

THE ECONOMICS OF POPULATION AGING

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1. Introduction

Around the world, and especially in the industrialized countries, populations are aging. The median age of the population and the fraction of the population that is elderly are climbing well above the levels that have ever been witnessed. At the same time, the fraction of the population made up of children, and the rate at which the population is growing, are falling.

While population aging is not a new phenomenon, currently anticipated increases in the average age of the population are likely to have more radical effects on the economy than in the past. While past aging generally lowered the burden on society posed by dependent children and the elderly, the future aging will raise this burden. Furthermore, the aging currently in prospect will affect governments' role to a larger degree (and once again, in a more adverse fashion) than in the past. Finally, the dramatic shifts in fertility which took place after World War II have led to a rapid increase in the rate of population aging.

Predicting how population aging will affect the economy is inherently difficult.¹ Since even rapid aging is a slow process in comparison to the other experiments considered by macroeconomists (for example, the effect of monetary policy), it is almost impossible to disentangle empirically the effects of aging from the effects of other, contemporaneous changes. Thus, predicting the effects of aging must rely heavily on the application of "off the shelf" macroeconomic models. In this chapter I examine how changing the age structure of the population in these models affects such variables as consumption, wages, government spending, and saving.

The rest of this chapter is organized as follows. Section 2 presents the basic data on how the age structure of the population is evolving over time. It also explores the causes of the change, examining trends in fertility and mortality and the relative importance of these two factors in current aging. Finally, the section discusses the potential for immigration to affect the process of population aging.

Section 3 considers the effects of population aging on production and consumption in the economy as a whole. Most of the section focusses on how aging affects the overall burden of dependents (children and the elderly) who must be provided for by working-age adults. But the section abstracts from the question of how resources are transferred to these dependents. The section also considers how aging affects the labor market.

In abstracting from the details of how dependents are provided for, Section 3 misses many of the important effects of aging. In the real world it is not only important that dependents are cared for, but also how they are cared for. For elderly dependents, there are three sources of support: the use of resources acquired during working life, the state, and the family. For dependent children, only the latter two sources are

¹ Recent surveys of the subject include Bos and Weizsacker (1989), Habib (1990), OECD (1988), Schulz et al. (1991), United Nations (1985).

available. The analysis in Sections 4, 5, and 6 considers the effects of aging in light of the three sources of support just mentioned. The life-cycle model, discussed in Section 4, focuses on the ability of individuals to transfer resources from their working years to their old age via saving. The key effect of aging in a life-cycle framework is to lower the saving rate, by increasing the fraction of the population that is dissaving and decreasing the fraction that is saving. Section 5 takes up the role of government programs in transferring resources to dependents, particularly the elderly. The section examines how demographic change will alter the size of government transfers, and also how changes in these transfers will impact the rest of the economy. Section 6 looks at transfers within the family, and at how these flows will be affected by the process of aging.

Section 7 concludes by discussing the magnitude of the effects of aging, and how they compare to another slow, inexorable process affecting the macroeconomy: growth. At their most severe, the effects of population aging are roughly comparable to those of the post-1973 productivity slowdown. At the same time, however, aging will lead to changes in specific channels through which support flows to dependents. Less money will flow through families to children, but more will flow through the government to the elderly. These changes will be much larger than the change in the *net* burden of dependency.

2. Population aging: facts and determinants

2.1. Facts and forecasts on population aging

Table 1 shows the age structure of the population for the world as a whole, for the 24 countries of the OECD, and for the US.² Population aging is seen in both a reduction in the fraction of the population that is under 20, and in an increase in the fraction over 64. In the OECD, most of the decrease in the fraction that is young has already taken place, and the most dramatic change in the future will be in the fraction of the population that is elderly. In the less developed countries, the process of population aging is not as far along, and over the next several decades the largest change will be the reduction in the fraction of the population that is young.

In the US, population aging is not a new phenomenon, but it has recently increased its pace. Between 1870 and 1990, the median age of the US population rose from 20.2 to 33.1 (a rate of 1.1 years per decade). Over the period 1990–2025, the median age is

² Throughout this chapter I rely on demographic forecasts from official sources to illustrate the expected magnitude of population aging. Mankiw and Weil (1989) show how inaccurate these forecasts can be: The US Census Bureau's forecast of births for 1963, made in 1953, was 443 000 births (11%) short of the mark, while the forecast for 1974 made in 1964 was 1.83 million births (58%) too high. Similarly, Ahlburg and Vaupel (1990) argue that uncertainty about future population growth is far greater than suggested by Census Bureau projections.

Table 1
Age structure of the population

	1950	1990	2025
<i>World</i>			
0–19	44.1	41.7	32.8
20–64	50.8	52.1	57.5
65+	5.1	6.2	9.7
<i>OECD</i>			
0–19	35.0	27.2	24.8
20–64	56.7	59.9	56.6
65+	8.3	12.8	18.6
<i>US</i>			
0–19	33.9	28.9	26.8
20–64	57.9	58.9	56.0
65+	8.1	12.2	17.2

forecast to rise to 40.9 (a rate of 2.2 years per decade). Comparing past aging to projected future aging, much more of the action in the past was in the reduction in the number of young people rather than in the increase in the number of old people: The fraction of the population that is aged above 64 rose 9.6 percentage points, from 3.0% to 12.6%, over the 120-year period between 1870 and 1990, compared with a projected increase of 7.2 percentage points over the next 35 years. The fraction below 15 fell from 39.2% to 21.4% over the last 120 years, and is projected to fall to 17.9% over the next 35 years.³

2.2. Sources of aging: fertility and mortality

In an economy closed to migration (which is discussed in Section 2.3), population aging results from two sources: an increase in the age at which people die, and a decrease in the rate at which births take place. An increase in longevity raises the average age of the population by raising the number of years in which each individual is old relative to the number in which he is young. A decrease in fertility raises the average age of the population by changing the relative numbers of people born recently (the young) and people born further in the past (the old). A second effect of reduced fertility, of course, is to reduce the rate at which the population grows. Throughout the world, both decreased fertility and decreased mortality are contributing to the aging of

³ Bogue (1985), United Nations (1991).

Table 2
Changes in fertility: 1965–2000^a

	1990 population (millions)	1990 GNP/capita (dollars)	Total fertility rate		
			1965	1990	2000
Low income					
China and India	1983.2	360	6.3	3.1	2.5
Other low income	1075.1	320	6.4	5.2	4.6
Lower-middle income	629.1	1530	5.6	4.0	3.4
Upper-middle income	458.4	3410	5.1	3.4	2.7
High income	816.4	19590	2.8	1.7	1.8

^aFigures are population-weighted averages.

Source: World Bank (1992).

populations. The next two sections look at the relevant data. Throughout this chapter, I take changes in vital rates as being exogenous. For a discussion of determinants of these rates, see Birdsall (1988) and Parts II and III of this *Handbook*.

2.2.1. Declining fertility

Table 2 shows the total fertility rate for the years 1965 and 1990, along with projections for 2000, for the major groups of countries as classified by the World Bank. The fertility rate is the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children at each age in accordance with the prevailing age-specific fertility rate. In the richest countries, the fertility rate is currently below the level required to sustain a constant population (roughly 2.1 children per woman).

Fig. 1 shows the fertility rate in the US for the years 1860 through 1989, and the Social Security Administration's three alternative forecasts through 2040.⁴ The figure shows both the long-term decline of fertility and the large, temporary rebound – the Baby Boom – which took place in the years after World War II. The Baby Boom interrupted the process of fertility reduction, and led to the creation of a cohort larger than both those that preceded it and those that followed, in most other industrialized countries as well as the US.⁵ The presence of the Baby Boom cohort complicates the process of aging, leading, for example, to a ratio of elderly people to the total population that will be temporarily higher than its long-run forecast level.

