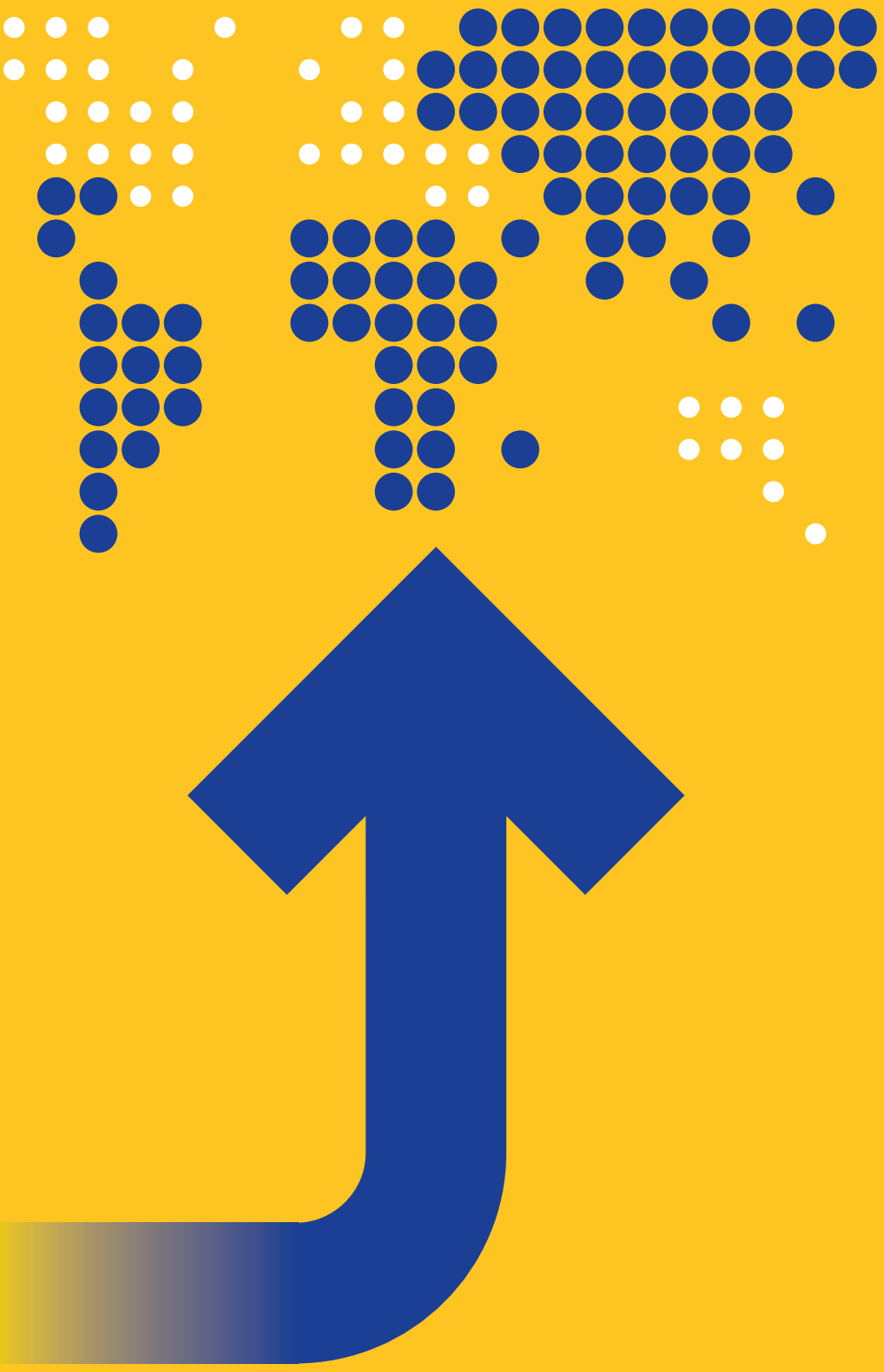


OCTOBER 28-30, 2018

TOKYO, JAPAN

EMERGING MARKETS FORUM

2018 GLOBAL MEETING

How Aging Societies May Affect Global Growth Prospects

Claudio Loser,
Jose Fajgenbaum,
Harpaul Alberto Kohli, and
Ieva Vilkelyte

Background Paper

Emerging Markets Forum
A nonprofit initiative of the Centennial Group

How Aging Societies May Affect Global Growth Prospects[1]

Executive Summary

Over the next few decades, the United Nations (UN) has projected that the world will experience significant demographic shifts due to lower birth rates and longer lifespans.[2] The world's population aged 65 and above will increase from 12 percent today to 16 percent in 2050, doubling the old-age dependency ratio[3] to 25.2. These demographic shifts would have material implications. Population aging, and its dynamics will influence a number of economic variables and behavioral responses, particularly economic growth, productivity, labor force participation, consumption choice, personal savings and thus investment, and public finances. Population aging is unavoidable, but public policies, technological advances, and behavioral responses may limit some of its adverse effects.

The key implications of population aging identified in this paper include:

- *Annual growth of GDP and GDP per capita for the world and most country groups would be lower under the baseline scenario than under any of the assumed scenarios*. Indeed, under these scenarios world GDP would grow between 0.06 and 0.5 percent a year faster than under the baseline, implying that GDP would be between 1.5 and 19 percent higher by 2050. Similarly, world GDP per capita would grow between 0.01 and 0.12 percent faster than under the baseline scenario, implying that world GDP per capita would be between 1.1 and 6.4 percent higher in 2050. However, under the counterfactual population growth scenarios (with constant age structures[4] and different assumptions about annual population growth[5]) it is possible to see the importance of the age structure prevailing in the base period (later referred to as initial conditions) for the projection period. GDP per capita would grow slower than under the baseline in most emerging market and developing regions, particularly in Sub-Saharan Africa, where GDP per capita could be as much as 15 percent lower than under the baseline in 2050.
- *The declines would be greater in countries with significant population aging.* This goes beyond the impact of a changed age structure of the labor force. While this paper does not directly address individual countries, these outcomes could be central to understanding why countries with falling growth rates—or even actual reductions—in population and labor force, have seen a decline in GDP growth. Japan, some European countries, and possibly China and Russia among others may fall in this category and may require further analysis.
- *Higher growth rates in the labor force in certain regions cannot be expected to compensate for the declines in other regions*. Specifically, lower labor productivity and problems with the absorption of the increased labor force in Sub-Saharan Africa, compared to regions where labor force growth is decelerating sharply, would possibly result in a sharper decline in the rate of growth globally. The growing barriers to peoples' movements between regions would further complicate this outlook.
- *Personal savings as a ratio to GDP would be expected to decline, although at varying rates depending on the initial conditions and the aging process.* If the personal propensities to save by age group remain in the United States as in 2015, the personal savings pool would increase slightly

1. This paper is a revision of an earlier version and includes higher personal savings rate estimates, and alternative scenarios with constant growth rates in population globally and in all regions.
2. It should be noted that long-term projections of the size and age composition of the population are subject to considerable uncertainty, and that the estimates presented here are lower bounds of the prospects for the next decades.
3. Ratio of population aged 65 and above per hundred population aged 15 to 64.
4. Either population grows at the pace predicated by the UN or at the average rate of the last five years. The results will be different if the estimate is based on historical rates of growth for each age category, as the ratio of the labor force to capital would decline, and thus would per capita income.
5. Under which the age and gender composition of the population and the labor force participation rate in 2017 remain unchanged, but the population grows at the rate observed in 2013-17.

as a proportion of GDP,[6] over the period of the projections (2018-2050) but could be expected to decline subsequently. In the case of the European Union (EU), the pool of personal savings would decline as a proportion of GDP. Other studies suggest that China, India and Japan will show a pattern similar to that of the EU. Moreover, the global economy will show the same pattern. Even if corporate and public savings remain as in the baseline, the slower growth of personal savings and higher real wages could well lead to rising real interest rates and therefore slowing investment growth. This, in turn, would lead to weaker growth of GDP than otherwise, with a potential vicious cycle of slower growth of GDP, savings, and investment.

- *An increase in the rate of participation of older workers, other things equal, would help raise the rate of per capita GDP growth.* However, the increase in the participation rate of older workers and the resulting increase in output will not be enough to compensate for an increasingly smaller relative labor force of younger workers in today's advanced countries but will be sufficient to offset the aging effect in emerging economies (to the extent that productivity of labor increases). Of course, if personal savings declines in terms of GDP, the total impact of increased labor force participation by older workers will be smaller—GDP per capita would only be 3 percent higher than in the baseline scenario (i.e., no increase in participation).
- *GDP growth would likely decline as the consumption basket of an aging population shifts toward services.* As the composition of spending (and thus output) of an aging population shifts toward services, a significant decline in total factor productivity can be expected. Productivity of the service sectors has been considerably lower than that of other sectors. This paper estimates that, in the absence of important technological changes in the service sectors and with lower savings, the annual rate of GDP growth would decline by about half of a percentage point.
- *The effect of an aging labor force on per capita GDP7 vvaries among different regions.* This effect is particularly strong in the European Union and in Emerging Asia (declines of 0.3 and 0.1 percent a year, respectively). Latin America shows no decline. However, the impact of lower labor productivity appears to be somewhat stronger in the case of Latin America than in other regions. Finally, the impact of an increase in labor force participation by those aged 65 and above is more pronounced in Sub-Saharan Africa. This region shows an increase of 0.4 percentage points, as the region has labor force dividends before the lower fertility impacts the labor force.
- *Growing aging-related outlays are expected to raise fiscal deficits considerably.* The estimated steady increase, to a cumulative 5 percentage points of GDP by 2050, is likely to drive public debts to unsustainable levels. It is noteworthy that this fiscal problem is of a larger magnitude, as a proportion of GDP, in the case of emerging and developing economies because they face a more rapid aging process than the advanced economies, which are already confronting the impacts of aging. Clearly, the deterioration in public finances, if not addressed, would have dire consequences.
- *The well-being of the world is highly dependent on the rate of investment and technological advances.* If these falter, the situation would look more precarious.

While the driving forces of population aging are here to stay, a multi-prong policy response can ameliorate their effects. Such a policy response would include:

- *Addressing some of the driving forces of population aging.* This could include encouraging higher fertility in certain countries and regions, and facilitating immigration to aging countries or regions, as this would increase young workers and give aging countries time to adjust.
- *Encouraging and facilitate elderly and female labor force participation*. This should include removal of mandatory retirement ages, facilitation of part time work, elimination of mandatory withdrawals from retirement accounts, and establishment of conditions for women to increase their participation in the labor force, such as the provision of child care facilities.
- *Encouraging personal savings.* This should include an educational campaign to promote savings and simplify rules on retirement accounts. This would induce individuals to accumulate higher savings

6. US Bureau of Labor Statistics estimates of savings. This result has been revised from the previous version, which showed a decline under the assumption that the level of savings per capita for each age bracket remained constant in real terms, and not as a ratio to GDP.
7. Relative to a constant ratio of workers aged 65 and above to workers aged 25 to 64.

for retirement and, in turn, increase investment and economic growth relative to the baseline. It should be noted that governments have a stake in encouraging saving for retirement, as this would reduce elderly dependence on public programs.

- *Encouraging an environment that significantly promotes enhancement of technology and innovation.* This is of the essence to continue to improve living standards all over the world or, as a minimum, to help preserve the gains observed in per capita income in recent decades. Without technological improvements, even the current levels of income cannot be guaranteed.
- *Improving the skills of new workers in Africa, as most of the growth in the labor force will take place there*. One of the most urgent and likely difficult challenges will be the buildup of the human capital required to fulfill the continent's potential in the aging environment. To this end, an effective education system will need to play the central role. However, the region has lagged others in this regard. Even among the most advanced countries of the region, the quality of education is defective, and needs considerable improvement.
- *Taking the difficult but necessary measures to avoid unsustainable fiscal situations.* These measures should include strengthening public pension plans through a combination of extending retirement ages and increasing contributions, reducing aging-related spending, raising revenue, and improving the efficiency of non-aging related spending. In the absence of these measures, fiscal crises would be unavoidable, with devastating consequences.

In addition to the issues elaborated in the paper, panel discussants may want of focus on the following issues on Aging and Growth as well.

Several issues arise in relation to the impact of the actual and prospective aging of the population and work force for most regions in the world. Some of these issues are presented below. Clearly, this list is only an enumeration and is not meant to restrict the areas of discussion.

Countries that are at a point of virtual stagnation or actual decline in population (e.g. China, Japan, some European)

- What are the lessons for ageing countries that can be drawn from the experience of those societies that are already facing the problem?
- How technology has contributed or can contribute to solve the problems arising from aging beyond the general improvements in factor productivity?
- While the clear conceptual view is that people should relocate from "surplus" countries to areas with falling rates of growth or of levels of the labor force, is this a viable approach?

Emerging Countries/Africa

- Some emerging market and developing economies are aging at a relatively early stage of development. Are these countries destined to remain under-developed? Can new technologies help them leapfrog and advance in the short time frame they have before aging sets in?
- Africa is the major exception to the aging trend in the world. Will the region be able to take advantage of this exceptionally advantageous position and provide the needed manufactures and services to the aging world?
- If the prospects for the point above are poor, what should be the plan of action to ameliorate the effects of aging in the rest of the world?

Aging and Inequality

- What can be done to deal with the emergence of serious inequality issues among generations, and more specifically an increased tilt of income toward older generations and away from the young?

Awareness Development, and Multilateral Cooperation

- Is there an appropriate level of awareness of the aging process and its effects among countries not yet affected but likely to be hit by aging within the period of one generation? What can be done to raise such awareness?
- Is there a role for multilateral institutions in addressing the aging issues discussed in the paper?

A Global Initiative on Aging?

In view of the global nature of the aging phenomenon, its considerable importance, and the relatively little awareness of the aging process and its multiple effects, would it not be appropriate to launch a worldwide initiative (or forum) that helps policy-makers become cognizant of aging issues and learn from other countries' experience on how to address them. If so, how should this initiative be framed? Should a global institution take on this responsibility or should it be an institution like the G20? There is a clear advantage of having global gatherings (best way to learn from others), but how often should these gatherings be? Perhaps every 3-5 years?

How Aging Societies May Affect Global Growth Prospects

Claudio Loser, Jose Fajgenbaum, Harpaul Alberto Kohli, and Ieva Vilkelyte

I. Introduction

One of the megatrends identified in *The World in 2050* is the aging of the world's population.[1] Some of the consequences of this phenomenon were presented in that study, to the extent that labor force growth reflected the population growth projected by the UN[2] and some increased labor force participation by the elderly.

This paper seeks to identify more specifically how the aging phenomenon is affecting, and is likely to affect, economic developments, particularly GDP growth,[3] relative to the central scenario presented in *The World in 2050* (the baseline scenario for this paper). Clearly, a key aspect of how aging affects future growth derives from the considerable changes in the demographic structure of the population, due to both lower birth rates and longer lifespans. Indeed, the share of the world's population aged 65 and above is projected to increase from 12 percent today to 16 percent in 2050, according to the medium variant of the UN population projections.[4] The global old-age dependency ratio (population aged 65 and above per hundred population aged 15 to 64) would double to 25.2 by 2050, led by the rapid aging of the population in emerging and developing countries.

Other important aspects of aging discussed in this paper include:

- Older cohorts of the population tend to work longer than in the past. This has been noticeable in the US, especially in the cases of workers enjoying their job, managers, professionals, and workers in other non-strenuous activities.
- As these cohorts become a larger share of the population, they induce a shift in the population's consumption basket toward services.
- Aging affects future growth of personal (and national) savings and investment.
- Aging places pressure on public finances because of growing spending on aging-related programs (such as pensions and health).

This paper by no means is comprehensive or seeks to provide answers for all issues related to aging. It does not address potential positive consequences for welfare resulting from shrinking populations. Indeed, the population growth rate of the past, i.e., population doubling every 35 years or so, is unsustainable. In this regard, an aspect of great significance, but not discussed here, is that easing population pressure helps to contain the use of energy and fossils fuels, benefiting the environment. It also helps increase investment in people, promising inclusive growth and higher living standards.

This paper follows two complementary methodologies: several econometric exercises, based on historical data, which help isolate specific aspects of aging, and the Centennial growth model, with all the complexities and interactions that it entails. Despite the latter, the two methodologies show outcomes that are consistent in terms of the direction of change, and broadly similar in terms of the range of results. Conceptual analysis of some aspects of aging that are likely to have significant effects on economic growth, if not addressed in a timely manner, complements this work.

Nevertheless, while elaborating on the potential effects mentioned above and some appropriate policy responses, more thorough and specific analysis of the consequences of aging on different regions and countries is certainly needed. The authors are aware of the need for further study to understand these consequences more fully, to quantify them, and to formulate specific plans of action.

This paper has benefited from the extensive literature on the behavioral responses associated with aging, briefly summarized in Box 1.

1. Kohli, Harinder, *The World in 2050*, Oxford, 2016.
2. The 2015 Revision of the UN World Population Prospects.
3. The aging phenomenon reflects a shift in the global age structure resulting from a combination of decline in fertility rates and an increase in life expectancy.
4. The medium variant is used for the analysis throughout this paper.

Box 1: Behavioral Responses to Demographic Changes

Considerable amounts of research have focused on the behavioral aspects of demographic changes and the associated government policy adjustments. This box summarizes some of these research efforts.

