Vanguard Research:
Megatrends

The economics
of a graying world

About the Megatrends series

Megatrends have accompanied humankind throughout history. From the Neolithic Revolution to the Information Age, innovation has been the catalyst for profound socioeconomic, cultural, and political transformation. The term "Megatrends" was popularized by author John Naisbitt, who was interested in the transformative forces that have a major impact on both businesses and societies, and thus the potential to change all areas of our personal and professional lives.

Vanguard's "Megatrends" is a research effort that investigates fundamental shifts in the global economic landscape that are likely to affect the financial services industry and broader society. A megatrend may bring market growth or destroy it, increase competition or add barriers to entry, and create threats or uncover opportunities. Exploring the long-term nature of massive shifts in technology, demographics, and globalization can help us better understand how such forces may shape future markets, individuals, and the investing landscape in the years ahead.

Vanguard Investment Strategy Group's Global Economics Team

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Megatrend: **The economics of a graying world**

■ Lower fertility rates and longer life expectancies are expected to drive unprecedented shifts in the composition of populations globally, as the percentage of those age 65 and older is estimated to nearly double, from 8% in 2015 to 15% in 2045. Though demographics are only one factor affecting economic growth, these changes have important implications for how economies may evolve.

■ We estimate that these demographic trends will have a neutral to negative impact on long-term GDP growth through lower population growth and lower participation in the labor force. These downward pressures may be offset by the higher productivity growth that is needed for a shrinking number of workers to support a growing number of retirees. On balance, the overall impact will be muted, as demographic changes have only an indirect and minor effect on productivity growth, the main driver of economic growth.

■ From an investor's perspective, although demographics may exert downward pressure on the risk-free interest rate, risk premia are not clearly linked to demographic changes. In light of these conclusions, a low-cost, globally diversified portfolio provides the best chance of investment success through exposure to a variety of growth and demographic outlooks.

Authors

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The testing ground for one of the first major pilot programs for autonomous vehicles might come as a surprise—it's not in Silicon Valley, but nearly 3,000 miles away, in the residential community of The Villages, Florida. With a population of over 100,000, consistent weather, and a road network much simpler than in most metropolitan areas, The Villages in many ways is the perfect site for this exciting technological frontier. But perhaps even more important, demand for autonomous vehicles is abundant in a retirement community where residents' median age is 67.

Technologies developed for and adapted to the needs of retirees will continue to become more widespread. Developed economies around the world are aging, and as a result, transportation, leisure, and consumption patterns (just to name a few) are evolving to reflect this changing demographic landscape. How these changes ultimately affect economies will be determined by an interplay of many factors, and could end up contradicting many common assumptions about aging populations (see **Figure 1**).

Introduction: Population growth is declining as life expectancy is rising

The global population has nearly tripled to more than 7 billion since the end of World War II, growing at a peak rate of more than 2% per year in the late 1960s. Since that time, however, developed countries and the rest of the world have experienced declining population growth rates, as shown in estimates from the United Nations (see **Figure 2**). This trend reflects falling fertility rates and is expected to persist for decades, raising concerns about negative pressures for economies, governments, and financial markets.
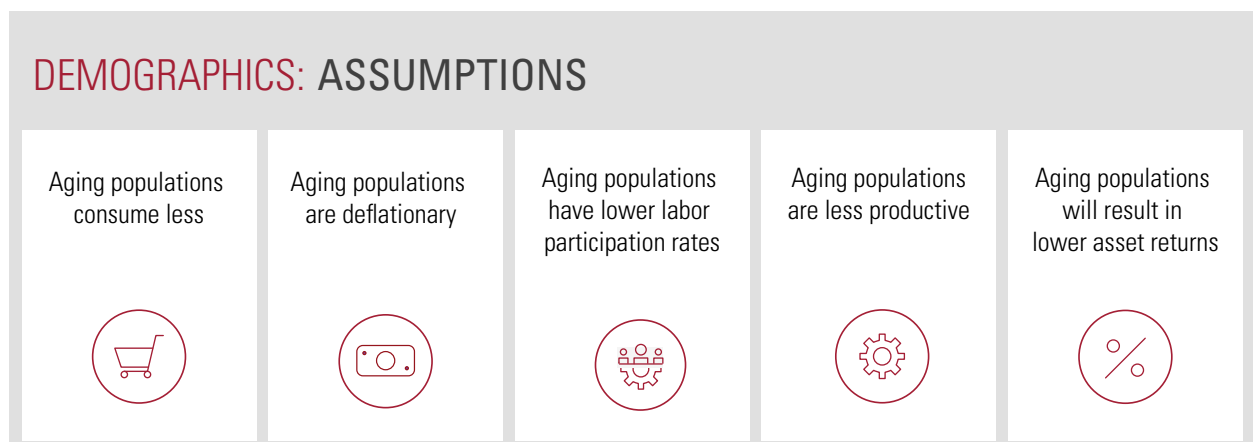
The other consequential demographic trend is increased life expectancy. Together, these trends will shift the composition (or age structure) of populations around the world toward a higher proportion of elderly. Age structure is commonly expressed by a dependency ratio, which is the number of younger and older persons in a society relative to the number of working-age persons.[1]

KEY CONCEPT EXPLAINED

Dependency ratio is the number of young and old persons relative to the number of working-age persons.

FIGURE 1

Reality is more nuanced than these common assumptions suggest

DEMOGRAPHICS: ASSUMPTIONS

Aging populations consume less

Aging populations are deflationary

Aging populations have lower labor participation rates

Aging populations are less productive

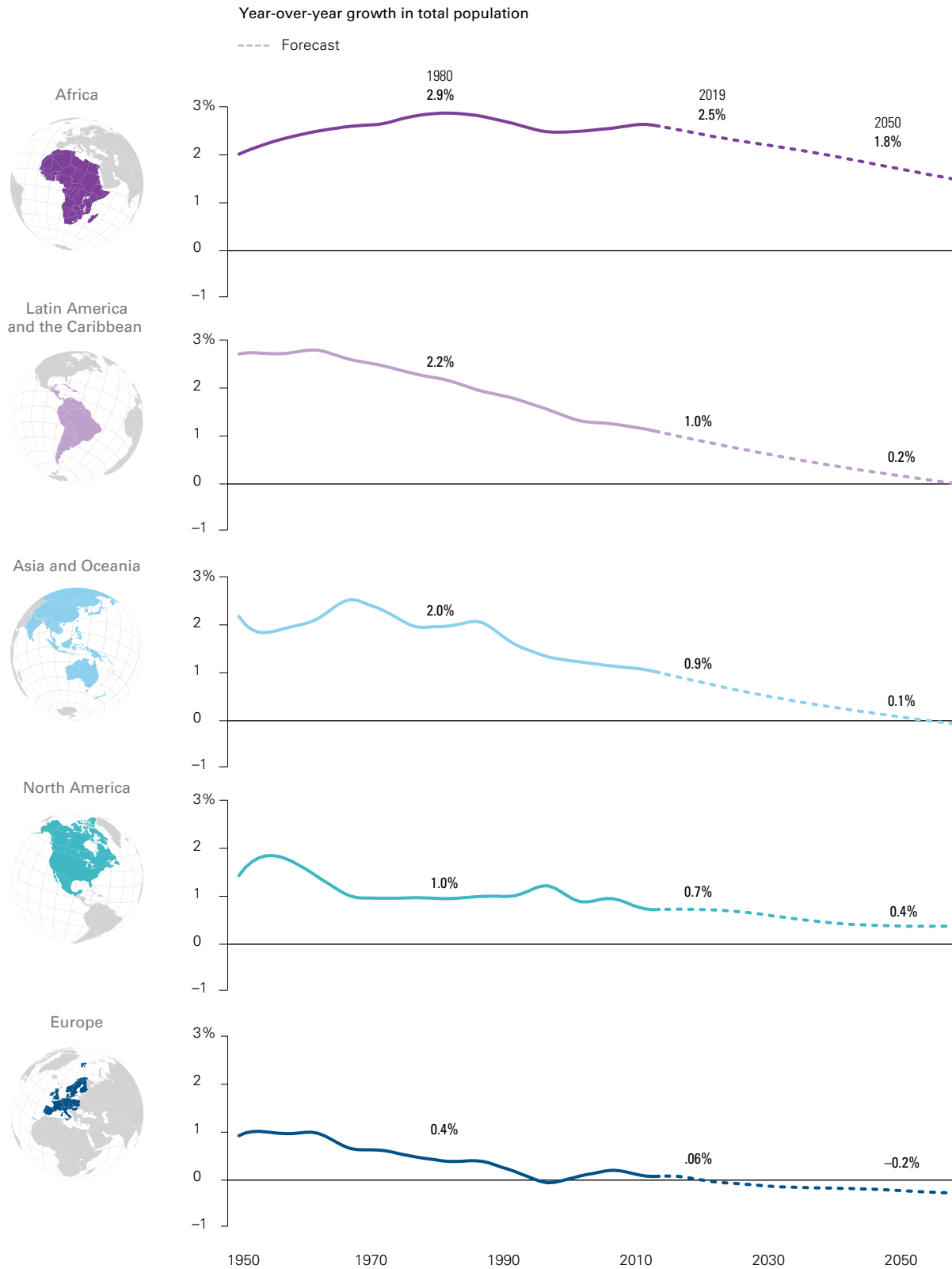Aging populations will result in lower asset returns

Source: Vanguard analysis.

1 Throughout this paper, the dependency ratio refers to the ratio of those under 25 and over 64 to the number of working-aged.

FIGURE 2

Slowing population growth is a global phenomenon

Year-over-year growth in total population

- - - - Forecast

Africa

3%
2
1
0
−1

1980
2.9%

2019
2.5%

2050
1.8%

Latin America and the Caribbean

3%
2
1
0
−1

2.2%

1.0%

0.2%

Asia and Oceania

3%
2
1
0
−1

2.0%

0.9%

0.1%

North America

3%
2
1
0
−1

1.0%

0.7%

0.4%

Europe

3%
2
1
0
−1

0.4%

.06%

−0.2%

1950   1970   1990   2010   2030   2050

Sources: Vanguard analysis, based on data from *World Population Prospects: The 2017 Revision,* United Nations Department of Economic and Social Affairs.

Like slowing population growth, rising dependency ratios are a global phenomenon, beginning in the 2010s with Europe and North America (see **Figure 3A**). Europe's dependency ratio will rise most quickly, exceeding the prior highs of the post-war period, while the ratio for Asia, Oceania, and Latin America in aggregate will increase modestly through the 2020s and 2030s.[2]

These projections seem to exhibit a reversion to levels within a "normal" historical range experienced in prior decades. This is because the dependency ratio measures the relative number of *both* young and old dependents, so does not express which group is causing the expected increase. In the 1950s, dependency ratios rose because of an increase in the number of young dependents (under 25); in the 2010s and the decades ahead, dependency ratios will rise because of an increase in the number of elderly dependents (65 and over), leading to an unprecedented proportion of elderly persons in the population (see **Figure 3B**). **The increase in the dependency ratio is less important than the cause of the increase, as modern economies have never had such a high proportion of elderly make up their populations.**

Demographic trends are relatively reliable within a 15-year time horizon because populations and the generations within them grow and age at a steady and predictable rate, according to the National Research Council. As a result, many observers expect the same reliability when speculating on the effects these demographic trends may have on economies and markets. For example, the postwar population boom has coincided with rapid economic growth during decades of globalization, leading many to believe that lower economic growth must accompany lower population growth. Although population growth does have a direct effect on economic growth, there are many more indirect or "second-order" effects to consider when evaluating the impact of demographic changes on economies and financial markets.

The goal of this analysis is to establish a framework by which to understand the dynamics between demographics and economics, along with the likely effect on economic growth and financial markets in the coming decades. We first review the connections between demographic changes and overall economic growth, including the economic characteristics of each age cohort. Next, we examine the components of economic growth in more detail to develop expectations for how these changes will affect economies in aggregate. Lastly, we consider the implications for public finances and financial markets, and how investors should respond.