⁴ Coale and Zelnik (1963) and Wade (1989). Data prior to 1926 are for whites only.

⁵ See OECD (1988).

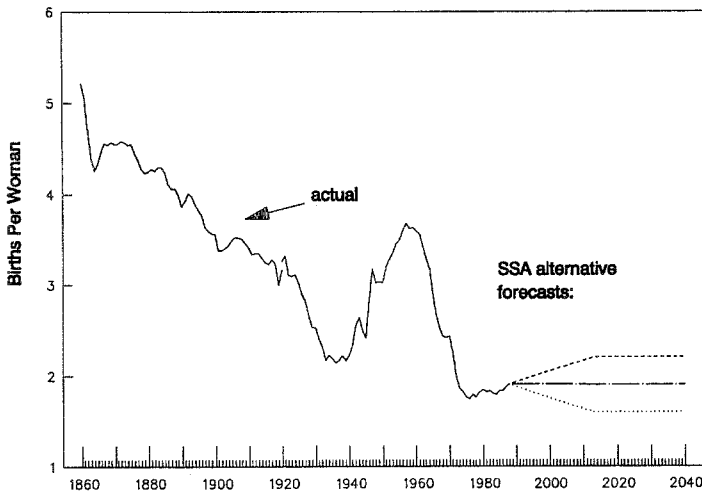


Fig. 1. Fertility rate: actual and forecast. Data prior to 1926 are for whites only.

2.2.2. Declining mortality

Table 3 shows the life expectancy of men and women in the US at different ages from 1900 projected through 2050. Among the points to note about the table are that increases in life expectancy at birth are increasingly the result of improvements in old-age life expectancy. For example, the 8.6 year improvement in men's life expectancy at birth that took place between 1930 and 1960 was accompanied by an increase of only 1.2 years in life expectancy at age 60, while the increase in life expectancy at birth of 5.7 years that took place between 1960 and 1990 was accompanied by an increase of 2.7 years in life expectancy at age 60. Declines in mortality have also been more dramatic for women than for men: the gap between women's and men's life expectancy at birth grew from 3.4 years to 7.6 years over the period 1930–1990, and the gap at age 60 grew from 1.3 to 5.2 years.

2.2.3. Fertility and mortality declines in stable populations

Insight into the sources of population aging can be gained by looking separately at the effects of changes in birth and death rates on a *stable population*. A stable population is one in which the age-specific rates of birth and death have been constant for sufficiently long that the age structure of the population – that is, the fraction of the popu-

Table 3
Changes in life expectancy by age in the US

	Year					
	1900	1930	1960	1990	2020	2050
<i>Men</i>						
Birth	46.6	58.0	66.6	72.3	74.4	75.8
Age 20	41.7	45.1	49.7	53.7	55.7	57.0
Age 40	27.5	28.8	31.3	35.3	37.1	38.5
Age 60	14.2	14.7	15.9	18.6	20.0	21.2
Age 80	5.0	5.4	6.1	7.5	8.4	9.2
<i>Women</i>						
Birth	49.1	61.4	73.2	79.9	82.1	83.8
Age 20	42.9	47.5	55.6	60.9	63.1	64.7
Age 40	28.7	31.0	36.6	41.6	43.7	45.3
Age 60	15.0	16.0	19.6	23.8	25.7	27.1
Age 80	5.3	5.8	7.0	9.9	11.3	12.4

Source: Faber (1982).

lation made up of people of each age – has stabilized.⁶ Note that there is nothing inconsistent with a population growing (or shrinking, for that matter) and it being stable. Of course, birth and death rates have never been constant long enough for a stable population to be observed, but an examination of stable populations allows one to ask questions such as: “what if the birth rate fell while the death rate remained constant?” An examination of stable populations also makes it possible to gauge the relative importance of changes in birth and death rates in producing the actual changes in population age structure that are taking place.

Table 4 presents information about four stable populations, along with the US population in 1989 as a reference. The four stable populations are created by combining two birth profiles with two mortality profiles. The first birth profile used is that for the cohort of women born 1930–1934, which experienced the highest fertility of the cohorts that went through the Baby Boom, returning fertility to the level not experienced since the cohort born around 1875.⁷ The second birth profile used is the cross-sectional pattern of birth rates for 1986, which, with slight alteration, is the one used in the Social Security Administration 1989 forecasts (Wade, 1989). The death rates are those for 1980 and 2030 (Faber, 1982). The standard assumption of 105 male births for every 100 female births is used in constructing the stable populations.

⁶ See Keyfitz (1985: Chapter 4 for a discussion of stable population theory; Chapter 7 for an application to population aging).

⁷ See Fig. 5.3 in Goldin (1990).

Table 4
Stable populations under alternative fertility and mortality^a

Fertility:	1930–1934 cohort	1930–1934 cohort	1986	1986	Actual 1989
Mortality:	1980	2030	1980	2030	
Growth rate (%)	1.45	1.48	–0.50	–0.47	1.06
Fraction 0–19	0.384	0.374	0.228	0.214	0.288
Fraction 65+	0.098	0.118	0.208	0.249	0.125
Fraction 80+	0.023	0.036	0.060	0.094	0.027
Fraction 90+	0.004	0.009	0.012	0.028	0.004

^aActual figures for 1989 from US Bureau of Census (1991). Growth rate of population for 1989 is the growth from 1989 to 1990.

Using Table 4, one can gauge the relative importance of changes in births and changes in deaths by considering changing only one component at a time. Moving from the birth rate for the 1930–1934 cohort to the 1986 birth rate raises the fraction of the population that is aged 65 or over by 10.1 percentage points if death rates are held constant at their 1980 level, or by 13.1 percentage points if death rates are held constant at their 2030 level. By contrast, moving the death rate from its 1980 level to its 2030 level raises the fraction of the population aged 65 and over by 2.0 percentage points holding birth rates at the level of the 1930–1934 birth cohort, or 4.1 percentage points holding birth rates at their 1986 level. The total change in the fraction of the population 65 and over when both fertility and mortality decline, 15.1 percentage points, is the sum of these two effects along with a small interaction effect. Thus at least two-thirds of the increase in the fraction of the population over 65 is due to the change in birth rates. Similarly, at least 90% of the fall in the fraction 19 and under is due to the change in births.⁸

Although both fertility and mortality changes lead to population aging, they differ in how they affect aging as seen from the point of view of the individual. Changes in fertility do not affect the fraction of an individual's life that he or she can expect to spend in each age group, while changes in mortality have precisely such an effect. Lee (1994c) shows that for life expectancies at birth of between 35 and 70 years, an increase in life expectancy leads to a larger increase in the expected time spent in the 15–64 age group than in the time spent in the 65+ age group, although the proportional change in the number of years spent in the latter age group is far larger. Beyond

⁸ Holding age-specific mortality rates constant, a reduction in fertility rates unambiguously leads to an aging of the population. A similar hypothesis – that holding constant fertility rates, a reduction in age-specific mortality also unambiguously leads to population aging – is not true. Lee (1991) shows that for populations with life expectancies below 65 or so, decreases in mortality lead to a reduction in the average age of the population – the mechanism being that reduced mortality raises the number of women who live to childbearing age, and thus raises the population growth rate.

a life expectancy of 70, increases in life expectancy raise the absolute number of years spent in the 65+ age group by more than the number of years spent in the 15–64 age group.

A final point to note about Table 4 is the relation between the current age structure and the stable populations. If one takes the first column as representing a starting point, and the fourth column as representing a destination, it is clear that the younger part of the age structure is much further along on its adjustment than is the older part. Roughly speaking, the transition from a young population to an old population is seen first in the younger part of the age distribution, and only later in the older part of the age distribution. This fact, which is crucial in understanding the dynamics of changes in dependency during the transition to an older population, is discussed further below (see Sections 3.1 and 3.4).

