respond to demographic change and influence economic outcomes. Important research on these and other topics is typically carried out at the national level, but with implications for global outcomes. The research presented here provides a baseline for considering global change and identifying important ways population may contribute to and interfere with economic progress.

1. The era of population driven economic growth is ending

The “demographic transition” is the movement of a population from high fertility, high mortality and a young age distribution to low fertility, low mortality and an old age distribution, a process that can take a century or two. The middle stage of the global demographic transition fuelled global GDP growth, total and per capita, because the working age population grew more rapidly than of the total population (Bloom and Canning 2001). According to Table 1, between 1950 and 1975 population growth was very high at 1.92% per year and, because it was concentrated among children, higher than the growth of effective labor. Population growth was lower for 1975 and 2000, but global effective labor grew at 2.21% per year, .56% per year faster than total population. Between 2000 and 2020, effective labor continued to grow more rapidly than population. Looking forward, the global effective labor force will grow much more slowly than in the last seventy years and more slowly than population for the first time since 1950-1975.

The calculations in Table 1 were first done for each of the 186 individual countries so they reflect the geographic distribution and heterogeneity of the global population and their changes over time. Effective labor (L) is calculated for each country by multiplying its labor income profile by its actual or projected population at each age and then summing. These country L's are then summed to find global effective labor. Similarly, GDP growth calculations depend on labor productivity in each country, and global GDP growth is derived from these.

Table 1. Growth rates for Global Aggregates in percent.

	Annual growth rate (Gr)					Gr(wL)/ Gr(GDP)
	Population	L	$w_b L$	GDP	Productivity	
	(A)	(B)	(C)	(D)	(E)	(F)
1950-75	1.92%	1.65%	1.27%	4.65%	3.34%	0.27
1975-00	1.65%	2.21%	1.80%	3.20%	1.38%	0.56
2000-20	1.20%	1.44%	1.14%	3.58%	2.42%	0.32
2020-60	0.66%	0.62%	0.23%	2.65%	2.42%	0.09

Notes: All global aggregates are based on values for 186 economies. Population data from UN (United Nations Population Division 2019). L is effective labor force. $w_b L(t) = \sum_j w_b(j) L(j,t)$ is effective labor in economy j in year t weighted by productivity, $w_b(j)$, measured as GDP per effective worker, in economy j in 2010. GDP from 1960 to 1999 from Maddison(Maddison 2001), from 2000 to 2018 from World Bank(World Bank 2019), and 2019 to 2060 based on growth rate of $w_b L$ plus assumed continuation of 2.46% productivity growth (SI). Column F is the ratio of C to D, the share of GDP growth accounted for by growth of weighted effective labor.

The effect on GDP of growth in effective labor depends on where effective labor is growing. The impact of place j is incorporated using economy-specific weights, GDP per effective worker in 2010 denoted $w_b(j)$. Combining age and place, $w_b(j)L(j,x,t)$, the impact on global GDP growth of demographic change is lower than population growth for two reasons. First, effective labor is growing at about the same rate, slightly lower, than population. Between 1975 and 2020, effective labor grew much more rapidly than population because population growth was concentrated at ages with high standardized, labor income. This is no longer the case. Compare columns (B) to (A). Second, growth is concentrated in lower income economies and, hence, growth of productivity-weighted effective labor is less than growth of effective labor (compare column (C) to column (B)). For the next 40 years $w_b L$ is projected to add only 0.23%/y to GDP growth as compared with 1.8%/y for 1975-2000. Only 9% of future GDP growth is projected to be due directly to demographic change as compared with 56% during 1975-2000 (column F). The era of global GDP growth fueled by population numbers is coming to an end.

GDP growth rates and the size of the economy are important for at least two reasons. First, they are critical in determining carbon emissions. Demography is an important driver of both growth and size, and its influence at the global level is better measured by productivity-weighted effective labor than by population size or by effective workers *L*. The estimated elasticity of carbon emission with respect to population growth, which is imprecisely estimated as unity in both high income (HI) and developing economies, should apply for productivity-weighted effective labor (Bongaarts and O'Neill 2018; Liddle 2015). The sharp drop in the growth rate of $w_b L$ should translate roughly into a one-for-one drop in growth of emissions. The second reason is that slower anticipated growth of GDP may discourage investors, reducing aggregate demand and potentially contributing to secular stagnation (Keynes 1937; Rachel and Summers 2019).

2. Prime-age adults are being squeezed by population aging.

On average per capita consumption is higher for prime-age adults than for children and seniors. In countries with older populations, however, per capita consumption for seniors is higher than per capita consumption for prime-age adults. Moreover, children living in aging countries also appear to gain, in terms of per capita consumption, relative to prime-age adults. Apparently aging has not led to a generational divide, pitting the old against the young. However, with population aging prime-age adults are being squeezed by a shift in resources to both the young and the old. The connection between aging and generational distribution of consumption is charted for 186 economies in Figure 2 (reduced in size).