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2 The dependency ratio in Asia and Oceania is expected to rise modestly through 2050; however, it is important to note that this muted inflection is affected by diverging trends in dependency ratios in China and India. Although India's dependency ratio is expected to continue to decline through 2050, China's demographic outlook is much less favorable. From a low of 0.67 in 2016, China's dependency ratio is expected to climb to ~1 by 2050, indicating an equal number of working-age adults to dependents.

Dependency ratios are projected to rise …

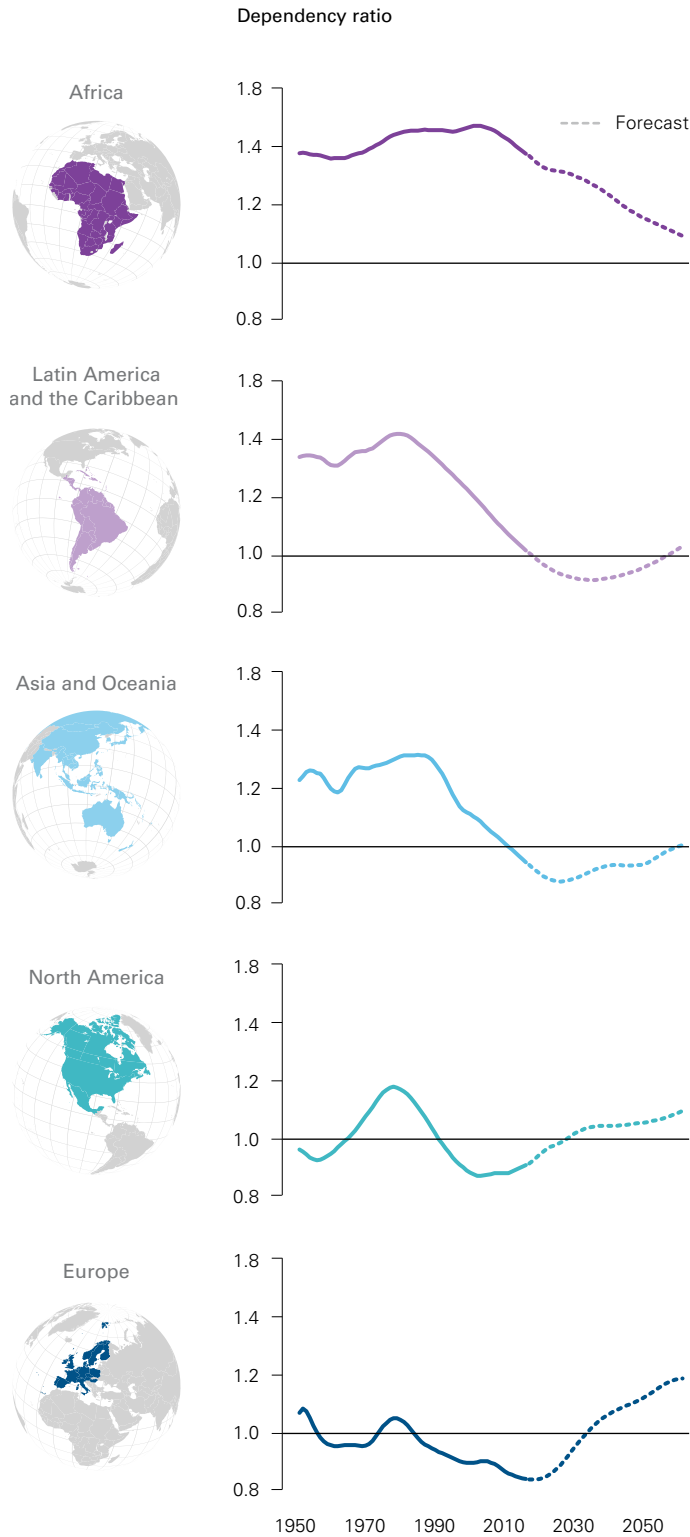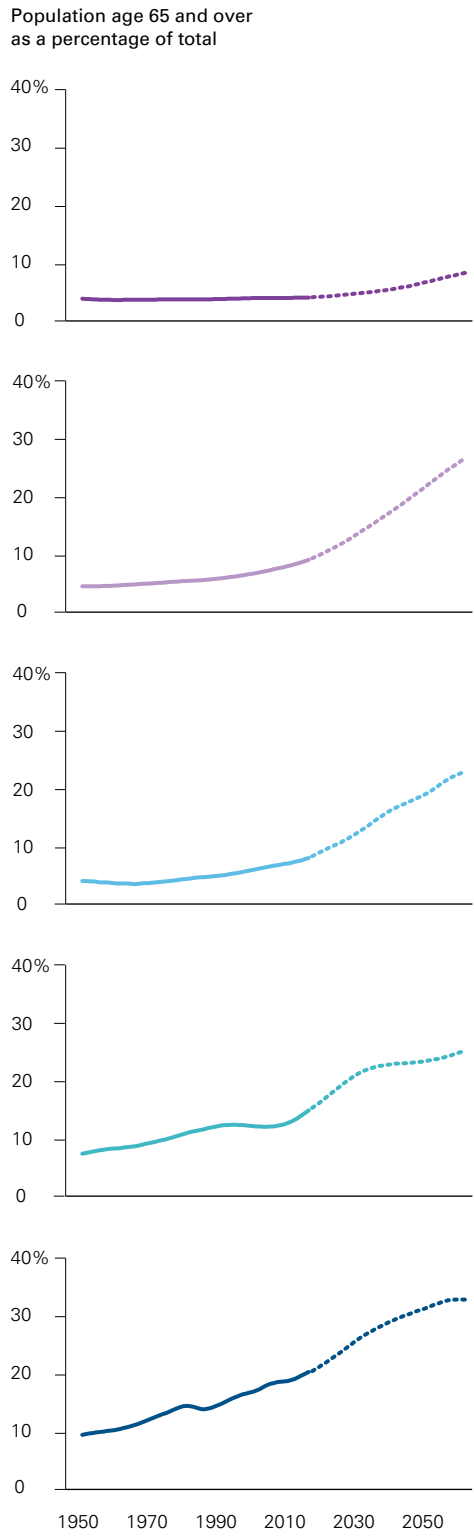## … driven by larger old-age cohorts

Dependency ratio

Population age 65 and over
as a percentage of total

Africa

Latin America
and the Caribbean

Asia and Oceania

North America

Europe

Sources: Vanguard analysis, based on data from *World Population Prospects: The 2017 Revision.*

Demographics play a key role in economic activity

The size and composition of a population is a fundamental determinant of total economic activity because it reflects the number of people making, selling, and buying. This is apparent if we examine economic output (measured as GDP) as three distinct components.

This simple identity (shown to the right) demonstrates that the number of people (population), the proportion of people employed (participation), and how efficiently those employed create output (productivity) are basic determinants of total economic activity.[3] **In short, GDP (and, in turn, GDP growth) is determined by differences in population, participation, and productivity.**

This identity can also be rearranged to express GDP per person, which describes the living standards of an average person in a given economy. By this measure, lower population growth can actually increase the wealth per person in an economy, as long as growth in productivity and participation remains constant or increases. In this analysis, we focus on GDP rather than GDP per person, examining the effect of demographic trends on the population, participation, and productivity components outlined above.[5]

In addition to demography, institutional factors that facilitate economic activity and promote innovation remain key drivers of GDP growth, as is evident in the outsized contribution of productivity in historical growth rates across countries (see **Figure 4**).[6] Population growth has a relatively small contribution to average annual GDP growth, even in a country such as India that has experienced rapid population growth. On the other side of the spectrum, the same holds true of countries with low population growth. In the case of Japan, falling GDP growth is attributable to falling productivity growth rather than population growth, which has consistently fluctuated between 0% and 1% for decades. Coincident

examples of slowing population growth and declining economic growth in many developed economies, such as Japan, suggest demographic changes have second-order effects, but the evidence is far from conclusive that slowing population growth guarantees economic malaise. **In other words, demographics have a significant, direct impact on the smallest contributors of GDP growth (population and participation) and a minor, indirect impact on the largest contributor of GDP growth (productivity).**

KEY CONCEPT EXPLAINED

GDP is determined by differences in population, participation, and productivity:[4]

$$\text{POPULATION} \times \frac{\text{EMPLOYMENT}}{\text{POPULATION}} \times \frac{\text{GDP}}{\text{EMPLOYMENT}}$$

Economic output (measured as GDP) reflects the number and efficiency of people making, selling, and buying. We examine it as three distinct components:

Population: Total number of people

Participation: Proportion of population employed

Productivity: Output by those participating in employment

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3 *Participation* as used in this paper is the employment-to-population ratio. This term should not be mistaken for labor force participation, which is more narrowly defined as the proportion of those employed relative to the labor force.
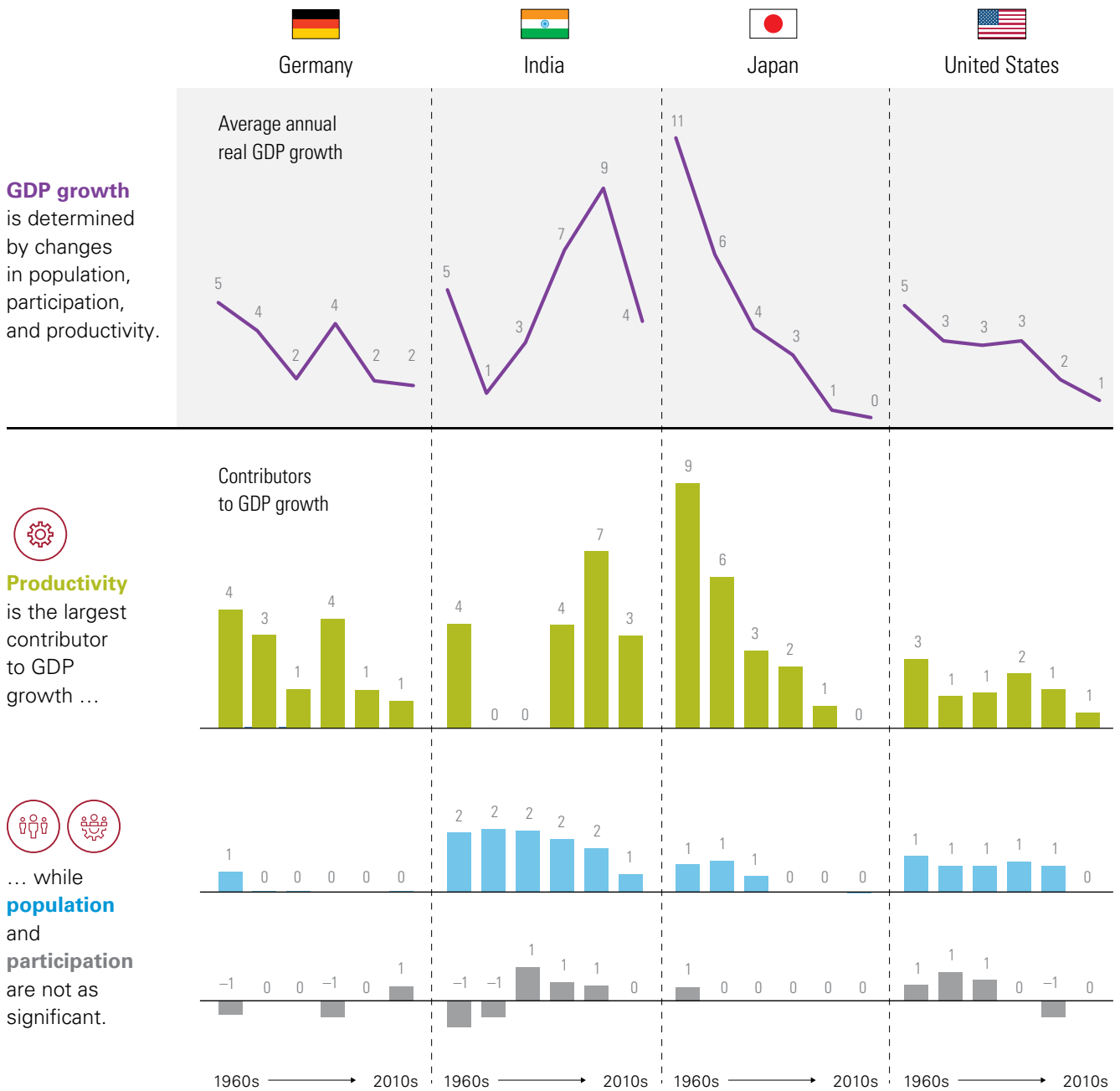
4 Note that the population and employment terms divide out, leaving the identity of GDP equal to itself.