2.3. Immigration

The above analysis considered the determinants of population aging in a closed economy. In fact, immigration has played an important role in the evolution of the population in many countries. The annual flow of legal immigrants as a fraction of the current population in the US was 0.34% in 1993,⁹ but historically it has ranged much higher. Over the period 1844–1910, annual immigration to the US averaged 0.79% of the population.¹⁰ To the extent that population aging is viewed as an economic problem, changes in immigration policy hold the possibility of ameliorating its effects.

Fig. 2 graphs the age structure of the US population in 1987 along with the age structures of the net flows of legal and illegal immigrants assumed in the Social Security Administration's 1989 middle forecast. Both groups of immigrants are significantly younger than is the current US population, much less the population as it will exist in several decades.

In order to assess the potential effects of changes in immigration on the age structure of the population, Table 5 considers the experiment of changing the level of net migration as a fraction of the total US population, holding constant the age and sex composition of net migration. It is assumed that immigrants will have the same fertility and mortality profiles as natives.¹¹ The age and sex composition of immigrants and the ratio of legal to illegal immigrants are those underlying the Social Security Administration's forecasts.¹² Variations in the ratio of net migration to total population,

⁹ US Immigration and Naturalization Service (1994). Estimates of the size of the illegal immigration differ greatly. See Warren and Passel (1987) and Borjas et al. (1991).

¹⁰ US Bureau of the Census (1991).

¹¹ See Blau (1992).

¹² Wade (1989). The SSA assumes that the net flow of illegal immigrants will be one half the net flow of legal immigrants. The SSA forecasts assume a constant absolute level of immigration; in these projections I assume a constant ratio of immigrants to total population.

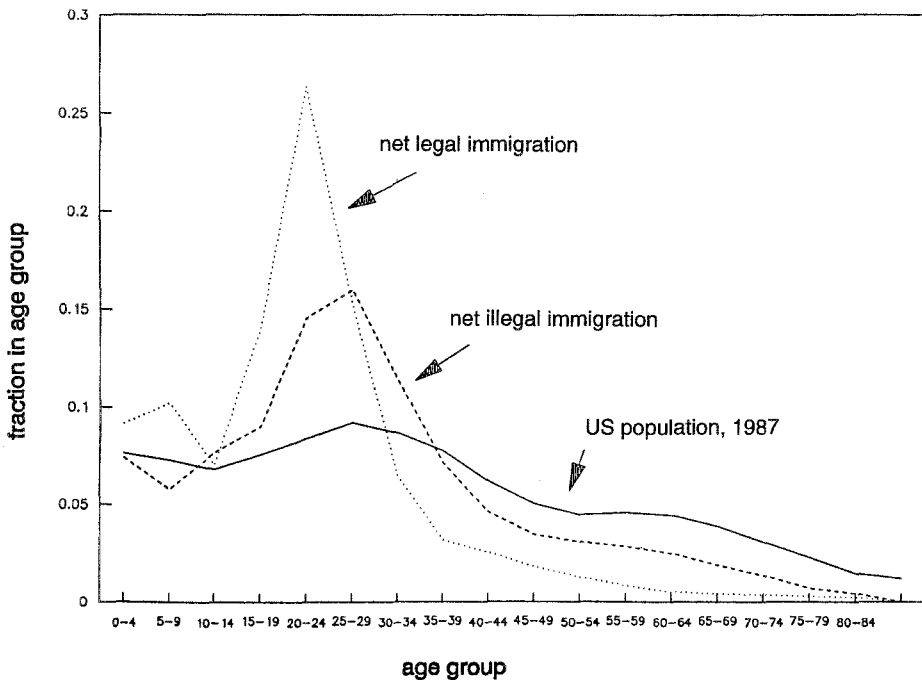


Fig. 2. Age structure of population and immigration flows.

ranging from zero to 1.0%, the level experienced during the peak decade of 1901–1910, are considered. It is assumed that the level of immigration relative to total population is constant at its new level starting in 1990. The table shows the total size of the population and its age structure under each scenario.

The table shows that increases in the flow of immigrants hold the potential to forestall population aging, but only at the cost of greatly increasing the size of the population. Raising the rate of immigration from 0.25% to 0.5% would raise the projected size of the population in 2040 by 18%, and lower the fraction of the population that is 65 and over from 19.1% to 17.7%. Raising the rate of immigration to 1.0% would lead to an age structure of the population only slightly older than the current one (15.3% aged 65 and older, compared to 12.5% in 1989), but to a population of 476 million by 2040. The last column of the table considers the experiment of holding the rate of immigration at 0.25% until 2019, then increasing it to 1.0% for the period 2020–2040. Such a policy might come about if the government increased the flow of immigrants in response to aging.¹³ It leads to the same decrease in the fraction of the population

¹³ Felderer (1994).

Table 5
Projected population under alternative rates of immigration^a

Immigration rate (%)	0	0.25	0.5	0.75	1.0	0.25/1.0
Population in 2040: (millions)	249	294	346	406	476	353
% aged 0–19	22.7	23.3	23.8	24.4	24.8	24.6
% aged 65+	20.8	19.1	17.7	16.4	15.3	16.7

^aThis table shows the size and age structure of the population under alternative assumptions about the rate of immigration as a fraction of total population. The last column assumes an immigration rate of 0.25% from 1990 to 2019, and 1.0% from 2020 to 2040. All projections use mortality estimates from Faber (1982) and 1986 age specific fertility rates. Estimates of the age/sex composition of immigrants (both legal and illegal) come from Wade (1989).

Source: Author's calculations.

that is elderly with a smaller increase in total population than the policy of immediately increasing the flow of immigrants.

3. Aging, production, and consumption

This section considers the effects of population aging on the production and consumption in the economy. It considers the effect of aging in changing fraction of the population made up of non-productive dependents, but abstracts from the question of how resources are transferred to these dependents. The section highlights two important effects: first, the change in the dependency burdens of the young and the elderly contingent on population aging. Second, the economic effects of slower population growth, which is an integral part of population aging induced by lower birth rates.

3.1. The effect of population aging on youth and old-age dependency

The simplest measure of the economic impact of a dependent age group on society's resources is the *dependency ratio*, the number of people in a dependent age group divided by the working-age population. Fig. 3 graphs the youth and old-age dependency ratios for the US from 1950 to 1990, and the projected movements of the ratios through 2060. The aging of the population will have opposite effects on the burdens of youth and old-age dependency. The passage of the Baby Boom cohort appears as a bulge in youth dependency starting in 1960, and a bulge in old-age dependency starting in 2020.