- Increases in life expectancy could encourage individuals to stay in the workforce longer or induce governments to increase labor force participation of older-aged cohorts. However, despite a significant increase in life expectancy, in most OECD countries the increase in the effective retirement age has been modest (Bloom et al. 2010).
- Population aging could have an impact on labor productivity, although the evidence suggests that an older labor force is not necessarily more—or less— productive (Burtless 2013; Maestas, Mullen, and Powell 2014).
- Increased life expectancy could also encourage higher savings during the working life in order to finance a longer retirement period (Bloom et al. 2003). The consequent lower interest rates (Kulish et al. 2006) could encourage capital accumulation. However, this effect may be more than offset by dissaving by the elderly (Lee et al. 2010), depending on their share in population.
- The decline in birth rates could encourage higher female labor force participation (Bloom et al. 2007) but unleashing the full potential would require a comprehensive set of policies to support and promote female employment (Elborgh-Woytek et al. 2013).
- Labor supply could increase as a reaction to possible wage increases resulting from labor scarcity (Dolls et al. 2015). However, the decline in population could also reduce aggregate demand for goods and services, which, in turn, could lower the demand for labor.
- Lower birth rates could increase investment in human capital, raising labor productivity, which could more than offset the potential loss in output from the decline in population size (Lee and Mason 2010).
- International capital flows could be affected, with capital flowing from countries with older populations to countries with younger populations (Borsch-Supa, 2002).
- The capacity to innovate could change with aging. Empirical evidence points to an inversely U-shaped relationship with the highest performance shown between ages 30 and 50 (Frosch 2009).
- The political behavior of an aging electorate could reshape policies to favor the interests and needs of older populations (Peterson 1999) or lead to replacement migration policies (Tyers and Shi 2007).

II. Alternative scenarios on how aging is affecting and is likely to affect economic developments in the future

This paper addresses this issue by studying a number of effects of aging and quantifying them to the extent possible by i) applying the results of regression analysis to the baseline scenario growth estimates, under different assumptions; ii) applying the Centennial growth model to the baseline scenario growth estimates, under similar assumptions; and iii) conceptually analyzing some aspects of aging that are likely to have significant effects on economic growth if not addressed in a timely manner.

Regression analysis and alternative scenarios on how aging affects growth

To analyze the effect of labor force aging—older workers' participation in the labor force—on output, this section explores the relationship between the growth of two age groups of the working population (those aged 65 and above and those aged 25 to 64), the growth of labor productivity, and the growth of output. The analysis is based on econometric exercises using data for the world and for different country groups and regions during the period 1990-2016. The results of the regressions are used to develop different scenarios for the period up to 2050. Clearly, the scenarios are of general and thus tentative nature. Even so the results of these scenarios are sobering.

The main findings of the regressions are:[5]

- Output per worker falls as the share of those aged 65 and above in the employed work force increases, consistent with studies that show a decline in productivity with aging;
- Output per worker would also tend to decline if population growth is the same as in the baseline scenario and the age structure remains as in the last five years, assuming that the ratios of savings and investment to GDP remain stable.
- Output grows as the labor force participation rate of those 65 and above increases,[6] partly offsetting the just mentioned fall; and
- Declines in the savings and investment ratios to GDP and in the growth in Total Factor Productivity (TFP), as described elsewhere in the paper, would have a negative effect on the rate of growth of GDP.

5. The regressions are run in logs; thus, the coefficients provide rates of change.
6. Labor force participation by the elderly in the US bottomed out and started to rise 20 years ago. The wealthiest individuals seem to find it easier to work longer, and have a much lower propensity to spend what they earn.

Table 1: Regression results for GDP growth (log form)

	World	Advanced countries	Emerging and developing countries	European Union	Latin America & the Caribbean	Sub-Saharan Africa	Emerging and Developing Asia	Middle East & North Africa
Intercept	0.002	-0.002	0.003	-0.002	0.003	0.002	0.003	0.010
Employed 65 + 1/	0.047	0.031	0.099	0.007	0.003	0.244	-0.024	-0.040
Employed 25-64	0.678	0.982	0.663	1.128	0.801	0.881	0.838	1.084
Output per Worker	1.116	0.860	1.057	0.745	1.096	0.824	0.984	0.536
R^2	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.996

1/ Low T value
Source: UN, ILO, IMF and Centennial estimates

The following equation is used for the regressions:

$$Log\ GDPt = A + B\ log\ EL(65+)t + C\ log\ EL(25-64)t + D\ log\ (GDP/W)\ t \quad (1)$$

Equation (1) indicates that GDP is a function of the employed labor force aged 65 and above (EL65+) and aged 25-64 (EL(25-64)),[7] and output per worker (GDP/W). The latter is a conceptual second best to having two separate variables: (i) capital intensity per worker and (ii) TFP, which are not available systematically. The use of output per worker in the regression reflects the fact that data for this variable are available for the different groups of countries, while data for TFP are available only for selected areas.

Based on these results, Table 2 below shows five alternative stylized scenarios for the period through 2050:

- The first scenario is the baseline (the central scenario of The World in 2050), which is based on the medium variant of the UN projections for population growth and labor force participation. In the baseline scenario, it is assumed that labor productivity grows at an annual rate of 1.9 percent. This is consistent with TFP growth of 1 percent. Capital intensity is also assumed to increase.
- The second scenario assumes that the participation rate among workers aged 65 years and older rises gradually to reach an increase of 50 percent with respect to the baseline, namely from 21 to 31 percent.
- The third scenario assumes that the age structure of the last five years is maintained through 2050, and that population grows at the rate envisaged in the baseline scenario.
- The fourth scenario also assumes that the age structure of the last five years is maintained through 2050 but that population grows at the rate of the last five years.
- The fifth scenario shows a decline in the rate of growth of labor productivity, namely a decline in the rate of growth of output per worker of 0.5 percentage point associated with a shift in output composition toward services. This scenario also assumes lower ratios of savings and investment to GDP, and that there is no change in the population from 2017.
- In all cases, output per worker is adjusted down (up) when the labor force grows faster (slower) than in the baseline scenario because a rise (fall) in the ratio of labor to capital leads to a decline (increase) in marginal productivity of labor as well as wages.

Table 2 shows the average annual growth rates of GDP and GDP per capita under the different scenarios for the world, advanced economies, emerging and developing economies, and several regions during the period 2017-50. Appendix 2 provides greater detail for each scenario on the average annual growth rates of GDP and GDP per capita for 2020, 2030, 2040, and 2050, based on the estimates of employed people aged 65 and above, employed people aged 25-64, and output per worker.

Several main trends can be derived when comparing the various scenarios:

- The average rate of GDP growth for the world and each group of countries declines as population ages. GDP per capita will continue to increase but at declining rates. However, capital and technology accumulation do not depend directly on the labor force. Thus, ceteris paribus, with faster rates of growth of the labor force, output per worker will decline, and so will per-capita income growth in most circumstances.
- An increase in the participation rate of older workers, other things equal, would help increase the growth of GDP per capita relative to the baseline scenario. However, the increase in the participation rate of older workers and the resulting increase in output will not be enough to compensate for

7. Implicitly, this includes the debatable assumption that the rates of unemployment for the two age groups are the same.

Table 2: GDP and GDP per capita as a function of labor force and output per worker

	Average GDP per capita Growth (2017 to 2050)	Average GDP Growth (2017 to 2050)
World		
Baseline Scenario	2.62%	3.51%
Gradual increase in 65+ labor force participation	2.69%	3.59%
65+ to 25-64 employed ratio constant	2.61%	3.50%
Population grows at 5-year historical rate	2.40%	3.67%
Baseline Scenario with output per worker growth 0.5% less	2.06%	2.95%
No change in population from 2017	3.05%	3.14%
Advanced Economies		
Baseline Scenario	1.43%	1.62%
Gradual increase in 65+ labor force participation	1.47%	1.67%
65+ to 25-64 employed ratio constant	1.49%	1.69%
Population grows at 5-year historical rate	1.52%	1.93%
Baseline Scenario with output per worker growth 0.5% less	1.00%	1.19%
No change in population from 2017	1.72%	1.71%
Emerging and Developing Economies		
Baseline Scenario	3.44%	4.35%
Gradual increase in 65+ labor force participation	3.58%	4.49%
65+ to 25-64 employed ratio constant	3.32%	4.23%
Population grows at 5-year historical rate	3.33%	4.60%
Baseline Scenario with output per worker growth 0.5% less	2.91%	3.81%
No change in population from 2017	3.73%	3.75%
European Union		
Baseline Scenario	0.92%	0.92%
Gradual increase in 65+ labor force participation	0.93%	0.93%
65+ to 25-64 employed ratio constant	1.00%	1.00%
Population grows at 5-year historical rate	1.11%	1.25%
Baseline Scenario with output per worker growth 0.5% less	0.56%	0.55%
No change in population from 2017	1.34%	1.37%
Latin America and the Caribbean		
Baseline Scenario	2.39%	2.98%
Gradual increase in 65+ labor force participation	2.39%	2.98%
65+ to 25-64 employed ratio constant	2.42%	3.01%
Population grows at 5-year historical rate	2.20%	3.30%
Baseline Scenario with output per worker growth 0.5% less	1.76%	2.35%
No change in population from 2017	2.55%	2.53%
Sub-Saharan Africa		
Baseline Scenario	3.13%	5.45%
Gradual increase in 65+ labor force participation	3.47%	5.80%
65+ to 25-64 employed ratio constant	3.14%	5.46%
Population grows at 5-year historical rate	2.98%	5.39%
Baseline Scenario with output per worker growth 0.5% less	2.71%	5.03%
No change in population from 2017	2.50%	2.48%
Emerging and Developing Asia		
Baseline Scenario	6.38%	6.81%
Gradual increase in 65+ labor force participation	6.35%	6.77%
65+ to 25-64 employed ratio constant	6.52%	6.94%
Population grows at 5-year historical rate	6.31%	7.27%
Baseline Scenario with output per worker growth 0.5% less	5.89%	6.31%
No change in population from 2017	6.63%	6.62%
Middle East and North Africa		
Baseline Scenario	0.84%	2.17%
Gradual increase in 65+ labor force participation	0.77%	2.11%
65+ to 25-64 employed ratio constant	1.05%	2.39%
Population grows at 5-year historical rate	1.21%	3.17%
Baseline Scenario with output per worker growth 0.5% less	0.57%	1.90%
No change in population from 2017	0.85%	0.91%

Source: Centennial-Group. See Appendix Table A1.2 for further details.

the decline in output due to an increasingly smaller labor force of younger workers in the advanced economies. But GDP growth would be higher in the emerging and developing countries, particularly in Sub-Saharan Africa, and, for some time, in Latin America and the Caribbean, because of the demographic dividend.

- The well-being of the world will be highly dependent on the rate of investment and advances in technology. If these falter, the situation would look more precarious.
- As noted above, the aging-related shift in the composition of spending (and thus output) toward services is likely to result in a significant change in TFP and therefore economic growth (see section "Composition of consumption basket and output"). If GDP per worker were to grow at a rate of 1.4 percent a year as opposed to the 1.9 percent assumed in the baseline scenario, the annual rate of growth of GDP would decline by about one half of a percentage point.
- The stylized scenarios provide further support to the adverse effect of aging on output but not on a general basis. Specifically, if the current age structure were maintained, even with the same rate of growth assumed for the baseline scenario, GDP growth for aging regions would have been higher than in the baseline, reflecting higher productivity of the age group below 65. However, in regions where aging of the labor force is not occurring, like in Sub-Saharan Africa, the reverse would be the case.
- If the rate of growth of population and the labor force and their structure were to be the same as during the last five years, the annual rate of growth of GDP would be higher than in the baseline scenario, but GDP per capita would be lower because of lower marginal productivity. If the labor force were to increase relative to total population (as in Sub-Saharan Africa), the opposite would be true.
- The effect of aging of the labor force on GDP per capita, relative to a constant ratio of workers aged 65 and above to workers aged 25 to 64, is particularly strong in the European Union and Emerging Asia (a decline of 0.6 percentage points a year). Latin America and the Caribbean shows a decline of 0.4 percentage points and the opposite is the case for Sub-Saharan Africa. However, the impact of an increase in labor force participation for those 65 and above is more pronounced for the Sub-Saharan region. Finally, the impact of lower labor productivity appears to be somewhat stronger in the case of Latin America than for other regions.

Centennial growth model and scenarios on how aging affects growth

The Centennial growth model provides a broad and versatile tool to analyze in detail different scenarios, on the basis of the different assumptions applied in the previous section. It therefore helps compare the baseline scenario A (which is the central scenario presented in The World in 2050, and is based on the UN medium variant of population growth) with the following scenarios in terms of average growth rates of GDP, GDP per capita, TFP, employment and capital for the world and various groups of countries during 2017-2050, as shown in Table 3. Scenario B modifies scenario A by assuming a higher labor force participation of those aged 65 and above; scenario C modifies scenario B by assuming lower personal saving; scenario D assumes that the age structure of the population will remain as in 2013-18 and that the population would grow at the same rate as in scenario A; and v) scenario E modifies scenario D by assuming that the population grows at the same rates as in 2013-18.

Figures 1 and 2 show the trajectory of per capita GDP growth rates for the world, advanced economies, and emerging and developing countries under the five scenarios discussed above. Appendix I provides information on GDP, and the behavior of growth for different regions. Figure 1 compares the baseline scenario with that increased participation for those +65, and the scenario with this increased participation and lower savings. Figure 2 shows the baseline scenario, and the counterfactuals of constant age structure and constant population growth with constant age structure.

These tables and figures present some noteworthy results for the annual rates of growth of GDP and GDP per capita over the period 2017 to 2050, for the various regions and under the five scenarios. For instance, scenarios B and C show that the higher labor participation of those 65 and above (with and without lower personal saving) would lead to higher annual growth of GDP and GDP per capita than in the baseline aging scenario A for all groups of countries. Similarly, scenarios D and E (counterfactual scenarios because they attempt to remove the effect of aging) show higher annual rates of growth of GDP

Table 3: Average growth rates, 2017-2050, for key indicators

	Baseline scenario (A)	Higher labor participation of those aged 65+ (B)	Higher labor participation of those aged 65+ and lower saving (C)	Constant age structure and pop growth as in Baseline (D)	Constant age structure and growth of pop (E)
GDP					
World	0.84	2.17	0.84	2.17	0.84
Advanced Economies	0.77	2.11	0.77	2.11	0.77
Emerging & Developing Countries	1.05	2.39	1.05	2.39	1.05
Sub-Saharan Africa	1.21	3.17	1.21	3.17	1.21
Latin America & Caribbean	0.57	1.90	0.57	1.90	0.57
Emerging Asia	0.85	0.91	0.85	0.91	0.85
Middle East & North Africa	0.84	2.17	0.84	2.17	0.84
GDP per capita					
World	2.38	2.49	2.44	2.50	2.39
Advanced Economies	1.56	1.66	1.57	1.83	1.79
Emerging & Developing Countries	3.06	3.17	3.14	3.12	3.04
Sub-Saharan Africa	2.56	2.59	2.62	2.17	2.06
Latin America & Caribbean	2.37	2.49	2.44	2.37	2.28
Emerging Asia	3.89	4.01	3.97	4.00	3.90
Middle East & North Africa	1.60	1.66	1.63	1.65	1.57
TFP					
World	1.50	1.50	1.50	1.62	1.60
Advanced Economies	1.18	1.17	1.18	1.15	1.16
Emerging & Developing Countries	1.89	1.90	1.90	2.01	2.01
Sub-Saharan Africa	1.17	1.15	1.17	1.24	1.20
Latin America & Caribbean	1.48	1.48	1.48	1.51	1.50
Emerging Asia	2.46	2.46	2.46	2.52	2.51
Middle East & North Africa	0.67	0.68	0.68	0.78	0.87
Employment					
World	0.85	0.96	0.96	0.80	1.28
Advanced Economies	0.01	0.15	0.13	0.35	0.64
Emerging & Developing Countries	0.98	1.09	1.09	0.87	1.38
Sub-Saharan Africa	2.82	2.90	2.89	2.26	2.73
Latin America & Caribbean	0.75	0.89	0.89	0.71	1.19
Emerging Asia	0.53	0.66	0.66	0.56	1.09
Middle East & North Africa	1.74	1.81	1.81	1.63	2.34
Capital					
World	3.33	3.40	3.25	3.41	3.62
Advanced Economies	1.84	1.94	1.64	2.02	2.19
Emerging & Developing Countries	4.17	4.24	4.14	4.21	4.46
Sub-Saharan Africa	5.40	5.38	5.44	5.14	5.30
Latin America & Caribbean	3.01	3.08	2.94	2.98	3.20
Emerging Asia	4.69	4.77	4.66	4.76	5.01
Middle East & North Africa	3.26	3.30	3.19	3.29	3.71