5 Although GDP per person may better capture economic well-being, overall GDP has direct implications for real interest rates and, in turn, financial markets. Therefore, GDP is a more appropriate measure for our purpose of assessing the implications of demographic changes for economies and financial markets.

6 The economic growth literature cites institutional factors such as property rights, trade openness, and rule of law as important prerequisites for economic development.

FIGURE 4

**Productivity, not population, has been the most important contributor
to long-run GDP growth**

	Germany	India	Japan	United States

GDP growth is determined by changes in population, participation, and productivity.

Average annual real GDP growth

Productivity is the largest contributor to GDP growth …

Contributors to GDP growth

… while **population** and **participation** are not as significant.

1960s ⟶ 2010s   1960s ⟶ 2010s   1960s ⟶ 2010s   1960s ⟶ 2010s

Notes: GDP growth figures are expressed as percentages. Results are averages for each decade. Components may not sum to aggregate percentage growth due to rounding.
Sources: Vanguard analysis, based on data from the Penn World Tables.

A population's composition is just as important as its size

As previously noted, the other consequential global demographic trend relates to the age structure of populations, which has a less direct impact on growth through the participation and productivity components. Age structure, commonly measured by the dependency ratio, is just as critical as population growth because of the different characteristics each age cohort exhibits throughout the human lifespan.

From an economic perspective, a population is divided into three parts. The young-age cohort (ages 0–24) does not contribute meaningfully to production and shows steadily increasing consumption into young adulthood. This group also has the most substantial effect on growth via expectations, as businesses invest because they anticipate higher future demand for goods and services. The working-age cohort (ages 25–64) is made up of net savers, as they innovate and produce in excess of their personal consumption in order to support children and elderly dependents, as well as save for retirement. An individual typically realizes the highest levels of income and saving during these years. The old-age cohort (ages 65 and over) is increasingly difficult to generalize because of longer life expectancy; however, at some point this group leaves the workforce and shifts to being net spenders, consuming in excess of their public and/or private retirement income.

These generalized characteristics of age cohorts highlight the importance of such a significant proportion of elderly in the population. Although it is impossible to predict how this generation of elderly will change its behavior to adjust to evolving circumstances, past consumption patterns challenge the common narrative of a precipitous decline in demand for goods and services. A summary of survey data from 40 countries illustrates these generalizations (see **Figure 5**). Youth consume the least of any age cohort but grow their consumption (and later, income) at the fastest rate. Income peaks in middle age and exceeds consumption in a period of net savings. And contrary to common belief, the elderly do not reduce

Population is divided into three parts, called cohorts:

Young-age cohort
(ages 0–24)

- Does not contribute meaningfully to production
- Steadily increases consumption

Working-age cohort
(ages 25–64)

- Realizes highest level of income
- Supports children and elderly dependents

Old-age cohort
(ages 65 and over)

- Leaves the workforce
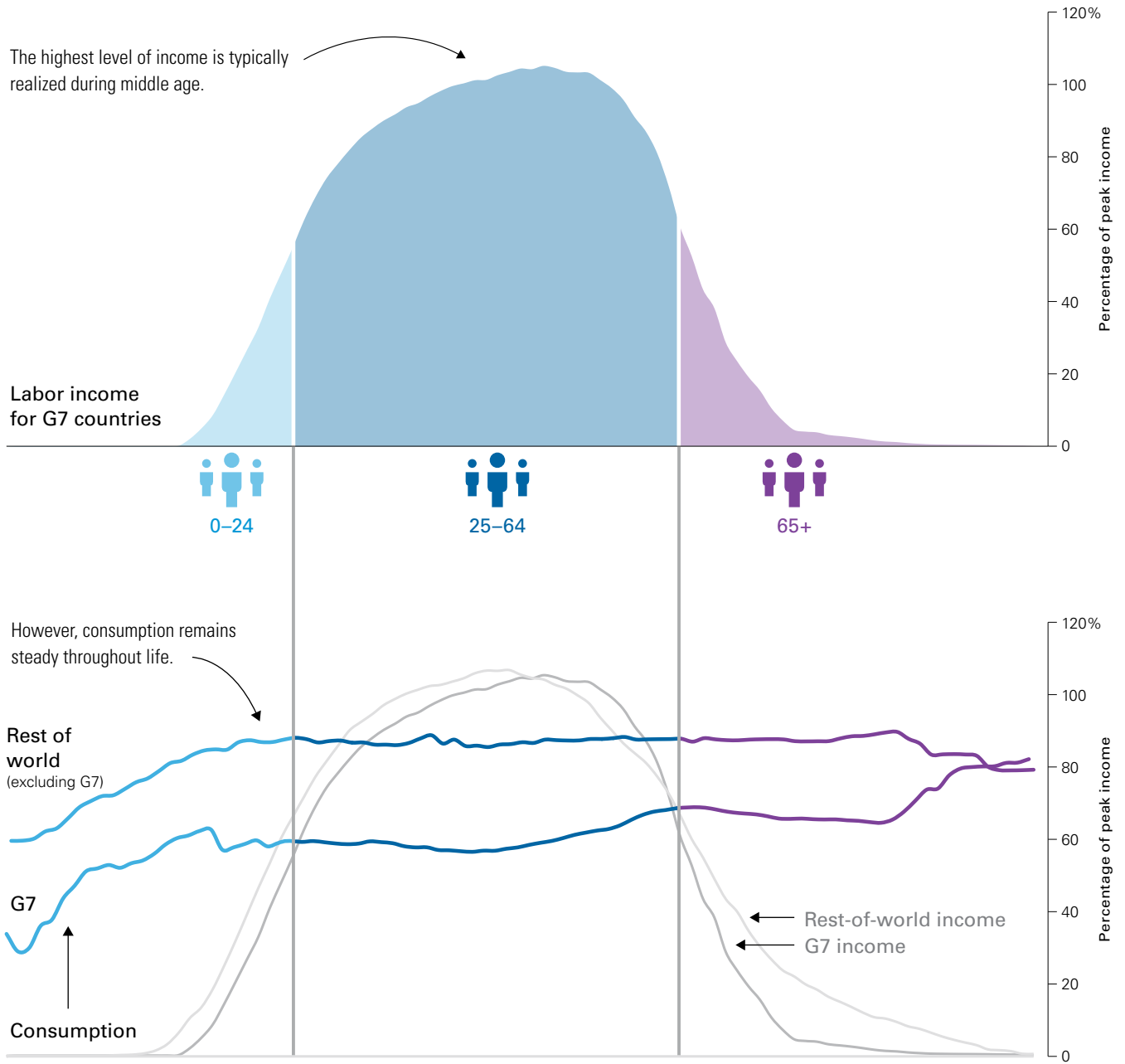- Consumes in excess of retirement income

Net spenders consume **more** than their income, and net savers consume **less** than their income.

their consumption despite a sharp drop in labor income. Consumption remains about 70% of prime-age labor income throughout life, beginning in young adulthood, and can even increase if costly end-of-life care is necessary. This is the case especially for consumption in developed countries (denoted as G7 in the figure).

Looking at the United States as a proxy for developed economies, data from the Bureau of Labor Statistics confirm these consumption patterns and highlight the

FIGURE 5

Consumption as a percentage of peak income is steady after young adulthood

The highest level of income is typically realized during middle age.

Labor income for G7 countries

0–24

25–64

65+

However, consumption remains steady throughout life.

Rest of world
(excluding G7)

G7

Rest-of-world income
G7 income

Consumption

G7: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.

Sources: Vanguard analysis, based on data from U.N. National Transfer Accounts.

shift in expenditures as a person enters retirement (see **Figure 6**). Food and education expenses decline marginally, while money previously spent on apparel, leisure, and transportation are instead spent on housing and health care. In short, consumption does not decline but shifts, reflecting changing needs and priorities. We can expect a larger elderly cohort to have a neutral rather than negative effect on total consumption levels. However, it is important to recall that the trend is not only about a large elderly cohort but also a small young-age cohort. **So although a large elderly cohort implies that consumption *levels* will remain stable, a small youth cohort means that consumption *growth* will be lower.**

The shifting proportions of these age cohorts also have important implications for inflation. As our analysis of expenditure data does not support the hypothesis of a significant decline in consumption, we do not expect that demographic factors will be a major headwind for inflation in the coming decades (see the text box on page 13). However, today's retirement-driven increase in the dependency ratio could have different consequences than the fertility-driven increase had in the 1960s, even though both cohorts are net spenders. The key element may not simply be the dependency ratio itself but the consumption growth that accompanies a large, maturing young-age cohort. For example, in the U.S. the large proportion of baby boomers reaching young adulthood in the 1960s and 1970s drove rapid

Recall that GDP is determined by differences in population, participation, and productivity:

$$\text{POPULATION} \times \frac{\text{EMPLOYMENT}}{\text{POPULATION}} \times \frac{\text{GDP}}{\text{EMPLOYMENT}}$$

Dependency ratio is the number of young and old persons relative to the number of working-age persons.

consumption growth for the overall economy and may have bid up prices of consumer goods. Absent this large young-age cohort, demographic changes may have little effect on inflation.

These analyses of consumption and inflation highlight the uncertainty of predicting the impact of demographics; past correlations may suggest one outcome, but other factors may more than offset this initial conclusion.[7] Separating GDP into population, participation, and productivity components provides a simple but comprehensive means of exploring the dynamics between demographics and economic growth.

FIGURE 6

Older U.S. generations exhibit a shift, rather than a decline, in consumption
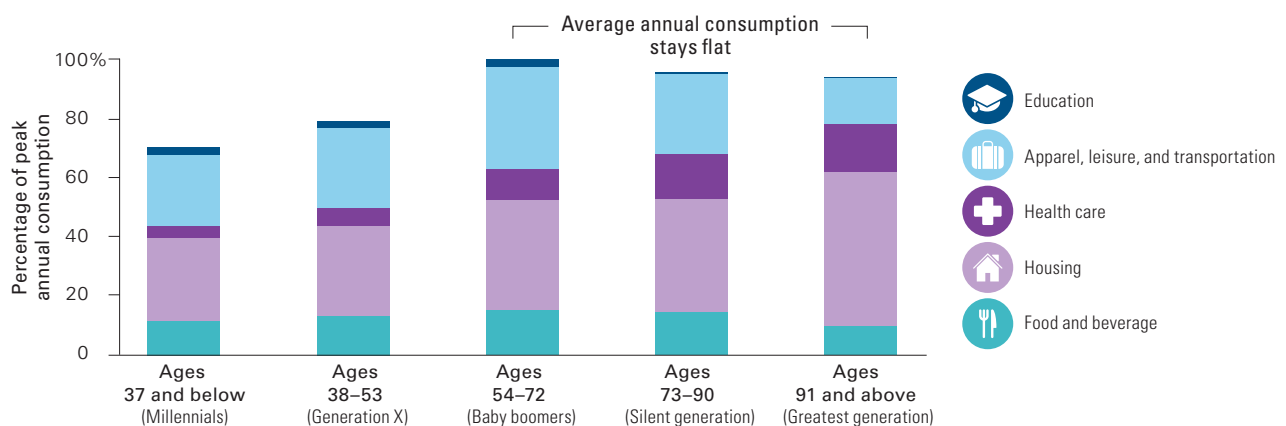
Note: Data are as of June 2016.
Sources: Vanguard analysis, based on data from the U.S. Bureau of Labor Statistics.

[7] Other factors add further uncertainty to forming precise predictions about future consumption. For example, technological advances could lower the expected cost of health care during retirement, making it possible for retirees to allocate more toward leisure than necessities. On the other hand, realized or expected shortfalls in retirement income could prompt retirees to cut spending more than expected. This uncertainty also can be attributed to the fact that the data ignore generational differences in retirement, providing only a snapshot of the individuals who retired in the past two decades. As every generation is born into different political, cultural, and economic circumstances, each can be expected to have its own preferences and behaviors. So, projections of consistent behavior from one generation to the next are made with a high degree of uncertainty. For additional reading on the topic, see the Strauss-Howe generational theory (Strauss and Howe, 1997).