Adding the youth and old-age dependency ratios together gives the total dependency ratio. Doing so is problematic, however, since there is no presumption that old people and children are dependent in the same way or to the same degree. Cutler et al. (1990) construct a measure of consumption "needs" that varies by age, adjusting for

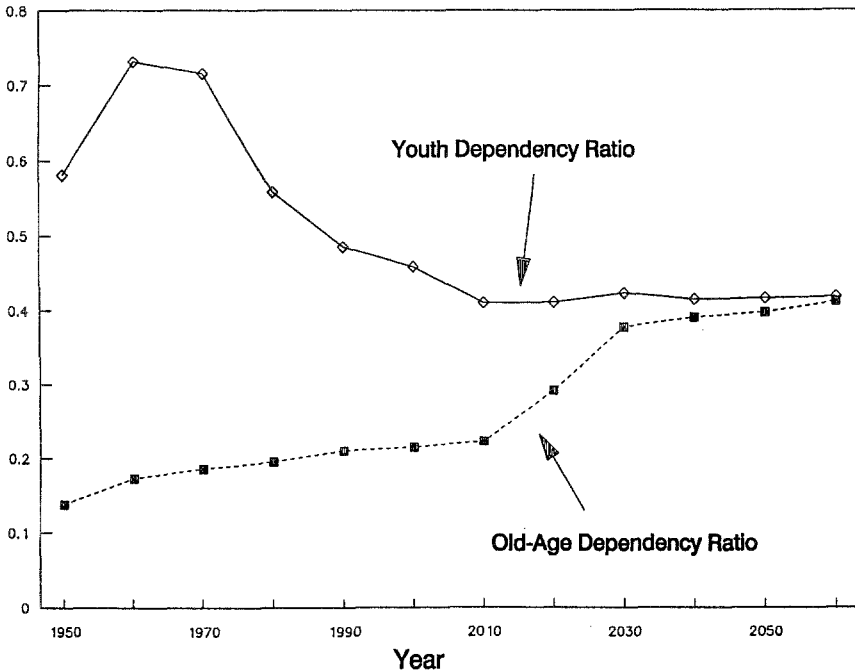


Fig. 3. Youth and old-age dependency ratios: 1950–2060.

the different levels of education spending, medical spending, and other consumption of children, the elderly, and working-age adults. Their summary measure weights people aged under 20 at 0.72 the consumption need of a working-age adult and people over 65 at 1.27 times the consumption need of a working age adult. Using these weights, one can construct a needs-adjusted dependency ratio.

Fig. 4 graphs the two measures of the dependency ratio for the period 1950–2060. The figure shows that, by either measure, the US is currently experiencing a transitory lull in the total burden of dependency: low population growth has reduced the burden of youth dependency, but has not yet increased the burden of old-age dependency.¹⁴ When the consumption needs are not adjusted for age, the projected dependency ratio will rise by 8.0% of its 1990 value between 1990 and 2060. Using the adjusted measure of consumption needs, the ratio of dependents to working-age population rises by 13.0% of its 1990 level between 1990 and 2060. In both cases, almost all of the in-

¹⁴ A similar pattern holds for the OECD taken as a whole, as well as for most OECD countries individually (OECD, 1988).

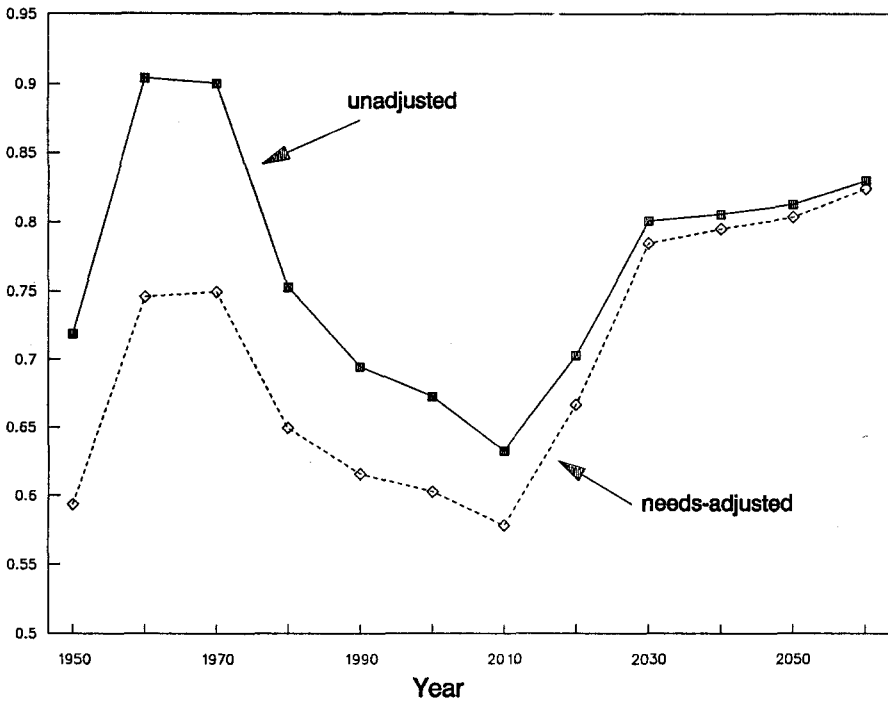


Fig. 4. Total dependency ratio: 1950-2060.

crease in dependency takes place between 2010 and 2030. Using the unadjusted measure of dependency, the long-run burden of dependency is lower than the burden faced when the Baby Boom generation was going through childhood. Adjusting for consumption needs reverses this conclusion, however.

3.2. Age structure, population growth, and dependency in stable populations

As discussed above, the primary force driving the population aging that is taking place today is reduced fertility. The effect of the reduced fertility, via the channel of slower population growth, on age structure, dependency, and consumption, can be analyzed using a simple model in which output is produced with only labor.¹⁵ Total consumption at every point in time is equal to total output. Let $c(x)$ be consumption by people of age x , $y(x)$ be the output produced by people of age x , and $N(x)$ the number of peo-

¹⁵ Lee (1980).

ple aged x . The economy's budget constraint is that total consumption be equal to total output:

$$\int_0^T N(x)c(x) dx = \int_0^T N(x)y(x) dx, \quad (1)$$

where T is the maximum age to which a person can live.

It is assumed that individuals have consumption needs that vary by age, where $\hat{c}(x)$ is the vector of consumption needs. Define the *support ratio* (α) as the ratio of the productive capacity of the economy to the consumption needs of the population:¹⁶

$$\alpha = \frac{\int_0^T N(x)y(x) dx}{\int_0^T N(x)\hat{c}(x) dx}, \quad (2)$$

Actual consumption of people at each age is assumed to be proportional to consumption needs. The support ratio then determines the level of consumption that is consistent with the aggregate budget constraint: $c(x) = \alpha\hat{c}(x)$. The larger is the part of the population that is in its productive years relative to the part of the population that has high consumption needs, the larger is the support ratio. The higher is the support ratio, in turn, the higher will be each individual's needs-adjusted consumption.

To analyze how the rate of population growth affects the support ratio, we consider the case of stable populations. Let $p(x)$ be the probability of living from birth to age x , and n the growth rate of the population. In a stable population, with the total population size normalized to one, the number of people at each age will be

$$N(x) = \frac{e^{-nx} p(x)}{\int_0^T e^{-nx} p(x) dx}. \quad (3)$$

Substituting this expression into the equation for the support ratio gives

$$\alpha = \frac{\int_0^T e^{-nx} p(x)y(x) dx}{\int_0^T e^{-nx} p(x)\hat{c}(x) dx}. \quad (4)$$

¹⁶ Cutler et al. (1990). This same ratio, at the level of households, is examined by Chayanov (1966). In the case where all people have equal consumption needs, α is just the inverse of one plus the total dependency ratio.