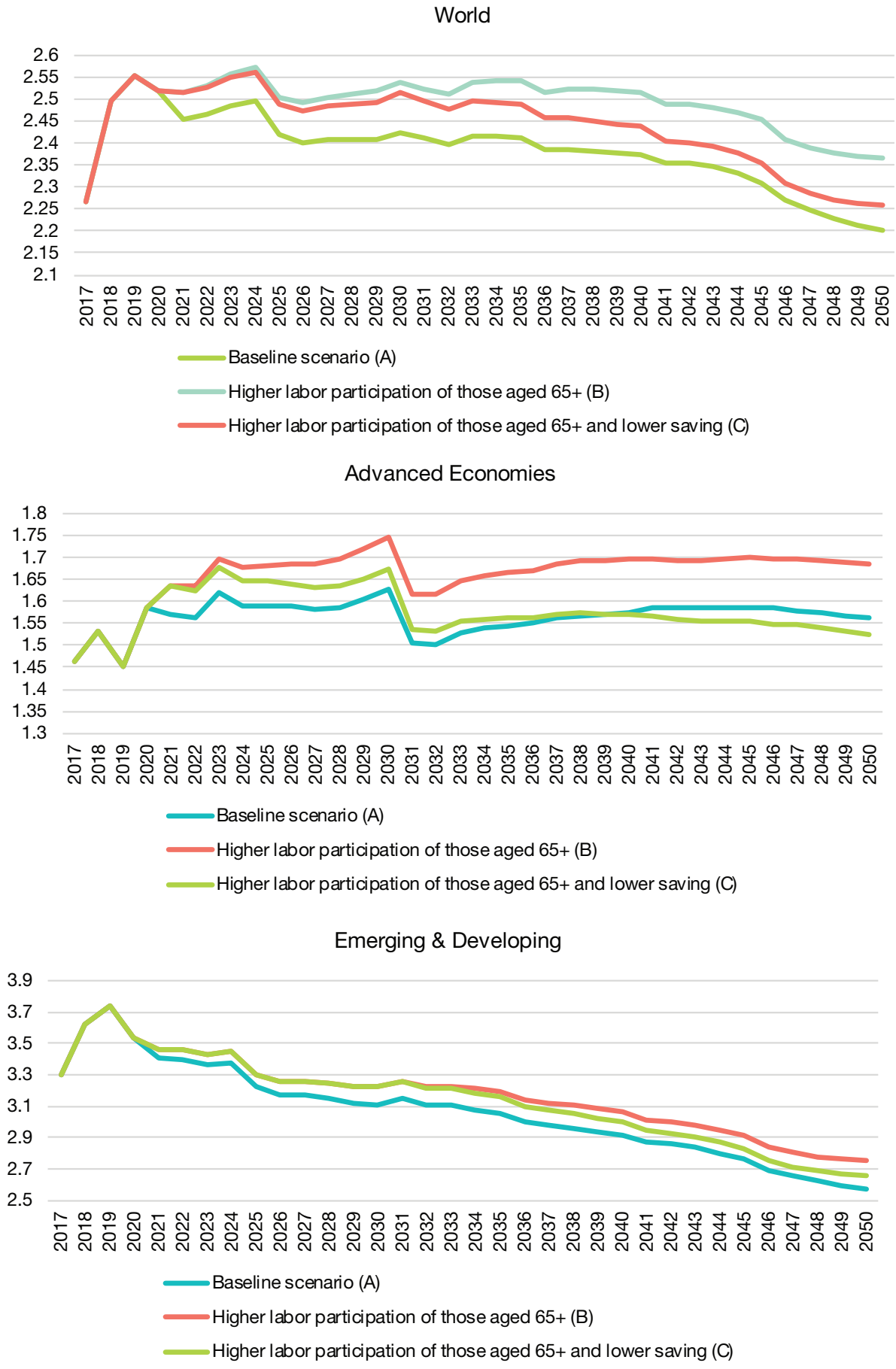
Source: Centennial-Group.

and GDP per capita in all groups of countries, except for Sub-Saharan Africa,[8] than in the baseline scenario.

As noted, several studies conclude that worker productivity declines after a given age, depending on the productive sector, and that such a decline has a negative impact on total productivity. While not disputing this

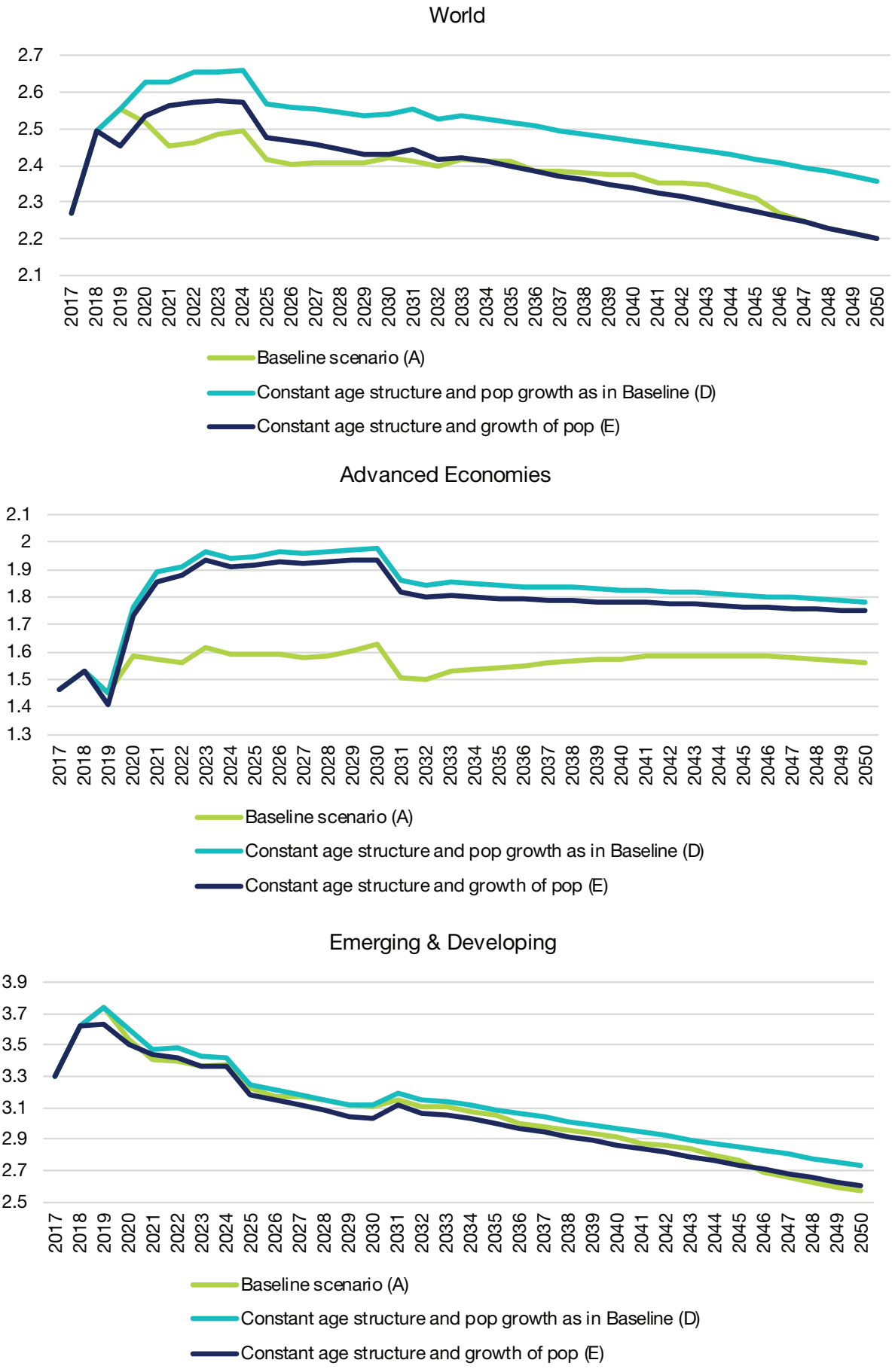
8. Latin America and the Caribbean would also show lower annual growth in GDP per capita in scenario E.

Figure 1: GDP per capita growth rates, baseline compared to Scenarios B and C



Source: Centennial Estimates.

Figure 2: GDP per capita growth rates, baseline compared to Scenarios D and E



Source: Centennial Estimates.

finding, this section seeks to assess the dynamic impact of an increase in the labor force participation rate of older workers on GDP growth, and confirm the findings derived above on the basis of regression analysis.[9]

The scenario assumes: i) the labor force participation of those 65 and above gradually increases to a level 50 percent higher than currently; and ii) the savings ratio to GDP (and thus investment ratio) gradually declines to a level that is 2.5 percentage points of GDP lower than in 2017 (see section "Savings and Investment"). This scenario shows an increase in the rate of annual growth of GDP over the baseline scenario, even with lower investment growth. For the world, the average annual growth rate in per capita income increases 0.06 percentage points, for a cumulative 3 percent increase. For advanced countries, the increase in labor force participation would effectively offset the decline in savings and investment, while for emerging and developing countries the increases would be 0.08 percentage points and 4 percent, respectively.[10] If the scenario is modified to include only the increased participation of those 65 and above, the exercise shows an increase in growth for the world, even though the effect would be either small or negative in the case of Asia and Sub-Saharan Africa.

A key observation that can be derived from this scenario is that even granting that older workers are less productive, their increased participation in the labor force would lead to increases in GDP and GDP per capita growth relative to the baseline, even as savings rates decline. As discussed in previous sections, the pure increase in the participation rate of the population aged 65 and above would have a significant effect on income per-capita.

The table demonstrates that different assumptions about the aging process could have significant diverging effects on global annual GDP and GDP per capita growth and therefore on cumulative global GDP and on GDP per capita by 2050.[11] For example, the counterfactual scenarios D and E show that world annual GDP growth would be 0.12 and 0.5 percentage points, respectively, higher than under the scenario A, implying a global GDP that would be 6 and 19 percent, respectively, higher by 2050. However, in terms of global GDP per capita, scenario D shows the same differences with the baseline scenario, while scenario E shows only marginal differences (6 and 1 percent, respectively).

But, Table 3 shows that these diverging effects on annual GDP and GDP per capita growth, and therefore on cumulative GDP and GDP per capita by 2050, depend heavily on the initial conditions of the aging process under the different scenarios. This can be seen when comparing the various groups of countries. For the advanced economies, all scenarios show higher annual rates of growth of GDP and GDP per capita than under the baseline scenario because the labor force increases at a faster rate. The annual growth rate of GDP would range from marginally higher in scenario C to 0.52 percent under scenario E; the latter would imply that GDP would be 17 percent higher than under scenario A by 2050. However, for the Sub-Saharan region the annual rate of growth would be lower by 0.4 and 0.05 percent lower under scenarios D and E, respectively, than under scenario A; the former would imply that GDP would be 12 percent lower than under scenario A by 2050.

But the relevance of the initial conditions for the projection period is more noticeable when comparing the outlook for annual GDP per capita growth under the various scenarios. While all scenarios show that annual GDP per capita would grow at a faster rate than the baseline scenario for the advanced economies and all emerging and developing countries, the reverse is the case for Sub-Saharan Africa under scenarios D and E because they maintain the population structure constant, and thus do not reflect the demographic dividend resulting from the incorporation of those initially below working age entering into the working force. Indeed, the cumulative effect of slower growth under scenario D and E would cause GDP per capita in 2050 to be as much as 12 and 15 percent, respectively, lower than under scenario A. Furthermore, GDP per capita in the countries in Latin America and the Caribbean as well as those in the Middle East and North Africa would also grow at slower rates under scenario E than under scenario A, for the same reason, causing GDP per capita to be 3 and 1 percent, respectively, lower by 2050.

These results confirm the findings derived from the regression analysis, although the numbers are marginally different because of the different methodology and somewhat different initial behavioral scenarios.

Table 3 also shows some interesting results. For example, TFP growth in the advanced economies would remain virtually the same under all scenarios, but that for the emerging and developing countries, particularly in the Middle East and North Africa, would be significantly higher than the baseline scenario. By contrast, employment growth would be higher under all scenarios relative to the

9. Other impacts of a higher labor force participation rate by older people are discussed below.
10. The annual growth rate increases would be 0.06-.07 percent for Sub-Saharan Africa and LATAM, and 0.8 percent in Asia, where the growth in the productivity of labor is higher.
11. Clearly, the demographic scenarios presented here are subject to considerable uncertainty.

baseline, except for scenario D. This lower employment growth reflects the lower rate of growth of the labor force under this scenario than under the baseline, and affects strongly Sub-Saharan Africa[12] and Latin America and the Caribbean. Table 3 shows that capital would grow faster under all scenarios[13] relative to the baseline, except for scenario D, where Sub-Saharan Africa and marginally Latin America and the Caribbean show weaker GDP growth than the other groups of countries.

III. Analysis of other potential effects of aging on GDP growth

Composition of consumption basket and output

A well-known fact is that as people get older their consumption basket shifts toward services. Thus, an aging population could lead to a change in the composition of aggregate demand, and as a result adjustments in output and the trade structure would mirror such a change. Because productivity and productivity growth of the services sector remain lower than those of manufacturing, agriculture, and other non-services sectors, a decline in an economy's growth may well be expected from a shift in the composition of output toward services.[14]

Indeed, recent studies show shift toward services. For instance, an IMF study suggests as much for high-income countries.[15] World Bank data show the relentless pace of growth of the share of services in world output over the last twenty years (including for all income groups—high, middle, and low) (Figure 3). Concurrently, the shares of industry and agriculture show considerable declines in all regions, except for the low-income countries where the shares of industry increased somewhat but stabilized more recently, while the shares of agriculture declined. Services already constitute about three quarters of GDP in the high-income countries, somewhat less than 60 percent in middle-income countries, and almost one-half of GDP in low-income countries.

The changes in the composition of output during 1995-2015 reflect considerable differences in TFP annual growth rates among sectors:

- For the U.S.,[16] the average annual TFP growth rates were 1.25 percent for agriculture, 1.03 percent for mining, 0.88 percent for manufacturing (of which durable manufacturing was 1.70 percent), 1.1 percent for trade and information, 0.5 percent for finance, and a dismal 0.17 percent for all other services (with education falling 0.57 percent).
- For the EU countries, information from the OECD shows that the annual TFP growth rates were 2.38 percent for industry (of which about 1 percent may have been contributed by an increase in capital intensity) and 1.27 percent for the services sector (with personal services declining 0.17 percent).

To illustrate the potential impact on future global growth of a shift toward services in the composition of output, and in the absence of global data on TFP growth rates for individual sectors, a decline in TFP growth of .41 percent is assumed (see Section II). This decline in TFP growth is based on two factors: i) the annual average rate of growth of the share of services in total output (0.5 percent) over the last twenty years (1995-2015), and ii) conservative assumptions based on the observations for the US and the EU about annual TFP growth rates for the non-services sectors (1.75 percent) and the services sector (0.665 percent).

Thus, the alternative scenario discussed above assumes that the TFP growth rate for the US--which determines the frontier growth of productivity--would decline, directly affecting the growth path for different groups of countries.

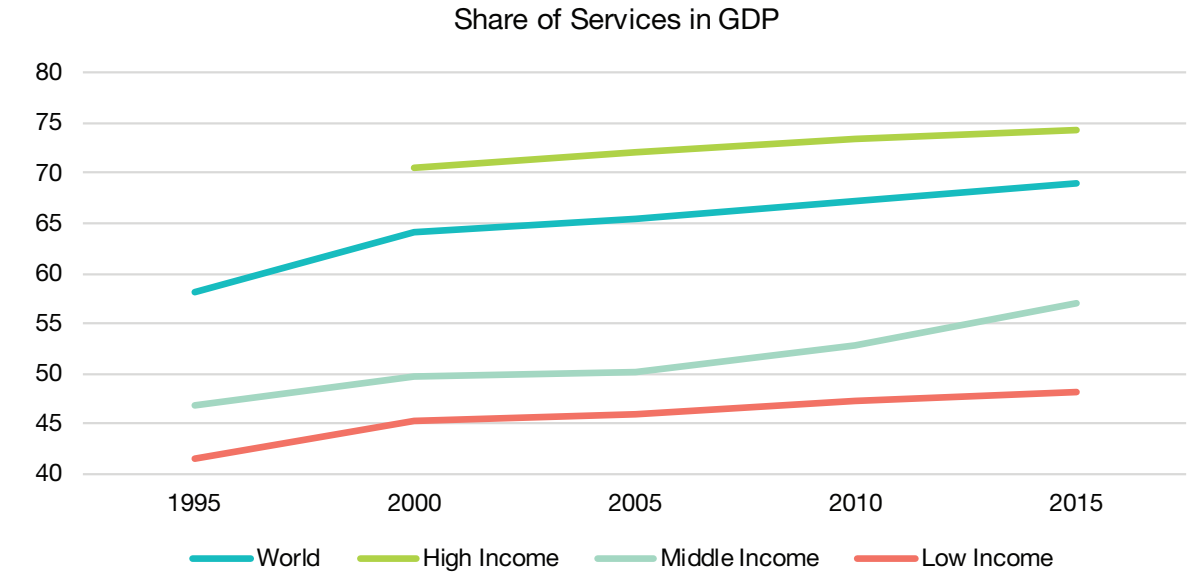
Savings and Investment

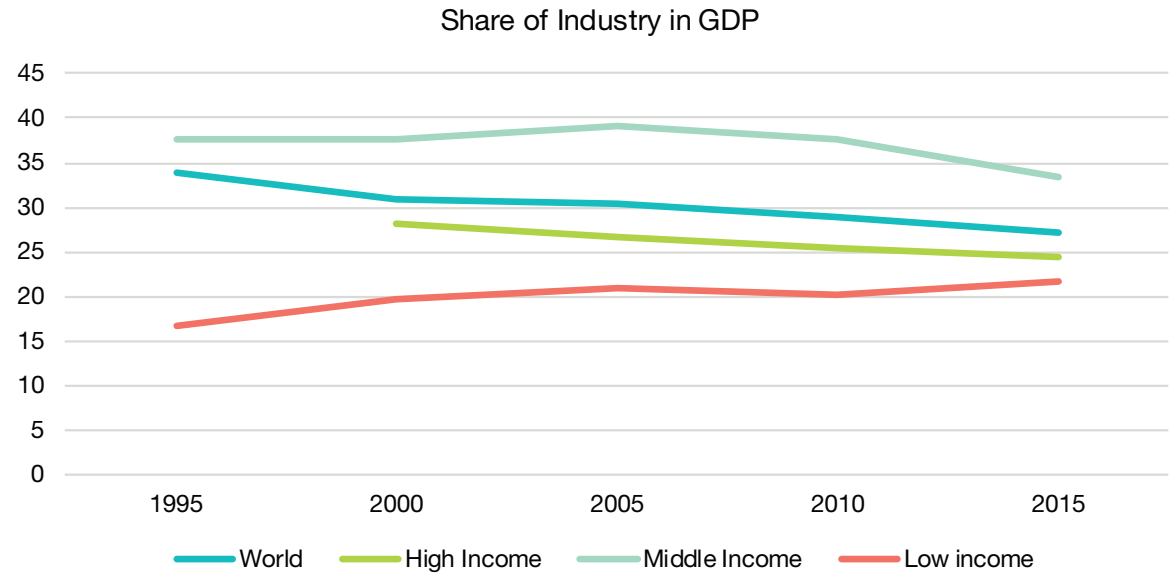
Does aging affect the growth of the pool of personal savings and therefore the growth of investment, which is a key input of the Centennial growth model?[17]