Demographics are only loosely related to inflation

The effect of demographic trends on inflation is widely disputed. There is a common assumption that aging populations are deflationary because people consume less in old age, reducing aggregate demand for products, as seems to be the case in rapidly aging societies such as Japan. **However, our analysis of consumption data above shows that across both developed and emerging markets, consumption as a percentage of peak income remains relatively smooth throughout life, starting in young adulthood.** This steady level of consumption corresponds to neither decline nor growth in consumption, in contrast to the consumption growth present from childhood to young adulthood. So while the claim that aging populations are deflationary seems to be unsubstantiated, it may be true that a high proportion of young children in a population can be inflationary, as prices are supported by growing aggregate demand.

In terms of our current demographic outlook of lower birth rates and a higher proportion of elderly, this relationship between demographics and inflation likely implies that there will be an absence of a strong inflationary tailwind rather than an active deflationary force from demographics. With low population growth in many developed economies, this phenomenon is likely one factor that is restraining inflation.

Other researchers have focused on the dependency ratio rather than aggregate population growth. Economists from the Bank of Finland have projected that the increase in dependency ratios will put upward pressure on prices, as the proportion of net spenders (young- and old-age cohorts) increases relative to the proportion of net savers (working-age cohorts) (Juselius and Takats, 2016). Using projections of dependency ratios, they expect the inflationary pressure from demographics in the 40 years after 2010 to raise global inflation rates by roughly three percentage points, less than the five percentage point disinflationary impact realized in the 40 years preceding 2010.

Examining inflation data from the Organization for Economic Cooperation and Development (OECD) with the U.N. population projections, the connection between age structure and inflation across a set of 21 countries seems quite tight (see **Figure 7**). This figure compares the median dependency ratio with the median annual inflation rate, which exhibit a positive correlation. Intuitively, a rising proportion of net spenders (i.e., dependents) in a population will put upward pressure on prices. In summary, evidence from consumption data and dependency ratios do not support the claim that demographics will exert further deflationary pressures in coming years; if anything, the upside risks from demographics to inflation seem to outweigh the downside risks.

FIGURE 7

The proportion of net spenders to net savers may be one structural driver of inflation
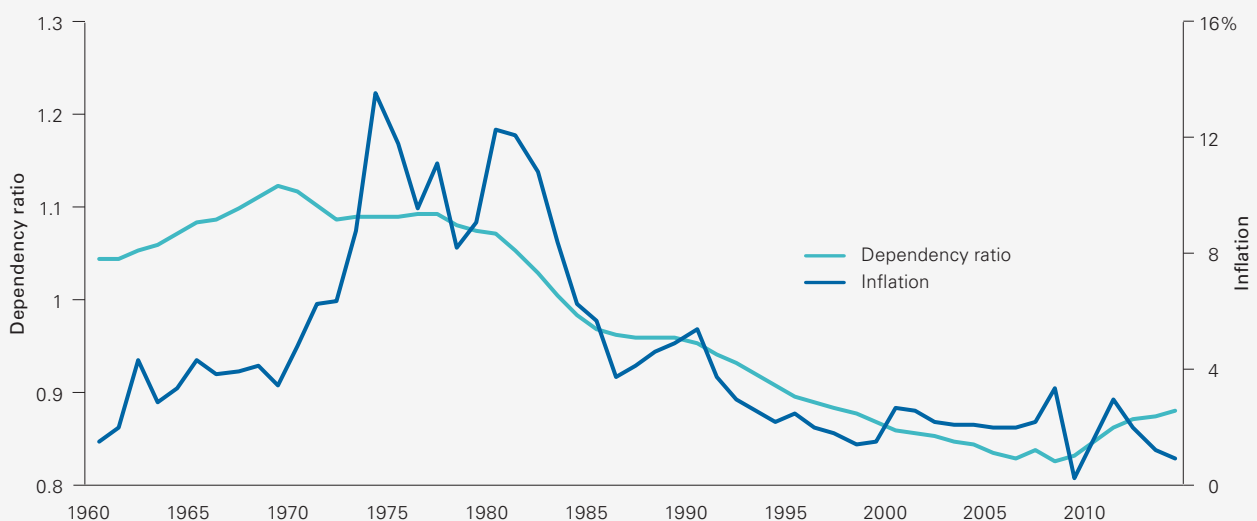
Sources: Vanguard analysis, based on data from the OECD and *World Population Prospects: The 2017 Revision*.

Population

A larger population means more people are engaged in economic activity, so population growth directly affects the population component of economic growth. As previously noted, declining population growth is a global phenomenon. Regardless of the cause, this demographic tailwind for most economies has faded, with population growth expected to decline to well below 1% globally by 2050.

An examination of these projections at a more granular level provides some insight into which areas will be most affected by slowing population growth. Most of the growth in the working-age cohort in the postwar period has occurred in Asia, especially China (see **Figure 8**). Growth in this age cohort peaked in 2013; since then, Asia's contribution to that cohort has diminished significantly.[8] This trend is expected to continue for decades. Of the almost 3 billion people worldwide who are expected to join the middle class by 2050, most will come from emerging markets in Southeast Asia and Africa. Relatively high population growth is only one factor driving the expected outperformance of these emerging markets.

Population forecasts are relatively reliable within 15 years, but beyond this time horizon slightly different assumptions on fertility rates widen estimates and reduce reliability. It is possible that fertility rates in many countries could remain steady or even increase, leading to higher population growth and a lower proportion of the old-age cohort. Given that many countries are now near the "replacement rate" necessary to maintain a stable population, it is possible that fertility rates may fluctuate near this natural lower bound rather than continue declining.
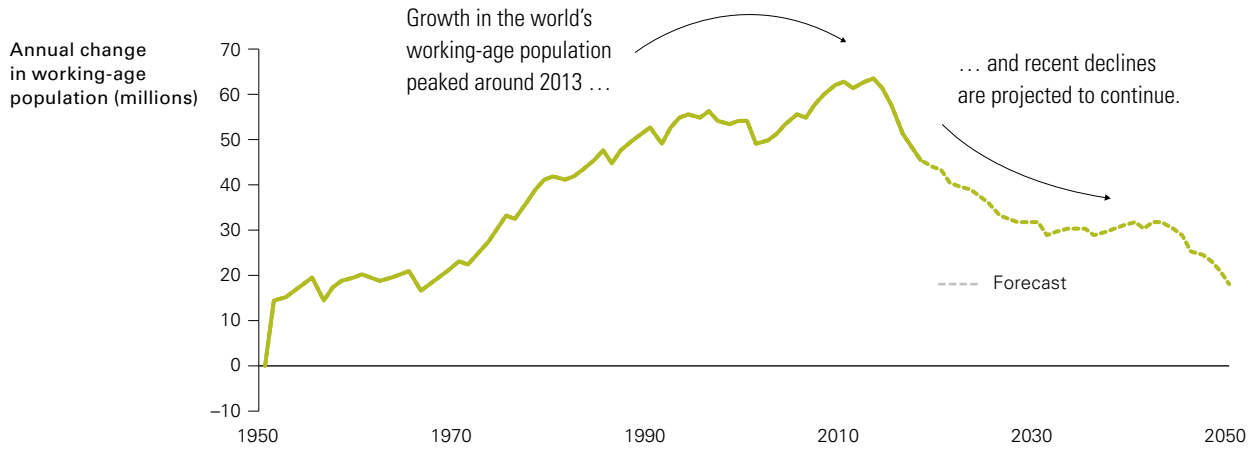
Outside of the possibility of higher-than-expected fertility rates, the other offsetting factor to these population projections is immigration. Although immigration will not affect total global population growth, promoting immigration is one way developed countries such as the United States, Canada, and the United Kingdom have bolstered domestic population growth.[9] This is not only important for overall population growth, it can also be a means of attracting high-skilled talent from other countries. As of 2014, two-thirds of OECD member nations had recently implemented, or were in the process of implementing, policies designed to increase high-skilled immigration. Companies and research institutions have come to rely on international migration alongside domestic labor markets to effectively innovate, especially in STEM fields. According to a study conducted by researchers at the Ohio State University, one in eight of the world's scientists most frequently cited between 1981 and 2003 was born in developing countries; 80% of them moved to the developed world (Van Noorden, 2012). Faced with lower fertility rates, developed markets could implement policy changes to increase migration and bolster economic growth via higher population growth.

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8 As with dependency ratios, different countries in Asia have vastly different outlooks for their working-age populations. For example, China's working-age cohort is estimated to have inflected from growth to decline, while India's working-age cohort is estimated to continue to grow through 2050.
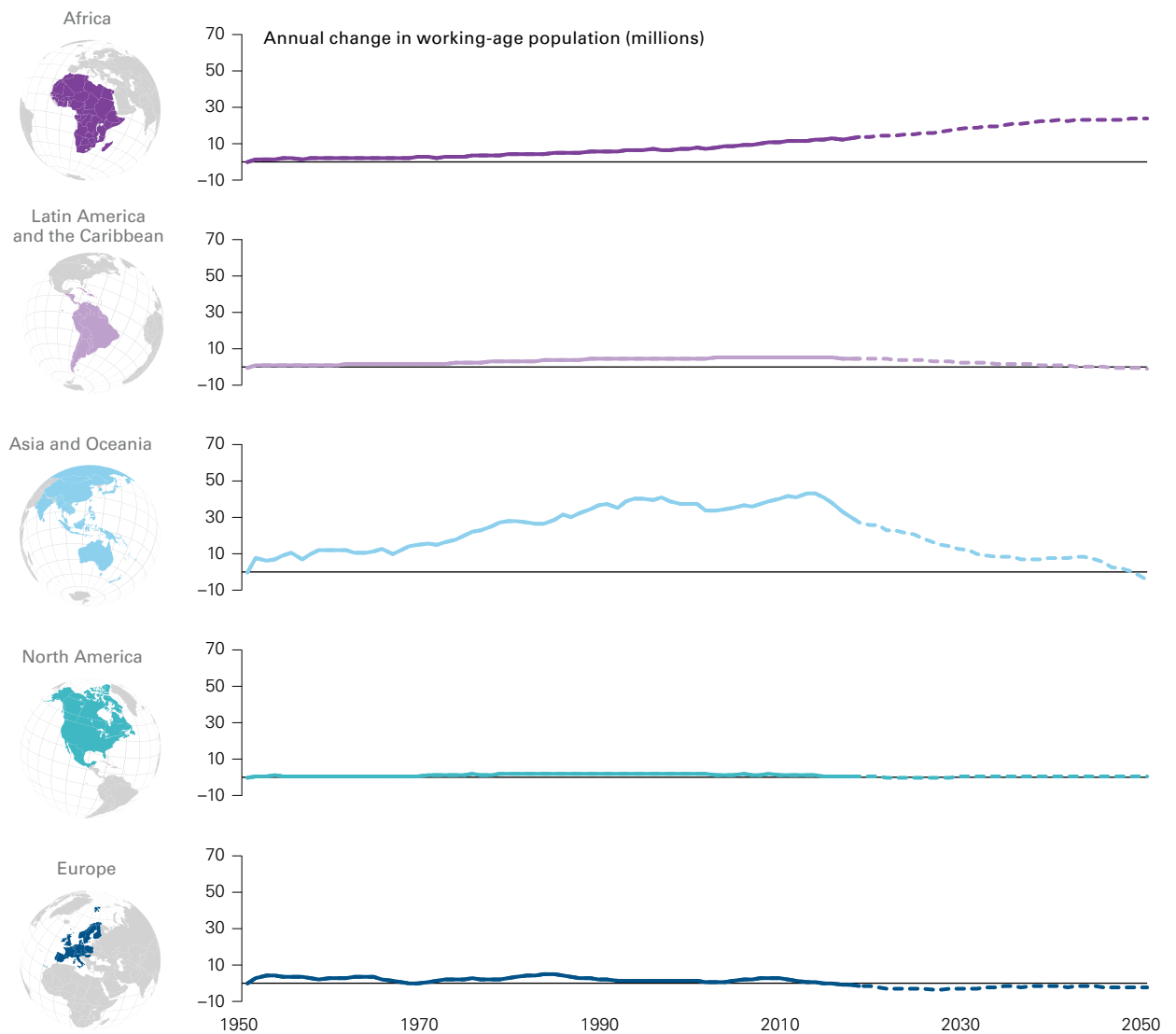
9 For an analysis of the impact of immigration on economic growth, see the Vanguard research paper on the long-run effect of Brexit, *It's Not EU, It's Me: Estimating the Impact of Brexit on the UK Economy.*

FIGURE 8

Growth in the number of working-age individuals has already started to decline

Annual change
in working-age
population (millions)

Growth in the world's
working-age population
peaked around 2013 …

… and recent declines
are projected to continue.