We can now look at the effect of changing the growth rate of the population, n , on the support ratio in a stable population. Taking logs of both sides of Eq. (4) and differentiating:

$$\frac{d \ln(\alpha)}{dn} = \frac{-\int_0^T x e^{-nx} p(x) y(x) dx}{\int_0^T e^{-nx} p(x) y(x) dx} + \frac{\int_0^T x e^{-nx} p(x) \hat{c}(x) dx}{\int_0^T e^{-nx} p(x) \hat{c}(x) dx} = A_c - A_y, \quad (5)$$

where A_y is the average age (looking cross-sectionally at the population) at which production takes place, and A_c is the average age at which consumption takes place.¹⁷ The change in the support ratio resulting from an increase in population growth (looking across stable populations) is proportional to the difference between the average age of consumption and the average age of production. If A_c is greater than A_y , then increasing population growth raises the support ratio and the level of needs-adjusted consumption, since it shifts the population toward younger ages. Assuming that $y(x)$ is more concentrated toward the center of life than is $c(x)$, the average age of production will be higher than the average age of consumption for rapidly growing populations, and a reduction in n will increase the support ratio. Similarly, A_y will be lower than A_c for populations with sufficiently small n . For the rate of population growth which maximizes the support ratio, it will be true that $A_y = A_c$.¹⁸

3.3. Implications of changes in morbidity and mortality for support ratios

In analyzing the effects of population aging on the burden of old-age dependency, Section 3.1 assumed an equal burden of dependency for all people over 65. However, aging due to either lower mortality or to lower fertility will affect the age distribution within the group traditionally treated as elderly. Moving between the first and second columns of Table 4, that is, holding fertility constant and reducing mortality, raises the fraction of the over-65 population that is over 80 from 23.7% to 29.0%. Moving between the first and third columns of the table, that is, holding mortality constant at its

¹⁷ This is a special case of a more general result presented in Lee (1991): let $g(x)$ be the quantity of some characteristic exhibited by people of age x , A_g be population-weighted average age of characteristic g , A_p be the average age of the population, and G_p be the average amount of the characteristic in the population. Then looking across stable populations: $d \ln(G_p)/dn = A_p - A_g$.

¹⁸ Lee (1994a-c) estimates that for the US, $A_c - A_y = 4$. Ermisch (1989a, b) reports similar estimates for Japan and the UK. Ermisch also reports that even with fertility rates as high as those of the baby boom and mortality rates as high as those of the UK in the late nineteenth century (but holding lifetime paths of consumption needs and productivity at their current levels), it would be the case that A_c exceeded A_y in a stable population. Willis (1982) models the relation between the average ages of producing and consuming, on the one hand, and the rate of fertility, on the other, as being simultaneously determined.

1986 level, and reducing fertility, raises the fraction of the over-65 population that is over 80 from 23.7% to 30.8%. Combining fertility and mortality reductions would raise the fraction of the elderly population that is aged 80 and over to 37.5%.

In cross-section, there is great variation in the health burden imposed by old people of different ages: of the US population aged 65–74 in 1985, 1.3% lived in nursing homes, compared to 5.9% of the population aged 75–84 and 23.0% of the population aged 85 and above.¹⁹ Thus treating the population over 65 as a homogeneous group will clearly understate the increase in the health burden of aging. Such a problem can, of course, be addressed by subdividing the elderly population into more finely-delineated age groups.

A more subtle question is whether and how the age-specific needs of the elderly can be expected to change in the face of population aging. To the extent that population aging is due to reductions in fertility with constant mortality, the assumption of a constant age-specific dependency burden seems reasonable. To the extent that aging is due to reduced mortality, however, it is questionable. As the life expectancy of people at each age increases (that is, as the probability of dying at any given age falls), will the average health of people at each age also change, and in which direction?

There are potential effects that should both increase and decrease the age-specific rates of morbidity. To the extent that mortality improvements come about by saving the lives of people who remain disabled, we would expect to see a deterioration in age-specific health. Poterba and Summers (1987) calculate that 9.0% of the men and 16.9% of the women over 60 in 1980 would not have been alive if their cohort had experienced the mortality of cohorts born 30 years earlier. At higher ages, the fraction of the population made up of these “marginal survivors” is even higher: for example 15.1% of men and 35.2% of women over 80 in 1980 would not have been alive given the mortality experience of the cohort 30 years older. Marginal survivors may be in worse health than people who would have lived anyway either because they were more frail to begin with, or because the disease which would have killed them has left them disabled. In either case, lowering mortality will lead to a rise in age-specific disability rates. Poterba and Summers estimate that the presence of marginal survivors, as compared to the cohort born 30 years earlier, lowered the life expectancy of the pool of 70-year-olds by approximately one year in 1980.

On the other hand, to the extent that a reduction in life-ending disease is paralleled by a reduction in disabling disease, the health of people at each age could be expected to improve.²⁰ A simple example of this second effect is end-of-life medical expenditures, which make up a large part of health-care costs. Improvements in mortality lower the fraction of the population in any age group that are near the end of their lives, and thus lower age-specific rates of spending on end-of-life medical care.²¹ The

¹⁹ US Senate (1991). The total for all people above 64 was 5.0%.

²⁰ Fries (1980).

²¹ Fuchs (1984).

belief that reduced mortality will be paired with improved age-specific health underlies the legislated increase in the US Social Security program's normal retirement age (the age at which a retiree receives full benefits) from 65 to 67 over the period 2003–2025.

Which of these two effects predominates is an empirical question. Poterba and Summers find that past increases in the frailty of the pool of survivors at each age have approximately offset overall reductions in morbidity, leaving the age-specific health approximately unchanged. They write: "Reductions in mortality do not seem to be associated with reductions in morbidity at each age. There is little reason to think that the health status of the typical 65-year old twenty years from now will be better than it is now" (p. 51). Schneider and Guralnik (1987), reviewing a large number of empirical studies, reach a similar conclusion. Crimmins et al. (1989) find that the effect of mortality improvements on disability is sensitive to the definition of disability used: looking at white women aged 65, for example, overall life expectancy increased by 1.7 years between 1970 and 1980; over the same period expected remaining life free from any disability increased by only 0.2 years, but expected life free from bed disability increased by 1.2 years.

3.4. *Aging and sustainable consumption in a model with capital*

An increase in the dependency ratio, holding constant both the amount of output produced by each working-age adult and the fraction of that output that is consumed, clearly implies a reduction in the amount of consumption per person. Friedlander and Klinov-Malul (1980) and Cutler et al. (1990) point out that in the case of population aging due to a reduction in fertility, there is a second important effect on consumption: slower population growth reduces the fraction of output that must be devoted to producing new capital. For a country to retain a constant capital–labor ratio, some output must be diverted to investment in order to supply new workers with capital. Fewer new workers means lower required investment and more consumption.²²

Consider an economy in which the consumption needs and labor supplies of individuals vary by age. Specifically, let consumption needs of individuals aged x be given by $\hat{c}(x)$, as in Section 3.2, and assume that the population can be divided into dependents and workers, with the latter each supplying one unit of labor and the former supplying zero. Let k be the level of capital per worker and $f(k)$ be the production

²² An example of this effect is the decline in required housing investment, and, possibly, a decline in the price of housing, that should accompany a slowing of population growth. See Ermisch (1988) and Mankiw and Weil (1989).

function in per-worker terms. Analogously with Section 3.2, define α (the support ratio) as the ratio of workers (W) to the total consumption needs of the population:²³

$$\alpha = \frac{W}{\int_0^T N(x)\hat{c}(x) dx}, \quad (6)$$

where $N(x)$ is the number of people aged x .

Define C as total consumption in the economy, and define c as needs-adjusted consumption per capita:

$$c = \frac{C}{\int_0^T N(x)\hat{c}(x) dx}. \quad (7)$$

Let δ be the rate of depreciation, and n the growth rate of the labor force (which, in a stable population, is the same as the rate of growth of the population).²⁴ The derivative of the per-worker capital stock with respect to time is given by

$$\frac{dk}{dt} = f(k) - (n + \delta)k - \frac{c}{\alpha}. \quad (8)$$

In steady state, capital per worker is constant. The steady-state locus of feasible combinations of needs-adjusted consumption per capita and capital per worker is given by

$$c = \alpha[f(k) - (n + \delta)k]. \quad (9)$$

A decrease in α (that is, an increase in the number of dependents relative to the number of workers) will reduce the level of consumption possible at any level of capital per worker. A reduction in n , the rate of labor force growth, will reduce the burden of providing capital to new workers, and will raise the consumption level consistent with any steady-state capital stock. Population aging associated with lower fertility will lower n and have an ambiguous effect on α , depending on the average ages of production and consumption.