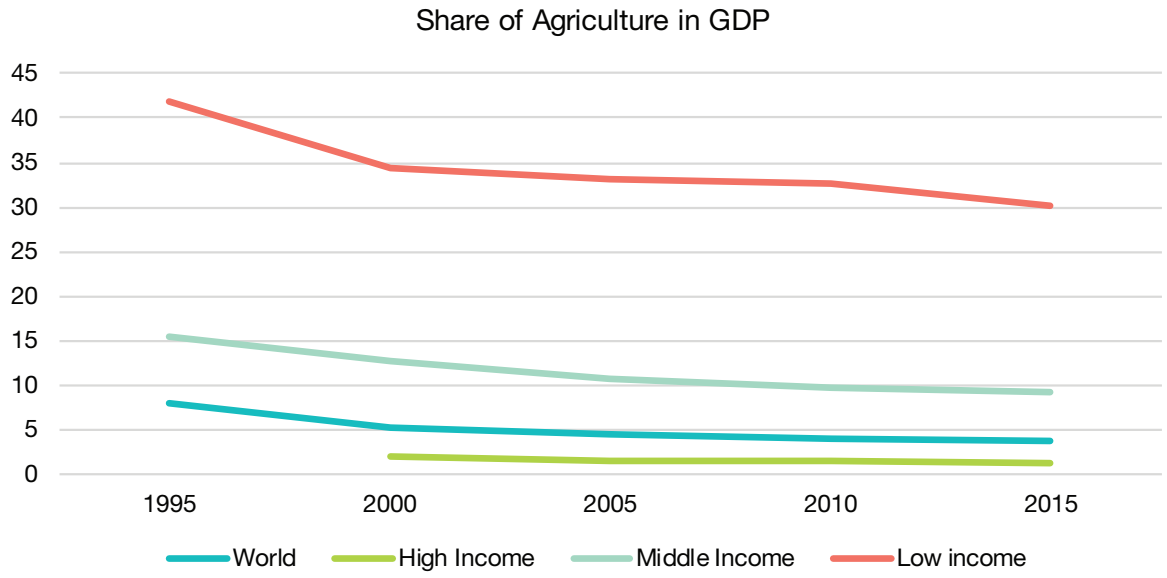
This paper assumes that the pattern of personal savings over time predicted by the life cycle hypothesis will hold in the future.[18] Put differently, that individuals prefer to smooth their consumption over their lifetime, dis-saving (typically by borrowing) in an early age, beginning to save as income increases, accumulating savings as one matures, and then starting to reduce saving as one ages. A corollary of this hypothesis is that increased longevity will lead individuals to accumulate higher saving to cover a

12. Employment growth in Sub-Saharan Africa under scenario E is also slower than in the baseline.
13. By definition, capital growth under scenario B would be lower than under the baseline.
14. Technological improvements may offset or more than offset this effect, although recent trends have not shown this effect.
15. Era Dabla-Norris et. al, The New Normal: A Sector Level Perspective on Productivity Trends in Advanced Economies, 2015.
16. The information on TFP is obtained from the US Bureau of Labor Statistics-KLEMS. KLEMS (K-capital, L-labor, E-energy, M-materials, and S-purchased services) refers to broad categories of intermediate inputs that are consumed by industries in their production of goods and services.
17. For macroeconomic consistency, the paper assumes that the saving-investment gap remains unchanged, i.e., if aging were to affect personal savings and thus national savings, real interest rates would adjust to induce a level of investment that would keep the gap unchanged in relation to GDP.
18. US Bureau of Labor and Statistics. Beyond the numbers, December 2015. Numerous empirical studies and work by the Bureau of Labor and Statistics of the U.S. have corroborated this hypothesis.

Figure 3: Share of Services, Industry and Agriculture in GDP (in percent)







Source: World Bank and Centennial Estimates.

Box 2: Aging and the special challenges faced by Africa

Through 2050 populations of all regions of the world will age (as measured by expected median age compared to that in 2015). However, not all regions will age uniformly during that period. More specifically, the median age will increase by 4.5 years in Sub-Saharan Africa, the lowest increase among emerging and developing countries; the median age increase for all other regions will range between 8 years in MENA and 12 years in LATAM. The median age of the already older advanced countries will increase by 5 years. Furthermore, by 2050 Sub-Saharan Africa will hold the youngest population worldwide—the median age will be slightly above 20 years. In comparison, the median age in other emerging and developing countries will be in the low forties (except for MENA which will have a median age of 34) and in advanced countries will be 45. In addition, Africa will be, by far, home to the fastest growing population in the world.

As the production structure of the aging countries and regions shifts toward services, it provides an excellent opportunity to the "younger" regions to supplement the supply of manufacturing goods. Africa, and particularly Sub-Saharan Africa, as the youngest of the emerging and developing regions, would be in an exceptionally favorable position to fill this role. Indeed, Africa is projected to increase its export share in world exports from 3 percent in 2012 to 10 percent in 2060 (Lamy 2016).

For this projection to be realized, the productivity of the African export sectors needs to increase faster than that of the rest of the world. And for that, Africa needs to overcome the considerable challenges it faces—it needs to undergo a significant transformation over the next few decades. Voluminous work has been completed on this subject, and this paper is not the place to discuss it. Undoubtedly, however, developing a skilled and productive labor force is key—one of the most urgent and likely difficult challenges faced by Africa is the buildup of the human capital required to fulfill its potential in the aging environment just described.

To this end, an effective education system will need to play the central role. However, Africa's performance regarding education has lagged that of other regions. Even among the most advanced countries in the region, the quality of education is at best defective, and at worst dysfunctional.[1]

The current deficiencies need to be addressed with increasing commitment, effort, and investment in strengthening education effectiveness, as opposed to the simple concept of time at school. This is by no means a problem in Africa alone, but seems particularly critical for the region to reap its demographic dividend and warrants major local and international efforts. Otherwise, the much-needed increase in total factor productivity will remain hostage to poor human capital.

1. For a thorough description of the current deficiencies and a reform agenda, see Alavuotunki, K. and Reinikka, R., "Building Human Capital: Improving Education Quality" in Africa 2050 (2017).

longer retired life and therefore a longer period of dis-saving. An alternative would be for individuals to decide not to change their cumulative savings but participate longer in the labor force. Of course, a combination of these behaviors can also be envisaged.

Given that the aging phenomenon includes lower birth rates and a longer lifespan, there are two perspectives for analyzing the effect of aging on personal savings rates (the mass of personal savings as a proportion of income):

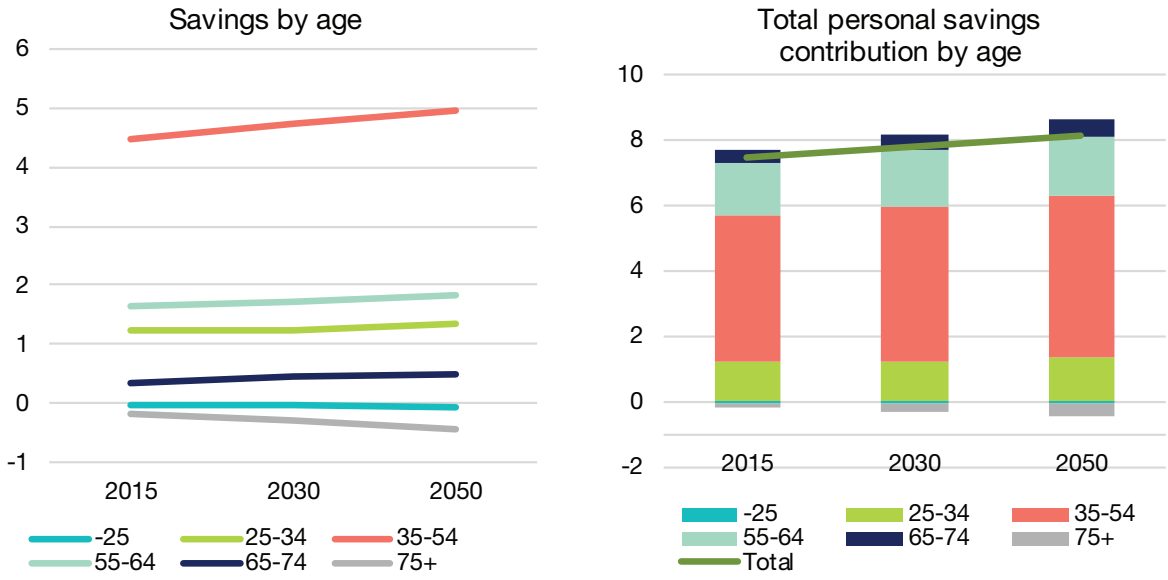
- From the longevity perspective, the response seems relatively simple. The pool of personal savings as a proportion of GDP would be larger as older people would either save for a longer period or reduce their pool of savings at a slower pace because they would work longer (or a combination of these responses to aging). Moreover, personal savings could be higher than before the aging phenomenon because young people know that they will live longer and even if they were to expect to work longer, they may anticipate the need for a larger pool of savings to cover a longer period of retirement. The combination of these behaviors would lead (ceteris paribus) to a larger pool of national savings as a proportion of GDP and, therefore, cause real interest rates to decline and induce higher investment and faster economic growth; as older people begin to dis-save, the reverse would be the case. A recent US Federal Reserve study based on the changing age structure of the US population concludes that the savings pool would continue to increase and therefore low interest rates would continue.[19] Similarly, a recent study by PIMCO[20] notes that the ratio of peak savers to the elderly could even rise in the short term and would not drop below the current level until 2030, thereby increasing the pool of personal savings. It observes, however, that this would only delay an eventual decline in savings ratios.
- From the perspective of the change in the population age structure (i.e., the combination of increases in longevity and declines in birth rates),

19. It also concludes that investment and economic growth will remain low.
20. Tracey, M. and Fels, J., "70 Is the New 65: Demographics Still Support 'Lower Rates for Longer'", PIMCO, 2016.

the response is not as simple. Before the aging phenomenon, the young cohorts grew faster than the older cohorts, causing the pool of savers and thus personal savings to grow. The larger the difference in the growth rates of these two groups, the larger the growth of the savings pool. This led to a strong increase in savings and thus investment and GDP growth. Does the reverse hold with aging?

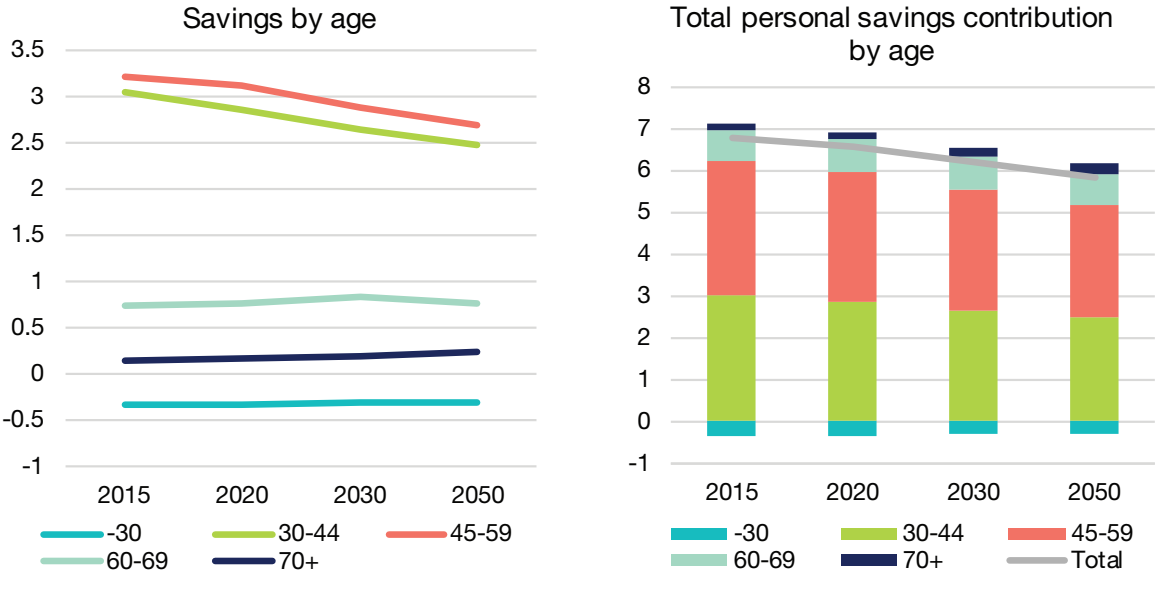
As fertility declines, the relative size of the cohorts aged 25-29 to 64-69 (the "savers") will diminish and therefore these cohorts' savings in terms of GDP would be lower than the savings to GDP ratio of the same cohorts in the past. In addition, as the relative size of the older cohort becomes larger their dis-saving in terms of GDP could be larger than the dis-saving of the older cohorts of the past. If the labor force is relatively young, savings may increase even as population ages, as is the case in the US at present. Savings will tend to decline if the labor force is older, as is the case of the EU. Figures 4 and 5 show the trajectory of the personal savings rate as a proportion of GDP for different age brackets, and their contribution to total savings for the US and the EU, for which information was

Figure 4: US Personal Savings (percent of GDP)



Source: US Bureau of Labor statistics and Centennial estimates

Figure 5: EU Personal Savings (percent of GDP)



Source: Eurostat and Centennial estimates

available for this study. Other studies show a prospective sharp decline in saving rates for Japan and China, and a considerably smaller one for India.[21]

Figures 4 and 5 are based on the simple application of the 2015 savings rate of each age cohort (estimated by the Bureau of Labor Statistics for the US and Eurostat for the EU) to the corresponding population estimated by the UN population projections.[22] Both the increase in the rate of personal savings for the US and the decline for EU are relatively gradual. For the US, the cumulative increase in the rate of personal savings for the period 2015-50, is 0.7 percentage points of GDP; in the case of the EU the decline is one percentage point over the same period. The increase in the US decelerates over time, and as the population ages, it can be expected to show a decline beyond the period of the projection. In the case of the EU, the decline in savings to GDP slows as well, as the process of aging of the population tends to slow down over time. The study by Curtis et.al, 2015, uses a different methodology, and shows sharper drops in savings to GDP over the period, ranging from more than 10 percentage points for China, 7 percentage points for Japan, and 2 percentage points for India.

In these circumstances and if corporate and public savings in terms of GDP remain as in the base period, the slower growth of personal savings would lead real interest rates to rise and thereby slow the growth of total investment. This, in turn, would lead to a potential vicious cycle of slower growth, slower savings, and slower investment.

Furthermore, public savings is likely to decline, as discussed in section C below, further aggravating the trend. In addition, higher real interest rates could attract capital flows to "aging countries and regions" with adverse effects on investment growth and thus GDP growth rates of emerging and developing countries and regions with younger populations, such as Sub-Saharan Africa and the Middle East and North Africa (MENA).

The conclusion that slower growth of personal savings would lead real interest rates to rise and the growth of total investment to slow holds if the participation in the labor force of workers aged 65 and above is the same as assumed in the baseline scenario. However, if that labor participation rate is higher, GDP growth would be higher and lead to higher personal savings, as discussed above. The net effect of increased taxation to keep public sector deficits from growing, (see the next section) and a higher labor force participation rate by workers aged 65 and above (i.e., higher GDP growth) on personal savings will depend on the relative size of each trend.

The expected financial outlook of the national security system can also influence personal savings. For instance, would the system move into unsustainable deficits and therefore lead to gradual reductions in retirement benefits through a combination of lower retirement payments and higher (larger and/or longer contributions)?

From an individual point of view, it is interesting to note that decisions about personal savings may be affected by aging (declining fertility, increasing longevity) and the types of pension systems (defined contributions, defined benefits, defined annuities). When declining fertility is the main cause for aging, its effects on personal saving are positive, as individuals save more because the decline in the relative number of contributors would result in lower pension benefits (defined contributions) or higher contributions would be necessary to keep benefits unchanged (defined benefits). See subsection "Policy response and growth" for a discussion from a macroeconomic point of view.

Public Finances and growing aging-related public spending

Outlook

Aging has been leading to major changes in the structure of public spending in advanced economies in recent decades, as the growing demands for the various programs to care for the elderly (particularly health care and pensions) have been causing this component of public current expenditure to grow fast. In response, governments have implemented measures to contain these growing pressures and their impact on the fiscal balance. To the extent that aging-related spending has been offset by reductions in other current spending, increases in taxation or a combination of these measures, public savings and thus public investment have kept relatively unchanged, other things equal. This process has been difficult but generally feasible because the increase in aging-related spending to-date, although rapid, has been manageable, given its initial size.