- - - Forecast

Most of the growth occurred in Asia, especially China, but Asia's working-age population growth has diminished significantly since.

Africa

Annual change in working-age population (millions)

**Latin America
and the Caribbean**

Asia and Oceania

North America

Europe

Sources: Vanguard analysis, based on data from *World Population Prospects: The 2017 Revision*.

Participation

The ratio of total employment to the total population, expressed here as the participation rate, is another key driver determining the aggregate output of an economy. **As the number of retirees will outpace the number of young people entering the labor force, demographic projections imply that the proportion of the population employed will decline and thereby be a drag on GDP growth.** This expected drag, however, may be more than offset by second-order effects.

Long-term multicountry data sets can be employed to better evaluate the dynamics between demographics and participation. Analyses limited to a few countries or a few decades can often express spurious relationships that hold only for a particular time and place. As participation and productivity are less directly affected by demographics, it is also necessary to use controls to ensure that demographic variables carry significance even after accounting for other fundamentals to economic growth.[10] In our analysis, we construct a data set of annual demographic and economic data from 1950–2014, covering 61 countries. We also examine a subset of 21 countries that have the most reliable data, though this group includes primarily developed markets. (See the Appendix for details on data and results.)

Examining the median values of dependency ratios and participation for these 21 select countries shows an inverse relationship between the two (see **Figure 9**). As dependency ratios fell, participation rose. The expected rise in dependency ratios in the decades ahead will put downward pressure on participation and be a headwind to GDP growth; however, old-age cohorts in the labor force may choose to remain employed longer. This rise in effective retirement age and, in turn, old-age participation rates, confirms the notable divergence that has occurred in the most recent decade. This is particularly true in the United States, where the participation rate for the 55–64 age cohort is at record highs, while the 25–54 cohort participation is still below the levels prior to the 2008 global financial crisis, according to the OECD.

This trend may persist in the short term for several reasons. First, longer life expectancy and improved health could enable expected retirees to contribute to their professions into their 70s. Second, the developed markets that will have rising dependency ratios also have more service-oriented economies, which have jobs that are more accommodative than physically intensive manufacturing-oriented economies (Tufano et al., 2018). Third, individuals may choose to earn more labor income as perceived or realized shortfalls in public and private retirement savings emerge (see the text box on page 20).

Though this overlay of median values expresses the high level of correlation between the two, it ignores country-specific differences and other factors affecting participation. To test the significance of this correlation more robustly, we use a panel regression technique,

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10 Our control variables include life expectancy, capital formation as a percentage of GDP, and average years of schooling. Dependency ratios are calculated using United Nations data. All other data are from the Penn World Tables and the OECD.

similar to the methodology of many analyses of demographics.[11] The inclusion in our model of variables known as "fixed effects" controls for factors that are specific to a particular country and year, while capturing the underlying relationship between the dependency ratio and participation. Using both the full sample and select sample of countries, **the panel regression confirms that the dependency ratio remains a significant determinant of participation in an economy.**

Though effective retirement ages may continue to rise and support participation rates in the short term, the increased number of retirees will lower GDP growth in the long term through a lower or negative contribution of the participation component of GDP. Falling participation rates also will have important indirect consequences. As noted in a recent paper from the Bank for International Settlements (Goodhart and Pradhan, 2017), one reason that growth in wages, consumer prices, and productivity may have been under pressure is the rapid expansion of the global labor force that occurred when former Soviet countries and China joined the global economy, effectively more than doubling the working-age population available to multinational corporations. This surge in the supply of inexpensive labor reduced input costs as well as consumer prices.

These multidecade trends may reverse, as global working-age population growth decelerates, while old-age population growth accelerates. If consumption and, in turn, total output do not decline while the number of employed declines, there will likely be higher wage growth (and, in turn, higher consumer prices) as businesses compete for a limited and shrinking set of working-age individuals. The higher cost of labor could provide businesses an incentive to increase capital expenditures, suggesting that lower participation rates may also have important consequences for the third and most important component of GDP growth—productivity.

Falling dependency ratios enable higher participation
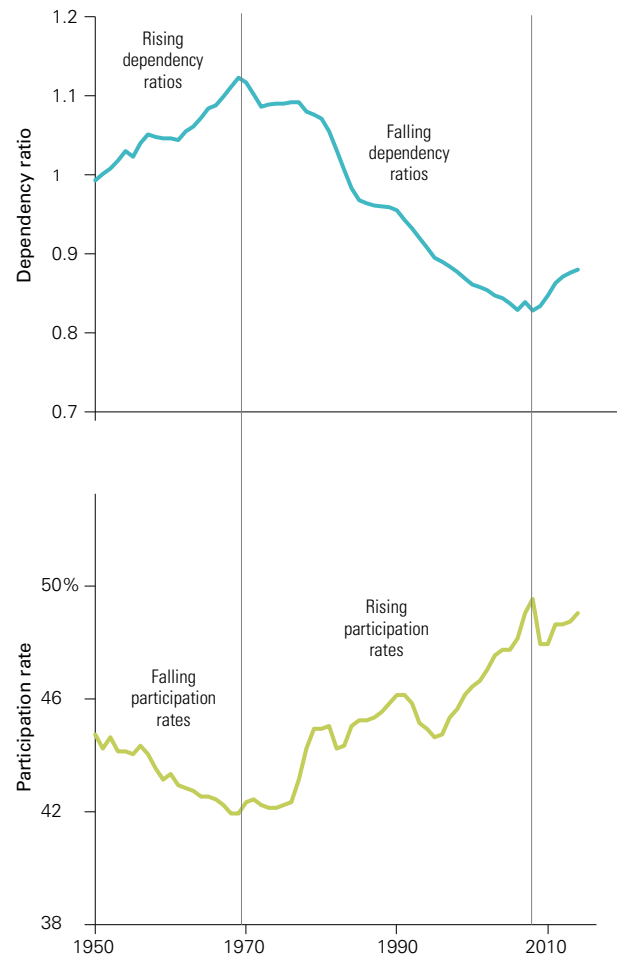
Sources: Vanguard analysis, based on data from the Penn World Tables and *World Population Prospects: The 2017 Revision.*

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11 For example, see Arnott and Chaves (2012).

Productivity

Productivity, expressed as output per worker, might seem unrelated to demographic changes, yet nations with faster-growing populations have tended to exhibit faster productivity growth. **Examining productivity across age cohorts highlights the self-reinforcing nature among the components of GDP and more fully explains why population growth and productivity growth often occur together.**

As population growth increases, more people eventually enter the workforce and raise the participation rate. With more people employed, total income increases. The associated savings of this working-age generation can then be channeled into investments that increase productivity to provide for the presumably larger generation that follows. **So, the number of children of a given working-age cohort is also important for productivity growth, as it embodies the expected level of demand used to justify long-term investments.** This is evident when considering the infrastructure projects that accompanied the birth of the baby boomers in the United States (such as the Interstate Highway System) and similar projects under way in India and Southeast Asia today.

Despite this intergenerational link, productivity growth is far more volatile than underlying demographic drivers, as seen in median values from the same data set as the Participation analysis (see **Figure 10**).[12] Here, the dependency ratio is replaced with the proportion of the 0–54 age cohort, as this captures both the current contributors to productivity growth (25–54 cohort) as well as expectations of long-term demand (0–24 cohort).[13]

Although the correlation does not appear as strong when comparing median values, the country-level panel regression analysis shows that the relationship between the 0–54 age cohort and productivity is statistically significant, even when controlling for other economic fundamentals and expanding the sample to 61 countries. (See the Appendix for detailed results.) Though significant, the amount of variation explained by the 0–54 cohort in the full sample is one-third that of the limited sample, suggesting that other factors such as institutions and technology better explain long-term productivity growth.

Though demographic trends are critical for each component of GDP, other factors may more than offset any unfavorable demographic drags on productivity. In certain industries of service-oriented economies, older employees may have expertise that makes them more productive than younger employees, so productivity growth may be supported by higher older-age participation rates. As the effective retirement age increases, companies will likely need to adopt more accommodative policies such as part-time positions and remotely located work. Over a longer time horizon, however, the competition for qualified workers will intensify as participation falls (as previously noted) and the workers still in the labor force realize more bargaining power with respect to pay and policy. As the cost of labor rises, businesses will be incentivized to invest in productivity-enhancing projects to realize more output per worker. Recent research has found this to be the case in countries with rising dependency ratios, noting a more rapid adoption of automation that more than offset negative impacts from demographics (Acemoglu and Restrepo, 2017). So, regardless of the demographic outlook, countries that adopt and maintain policies that encourage innovation are likely to realize higher productivity growth.[14]

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12 Productivity is expressed as output per worker, calculated as total GDP divided by total employment. Growth rates are expressed over a five-year period in order to smooth the series.

13 Though we have ended the working-age cohort at 64, for this analysis we end it at 54. This is a better reflection of when parents no longer provide for young dependents and also enables us to look at more granular age groups to assess their impact on productivity. For full results, see the Appendix.

14 Institutional factors also play a major role in explaining differences in productivity growth among countries; these factors most often refer to political legitimacy or rule of law, as well as infrastructure, education policies, and the ease of doing business. In developing economies, the variance in productivity performance is substantial. For example, China's productivity increased at a 5.7% annual rate from 1964 to 2014, while Mexico registered less than 1 percent annual productivity growth during this period, a difference that some attribute, in part, to the strength of political institutions. The productivity gap between developed and developing economies also remains huge. In fact, as of 2015, productivity in developed economies remains almost five times that of emerging economies. For additional reading, see McKinsey Global Institute (2015).

FIGURE 10

Productivity growth varies much more than underlying demographic trends
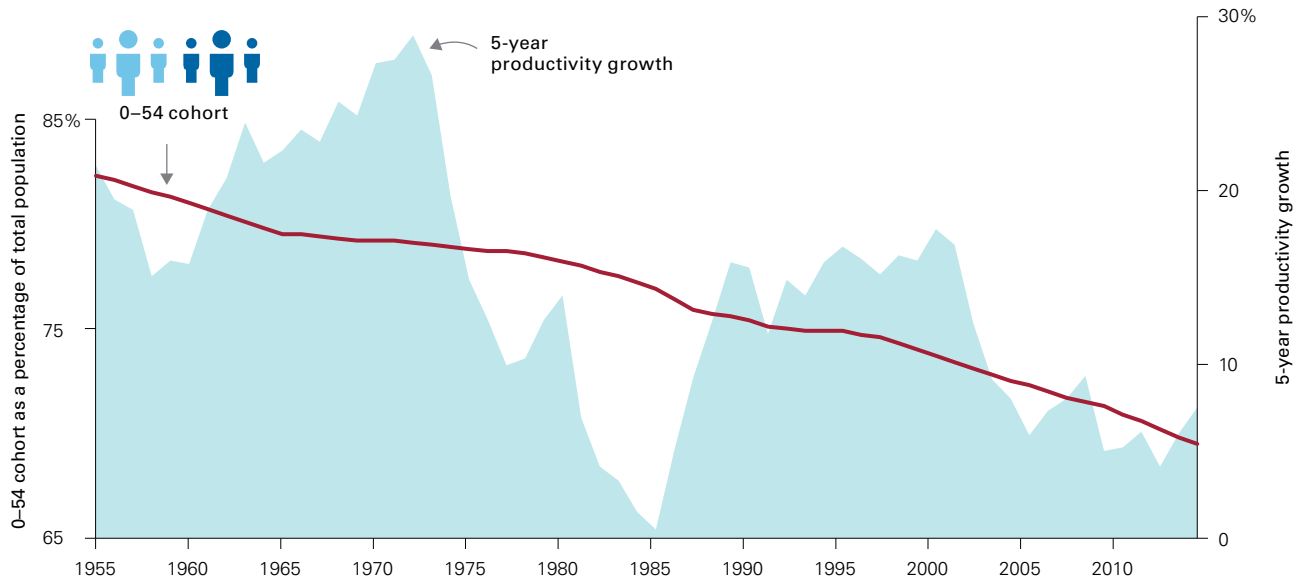
Sources: Vanguard analysis, based on data from the Penn World Tables and *World Population Prospects: The 2017 Revision.*