²³ In the model of Section 3.2, where output was produced using labor alone, α was defined as the ratio of output to consumption needs. If each worker produces a single unit of output, the two definitions are the same.

²⁴ For convenience, I hold technology constant. Labor-augmenting technological progress could be incorporated by redefining k and c to be their levels in this model divided by the number of efficiency units per worker.

Table 6
Effect of demographic change on consumption in steady states^a

<i>n</i> (%)	Fraction of population aged		α	Effect of dependency (%)	Effect of labor force growth (%)	Total consumption in per capita change (%)
	0–19	64+				
(1)	(2)	(3)	(4)	(5)	(6)	(7)
–1.00	19.2	24.5	0.556	–3.5	2.6	–0.9
–0.75	21.0	22.6	0.563	–2.2	1.9	–0.3
–0.50	22.8	20.7	0.569	–1.2	1.3	0.1
–0.25	24.6	19.0	0.573	–0.5	0.6	0.2
0.00	26.5	17.5	0.576	0.0	0.0	0.0
0.25	28.6	15.8	0.577	0.2	–0.7	–0.5
0.50	30.5	14.4	0.577	0.2	–1.4	–1.1
0.75	32.6	13.1	0.576	0.0	–2.1	–2.1
1.00	34.6	11.8	0.573	–0.5	–2.7	–3.2
1.25	36.7	10.6	0.569	–1.3	–3.4	–4.6
1.50	38.8	9.6	0.563	–2.2	–4.0	–6.2
1.75	40.9	8.6	0.556	–3.4	–4.6	–8.0
2.00	42.9	7.7	0.549	–4.7	–5.2	–9.9

^aThis table shows the effect of population growth on dependency and sustainable consumption in stable populations. Each row presents calculations for a different population growth rate, which is given in column (1). Column (4) gives the support ratio, α : working-age population divided by total age-adjusted consumption needs. Column (5) shows the effect on consumption relative to the base case of zero population growth of the change in the support ratio. Column (6) shows the effect of labor force growth on consumption, again relative to the case of zero population growth. Column (7) shows the combined effects of the support ratio and the labor force growth effects.

Source: Author's calculations.

In a stable population, of course, the rate of labor force growth, n , and the support ratio, α , are related. Table 6 explores how changing growth affects needs-adjusted consumption per capita, both through the effect on the dependency ratio and through the change in labor force growth. Each row considers a different labor force growth rate, given in column (1). For each rate of labor force growth, the age distribution of the stable population (based on 1980 mortality rates) is calculated, and the fractions of the stable population that are under 20 and over 64 are presented in columns (2) and (3). Column (4) shows the support ratio, α , calculated using the weights for old age and youth consumption needs from Cutler et al. (1990). The fifth column of the table shows the effect on consumption relative to the base case of zero labor force growth, of the change in the support ratio. Considering dependency alone, the labor force growth rate consistent with maximum consumption would be between 0.25% and 0.5%. This is simply the optimal population growth rate from the model that consid-

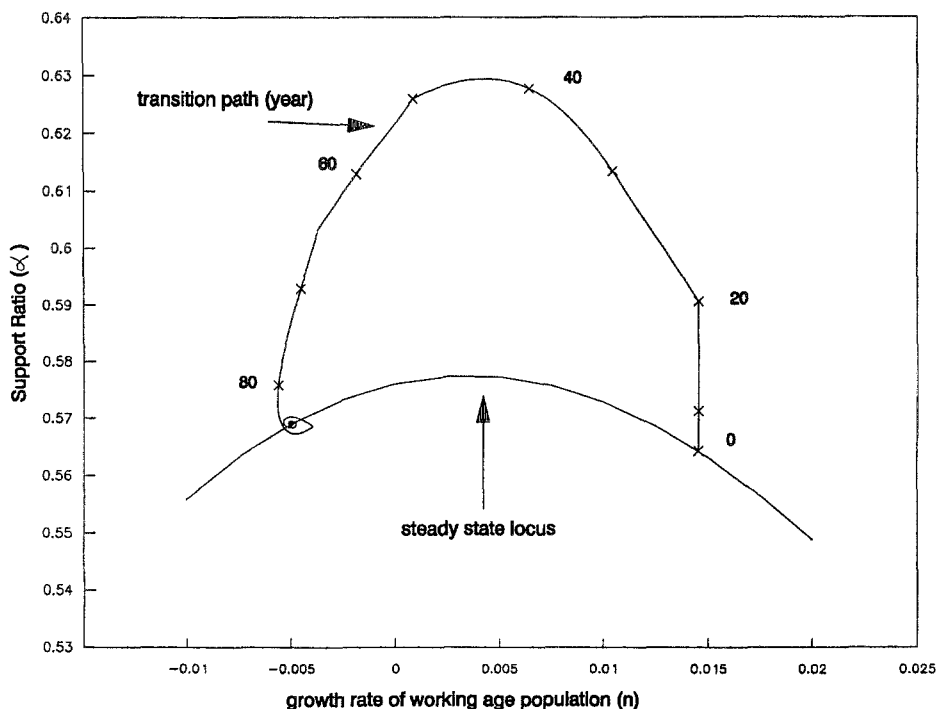


Fig. 5. Combinations of n and α in steady states and along transition path.

ered production without capital, presented in Section 3.2. The sixth column of the table shows the effect of labor force growth, via required investment, on consumption, again relative to the case of zero growth.²⁵ Lower labor force growth always leads to the investment effect on consumption being bigger. Column (7) of the table shows the combined effects of the support ratio and the labor force growth effects: the population growth rate that maximizes consumption is now *negative*: somewhere between -0.25% and -0.5% .

Table 6 says that in steady state needs-adjusted consumption would be approximately 6.1% lower in a country with a labor force growth rate of 1.5% than it would be in a country with a labor force growth rate of -0.5% . This is approximately the size of the change in population growth rates taking place in the US (as shown in Table 4). But in addition to the steady-state change, there are important effects that take place

²⁵ Following Cutler et al. (1990), the second-order term, representing the interaction of changes in both α and n , is assigned to n . Cutler et al. also show that in steady state the optimal level of capital per worker is invariant to the rate of population growth.

along the transition path from one level of population growth to another. Fig. 5 traces the combinations of the support ratio (α) and the growth rate of the working age population (n) along a transition path from high to low fertility. The figure is generated by holding mortality constant at its 1980 level throughout, and allowing age-specific fertility rates to linearly adjust over a 30-year period from their levels in the 1930–1934 cohort to their cross-sectional levels in 1986. The figure shows that along the transition path there is a far more dramatic change in the support ratio than one observes looking across steady states. This is because of the time lag between a decline in youth dependency and an increase in old-age dependency, both of which result from the fertility change.