However, the population projections by the UN suggest that aging of the population, and thus aging-related outlays, will continue to increase in future. As a consequence, further fiscal measures will be necessary to avoid unsustainable fiscal deficits and public debt increases.[23]

21. Demographics and Aggregate Household Saving in Japan, China, and India. Chadwick C. Curtis, Steven Lugauer,Nelson C. Mark. March 2015.
22. US Bureau of Labor Statistics (2015).
23. High fiscal deficits would move private savings away from financing investment, with considerable adverse effects on economic growth and

This is clearly illustrated by a recent IMF Staff Discussion Note.[24] The Note estimates that, in the absence of reforms, aging-related outlays would increase by 5 percentage points of GDP and 4.5 percentage points of GDP in more and less developed countries, respectively, between 2015 and 2050.[25] This increase mainly reflects growing health spending,[26] as past pension reforms are expected to keep pension spending relatively contained. The Note indicates that this increase is subject to uncertainty given that past UN population projections have proved to be biased upward, due to fertility rates declining faster than projected and longevity increasing faster than projected. The findings of the Note are confirmed by the econometric analysis carried out below.

Aging and no aging scenarios

Econometric analysis helps estimate the relationship between both public expenditure and revenue with GDP and the median population age. The historical data for these variables for different country groups and regions during the period 2000-2016 is used as a basis to develop two scenarios for the period through 2050: (i) no (median) aging after 2017 and (ii) medium variant of the UN projections for median age. Even so, they are in line with the main conclusion of the IMF Note: rising aging-related spending, without offsetting fiscal measures, will have major adverse effects on the sustainability of the public finances.

The main findings of the regressions are:[27]

- For advanced economies, public balances would deteriorate by as much as 5.2 percentage points of GDP in twenty years, and then slowly decline to 4.8 percentage points by 2050, as aging slows down;
- For emerging and developing countries, for which the aging process would be stronger and more sustained,[28] the estimated deterioration of the public balances would be as high as 9 percentage points of GDP, with a slight decline in the outer years.
- The deterioration of the public balances is not uniform among emerging and developing economies, depending on how far along in the aging process the countries/regions are and the adjustment measures already taken. For the period through 2036, the public balances would show virtually no change in MENA and deteriorations of 2.4 percent of GDP in Sub-Saharan Africa, 4.3 percent in Emerging Asia, and a catastrophic 9.5 percent in Latin America and the Caribbean. These deteriorations continue to increase beyond 2036 for most regions (Figures 6 and 7). These results should be seen with caution.

The equations used are:

$$Log\ Et = A + B\ log\ GDPt + C\ log\ MEt \quad (2)$$

$$Log\ Rt = A^* + B^*\ log\ GDPt + C^*\ log\ MEt \quad (3)$$

Equations (2) and (3) indicate, that both Expenditure (E) and Revenue (R) are functions of GDP and the Median Age (ME).

Table 4 shows the key coefficients for two groups of countries: the advanced economies and the emerging and developing countries. Results for the various regions are generally strong. Not surprisingly, GDP coefficients for the Expenditure equation but the age coefficients for the Revenue equation are weak.

Based on these results, the figures below depict the trajectories of the fiscal balances for the period through 2050, under the two scenarios mentioned earlier, i.e., one assuming no (median) aging after 2017 and one in line with the medium variant of the UN projections for median age, for the advanced and the emerging and developing countries, and for the regions.

Policy response and growth

Improved tax systems and more efficient public spending could help reduce the projected deficits to sustainable levels, although reductions in non-aging related outlays are likely to become less and less feasible over time. Thus, as aging-related spending expands, the need for a combination of higher taxation (or contributions) and cuts in such spending would become unavoidable.29 These measures are increasingly difficult from a political point of view and involve complex political economy dilemmas because they impact the various cohorts of the population differently and

an eventual fiscal crisis, due to growing levels of debt and declining rates of GDP growth.

24. B. Clements, Sanjeev Gupta, et al., "The Fiscal Consequences of Shrinking Populations" 2015.

25. The Note indicates that cutting the gender gap in labor force participation rates by half over 2015–50 would reduce aging-related spending by about 1 percentage point of GDP in 2050 in both the more and less developed economies.

26. On average, health care costs are projected to increase faster than economic growth, not only because of population aging but also because of technological improvements in health care that result in better although costlier services.

27. The regressions are run in logs; thus, the coefficients provide rates of change.

28. The marked difference of the impact of aging-related spending on the two groups of countries reflect the fact that the advanced economies are far along the aging process than the emerging and developing countries, and thus have already adopted important adjustment measures.

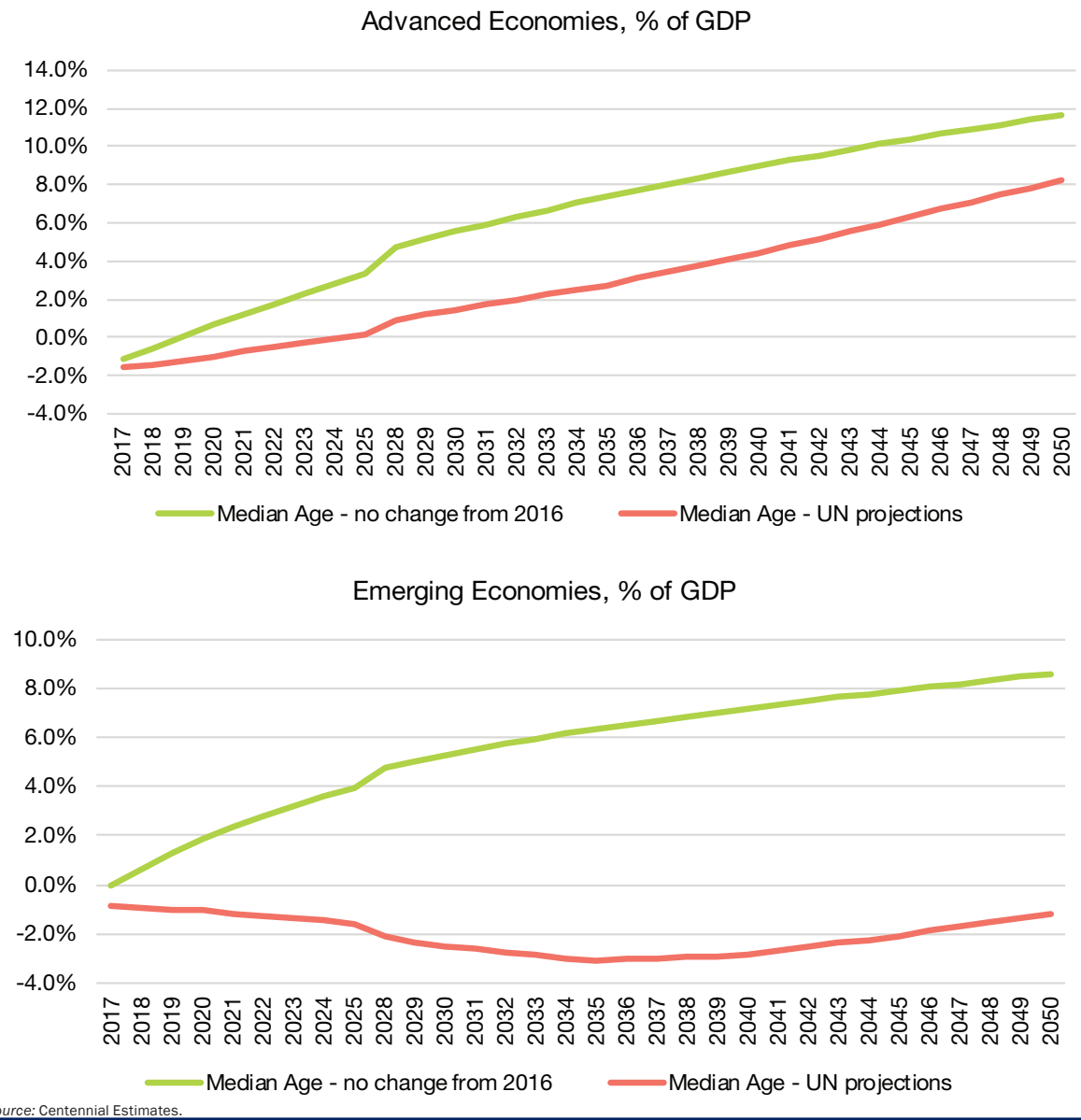
29. The cuts could include outright reductions in benefits and/or further increases in retirement age linked to longevity gains

Table 4: Public Expenditure and Revenue Regression results

	Advanced Countries	Emerging and Developing Countries
Expenditure		
Intercept	3.7	2.9
GDP 1/	-0.7	-1.7
Median age	5.9	16.2
R^2	0.84	0.93
Revenue		
Intercept	3.7	2.9
GDP	1.2	1.4
Median age 1/	1.0	-3.9
R^2	0.92	0.90

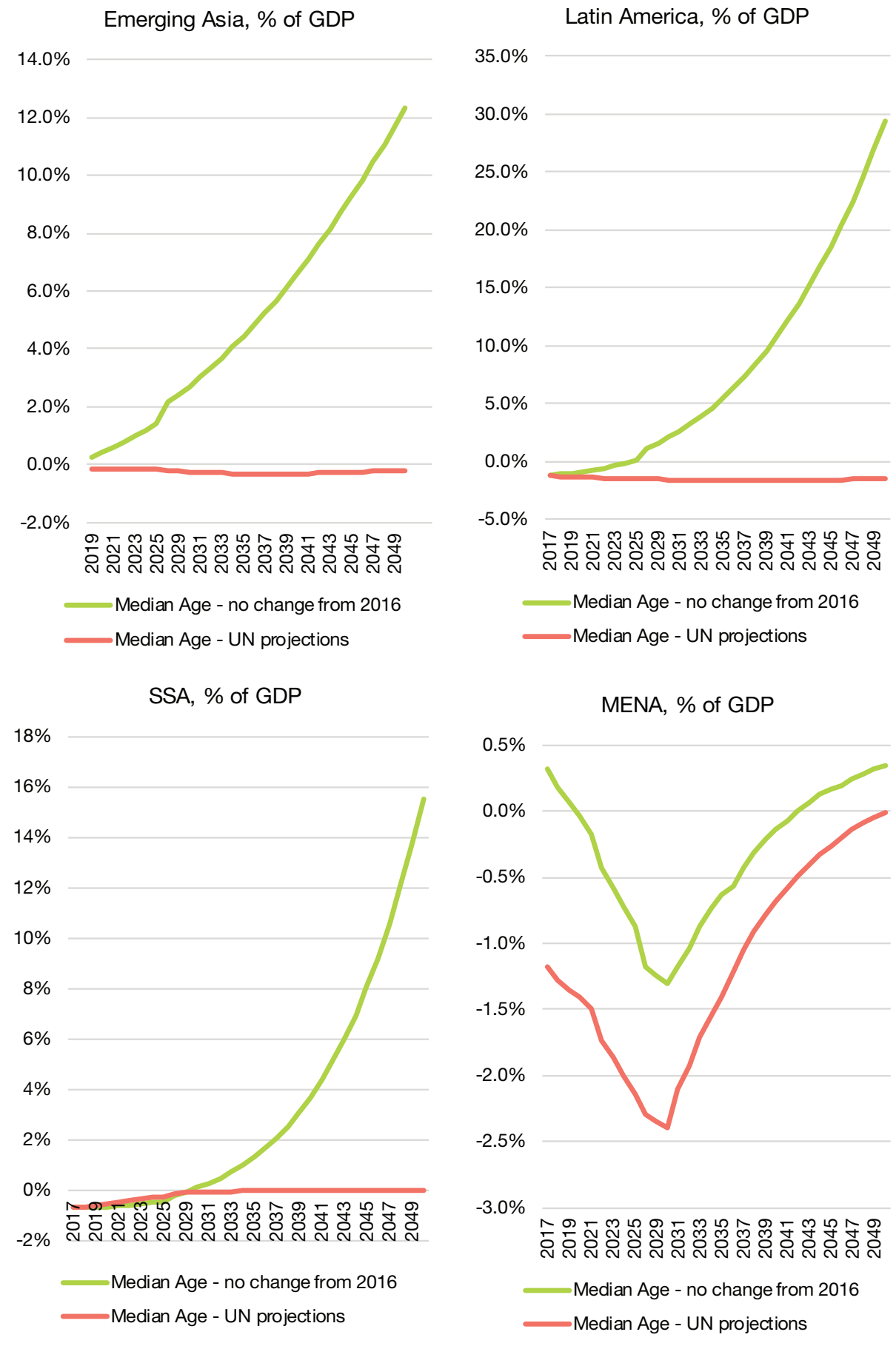
1/ Low T value
Source: UN, IMF, and Centennial estimates.

Figure 6: Projected fiscal balances through 2050



Source: Centennial Estimates.

Figure 7: Projected fiscal balances through 2050, by region



Source: Centennial Estimates.

the growing political force of the elderly voters. For instance, reducing aging-related spending directly affects the elderly, with no major adverse impact on the younger cohorts. Nevertheless, these measures will become unavoidable to ensure sustainability of the public finances and thus prevent a public debt crisis, with its adverse social and economic effects. In the end, the specific combination of taxation and cuts in aging-related spending would depend on the social priorities of each country.[30]

Abstracting from the potential adverse effect on economic incentives, which could be significant, an increase in taxation to cover higher aging-related spending will have an uncertain effect on personal savings, even if individuals quickly adjust their saving behavior in line with the prediction of the life cycle hypothesis. Other things equal, higher taxation could lead the 25-to-64 aged cohorts to increase their savings to compensate for the decline in their future income net of taxes. However, if some of the cohorts were to keep current consumption unchanged, their current savings would decline and therefore, as savings are depleted, their future consumption will be lower. At the same time, higher taxation on the 65 and above aged cohort would imply a corresponding reduction in consumption; thus, they could increase their dis-saving (i.e., reduce their existing savings pool) to limit such a reduction in consumption. Moreover, the extent of the increase in dis-saving is uncertain, as they may have to weigh current vs. future consumption as life expectancy increases.

It is possible to conclude, therefore, that the effects of increasing taxation to cover growing aging-related spending on total personal savings will depend on the changes in the propensities to save of the various cohorts and on the rate of growth of these cohorts. This uncertainty would not exist, however, in the case of strict Ricardian Equivalence, as the increase in taxation will have no effect on the growth of personal savings,31 and thus on investment growth.[32]

As noted above, reducing aging-related spending could be seen as increasing taxation. The 65 and above aged cohort may increase its dis-saving to avoid a reduction in consumption (offset in part by their concern about future consumption). The 25-to-64 aged cohorts will most likely increase their savings to help compensate for the reduction in future age-related benefits. Thus, the net effect on total personal savings is uncertain. As in the case of higher taxation, the effect of reducing aging-related spending on total personal savings will depend on the changes in the propensities to save of the various cohorts and on the rate of growth of these cohorts. Similarly, in the case of strict Ricardian Equivalence, reducing aging-related spending will have no effect on the growth of personal savings and thus on investment growth.

A possible policy to reduce the growing fiscal gaps is to increase the labor force participation rate of the cohort aged 55–64 (who have lower participation rates than those aged 25 to 54, with the exception of Africa).[33] The IMF Note, mentioned above, estimates that reducing by half the gap in the participation rates between individuals aged 55 to 64 and those aged 25 to 54 would reduce age-related spending by almost 1 percentage point of GDP in 2050 in the more developed countries, and about a third of this in the less developed countries.

Other potential policy responses to the fiscal challenges posed by population trends involve policies that attempt to change underlying demographics, such incentives to increase fertility and labor force participation, including of women and the elderly, and to promote immigration. While the latter may pose social and political difficulties in some countries, others may benefit from immigration, particularly in the form of a temporary boost to the work force, growth, and fiscal revenue, providing time for countries to implement needed age-related reforms. Eventually these new workers will also retire and exert pressure on spending (Gibson and McKenzie 2012).

In the previous version of this paper we said in a footnote "from a global perspective, immigration may involve a net zero-sum-game." This may not be correct. Considerable study of the many trade-offs is needed in order to reach a definite answer.

- From the individual migrant point of view, there is no doubt that he/she gains by moving to higher paying countries.
- From the recipient country, migrants may (initially) displace workers, leading to social difficulties and political issues; these countries may also need to increase social services, such as education and health, as well as housing to facilitate the absorption of immigrants.
- From the "donor" countries, emigration would cause an increase in aging, which could reach

30. In this regard, countries without social security systems in place may consider not introducing them at all. In these countries, individuals will continue to internalize the absence of a social security system through higher personal savings rates than otherwise.
31. In a strict "Ricardian Equivalence" context, increased taxation would lead to an equivalent reduction in consumption so as to keep private saving unchanged.
32. Put differently, the increased taxation would be covered one to one by a reduction in personal savings, which was held to eventually finance the previously envisaged public-sector deficits.
33. This policy may encounter strong opposition in many countries, as it is can be seen as raising the retirement age.

extremes as is the case of Bulgaria,[34] a country that has lost more than 10 percent of the economically active population—including skilled workers—since the 1990s. In these countries, policy-makers will need to implement sustained reforms to mitigate the economic impact of the demographic change.