Governments and citizens will need to adapt to aging populations

Aging populations will have implications beyond economic fundamentals and investment returns. Major sectors such as transportation and health care will be affected, as will areas outside economics, including culture and politics. Here we explore the significant ramifications that the resulting increase in dependency ratios will have on government revenue, expenditure, and debt for decades to come. A higher dependency ratio represents fewer primary taxpayers funding government expenditures on social programs, while overall spending for these programs escalates to accommodate the growing number of eligible citizens (see **Figure 11**). In the United States, the two largest social programs for the elderly, Social Security and Medicare, are expected to double, from 6% of GDP

in 2000 to 12% of GDP in 2047, according to Congressional Budget Office data from March 2017. These challenges are likely to be addressed through public policy changes and shifts in employment and savings preferences.
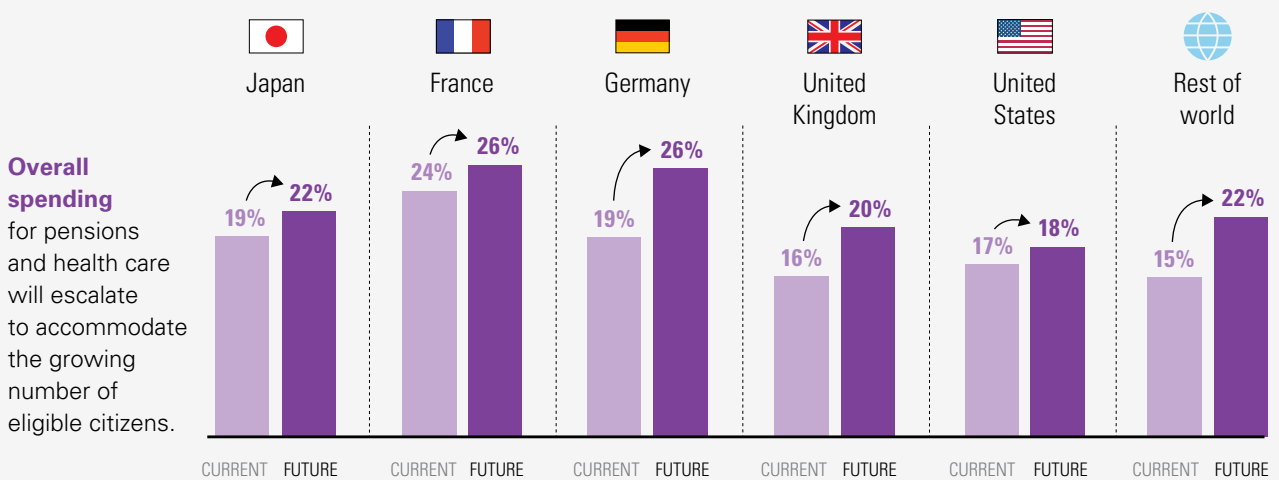
Although pension and retiree health care programs are often thought of as guaranteed entitlements, governments have several options to mitigate future budget shortfalls. Many high-income OECD countries have recently started addressing budgeting concerns

KEY TERM:

Pensions is an umbrella term used to describe national retirement income systems.

FIGURE 11

Pension and health care costs as a percentage of GDP

Overall spending for pensions and health care will escalate to accommodate the growing number of eligible citizens.

	Japan	France	Germany	United Kingdom	United States	Rest of world
CURRENT	19%	24%	19%	16%	17%	15%
FUTURE	22%	26%	26%	20%	18%	22%

Notes: Current spending for pensions and health care represents the average from 2013 to 2015. Future pension spending is expectations for 2050. Future health care spending is expectations for 2060. Health care spending was calculated as the midpoint between high cost-growth and low cost-growth scenarios and includes public funding for nonretiree health care programs.

Sources: Vanguard calculations, based on data from the OECD. For pension data, see OECD (2017). For health care data, see de la Maisonneuve and Martins (2014).

through a combination of raising eligibility ages, indexing eligibility to life expectancy, or modifying inflation adjustments. These changes, while politically unpopular, are softened by being gradually phased in over the course of years (see **Figure 12**). Policymakers are likely to continue using these modifications to improve long-term financial stability as the programs' share of overall spending climbs.
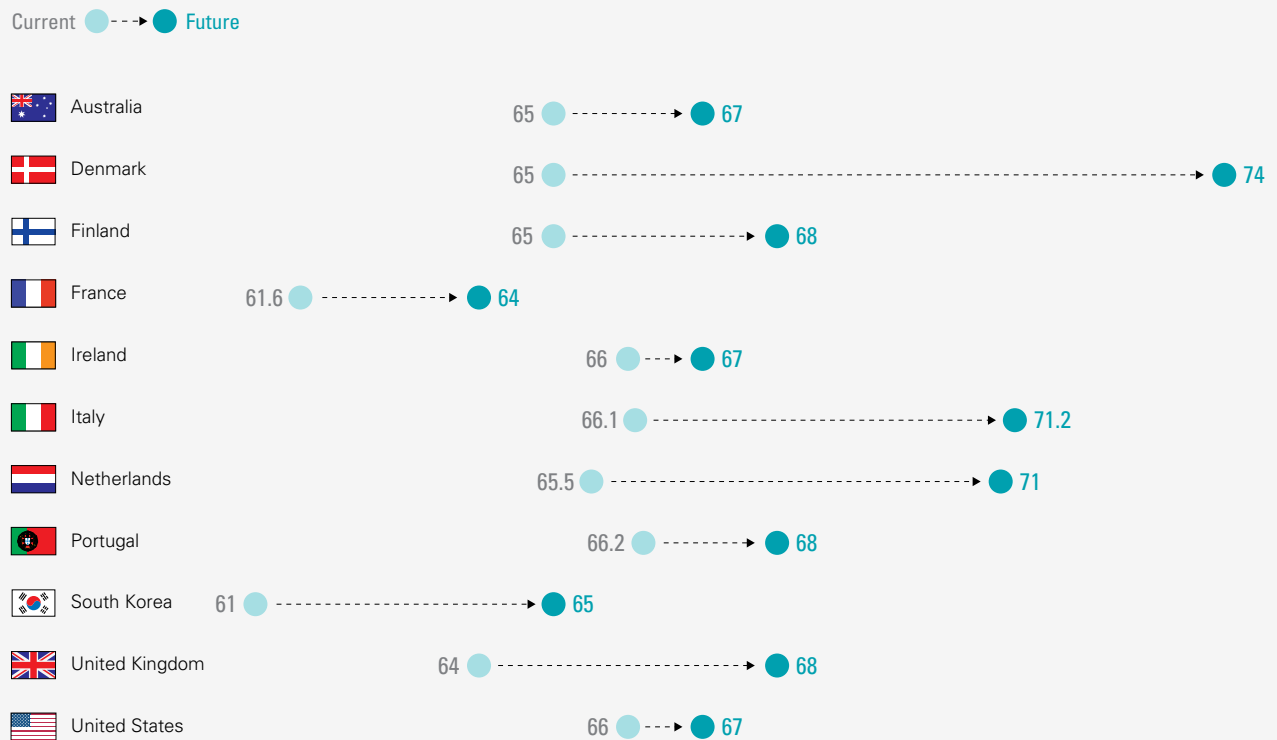
Long-term cost projections are significantly more uncertain than the demographic forecasts they are based on. Fertility rates, immigration, and life expectancy have all varied significantly throughout history. In the past, policymakers have underestimated life expectancies, creating shortfalls in public pension programs. Projecting long-term health care expenditures is especially challenging, considering the uncertainty

of technological progress. For example, in the United States, five conditions account for more than 27 percent of health care spending for those 65 and older.[15] A breakthrough in one of these conditions would have significant humanitarian and financial implications.

An additional motivation for raising eligibility ages is an attempt to encourage older workers to remain in the labor force longer. Contrary to headlines predicting rampant unemployment as a result of automation, many developed nations will face a labor shortage in coming years, and businesses and policymakers will incentivize older citizens to delay full retirement. U.S. labor force participation among those 65 and older has been climbing since first being measured in the mid-1990s. Globally, average effective retirement ages have started to climb after a 30-year secular decline. In the case of Japan, its

FIGURE 12

Eligibility ages for public retirement programs

Current ⬤ - - -▶ ⬤ Future

		Current		Future
🇦🇺	Australia	65	⬤ - - - - - -▶ ⬤	67
🇩🇰	Denmark	65	⬤ - - - - - - - - - - - - - - - -▶ ⬤	74
🇫🇮	Finland	65	⬤ - - - - - - -▶ ⬤	68
🇫🇷	France	61.6	⬤ - - - - - -▶ ⬤	64
🇮🇪	Ireland	66	⬤ - -▶ ⬤	67
🇮🇹	Italy	66.1	⬤ - - - - - - - - - - - -▶ ⬤	71.2
🇳🇱	Netherlands	65.5	⬤ - - - - - - - - - - -▶ ⬤	71
🇵🇹	Portugal	66.2	⬤ - - - -▶ ⬤	68
🇰🇷	South Korea	61	⬤ - - - - - - - -▶ ⬤	65
🇬🇧	United Kingdom	64	⬤ - - - - - - -▶ ⬤	68
🇺🇸	United States	66	⬤ - -▶ ⬤	67

Notes: Current eligibility age is calculated for a citizen with a full career from age 20. In countries that have different eligibility ages for males and females, the average is used. Future eligibility age refers to the year in which someone is eligible for full retirement benefits, assuming labor market entry in 2016 at age 20.

Sources: Vanguard calculations, based on data from the OECD.

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15 These five conditions, in order of amount spent, are ischemic heart disease, hypertension, diabetes mellitus, injuries from falls, and Alzheimer's disease (Dieleman, Baral, and Birger, 2016).

demographic composition has resulted in workers staying in the workforce until an effective retirement age of almost 71, which may become a common feature of other aging countries (see **Figure 13**).

The recent rise in effective retirement ages has a loose relationship to rising pension eligibility ages, since these changes are not effective for decades. Instead, this rise is a result of the heightened role of private retirement plans and the changing nature of work. The shift that occurred in several developed nations from defined benefit plans (such as pensions) to defined contribution plans (such as 401(k) plans) incentivizes workers to remain in the labor force longer. A paper by the National Bureau of Economic Research found that putting off retirement for three to six months has the equivalent impact of saving 1 percentage point more of earnings for 30 years (Bronshtein et al., 2018).