Fig. 6 examines the level of consumption that could be sustained while maintaining a constant capital–labor ratio, for the same demographic transition examined in Fig. 5. The increase in consumption along the transition path is far larger than the difference between consumption in the two steady states. The fertility transition raises consumption first by reducing youth dependency, and then by lowering the rate of growth of the labor force. Consumption peaks 47 years after the beginning of the transition at a

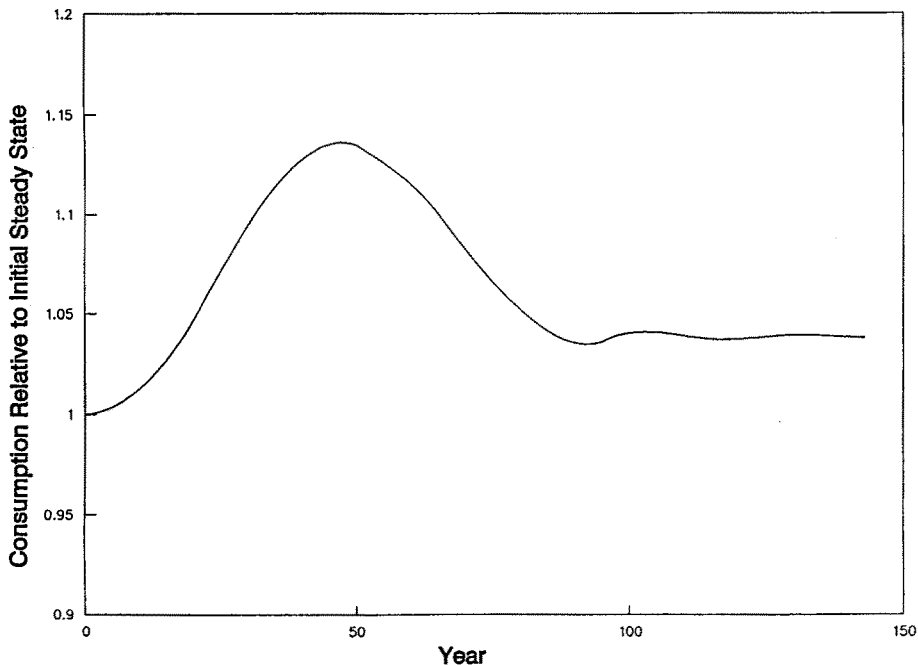


Fig. 6. Consumption during a demographic transition.

Table 7
Effect of projected demographic changes on steady-state consumption^a

Year	n (%)	α	Effect of dependency (%)	Effect of labor force growth (%)	Total change in per capita consumption (%)
1960	0.79	0.573	-7.4	0.4	-7.1
1970	1.61	0.572	-7.7	-1.8	-9.5
1980	1.80	0.606	-2.0	-2.4	-4.5
1990	0.88	0.619	0.0	0.0	0.0
2000	0.89	0.622	0.8	0.0	0.8
2010	0.52	0.634	2.3	1.0	3.4
2020	-0.22	0.600	-3.1	2.9	-0.2
2030	-0.10	0.560	-9.5	2.4	-7.1
2040	0.15	0.557	-10.0	1.8	-8.3
2050	-0.12	0.554	-10.4	2.4	-8.0
2060	0.03	0.548	-11.5	2.0	-9.4

^a n is the rate of growth of the working age population. α is the support ratio: working-age population divided by total age-adjusted consumption needs. The last three columns measure the effect of changes in the support ratio, changes in labor force growth, and the total effect of demographic change on the level of consumption that would keep the ratio of capital to efficiency unit of labor constant, given the values of α and n .

Source: Cutler et al. (1990: Table 3 and Data Appendix).

level 14% higher than its initial steady state. In the new steady state, consumption is only 4% higher than its initial level.²⁶

The actual aging of the population taking place in the US is more complicated than the scenario in Figs. 5 and 6, since mortality is changing as well as fertility, and the Baby Boom interrupted a monotonic fertility decline. But the key effect – that the transition allows for a temporary boom in consumption – remains. Cutler et al. (1990) calculate the effect on per capita consumption (adjusted to reflect varying consumption needs by age) of projected population aging over the period 1960–2060. They calculate the difference between the level of consumption that could be sustained in each year, given that year's values for α and n , and the level that could be sustained in 1990, in both cases holding capital per worker at its 1990 level. Their results are presented in Table 7. As in Table 6, the difference between sustainable consumption in each year and sustainable consumption in 1990 is decomposed into two parts: one due

²⁶ Although the optimal level of capital per worker in steady state is not affected by the rate of population growth, the same is not true along the transition path; see Cutler et al. (1990) for a full treatment of the transitional dynamics. The deviation of the level of capital per worker along the transition path from its steady-state level is not large, however: over the period 1990–2060, they find that the optimal level of capital per worker deviates from its steady-state level by at most 5%.

to the effect of dependency, and the other to the effect of changes in the labor force growth. The effect of changes in dependency is to increase the sustainable level of consumption over the period 1970–2010. This period corresponds to the lull between the decrease in youth dependency and the increase in old-age dependency, both of which follow from the slowdown in fertility. The depressing effect of changes in the labor force growth on sustainable consumption in 1970 and 1980 corresponds to the rapid increase in the growth rate of the labor force (and the corresponding need to supply new workers with capital) due to the entry of the Baby Boom. The overall effect of demographic change is to increase sustainable consumption over the period 1970–2010, and to lower it over the period 2010–2060. Once again, the largest impact of aging comes over the period 2010–2030, when sustainable consumption falls by over 10%.

3.5. Aging and the labor market

Just as population aging means more old people as a fraction of the population, it also means more old workers as a fraction of the labor force. To the extent that old and young workers differ in the input that they supply, the wages that they receive, the jobs that they occupy, and in their propensity to be unemployed or to move, population aging can be expected to have effects on the labor market. These will be both composition effects due to changes in the relative weights of different age groups in the total labor force, as well as general equilibrium effects on age-specific wages, mobility, and employment status.

The most natural experiment with which to analyze the effects of demographic change on the labor market – the experience of the large Baby Boom cohort – is discussed in Chapter 2 of this *Handbook*. The more long-term effects of population aging are in some ways similar, and in others different, from those encountered by the Baby Boomers. The Baby Boom cohort brought about a large increase in the relative size of every age group that it entered. For example, the fraction of the labor force aged 20–34 moved from 31.5% to 40.1% over the period 1966–1976 (Freeman, 1979). The changes in the relative sizes of different age groups in the process of aging in the United States is of roughly similar size: comparing the high fertility–high mortality population to the low fertility–low mortality population in Table 4, the fraction of the population aged 20–64 that is aged 20–34 falls from 42.3% to 32.1%. Similarly, using Social Security Administration forecasts, the fraction of the population aged 20–64 that is aged 20–34 will fall from 42.8% to 34.5% over the period 1990–2000. On the other hand, two salient features of the Baby Boom experience are not present in the case of permanent population aging. First, members of the Baby Boom generation were always in a crowded group. By contrast, to the extent that some age groups could become relatively crowded in the process of population aging, individuals will only be in the crowded group for part of their lives. Second, the movement of the Baby Boom

generation through the age structure has produced repeated changes in the age structure of the labor force, with consequent adjustment costs. By contrast, a permanent aging of the population will have no such adjustment costs in the long run.

3.5.1. *Lifetime wage profiles*

Over an individual's working life, his or her wage grows both because of changes in the average level of wages (due to capital deepening and technological progress) and because at each point in time there exists a cross-sectional age-earnings profile. One explanation for the existence and shape of the age-earnings profile is that younger and older workers provide different factors of production, and that these factors earn different wages. In particular, older workers possess higher levels of experience and skill, but lower levels of physical stamina. In such a case, demographic change, by changing the relative supplies of these factors, will lead to a change in the wage profile. Freeman (1979) finds that just such a model explains the changes in the relative wages of younger and older men over the period in which the Baby Boom cohort entered the labor force. Similarly, Welch (1979) estimates that a 10% increase in cohort size reduced wages to college graduates by 9% and to high school graduates by 4% upon entry into the labor force. On the other hand, Murphy et al. (1988) argue that over the course of a lifetime, the effects of generational crowding are relatively small: while members of large cohorts can suffer wages 10% below those of average-sized cohorts in the early years of their careers, such crowding effects diminish with experience, so that the present discounted value of lifetime wages for members of large cohorts is only 3% below that for average-sized cohorts.