- From the global perspective, migration mitigates the effect of population aging in the recipient countries, but increases the aging phenomenon of the "donor" countries as they lose a portion of their labor force and children. The net effect is most likely positive, as the migrants' productivity in the recipient countries is higher than in the donor countries.[35]

IV. Conclusions

The analysis conducted in this paper shows that the effects of aging on economic growth are serious, although with varying degrees of intensity across countries and regions. Relatively smaller 25-to-64 aged cohorts and more dependents per worker would suggest that aging has a negative effect. These broad effects are reflected in the results of the baseline scenario—slower GDP and savings growth, although not necessary on a per capita basis.

However, when behavioral responses are considered, these results may not necessarily hold. Longer lifespans would most likely lead individuals to accumulate higher savings. This, in turn, would increase investment and thus economic growth relative to the baseline. Similarly, individuals could work longer and thus help increase output as well as reduce their dis-saving.

The envisaged rise in aging-related outlays is expected to raise fiscal deficits by around 5 percentage points of GDP by 2050 and most likely drive public debt to unsustainable levels, unless spending is reduced, or revenue increased beyond trend. It is noteworthy that the regression analysis shows that the fiscal problem is of a larger magnitude, as a proportion of GDP, for the emerging and developing economies. This is because these economies face a more rapid aging process than the advanced economies, which are already well into the problem of aging and therefore would show a smaller increase in median age than the emerging and developing economies. The deterioration in public finances would have dire consequences, clearly underscoring the need for further reforms of aging-related spending.

Given the magnitude of the needed policy response, a multi-pronged approach will be required, including entitlement reform, policies that affect demographics and labor markets, better tax systems, and more efficient public expenditure. In many countries, it could be impossible to cut non-aging related spending to fully offset the impact of demographics on aging-related spending, thus necessitating broader public-sector reforms to improve the public finances.

The long-term projections of the size and age composition of the population are subject to considerable uncertainty. Relatively small changes in fertility, mortality, or migration rates can have an important impact on the projected increases in aging-related spending. For instance, if fertility were to decline faster than envisaged in the medium variant of UN population projections, spending pressures could be even greater than estimated.

Moreover, some specific outcomes and assumptions may be questioned. For example, are older people less productive? If so, by how much? Will this continue or be reversed in future? Is there a possible difference in productivity between those that would have entered the labor force anyway and those that constitute the bulk of the "increased participation" group? The answer may be in the affirmative, but subject to further inquiry.

An important point is that, as aging may reduce average productivity and the level of savings available for investment may decline, total factor productivity growth is of the essence. Technological progress needs to be accelerated, particularly in the services sectors. Advances in artificial intelligence may help considerably in this regard, and greater focus on this type of change will be an imperative.

As noted, this paper is by no means comprehensive. It does not address potential positive consequences for welfare resulting from shrinking populations. Indeed, the population growth rate of the past, i.e., population doubling every 35 years or so, is unsustainable. Easing population pressure helps to contain the use of energy and fossils fuels, benefiting the environment, and helps increase investment in people, promising inclusive growth and raised standards of living.

34. Other Eastern European countries, and Puerto Rico, may be in a similar situation.
35. Becker et al. (1990) suggest that population growth in high-income countries leads to grater income growth than in low income countries because of increasing returns from greater specialization and growth in investments in human capital.

Bibliography

Alavuotunki, K. and Reinikka, R., 2017, "Building Human Capital: Improving Education Quality" in Africa 2050, revised.

Bloom, David E., David Canning, and Günther Fink. 2010. "Implications of Population Ageing for Economic Growth." Oxford Review of Economic Policy 26(4): 583–612.

Bloom, David E., David Canning, Günther Fink, and Jocelyn E. Finlay. 2007. "Fertility, Female Labor Participation, and Demographic Dividend." NBER Working Paper 13583, National Bureau of Economic Research, Cambridge, MA.

Bloom, David E., David Canning, and Jaypee Sevilla. 2003. "Demographic Dividend: A New Perspective on the Economic Consequences of Population Change." RAND, Santa Monica, CA.

Borsch-Supan, Axel. 2002. "Labor Market Effects of Population Aging." Labor 17(S1): 5–44.

Burtless, G. 2013. The Impact of Population Aging and Delayed Retirement on Workforce Productivity. Center for Retirement Research of Boston College.

Clements, Benedict, Kamil Dybczak, Vitor Gaspar, Sanjeev Gupta, and Mauricio Soto. 2015. "The Fiscal Consequence of Shrinking Populations." IMF Staff Discussion Note SDN/15/21, International Monetary Fund, Washington, DC.

Dolls, Mathias, Karina Doorley, Alari Paulus, Hilmar Schneider, Sebastian Siegloch, and Eric Sommer. 2015. "Fiscal Sustain- ability and Demographic Change: A Micro Approach for 27 EU Countries." IZA Departmental Paper No. 9618, Institute for the Study of Labor, Bonn.

Elborgh-Woytek, Katrin, Monique Newiak, Kalpana Kochhar, Stefania Fabrizio, Kangni Kpodar, Philippe Wingender, Benedict Clements, and Gerd Schwartz. 2013. "Women, Work and the Economy: Macroeconomic Gains from Gender Equity." IMF Staff Discussion Note SDN/13/10, International Monetary Fund, Washington, DC.

Era Dabla-Norris et. al, The New Normal: A Sector Level Perspective on Productivity Trends in Advanced Economies, 2015.

Frosch, Katharina. 2009. "Do Only New Brooms Sweep Clean? A Review on Workforce Age and Innovation." MPIDR Working Paper 2009-005, Max Planck Institute for Demographic Research, Rostock, Germany.

Gibson, J. and McKenzie, D., 2012. The Development Impact of a Best Practice Seasonal Worker Policy.

Kohli, Harinder, 2016. The World in 2050. Oxford

Kulish, Mariano, Kathryn Smith, and Christopher Kent. 2006. "Ageing, Retirement and Savings: A General Equilibrium Analysis." Research Discussion Paper 2006-06, Reserve Bank of Australia, Sydney.

Lamy, Pascal. 2016. "Where will emerging markets stand in global trade" in "The World in 2050."

Lee, Ronald, and Andrew Mason. 2010. "Fertility, Human Capital, and Economic Growth over the Demographic Transition." European Journal of Population 26(2): 159–82.18

Lee, Ronald, Andrew Mason, and Daniel Cotlear. 2010. "Some Economic Consequences of Global Aging." Health, Nutrition, and Population Discussion Paper, World Bank, Washington, DC, December.

Maestas, N., Mullen, K., and Powell, D. 2014. The Effect of Population Aging on Economic Growth - SIEPR - Stanford Institute for Economic Policy Research. Stanford University. Stanford, CA 94305.

Onder, H. and Pestieau, P., 2014. "Is aging bad for the economy? Maybe." World Bank.

Peterson, Peter. 1999. "Gray Dawn: e Global Aging Crisis," Foreign Affairs 42 (January/February).

Tracey, M. and Fels, J., 2016. "70 Is the New 65: Demographics Still Support 'Lower Rates for Longer'", PIMCO.

Tyers, Rod, and Qun Shi. 2007. “Demographic Change and Policy Responses: Implications for the Global Economy.” World Economy 30(4): 537–66.

United Nations. 2015. “World Population Prospects: The 2015 Revision.” Department of Economic and Social Affairs, United Nations, New York. http://esa.un.org/wpp/.

U.S. Bureau of Labor and Statistics, KLEMS Statistics

US Bureau of Labor and Statistics. Beyond the numbers, December 2015.

Appendix I: The world in 2050—Alternative scenarios

The work in *The World in 2050* presents alternative scenarios for the emerging global economy through 2050 with a primary focus on Emerging and Developing Economies, using the Centennial standard growth model as a basis, taking into account megatrends discussed earlier in this book.

Since 1990, the average rate of growth for the Emerging and Developing Economies has been twice that of Advanced Economies. The trajectory has been far from smooth. Still, the long-term trend of the Emerging and Developing Economies gaining a greater share of global GDP will likely continue. Furthermore, as more and more residents of Emerging and Developing Economies join the middle class, they will have greater impact on the world economic structure and governance.

Despite the positive trend, the path ahead cannot be taken for granted. The strong performance of recent years was largely the result of a combination of factors such as opening up to trade worldwide, greater internal mobilization of domestic and external resources, a steady improvement in education levels and infra- structure services, the effects of the demographic (population growth) dividend, the acquisition of new technologies, the increased participation in global value chains, and for many, the commodity boom of 2000s (reversed in 2012) and importantly, stronger institutions.

Even if these generalizations about improved national policies and the global economic climate impact on countries' performance may help explain the increasing role of the Emerging and Developing Economies as a group on the world stage, different regions have performed varyingly. East and Southeast Asia have done exceedingly well, and India also in the more recent years. The Eastern and Central European as well as Central Asian countries saw a period of rapid growth between the fall of the Soviet Union and 2007, but have since been hurt first by the slow recovery of the European Union, and more recently by the decline in commodity prices (particularly by the prices of oil and gas). The same can be said about the economies of the Middle East and North Africa. Latin America also saw a decade of fast economic growth until 2011, with improved conditions for many of its poorer social segments. However, the trend has slowed down dramatically, partly as a result of the sharply lower commodity prices after 2012 and, in a number of cases, the re-emergence of poor macroeconomic policies. Finally, Africa has also suffered a slowdown since 2012, although not to the same extent as Latin America or the Middle East.

Even though the Advanced Economies as a group have seen a modest recovery since 2010, growth rates for all developing regions (other than Latin America and the CIS) still exceed those of the Advanced Economies. Nonetheless, when measured on a per capita basis, growth in the Advanced Economies may only be exceeded by that in Asian countries. While events since 2007 illustrate the complexities of the growth process for both advanced and Emerging and Developing Economies, under most plausible scenarios, growth in the Emerging and Developing Economies is likely to continue to exceed growth in the Advanced Economies through 2050.

On the basis of the evidence of the historical data, and using the well-established Centennial growth model used in previous studies, multiple scenarios were generated for the "World in 2050", by asking "what if" questions. The objective was to develop a set of scenarios under varying assumptions in order to visualize the impact of things going well or going badly, both for the factors used in the standard growth model and under global megatrends, where their impact could be quantified with a reasonable degree of confidence. The study presents just four of these scenarios, in order to allow a simple and clear presentation. These scenarios are not intended to constitute definitive projections.

The scenarios revolve around a "central" scenario considered most plausible for the global economy. A crucial assumption under this scenario is that the global productivity frontier (the United States economy) will continue to improve at an average annual rate of 1 percent, as it has for the past 100 years or so. It further assumes that only the advanced economies that have performed well in the past 20 years or so will continue to move at the same pace as the United States and similarly that emerging and developing economies that have a record of successful convergence in the past will continue to converge in the future as well. It also presents two further scenarios for the emerging and developing economies called "strong policy" and "poor policies and low productivity." Under the strong policy scenario, the assumptions about the global productivity frontier and the advanced economies' performance remain the same as in the central scenario but policy performance of emerging and developing economies is improved significantly.

The poor policies scenario combines two simultaneous adverse developments: a large number of emerging and developing economies fall in the middle-income trap as

a result of their inability to maintain a reasonable policy regime and the global productivity growth rate slows to only 0.6 percent per year (as argued by some cautious experts). While this scenario could be considered overly pessimistic, it cannot be ruled out altogether. The fourth scenario, even more optimistic than the strong policy scenario, assumes acceleration in the global productivity growth (as believed by some technologists) together with strong policies to test the impact of technical progress on the future of the world economy. Only the central Scenario is presented here. The world in 2050 presents the results for other scenarios in detail.

Central scenario

Under the central scenario, today's emerging and developing economies would grow at an average annual rate of 4.0 percent over the 2016-2050 period, in comparison to a rate of growth of 1.8 percent for today's advanced economies. The average rate of growth for Sub-Saharan Africa would be in the order 5.1 percent, and that of Emerging Asia, 4.4 percent. Under this scenario, the rate of growth of GDP in Latin America would be 3.1 percent and the Middle East 3.4 percent, and that of Emerging Europe 1.7 percent, slightly lower than Advanced Economies. Over time, the rate of growth of the global economy will decline as countries converge toward the global best practice and also as population growth rates decline worldwide (except in Sub-Saharan Africa).

Under the central scenario, the world will be very different from the one we see today. By 2050, the global economy will triple in size to total $339 trillion. The world will be significantly wealthier, with the global per capita income averaging close to $35,000 as compared to $15,000 today. Additionally, there will be dramatic improvements in the income levels and living standards of people who live in countries currently referred to as "developing."

In 2050, as many as 79 countries will have GDP per capita higher than the average 2015 income of Southern Europe (Spain, Portugal, Greece, Italy). The distinctions between developed and developing countries that were so distinct half a century ago will have virtually disappeared. Perhaps even more importantly, as many as 5.5 billion, or 57 percent, of the world's expected total population of 9.6 billion in 2050 will live in these 79 countries; only 1 billion people, or 14 percent of the world's population, enjoy such affluence today.

By 2050, Emerging Asia will account for just over half (51 percent) of global output under the central scenario. China, India, Japan and Indonesia will lead the way in this process. The rise of Asia will bring Asia's economic share in line with its share of world population and return to the balance of output that prevailed prior to the Industrial Revolution; though Asia's per capita income in 2050, at $37,000, will still be less than half of that of the countries defined as advanced today ($79,000).

By the end of the period, the three largest economies in the world, by far, will be China, India, and the United States (in that order), accounting between them for nearly half of total world GDP. The top ten biggest economies will include just four other current advanced economies (Japan, Germany, the United Kingdom, and France). This list of the top twenty economies in 2050 excludes four members of the current G20 (Argentina, Australia, Italy and South Africa), and incorporates five newcomers (Nigeria, Vietnam, Pakistan, Egypt and Thailand); currently, G20 also includes the EU.

Asia as a whole will account for about 61 percent of global growth between 2015-2050, and today's advanced economies for another almost 20 percent. The rest of the world will contribute only 20 percent of global growth, unless the other regions step up their economic performance, particularly Latin America and Sub-Saharan Africa, as postulated in the strong policy (optimistic) scenario.

The central scenario envisions a future where countries remain on the same trajectory that they have followed in the past. But to remain on their trajectory, countries will need to work harder than ever before for the simple reason that as they catch up with the more developed economies, it will become more and more challenging to further improve their productivity and competitiveness. It will require overcoming significant obstacles—political, social, and institutional—that must be overcome to realize even this plausible scenario. The strong policy scenario, while more desirable, should be regarded as a difficult goal to achieve. This scenario will require all developing regions to emulate the past record of East Asia. While such a goal is certainly possible, achieving this scenario will require great discipline and intense dedication to economic development on a massive scale.

The main message to the political, economic, and business leaderships is that the long-term future of the world is and will be in the hands of their leaders. Ultimately, it will be their actions, or non-actions, which will determine what kind of world future generations will inherit.

Projections Methodology

In the model GDP is estimated as a function of employment (number of workers), capital stock, and total factor

productivity for 187 countries between 2015–2050 under four different growth scenarios that we call "Central", "Best-Policy Optimistic", "Productivity-Growth Optimistic Scenario", and "Pessimistic". This section offers an abbreviated description of the model; a more detailed exposition, in Kohli, Szyf, and Arnold (2012), is available on request.[36] As seen in equation (1), a Cobb-Douglas function with constant returns to scale is assumed, with *a* equal to two-thirds:

$$GDP=TFP \times W^{a} \times K^{(1-a)} \qquad (1)$$

GDP figures are generated for three different measures: real GDP (constant 2012 prices); GDP PPP (constant 2012 PPP prices); and GDP at expected market exchange rates, which incorporates expected exchange rate movements and serves as this chapter's best proxy for nominal GDP. The model first takes the IMF WEO projections through 2018 and thereafter estimates annual real GDP growth for each country between 2015 and 2050.

Employment growth (growth in the number of workers) stems from changes in the employment rate and from labor force growth, which in turn stems from population growth and from changes in labor force participation rates. Population growth is based on the 2015 Revision of the UN's World Population Prospects, while labor force participation rates are projected separately, by gender, for seven age cohorts (15–19, 20–24, 25–29, 30–49, 50–59, 60–64, and 65+) to better capture cohort-specific trends. Male rates are projected directly; female rates are derived by projecting the difference between male and female rates for each age group. Labor force participation rates from 1980 through 2030 are taken from the International Labor Organization.

Capital stock growth, based on an initial capital stock and yearly investment rates and depreciation, is defined as:

$$(1+K\ (Growth)_{t})=K_{t}/K_{(t-1)}=(I_{(t-1)}/K_{(t-1)})-0.06 \qquad (4)$$

where K is the capital stock, 0.06 represents the yearly depreciation of 6%, and is the capital investment from the previous year, which is defined as the previous year's GDP (measured in constant 2012 PPP dollars) multiplied by the investment rate as a share of GDP. The initial capital stock is calculated using the Caselli method, with the following equation:

$$K_{0}=I_{0}/(g+0.06) \qquad (5)$$

where K_{0} is the initial capital stock, g is the average GDP growth over the subsequent ten years, 0.06 is the depreciation rate, and is the initial year's investment. For , for each country, the earliest year for which there exists capital investment data (year) is identified. The average of the investment rate values for year and the two subsequent years is computed and treated as the initial investment rate. This smoothing out of fluctuations in the initial investment rate is necessary to yield better estimates for certain countries in which there is much volatility in the earliest investment rate values. This rate is then multiplied by the GDP in year to determine . The earliest year possible is chosen for this estimate because the longer the time frame before the projections commence the more the yearly depreciations will reduce the effects on the model of any initial imprecisions in capital estimates.