Widespread adoption of technology and robotics has significantly reduced the physical demands of labor, while providing flexibility for older citizens to continue working in later years. A recently published Vanguard

research piece, *Megatrends: The Future of Work* (Tufano et al., 2018), found that the U.S. labor force spends nearly 50% of its time on uniquely human tasks, up from just 30% in 2000. The pace of these trends is expected to accelerate and will result in the labor market competing to entice older workers to remain in the labor force longer. **The changing nature of work, the incentives of working longer, and structural reforms to social programs will help ease the financial burden of aging populations.**
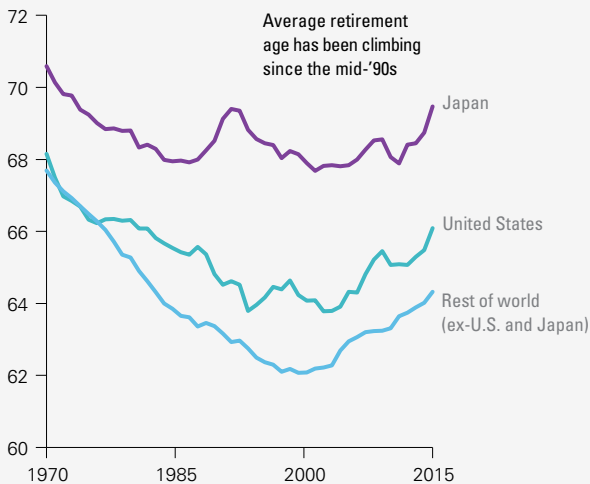
KEY CONCEPT EXPLAINED

Tasks that make up uniquely human occupations

- Identifying objects, actions, and events
- Repairing and maintaining mechanical equipment
- Repairing and maintaining electronic equipment
- Judging the qualities of things, services, or people
- Making decisions and solving problems
- Thinking creatively
- Updating and using relevant knowledge
- Developing objectives and strategies
- Interpreting the meaning of information for others
- Establishing and maintaining interpersonal relationships
- Assisting and caring for others
- Selling to or influencing others
- Resolving conflicts and negotiating with others
- Performing for or working directly with the public
- Developing and building teams
- Training and teaching others
- Guiding, directing, and motivating subordinates
- Coaching and developing others
- Providing consultation and advice to others
- Organizing, planning, and prioritizing work
- Interacting with computers
- Coordinating the work and activities of others

FIGURE 13

Average effective retirement age

Average retirement age has been climbing since the mid-'90s

Japan

United States

Rest of world (ex-U.S. and Japan)

Note: Average effective retirement age is calculated as the average measured statistic for male workers and female workers.
**Sources:** Vanguard calculations, based on data from the OECD.

Diversification is investors' best response to changing demographics

Having examined the relationship between demographics and economic fundamentals, we turn our attention to the possible implications of these population projections on investment returns. Demographic changes affect investment returns via two channels: the effects on aggregate economic growth, and changes in savings and investment preferences. Academic research has generally grouped these two channels together; however, we believe that evaluating them individually reduces the tendency to confound cause and effect and addresses specific demography-centered predictions regarding the future of asset returns. Both channels have distinct impacts on the three principal components of asset returns: risk-free interest rate (RFR), equity risk premium, and bond risk premium (see **Figure 14**).[16]

Demographics influence asset returns via two channels

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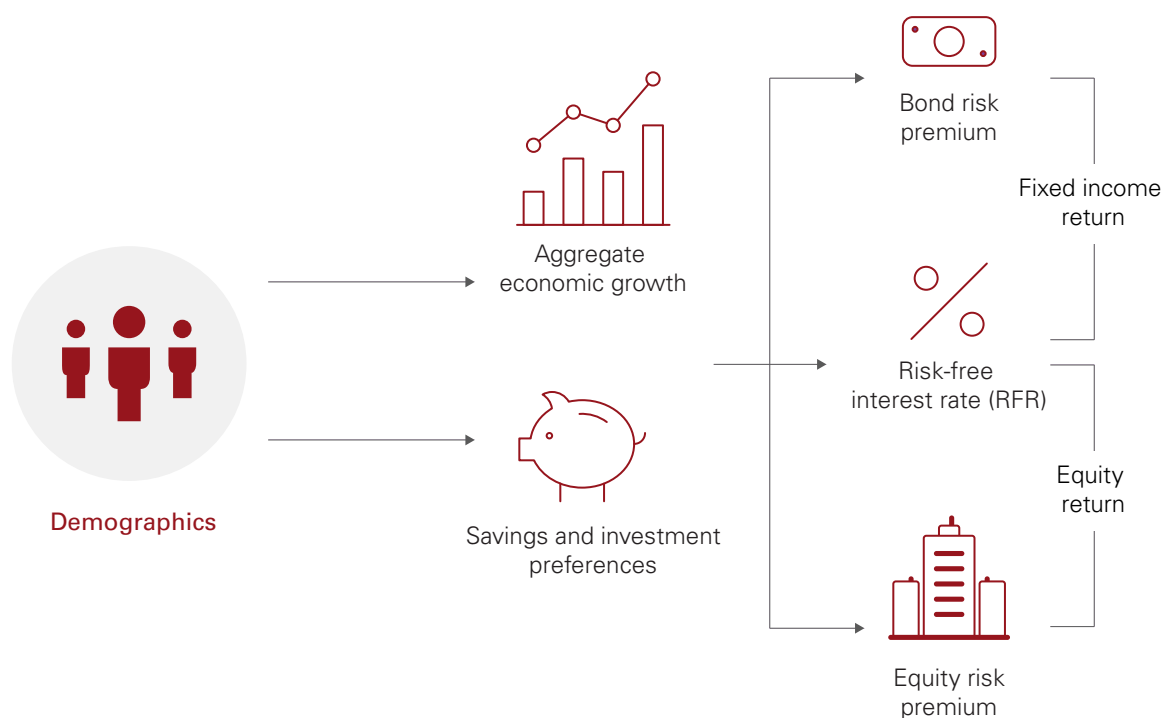
16 References to the risk-free rate in this paper are in real rather than nominal terms. The real rate incorporates inflation expectations, but for simplicity we are excluding demographics' effect on inflation in the main body of this analysis. See the text box on page 13.

23

Lower economic growth (GDP) will lower
the risk-free rate

Although projections of demographic trends are slow-moving and predictable, the implications for future GDP growth are much more nuanced. A review of each of the three components discussed in this paper (population, participation, and productivity) finds that there are competing factors when considering the implications of demographic trends. This complexity intensifies when assessing second-order effects on economic growth. On balance, demographic trends are likely to exert neutral to downward pressure on global GDP growth in the coming decades (see Figure 15). Lower fertility

rates will continue to contribute less to growth, though this may be partially offset in developed markets by immigration policy. At the same time, changes in the age structure toward a higher proportion of elderly reduce participation rates (and associated GDP growth), though service-oriented economies may accommodate higher effective retirement ages through structural changes in the nature of work. As these individuals retire but maintain steady levels of consumption, a shrinking number of working-age persons will need to create growing levels of output, potentially spurring investments to raise productivity, the most important and least demographically affected component of GDP.

FIGURE 15

On balance, demographic trends are likely to have a neutral to negative effect on GDP growth over the next 30 years

	POPULATION	**PARTICIPATION**	**PRODUCTIVITY**
Link between demographics and GDP component	Direct	Direct	Indirect
Demographic impact on GDP and growth	⬇	⬇	⬇ ⬆
Upside risks	▲ Higher fertility ▲ Higher immigration	▲ Higher old-age participation rates ▲ Higher female participation rates ▲ Increase in part-time employment	▲ Labor scarcity ▲ Wage inflation ▲ Automation
Downside risks	▼ Lower fertility ▼ Lower immigration	▼ Automation ▼ Earlier effective retirement	▼ Persistent expectations of lower fertility

Source: Vanguard analysis.

Traditional economic theory posits that real interest rates are inherently connected to economic growth and therefore, lower economic growth leads to a lower RFR. As a primary component of both equity and fixed income returns, a lower RFR, along with constant risk premia, would imply lower asset returns.[17] The relationship between economic growth and risk premia is much less apparent. Premia are incredibly volatile and unpredictable in the short-term, and in the long-term they appear to be driven more by macroeconomic volatility and risk attitudes than by consensus economic growth expectations (Davis, Aliaga-Díaz, and Thomas, 2012). In summary, the economic growth channel through which demographic trends influence asset returns is likely to exert neutral to negative influence over the next 30 years by putting downward pressure on RFRs.

Demographic impacts on savings and investment preferences

It seems likely that the spending habits of a rapidly aging population will change substantially, but what of their investment choices? For at least a decade, the financial press has speculated about how the aging U.S. baby boomer generation will cause a "sustained liquidation" by selling down their assets to fund their retirements, while smaller-sized subsequent generations will be unable the fill the void. Specifically, boomers will reduce risk by shifting allocation from equities to fixed income and cash instruments.[18] Although this theory seems reasonable at first glance, there are four key factors that suggest it is an unlikely outcome.

> Recall that net spenders consume more than their income, and net savers consume less than their income.

First, there is little evidence that overall savings rates will fall and cause interest rates to rise as populations age. In nearly every developed economy, the proportion of working-age to the total population is expected to decline as the post-World War II cohort enters the retirement phase. The age-cohort model shown in Figure 5 considers this working-age cohort as net savers, because individuals use this period to save a percentage of their income to fund future expenses. Because net savers will represent a smaller portion of the population, it follows that the drop in savings, all else equal, will cause interest rates to rise and equity prices to fall. Academic research has differed on whether dependency ratios affect national savings rates (Higgins, 1994; Cavallo, Sánchez, and Valenzuela, 2016; Hyung, 2013). Vanguard's research, using a variety of national savings figures, failed to find any significant relationship between a country's dependency ratio and savings rates. Additionally, shortfalls in retirement savings and increasing retirement ages may prompt those over 65 to continue saving well into traditional net spending years.

As a result, the relative number of pre-retirees in a population does not have a demonstrable effect on asset returns, based on historical evidence. Previous Vanguard research (Wallick, Shanahan, and Tasopoulos, 2013) analyzed 45 developed and emerging markets and found no statistical relationship between the percentage of the population age 65 and older and real stock returns. This confirms an earlier study the U.S. Government

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17 It is worth noting that a lower RFR could lead to higher equity returns in the short run, as a lower RFR is being used to discount future earnings.

18 In a traditional asset allocation schedule, or glide path, equity allocations begin descending when savers are in their early 40s and continue until they reach their late 60s or early 70s. This gradual decline marks a substantial portfolio shift from an 80%-plus equity allocation to a more conservative 20%–30% allocation.

Accountability Office conducted of Standard & Poor's 500 Index returns which found that, from 1948 through 2004, demographic variables generally accounted for less than 6% of return variability—far less than macroeconomic, financial, and other unexplained variables.

Second, even if these broad portfolio shifts do occur during this unprecedented period of aging, the distribution of equity ownership will dampen its effects. While the overall share of pre-retirees has risen in the United States over the past two decades, their share of overall equity market ownership is in line with historical averages, representing greater diversification of equity ownership among age cohorts.[19] This in large part is a result of higher equity market participation from younger investors through retirement-savings vehicles and post-retirees maintaining higher levels of equity ownership.

Reducing exposure to risk assets is a standard asset allocation strategy for the typical investor; however, equity ownership among pre-retirees is highly concentrated, with the top 10% of baby boomers holding nearly 85% of their generation's total equities.[20] These high-net-worth investors are likely to have objectives not captured in standard life-cycle consumption models, such as estate planning and charitable giving, and are less concerned with risk-reduction strategies.

Third, younger investors' balance sheets are not as great a risk as generally perceived. Although overall debt has risen for U.S. households under 35 since 1989 (almost exclusively driven by the growth in student loans), the decline in interest rates has resulted in debt service payments in the U.S. that are the lowest since 1989, the earliest recorded date.[21] Similarly, in Europe, younger households that carry debt average comparably low debt-service payments (14%). These low debt-servicing costs, along with the continued shift from defined-benefit to defined-contribution plans in several developed nations, will fuel higher levels of equity participation among younger cohorts than in prior generations.

Fourth, the globalization of financial markets that has occurred over the past 40 years has reduced potential risk posed by an individual country's demographic trends. A region's equity and fixed income assets are now affected by global supply-and-demand factors, mitigating the effects of local changes in demographics. **Figure 16** demonstrates the increasing role financial globalization has played in recent decades, a trend also reflected in foreign ownership of public debt.

The effects of financial globalization are not specific to the United States; all regions with open financial markets will benefit from a larger, global investor base, while investors benefit from having access to additional financial markets. This highlights the importance of constructing a globally diversified portfolio, which provides investors with exposure to regions with various demographic profiles. Unfortunately, many investors still demonstrate significant home bias in their portfolio allocation, as shown in **Figure 17**.[22]

Demographic trends are most likely to affect asset returns through their associated implications for overall economic growth. Predicting economic conditions is far from an exact science, and changes in productivity, the largest and least demographically affected component of GDP growth, could upend any asset-return projections. Predicting future asset returns based on a shift in investment and savings preferences fails to account for the concentration of equity ownership and globalization of financial markets. The most immediate and beneficial action an investor can adopt is to construct a globally diversified portfolio that minimizes the significance of any one country's demographic conditions.