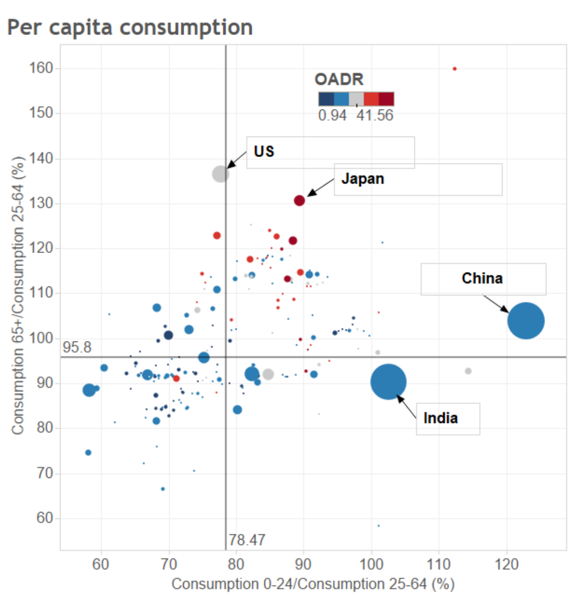

Figure 2. Per capita consumption for children (0-24) and the elderly (65+) as a percentage of values for those in the 25-64 age group, 186 economies, circa 2010, classified by Old Age Dependency Ratio (OADR) (color code) defined as the ratio of the population age 65+ to the population age 25-64. Size of bubbles varies with total effective labor of each economy in 2010.

Consumption for youth and elderly fall into four quadrants defined by median value lines. Older economies (red) fall mostly in the Northeast quadrant (relatively high consumption for both children and seniors), amplifying the economic effect of aging. The US, not yet very old, falls between the Northwest and Northeast quadrants where consumption by children falls at the median global value while consumption by seniors is astronomically high. In India and especially China consumption by children is very high possibly because child dependency has dropped to low levels while old-age dependency has not yet increased.

5. Population aging, viewed from an economic perspective, is accelerating sharply in high-income and upper-middle-income countries.

The economic impact of population aging depends on the costs and contributions of seniors that vary considerably from country to country. Data on the lifecycles can incorporate important information about the consumption by children and seniors and the economic value of their labor (Mason et al. 2017; United Nations Department of Economic and Social Affairs: Population Division 2019).

Here we will use a new measure, the *old-age gap*, defined as consumption in excess of labor income for those 65 and older. Then the old-age gap ratio (OAGAP) expresses that gap as a ratio to aggregate labor income. An OAGAP of x% indicates that a flat tax on labor income of x% would be required to fund the needs of seniors that are not met by continuing to work, ignoring potential use of asset income. The OAGAP improves on the old-age dependency ratio because the costs and contributions of older adults vary considerably across countries, over time, and in response to changes in public policy.

High consumption and low labor income at older ages in high-income economies amplify the effects of population aging. In middle-income and low-income countries, the OAGAP is only about half the OADR in 2019, but in high-income countries it is three quarters (not shown).

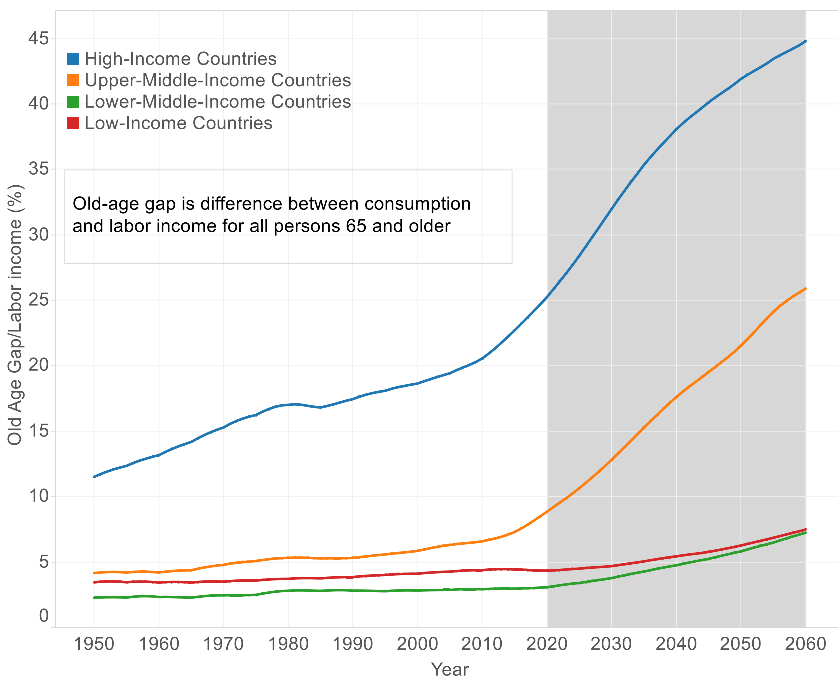

Figure 5. The OAGAP as a percentage of labor income, 1950-2060, four income groups (reduced in size).

Until recently aging has been concentrated in high-income economies, where the OAGAP increased by 13 percentage points since 1950 to reach 24.7 percent in 2019 (Figure 5). More recently the OAGAP has accelerated sharply in high-income countries and is projected to reach 44.8% in 2060. Aging is also beginning to accelerate in upper-middle-income countries with the OAGAP projected to increase from 8.5% in 2019 to 25.9% in 2060. In lower-middle-income and low-income countries, economic aging will be modest for the foreseeable future.