The model is calibrated by calculating total factor productivity (TFP) for an initial year (2018)[37] based on workers, capital stock, and historical GDP, with GDP and capital stock measured in purchasing-power- parity dollars at constant 2012 PPP prices. For subsequent years, TFP is projected. For the TFP projections, we differentiate four tiers of countries: converging; half-converging; non-converging; and fragile.

All countries begin with a default TFP growth rate of 1 percent, which, to a strong level of statistical significance, equals the average US rate over the past 40, 30, 25, and 20 years, and which, also to a strong level of statistical significance, equals the average rate of all non-converging countries over the same four periods. In our model, this is the fixed rate of productivity growth for non-converging, non-fragile countries in the central scenario. The background to this approach is that research shows that some growth differences between developing countries can be successfully modeled by separating them into two groups: converging and non-converging countries (Gill and Kharas, 2007). A country is deemed to be converging if its 2002–2012 and 1992–2012 average TFP growths are closer to what the model would predict for a converge (see below) than to what it would predict for a non-converger; for a converger, the lower its productivity relative to the global best practice, the more quickly it converges. This convergence reflects technology transfers from richer innovating countries, technology leapfrogging, the diffusion of management and operational research from more developed countries, and other ways that a country can shortcut productivity-improvement processes by learning from economies that are already at the productivity frontier.

36. This annex is based on Kohli (2011), but it has been updated with the methodology revisions detailed in Kohli, Szyf, & Arnold (2012), in which more details about the methodology and its derivation can be found.

37. 2 IMF WEO GDP growth projections are used through 2018.

In the model, the lower the country's productivity relative to that of the US, the larger the boost, and the quicker the catch-up.[38] The general equation for TFP growth is:

TFPGrowth = 1.0% + CB – FP (6)

where CB is the convergence boost benefiting "converging" countries and is the productivity growth penalty suffered by failing or fragile states. (Note that in the pessimistic scenario the 1.0% in the above equation is instead 0.6%, and in one optimistic scenario it is 1.3%.)

The growth scenarios for each country are based on the employment growth, capital deepening, and productivity changes over the period 2016-2050. The measure of GDP at expected market exchange rates adjusts the GDP estimate by expected changes in the real exchange rate. First, an equation is derived to establish a theoretical relationship between a country's real exchange rate and its PPP income relative to that of the US. Then, the country's modeled exchange rate converges towards the value that corresponds to its income in this theoretical equation. These relationships are not linear, and the countries for which increases in GDP PPP per capita most appreciate their real exchange rates are the countries whose incomes are between a third and two-thirds that of the United States, and not the poorest or richest countries. The model also projects the sizes of the low, middle, and high-income populations, again following Kharas, by measuring the number of people in each country with living standards—in PPP terms— within a certain absolute range. An income distribution for each country is derived from the World Bank's International Comparison Program.

The model calculates what share of the nation's income is available for consumption, and it distributes this consumption income over the population according to the income distribution. As the country's overall consumption income increases, the purchasing power of those at the bottom of the distribution increases, raising more to middle-income status.

The model makes separate projections for the optimistic, baseline, and pessimistic scenarios. The difference between the scenarios is how countries are classified, as converging, half-converging, non-converging, or failed; how countries gradually transition between classifications; and the value of the convergence coefficient. The specifications and timing of this sequence is paralleled in Kohli, Szyf, and Arnold (2012).

As noted above, the default TFP growth rate in the central and the best-policy optimistic scenarios is 1% per year. In the case of the pessimistic scenario, the default TFP growth rate is 0.6%, and in the productivity-growth optimistic scenario the default TFP growth rate is 1.3%.

The transition of individual countries, is gradual. That is, countries are made to adopt an intermediate state between failed and not-failed, or between converging and non-converging, by varying the values of and in equations (7) and (8).

For a detailed discussion of the methodology, including for projections of market exchange rates and of income classes and poverty, please see Kohli, Szyf, and Arnold (2012)

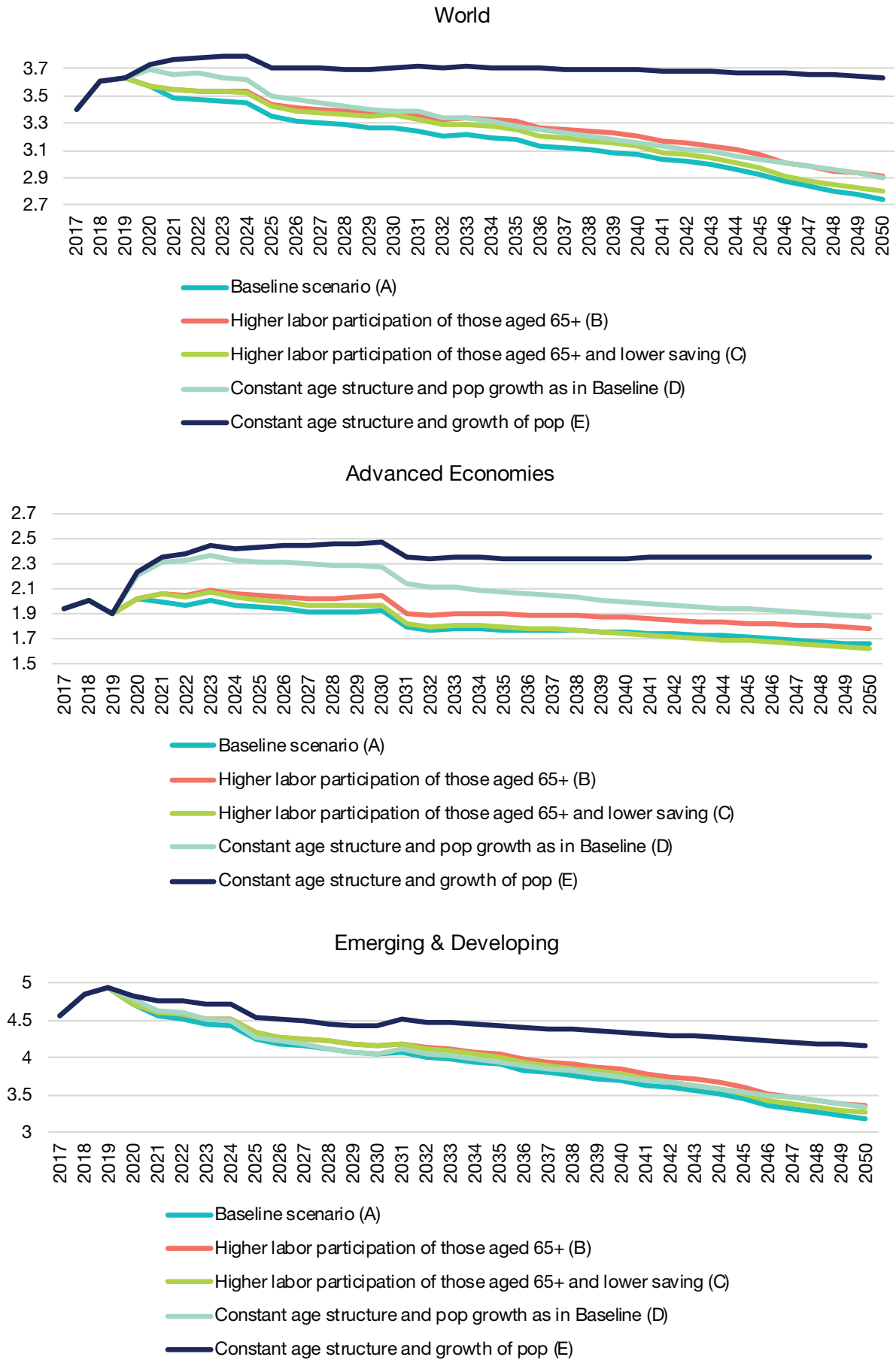
38. TFP is used in the convergence term instead of the per-capita income used by others for three reasons: first, if the equation were to use GDP per capita, over time the TFP of a converging country would not converge to that of the US but instead to other values. Also, since the convergence equation represents convergence of TFP, we use TFP in order to make the equation consistent with its purpose. Third, using the convergence coefficient from past research in tandem with an income-based convergence term yields large discrepancies with the recent historical data for TFP growth for many countries; using TFP yields a better fit.

Table A1.1: GDP growth rates

	Average 2017-2050	2017	2050
Baseline scenario (A)			
World	3.19	3.40	2.75
Advanced Economies	1.83	1.94	1.65
Emerging & Developing Countries	3.96	4.56	3.18
Sub-Saharan Africa	4.85	2.67	5.03
Latin America & Caribbean	3.00	1.05	2.59
Emerging Asia	4.41	6.20	3.24
Middle East & North Africa	2.93	1.77	2.68
Higher labor participation of those aged 65+ (B)			
World	3.29	3.40	2.91
Advanced Economies	1.92	1.94	1.78
Emerging & Developing Countries	4.07	4.56	3.36
Sub-Saharan Africa	4.91	2.67	5.15
Latin America & Caribbean	3.12	1.05	2.81
Emerging Asia	4.53	6.20	3.43
Middle East & North Africa	3.00	1.77	2.80
Higher labor participation of those aged 65+ and lower saving (C)			
World	3.25	3.40	2.80
Advanced Economies	1.84	1.94	1.62
Emerging & Developing Countries	4.04	4.56	3.27
Sub-Saharan Africa	4.91	2.67	5.15
Latin America & Caribbean	3.07	1.05	2.67
Emerging Asia	4.49	6.20	3.32
Middle East & North Africa	2.96	1.77	2.75
Constant age structure and pop growth as in Baseline (D)			
World	3.31	3.40	2.90
Advanced Economies	2.09	1.94	1.87
Emerging & Developing Countries	4.02	4.56	3.34
Sub-Saharan Africa	4.45	2.67	4.48
Latin America & Caribbean	2.99	1.05	2.74
Emerging Asia	4.51	6.20	3.48
Middle East & North Africa	2.98	3.01	3.01
Constant age structure and growth of population (E)			
World	3.69	3.40	3.64
Advanced Economies	2.33	1.94	2.35
Emerging & Developing Countries	4.46	4.56	4.15
Sub-Saharan Africa	4.83	2.67	5.29
Latin America & Caribbean	3.39	1.05	3.52
Emerging Asia	4.95	6.20	4.30
Middle East & North Africa	3.69	3.01	4.03

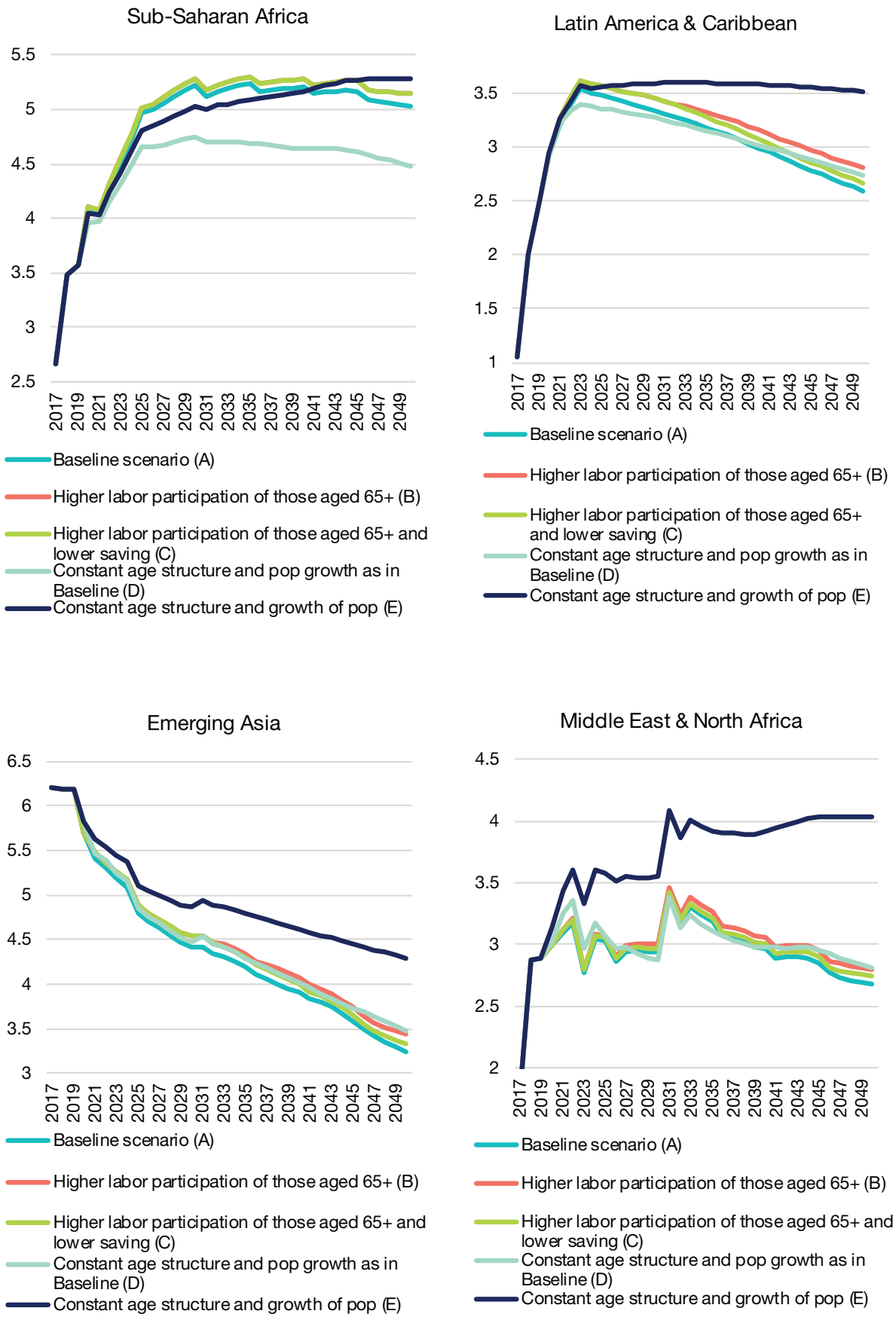
Source: Centennial-Group.

Figure A1.1: GDP Growth Rates, 2017-2050



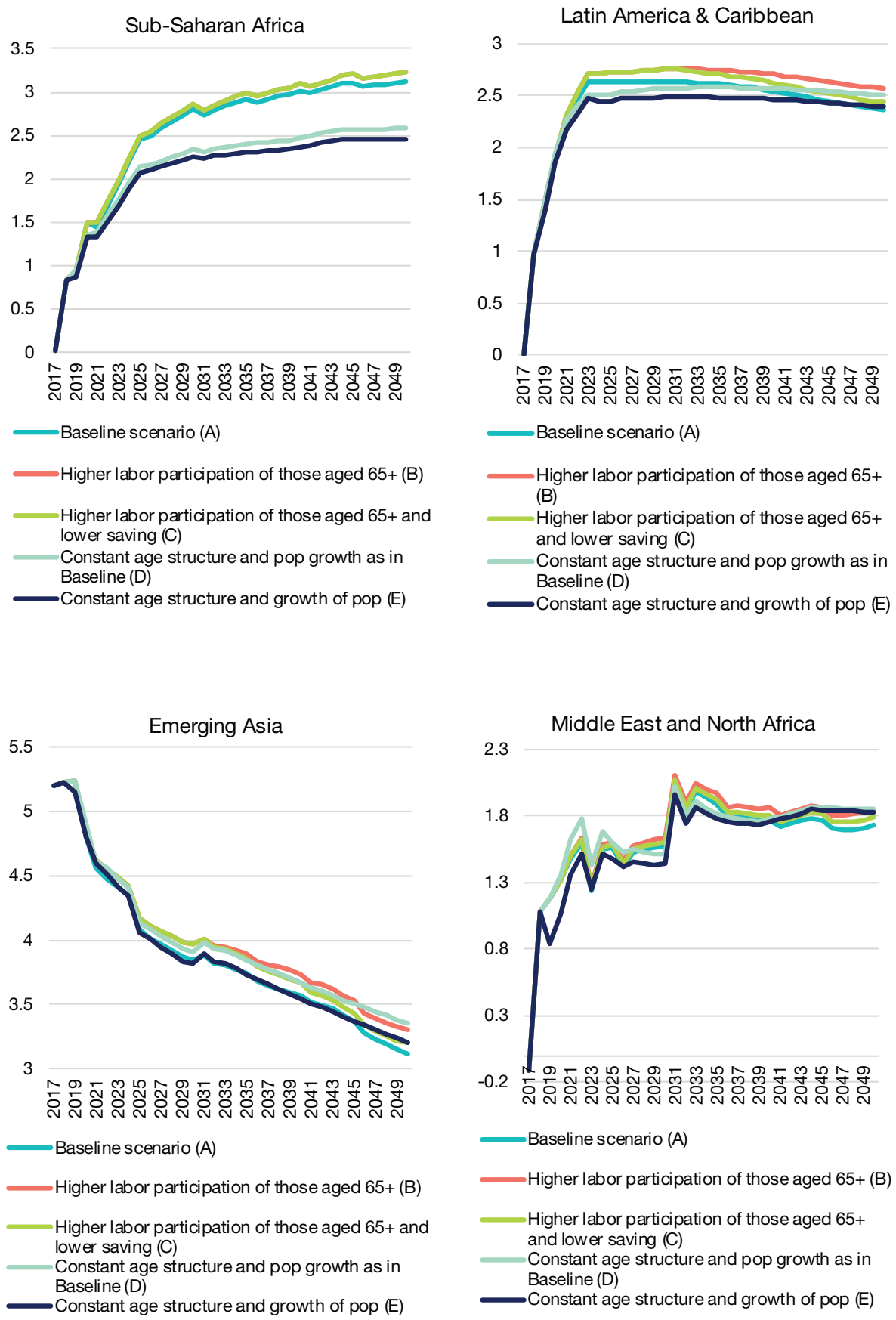
Source: Centennial Estimates.