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19 The pre-retiree (ages 45–64) share of overall equity ownership in 2016 was 52.3%; the previous 27 years averaged 52.2%, according to Vanguard calculations, based on data from the Federal Reserve Board's 2016 Survey of Consumer Finances.
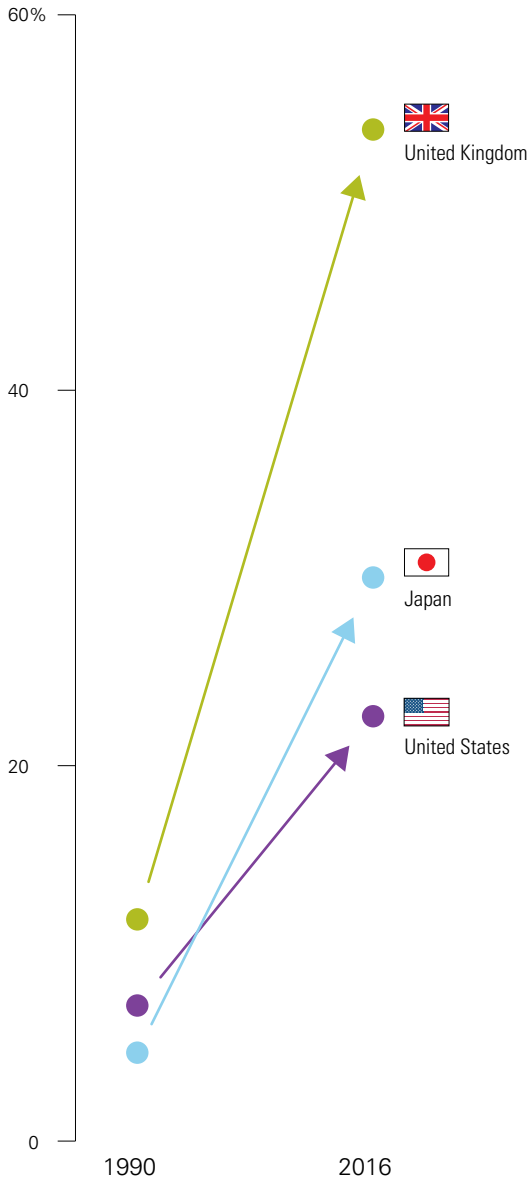
20 According to Vanguard calculations, based on data from the 2016 Survey of Consumer Finances.

21 According to Vanguard calculations, based on data from the 2016 Survey of Consumer Finances and the European Central Bank Household Finance and Consumptions Survey (2017). The ratio of average debt payments to income among debtor families in the U.S. has averaged 16.25% since 1989.

22 Home bias is the tendency of domestic investors to be overweighted in their own domestic markets and underweighted in foreign markets (relative to a global market-cap-weighted allocation).

FIGURE 16

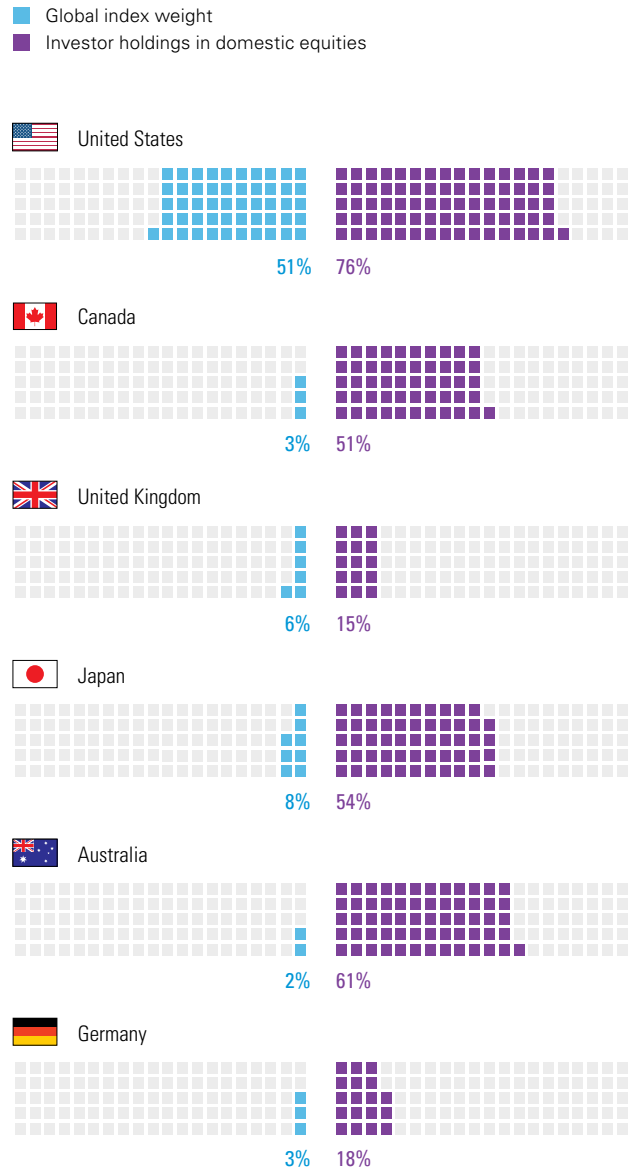## Foreign ownership percentage of domestic equities is increasing

FIGURE 17

Home bias is prevalent in most countries

Market-value weight

■ Global index weight
■ Investor holdings in domestic equities

	Global index weight	Investor holdings in domestic equities
United States	51%	76%
Canada	3%	51%
United Kingdom	6%	15%
Japan	8%	54%
Australia	2%	61%
Germany	3%	18%

FIGURE 18

The effects of demographics are more nuanced than many common assumptions hold

DEMOGRAPHICS: ASSUMPTION VERSUS COUNTERPOINT

	Aging populations consume less	Aging populations are deflationary	Aging populations have lower labor participation rates	Aging populations are less productive	Aging populations will result in lower asset returns
Assumptions					
Counterpoints	Consumption does not decline in old age but shifts toward a different consumption profile	A higher ratio of net spenders to net savers is inflationary	Higher retirement ages may in the short term support higher participation rates than implied by demographics	With steady demand and fewer people, productivity may in fact increase as higher labor costs spur investment	Demographics may reduce the risk-free rate but have no clear relationship to risk premia

Source: Vanguard analysis.

Conclusion

Lower fertility rates and longer life expectancies are shifting the age structure of populations toward smaller young-age cohorts and larger old-age cohorts—an unprecedented composition. We have examined some implications for the economic building blocks of population, participation, and productivity to develop expectations for the possible effects on overall GDP growth (see **Figure 18**). When evaluating the effects of demographics alone, lower population growth and a higher proportion of elderly will likely have a neutral to negative impact on long-run economic growth. When considering potential second-order effects, however, a shrinking workforce, along with rising wages, can incentivize firms to increase productivity, supporting GDP growth. These demographic projections do not imply decades of persistently low growth; they can be more than offset by unexpected developments in institutional and technological factors, which are the main drivers of economic growth.

The rapid population growth that followed World War II was a demographic phenomenon that had consequences for all aspects of society. Institutions and policies grew out of and adapted to these population changes as the post-war generation matured from young adulthood to working age, enabling advances in technology that formed the globalized economy we live in today. Further research in the *Megatrends* series will explore other economic drivers that facilitated this growth, such as the U.S. dollar's role as global reserve currency and the impact of the global exchange of knowledge. As this generation retires and another takes its place in the working-age cohort, these economic and political institutions will continue to adapt not only to changes in demography but also to changes in culture, geopolitics, and technology. The interplay of all these factors—not demography alone—will ultimately shape the future of economies and societies around the globe.

Panel regressions

The full results of the panel regression method introduced in the "Participation" and "Productivity" sections are presented below. The data set of annual demographic and economic variables includes 61 countries from 1950–2014. We also examine a subset of 21 countries that have the most reliable data, though this group primarily includes developed markets. Dependency ratios are calculated using United Nations data. All other data is sourced from the Penn World Tables and the OECD. A long-term multicountry data set provides a comprehensive sample to estimate the relationship between demographic and economic variables. We also include controls that might explain institutional and other nondemographic drivers of participation and productivity. These variables include life expectancy (quality of health care), capital formation as a percentage of GDP (investment), and average years of schooling (quality of education).

Panel regression results for participation

The participation rate measured as the proportion of total employment to total population is the dependent variable. We used three specifications for both the select sample of 21 countries and the full sample of 61 countries, for a total of six sets of results (see **Figure A-1**). The first specification, "dependency ratio," uses only the dependency ratio as an explanatory variable and is significant at the 1% level for both sample sets. To examine the changes in dependency ratio in more detail, the "age cohorts" specification uses the proportions of three age cohorts as explanatory variables. In both the select and full samples, each age cohort is significant with the expected signs; the working-age cohorts have the highest positive contribution, and the 70+ cohort has a negative contribution to participation. The only control that was included in the third specification is life expectancy, which was significant only in the full sample and did not reduce the significance of the dependency ratio.

FIGURE A-1

Participation regression results

	Select sample						Full sample					
	Dependency ratio		Age cohorts		Dependency/life expectancy		Dependency ratio		Age cohorts		Dependency/life expectancy	
	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic
Dependency ratio	−0.128**	−5.763			−0.133**	−5.972	−0.142**	−12.234			−0.141**	−12.199
Life expectancy					−0.004	−1.796					0.001*	2.267
25–54 cohort			0.539**	5.201					0.765**	8.511		
55–69 cohort			0.336*	2.400					0.595**	2.861		
70+ cohort			−0.422**	−2.609					−0.910**	−4.137		
R-squared	0.794		0.799		0.797		0.778		0.770		0.780	
Adjusted R-squared	0.765		0.769		0.767		0.756		0.746		0.757	
Total observations	273		273		273		793		793		793	

 * Denotes 5% significance level.
** Denotes 1% significance level.

Sources: Vanguard analysis, based on data from the OECD, the Penn World Tables, and *World Population Prospects: The 2017 Revision.*

Panel regression results for productivity

The five-year growth rate of productivity, measured as GDP per worker, was the dependent variable. Rather than the dependency ratio, this specification uses the proportion of the 0–54 age cohort as the demographic explanatory variable (see **Figure A-2**). Additionally, these specifications all use the control variables discussed above. Because productivity is measured as a five-year growth rate, all of the explanatory variables are expressed as five-year lags. This ensures that specification captures the demographic and economic conditions at the beginning of the five-year growth period. The controls had limited significance, while the 0–54 cohort had a positive coefficient that was significant at the 1% level. The alternative specification of detailed age cohorts indicated that the 70+ cohort was the most statistically significant. It is worth noting that the overall explanatory power of the specifications (measured by R-squared) is much lower in the full sample than in the select sample and substantially lower than the results for the panel regressions on participation. This reinforces our expectations that demographic variables have a smaller, less direct impact on productivity.

FIGURE A-2
Productivity regression results

| | Select sample | | | | Full sample | | | |
| | 0–54 cohort | | All cohorts | | 0–54 cohort | | All cohorts | |
	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic
0–54 cohort	1.265**	4.661			2.204**	5.083		
25–54 cohort			0.345	1.015			−0.315	−0.864
55–69 cohort			−1.158*	−2.571			−0.825	−0.994
70+ cohort			−1.231*	−2.057			−3.638**	−4.106
Average schooling	0.000	−0.014	0.000	0.030	−0.029*	−2.363	−0.029*	−2.214
Capital formation	−0.135	−1.140	−0.177	−1.403	0.116	0.855	0.091	0.664
Life expectancy	−0.017	−2.672	−0.017**	−2.682	0.001	0.803	0.001	0.961
R-squared	0.618		0.620		0.208		0.213	
Adjusted R-squared	0.556		0.554		0.117		0.120	
Total observations	252		252		732		732	

* Denotes 5% significance level.
** Denotes 1% significance level.
"Average schooling" is from the Barro-Lee Educational Attainment database.

Sources: Vanguard analysis, based on data from the OECD, the Penn World Tables, and *World Population Prospects: The 2017 Revision.*

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