Figure A1.1: GDP Growth Rates, 2017-2050 (continued)



Source: Centennial Estimates.

Figure A1.2: GDP per capita Growth Rates, 2017-2050



Source: Centennial Estimates.

Table A1.2: GDP as a function of labor force and output per worker

		Average GDP per capita Growth (from 2017)	Average GDP Growth (from 2017)	Employed 65+ (millions)	Employed 25-64 (millions)	Output per worker (USD 2011)
World						
2017				109.0	2,650.0	34,422
2030	65+ lbr force participation - UN projection	2.43%	3.64%	181.0	2,990.0	47,482
2040	65+ lbr force participation - UN projection	2.57%	3.58%	233.0	3,250.0	60,810
2050	65+ lbr force participation - UN projection	2.62%	3.51%	270.0	3,490.0	77,881
2030	Gradual increase in 65+ lbr force participation	2.50%	3.71%	221.0	2,990.0	47,466
2040	Gradual increase in 65+ lbr force participation	2.64%	3.65%	333.0	3,250.0	60,765
2050	Gradual increase in 65+ lbr force participation	2.69%	3.58%	441.0	3,490.0	77,789
2030	65+ to 25-64 employed ratio constant	2.39%	3.60%	126.3	3,044.5	47,482
2040	65+ to 25-64 employed ratio constant	2.54%	3.56%	139.2	3,343.1	60,810
2050	65+ to 25-64 employed ratio constant	2.61%	3.50%	149.6	3,610.0	77,881
2030	Population grows at 5-year historical rate	2.44%	3.81%	178.0	3,255.3	45,983
2040	Population grows at 5-year historical rate	2.52%	3.78%	251.5	3,872.2	56,718
2050	Population grows at 5-year historical rate	2.50%	3.73%	351.1	4,608.6	69,117
2030	65+ lbr force participation - UN projection AND output per worker growth .5% less	1.87%	3.07%	181.0	2,990.0	44,557
2040	65+ lbr force participation - UN projection AND output per worker growth .5% less	2.01%	3.02%	233.0	3,250.0	54,342
2050	65+ lbr force participation - UN projection AND output per worker growth .5% less	2.06%	2.95%	270.0	3,490.0	66,275
2030	No change in population from 2017	2.95%	3.19%	117.9	2,653.0	49,410
2040	No change in population from 2017	3.03%	3.17%	121.4	2,696.2	64,496
2050	No change in population from 2017	3.05%	3.14%	123.4	2,741.6	83,794
Advanced Economies						
2017				20.2	435.0	93,459
2030	65+ lbr force participation - UN projection	1.42%	1.71%	32.6	433.0	119,312
2040	65+ lbr force participation - UN projection	1.39%	1.63%	34.8	428.0	143,970
2050	65+ lbr force participation - UN projection	1.43%	1.62%	33.8	427.0	173,723
2030	Gradual increase in 65+ lbr force participation	1.47%	1.76%	39.5	433.0	119,291
2040	Gradual increase in 65+ lbr force participation	1.44%	1.68%	49.1	428.0	143,916
2050	Gradual increase in 65+ lbr force participation	1.47%	1.67%	54.5	427.0	173,629
2030	65+ to 25-64 employed ratio constant	1.56%	1.84%	20.6	447.0	119,312
2040	65+ to 25-64 employed ratio constant	1.49%	1.73%	20.5	445.0	143,970
2050	65+ to 25-64 employed ratio constant	1.49%	1.69%	20.4	443.5	173,723
2030	Population grows at 5-year historical rate	1.62%	2.00%	35.9	455.2	117,153
2040	Population grows at 5-year historical rate	1.56%	1.95%	46.5	470.7	138,906
2050	Population grows at 5-year historical rate	1.52%	1.93%	60.3	483.1	165,620
2030	65+ lbr force participation - UN projection AND output per worker growth .5% less	1.00%	1.28%	32.6	433.0	111,921
2040	65+ lbr force participation - UN projection AND output per worker growth .5% less	0.97%	1.21%	34.8	428.0	128,569
2050	65+ lbr force participation - UN projection AND output per worker growth .5% less	1.00%	1.19%	33.8	427.0	147,693
2030	No change in population from 2017	1.81%	1.77%	25.4	443.3	118,342
2040	No change in population from 2017	1.75%	1.73%	25.2	449.0	141,534
2050	No change in population from 2017	1.72%	1.71%	25.0	451.6	170,270
Emerging and Developing Economies						
2017				89.0	2,210.0	24,301
2030	65+ lbr force participation - UN projection	3.40%	4.53%	148.0	2,550.0	36,504
2040	65+ lbr force participation - UN projection	3.45%	4.45%	198.0	2,820.0	49,919
2050	65+ lbr force participation - UN projection	3.44%	4.35%	236.0	3,060.0	68,265
2030	Gradual increase in 65+ lbr force participation	3.56%	4.69%	182.0	2,550.0	36,478
2040	Gradual increase in 65+ lbr force participation	3.60%	4.61%	284.0	2,820.0	49,839
2050	Gradual increase in 65+ lbr force participation	3.58%	4.49%	387.0	3,060.0	68,089
2030	65+ to 25-64 employed ratio constant	3.22%	4.35%	104.4	2,598.3	36,504
2040	65+ to 25-64 employed ratio constant	3.33%	4.34%	117.8	2,931.8	49,919
2050	65+ to 25-64 employed ratio constant	3.32%	4.23%	127.5	3,173.7	68,265
2030	Population grows at 5-year historical rate	3.38%	4.68%	140.4	2,802.5	35,223
2040	Population grows at 5-year historical rate	3.39%	4.68%	201.6	3,462.0	45,933
2050	Population grows at 5-year historical rate	3.33%	4.60%	286.6	4,183.0	59,472
2030	65+ lbr force participation - UN projection AND output per worker growth .5% less	2.87%	3.99%	148.0	2,550.0	34,270
2040	65+ lbr force participation - UN projection AND output per worker growth .5% less	2.92%	3.92%	198.0	2,820.0	44,642
2050	65+ lbr force participation - UN projection AND output per worker growth .5% less	2.91%	3.81%	236.0	3,060.0	58,154
2030	No change in population from 2017	3.73%	3.78%	90.6	2,213.1	38,263
2040	No change in population from 2017	3.77%	3.79%	92.9	2,279.8	53,368
2050	No change in population from 2017	3.73%	3.75%	94.4	2,297.0	74,364

Source: Centennial Estimates.

Table A1.2: GDP as a function of labor force and output per worker (cont.)

		Average GDP per capita Growth (from 2017)	Average GDP Growth (from 2017)	Employed 65+ (millions)	Employed 25-64 (millions)	Output per worker (USD 2011)
European Union						
2017				6.0	200.6	83,154
2030	65+ lbr force participation - UN projection	0.77%	0.90%	9.7	188.0	106,750
2040	65+ lbr force participation - UN projection	0.84%	0.89%	10.3	179.0	129,366
2050	65+ lbr force participation - UN projection	0.92%	0.92%	9.8	172.0	156,773
2030	Gradual increase in 65+ lbr force participation	0.78%	0.91%	11.7	188.0	106,748
2040	Gradual increase in 65+ lbr force participation	0.85%	0.90%	14.6	179.0	129,359
2050	Gradual increase in 65+ lbr force participation	0.93%	0.93%	15.7	172.0	156,761
2030	65+ to 25-64 employed ratio constant	0.97%	1.10%	5.7	193.1	106,750
2040	65+ to 25-64 employed ratio constant	0.96%	1.01%	5.5	183.9	129,366
2050	65+ to 25-64 employed ratio constant	1.00%	1.00%	5.2	176.5	156,773
2030	Population grows at 5-year historical rate	1.10%	1.29%	9.8	199.3	104,494
2040	Population grows at 5-year historical rate	1.09%	1.24%	11.4	196.3	124,972
2050	Population grows at 5-year historical rate	1.11%	1.25%	13.3	195.1	149,370
2030	65+ lbr force participation - UN projection AND output per worker growth .5% less	0.40%	0.53%	9.7	188.0	100,140
2040	65+ lbr force participation - UN projection AND output per worker growth .5% less	0.47%	0.52%	10.3	179.0	115,533
2050	65+ lbr force participation - UN projection AND output per worker growth .5% less	0.56%	0.55%	9.8	172.0	133,292
2030	No change in population from 2017	1.32%	1.40%	7.9	203.2	103,709
2040	No change in population from 2017	1.32%	1.36%	7.9	203.6	123,130
2050	No change in population from 2017	1.34%	1.37%	7.8	205.8	145,949
Latin America and the Caribbean						
2017				11.3	227.2	29,952
2030	65+ lbr force participation - UN projection	2.53%	3.34%	16.8	265.0	39,467
2040	65+ lbr force participation - UN projection	2.46%	3.16%	22.3	284.0	48,797
2050	65+ lbr force participation - UN projection	2.39%	2.98%	28.0	291.0	60,333
2030	Gradual increase in 65+ lbr force participation	2.53%	3.34%	20.7	265.0	39,466
2040	Gradual increase in 65+ lbr force participation	2.46%	3.16%	32.2	284.0	48,795
2050	Gradual increase in 65+ lbr force participation	2.39%	2.98%	46.0	291.0	60,328
2030	65+ to 25-64 employed ratio constant	2.59%	3.40%	11.0	273.0	39,467
2040	65+ to 25-64 employed ratio constant	2.49%	3.20%	11.9	295.8	48,797
2050	65+ to 25-64 employed ratio constant	2.42%	3.01%	12.4	307.6	60,333
2030	Population grows at 5-year historical rate	2.57%	3.63%	16.3	300.8	37,639
2040	Population grows at 5-year historical rate	2.38%	3.47%	24.0	363.0	44,199
2050	Population grows at 5-year historical rate	2.20%	3.30%	35.0	439.9	50,018
2030	65+ lbr force participation - UN projection AND output per worker growth .5% less	1.88%	2.69%	16.8	265.0	37,028
2040	65+ lbr force participation - UN projection AND output per worker growth .5% less	1.83%	2.53%	22.3	284.0	43,589
2050	65+ lbr force participation - UN projection AND output per worker growth .5% less	1.76%	2.35%	28.0	291.0	51,313
2030	No change in population from 2017	2.71%	2.65%	10.1	227.9	41,360
2040	No change in population from 2017	2.62%	2.59%	10.2	229.8	51,956
2050	No change in population from 2017	2.55%	2.53%	10.3	232.7	64,378
Sub-Saharan Africa						
2017				14.3	255.1	9,213
2030	65+ lbr force participation - UN projection	3.05%	5.57%	19.0	404.0	12,189
2040	65+ lbr force participation - UN projection	3.11%	5.54%	27.1	550.0	15,118
2050	65+ lbr force participation - UN projection	3.13%	5.45%	40.9	717.0	18,750
2030	Gradual increase in 65+ lbr force participation	3.39%	5.93%	22.8	404.0	12,178
2040	Gradual increase in 65+ lbr force participation	3.46%	5.91%	37.7	550.0	15,090
2050	Gradual increase in 65+ lbr force participation	3.47%	5.80%	64.7	717.0	18,690
2030	65+ to 25-64 employed ratio constant	3.41%	5.94%	22.7	404.9	12,189
2040	65+ to 25-64 employed ratio constant	3.25%	5.69%	30.8	550.3	15,118
2050	65+ to 25-64 employed ratio constant	3.14%	5.46%	40.4	720.9	18,750
2030	Population grows at 5-year historical rate	3.15%	5.52%	18.0	408.7	12,143
2040	Population grows at 5-year historical rate	3.06%	5.46%	23.8	561.7	15,014
2050	Population grows at 5-year historical rate	2.98%	5.39%	31.5	770.9	18,285
2030	65+ lbr force participation - UN projection AND output per worker growth .5% less	2.63%	5.15%	19.0	404.0	11,436
2040	65+ lbr force participation - UN projection AND output per worker growth .5% less	2.69%	5.12%	27.1	550.0	13,505
2050	65+ lbr force participation - UN projection AND output per worker growth .5% less	2.71%	5.03%	40.9	717.0	15,948
2030	No change in population from 2017	2.76%	2.70%	12.4	273.4	13,582
2040	No change in population from 2017	2.57%	2.54%	12.4	275.8	17,787
2050	No change in population from 2017	2.43%	2.41%	12.4	277.8	22,808

Source: Centennial Estimates.

Table A1.2: GDP as a function of labor force and output per worker (cont.)

		Average GDP per capita Growth (from 2017)	Average GDP Growth (from 2017)	Employed 65+ (millions)	Employed 25-64 (millions)	Output per worker (USD 2011)
Emerging and Developing Asia						
2017				66.5	1,356.7	22,311
2030	65+ lbr force participation - UN projection	6.73%	7.41%	104.0	1,660.0	48,829
2040	65+ lbr force participation - UN projection	6.47%	7.01%	139.0	1,750.0	89,195
2050	65+ lbr force participation - UN projection	6.38%	6.81%	156.0	1,800.0	162,930
2030	Gradual increase in 65+ lbr force participation	6.69%	7.37%	128.0	1,660.0	48,836
2040	Gradual increase in 65+ lbr force participation	6.43%	6.97%	200.0	1,750.0	89,227
2050	Gradual increase in 65+ lbr force participation	6.35%	6.77%	257.0	1,800.0	163,023
2030	65+ to 25-64 employed ratio constant	6.87%	7.54%	82.5	1,681.7	48,829
2040	65+ to 25-64 employed ratio constant	6.64%	7.19%	88.5	1,804.8	89,195
2050	65+ to 25-64 employed ratio constant	6.52%	6.94%	91.4	1,863.9	162,930
2030	Population grows at 5-year historical rate	6.89%	7.85%	102.0	1,862.4	46,690
2040	Population grows at 5-year historical rate	6.54%	7.50%	148.9	2,253.3	80,109
2050	Population grows at 5-year historical rate	6.31%	7.27%	220.0	2,709.0	133,991
2030	65+ lbr force participation - UN projection AND output per worker growth .5% less	6.24%	6.91%	104.0	1,660.0	45,924
2040	65+ lbr force participation - UN projection AND output per worker growth .5% less	5.98%	6.52%	139.0	1,750.0	80,021
2050	65+ lbr force participation - UN projection AND output per worker growth .5% less	5.89%	6.31%	156.0	1,800.0	139,436
2030	No change in population from 2017	7.07%	7.05%	62.0	1,489.2	50,621
2040	No change in population from 2017	6.79%	6.77%	62.1	1,527.7	93,171
2050	No change in population from 2017	6.63%	6.62%	62.6	1,547.5	170,899
Middle East and North Africa						
2017				1.7	90.1	55,332
2030	65+ lbr force participation - UN projection	0.48%	2.18%	3.3	114.0	61,062
2040	65+ lbr force participation - UN projection	0.85%	2.33%	4.7	140.0	65,871
2050	65+ lbr force participation - UN projection	0.84%	2.17%	6.5	161.0	71,059
2030	Gradual increase in 65+ lbr force participation	0.41%	2.11%	4.1	114.0	61,068
2040	Gradual increase in 65+ lbr force participation	0.78%	2.26%	7.0	140.0	65,885
2050	Gradual increase in 65+ lbr force participation	0.77%	2.11%	11.2	161.0	71,085
2030	65+ to 25-64 employed ratio constant	0.75%	2.46%	2.1	115.8	61,062
2040	65+ to 25-64 employed ratio constant	1.06%	2.54%	2.6	143.2	65,871
2050	65+ to 25-64 employed ratio constant	1.05%	2.39%	3.1	166.9	71,059
2030	Population grows at 5-year historical rate	0.91%	2.96%	2.8	126.5	58,698
2040	Population grows at 5-year historical rate	1.18%	3.16%	3.9	172.1	60,586
2050	Population grows at 5-year historical rate	1.21%	3.17%	5.4	233.4	60,059
2030	65+ lbr force participation - UN projection AND output per worker growth .5% less	0.22%	1.91%	3.3	114.0	57,239
2040	65+ lbr force participation - UN projection AND output per worker growth .5% less	0.58%	2.06%	4.7	140.0	58,750
2050	65+ lbr force participation - UN projection AND output per worker growth .5% less	0.57%	1.90%	6.5	161.0	60,301
2030	No change in population from 2017	0.54%	0.70%	1.8	90.4	65,493
2040	No change in population from 2017	0.80%	0.89%	1.8	94.9	73,276
2050	No change in population from 2017	0.85%	0.91%	1.8	98.9	80,457

Source: Centennial Estimates.

The Emerging Markets Forum was created by the Centennial Group as a not-for-profit initiative to bring together high-level government and corporate leaders from around the world to engage in dialogue on the key economic, financial and social issues facing emerging market countries.

The Forum is focused on some 70 market economies in East and South Asia, Eurasia, Latin America and Africa that share prospects of superior economic performance, already have or seek to create a conducive business environment and are of near-term interest to private investors, both domestic and international. Our current list of EMCs is shown on the back cover. We expect this list to eveolve over time, as countries' policies and prospects change.

Further details on the Forum and its meetings may be seen on our website at http://www.emergingmarketsforum.org

The Watergate Office Building, 2600 Virginia Avenue, NW, Suite 201

Washington, DC 20037, USA. Tel:(1) 202 393 6663 Fax: (1) 202 393 6556

Email: info@emergingmarketsforum.org