The complementarity in production of workers of different ages implies that members of large birth cohorts, such as the Baby Boom, will be disadvantaged, since they will always be in the age group which is in large supply. In the case of a permanent aging of the population due to reduced fertility, however, the situation is more complicated. Population aging will raise the wages of the young relative to the old. But since every worker will be both young and old during his or her life, the welfare implications of such aging are not immediately clear. A simple model (Lam, 1989) can be used to demonstrate this point and to examine the welfare implications of changes in the growth rate of the population. Normalize the population to one, and let l_1 and l_2 ($= 1 - l_1$) be the numbers of young and old workers, respectively. Production is assumed to use only the two types of labor as inputs, $y = f(l_1, l_2)$, and to be constant returns to scale. Workers are paid their marginal products.

The present value of lifetime wages is

$$W = f_1 + \frac{f_2}{1+r}, \quad (10)$$

where the interest rate, r , is taken as exogenous. Differentiating Eq. (10) with respect to l_1 yields

$$\frac{dW}{dl_1} = f_{11} - f_{12} + \frac{f_{21} - f_{22}}{1+r}. \quad (11)$$

Given constant returns to scale, factor payments exhaust output:

$$f(l_1, l_2) = l_1 f_1 + l_2 f_2. \quad (12)$$

Differentiating Eq. (12) with respect to l_1 and rearranging yields

$$f_{21} = -f_{11} \left(\frac{l_1}{l_2} \right). \quad (13)$$

Differentiating Eq. (12) with respect to l_2 yields a similar expression. Using these and the equality $f_{12} = f_{21}$, Eq. (11) can be re-written as

$$\frac{dW}{dl_1} = f_{11} \left(1 + \frac{l_1}{l_2} \right) \left(1 - \frac{l_1/l_2}{1+r} \right). \quad (14)$$

Finally, assuming that the population is growing at rate n , Eq. (14) can be re-written as

$$\frac{dW}{dn} = f_{11} (2+n) \left(1 - \frac{1+n}{1-r} \right). \quad (15)$$

When $r = n$, changes in the rate of growth of population have no effect on the present value of lifetime wages. But this is a global *minimum*: workers are made better off the farther n is from r , no matter in which direction. The above result can be generalized to show that when productivity is growing at a rate of g per generation, the condition for the present value of wages being at their global minimum is $(1+n)(1+g) = (1+r)$.

One can now analyze the welfare implications of reducing n . Lower labor force growth will raise the wages of young workers, and lower those of old workers. The effect on the present value of lifetime wages will depend on how the sum of the growth rate of the labor force and the growth rate of productivity compares to the relevant interest rate. If $(1+n)(1+g) > (1+r)$, then reducing n will lower the present value of lifetime wages, while if $(1+n)(1+g) < (1+r)$, then further reductions in n will raise the present value of wages. The latter condition probably holds true.²⁷

²⁷ See Abel et al. (1989).

3.5.2. *Deviations between wages and marginal products*

The model presented above derives the age–wage profile as a result of differences in the marginal product of labor. A different approach is that of Lazear (1979), who argues that upwardly sloping wage profiles are part of a mechanism to prevent shirking by workers in the presence of imperfect monitoring. Workers post a “bond” (which is forfeit if they are fired) in the form of wages below their marginal products when young, and receive repayment in the form of wages above their marginal products when they are old. Among the virtues of the model is that it explains the desire of companies to apply mandatory retirement ages. Kotlikoff (1988a) finds strong evidence in favor of the Lazear model: wages start off below productivity, but rise above it as workers near retirement age.

The implications of population aging for a Lazear-type model of the age–wage profile depend on the manner in which firms finance deviations between wages and productivity (in a manner analogous to the funding of Social Security, discussed below). If this gap is financed on a “pay as you go” basis, then population aging will lead to a funding shortfall: the reduction in young workers’ wages below marginal product will no longer cover the excess of older workers’ wages above it. Thus population aging will have to lead to a reduction in the wages of one of the groups of workers. If, on the other hand, firms finance the deviation of wages from productivity on a “funded” basis – that is, if the firm actually puts aside the money to pay workers wages above their marginal products in their later years – then aging of the labor force will not necessarily affect the wage profile. (See Lazear (1990) for a more formal treatment of this problem.)

3.5.3. *Unemployment, mobility, and labor force participation*

A notable way in which young workers differ from older workers is that they have higher rates of unemployment. Holding these rates constant, demographic changes can have large effects on the average rate of unemployment. Flaim (1990) finds that shifts in the age structure of the labor force do a good job in explaining movements in unemployment over the period 1960–1990. It is not clear, however, whether these age-specific differences will be sustained in the face of future demographic shifts. To the extent that unemployment among the young is generated by last-in–first-out firing on the part of employers, demographic change will result in an increase in unemployment rates for older workers, leaving the natural rate of unemployment constant.

Related to the issue of unemployment is that of mobility. Young workers are more mobile than their older peers, partly because they have a longer period over which to recover the costs of moving, and also because they are less likely to have found a good match for their skills. Mobility of the young lends flexibility to the workforce in the face of sector- or location-specific shocks. An older workforce, if age-specific

mobility rates do not change, will be less mobile, and more prone to long-term unemployment.

The aging of the population, in affecting the age–wage profile, may also affect the timing of the retirement decision. Secular declines in labor force participation of the elderly have been dramatic – see Lumsdaine and Wise (1994) for a discussion. But it is hard to make the case that these observed declines are attributable to population aging. For the reasons given in Section 3.5.1, increasing the fraction of the labor force that is old should lower the relative wages of the elderly, and this might be likely to lower their labor force participation. Working against this trend will be the desire of governments to postpone retirement as a way of balancing public pension systems.

3.5.4. Seniority and promotion

A final labor market effect of population aging is on the speed with which individuals progress up the seniority ladder (Keyfitz, 1973, 1985; Cantrell and Clark, 1982). If promotions are based on seniority, and if the fraction of the workforce at each given rank is fixed (for example, the number of generals relative to the size of the army), then slower population growth implies that the age at which people attain given rank rises.

Let k be the percentile rank in the seniority distribution at which one obtains a given promotion. This rank is taken as fixed. Then in a stable population, the age, x , at which one attains this rank satisfies the condition

$$k = \frac{\int_x^\gamma e^{-na} p(a) da}{\int_\beta^\gamma e^{-na} p(a) da}, \quad (16)$$

where β is the age of beginning work, $p(a)$ is the probability of being in the labor force at age a , γ is the latest age of retirement, and n is the rate of population growth.

Table 8 shows the age at which workers will attain different ranks in the labor force for the stable populations considered in Table 4 as well as for the 1989 actual population. The table assumes that people start working on their 20th birthday and retire on their 65th birthday. Comparing the high-fertility, high-mortality population (Column 2) to the low-fertility, low-mortality population (Column 5), the age at which one reaches halfway up the seniority ladder rises by five years in the older population.

Bos and Weizsacker (1989) suggest that as consequence of population aging there is a danger that young people will be frustrated and discouraged by their slow rate of promotion. An alternative to later promotion is, of course, no promotion at all. If an

Table 8
Age of attaining different levels of seniority^a

	Stable populations				Actual 1989 population
	1930–1934 cohort	1930–1934 cohort	1986	1986	
Mortality:	1980	2030	1980	2030	
(1)	(2)	(3)	(4)	(5)	(6)
10%	23.2	23.3	24.7	24.8	23.0
25%	28.4	28.5	31.6	31.8	27.7
50%	38.1	38.3	42.8	43.0	37.0
75%	49.7	50.0	53.7	54.0	50.5
90%	58.2	58.4	60.4	60.5	58.8
95%	61.4	61.6	62.6	62.7	61.7

^aThis table shows the age at which an individual will achieve a given rank (shown in column (1)) in the labor force, which is taken to be all individuals aged 20–64. Columns (2)–(5) show the age at which the rank is achieved for the four stable populations calculated in Table 4. Column (6) shows the age at which the rank is achieved for the 1989 US population.

Source: Author's calculations.

occupation has an “up or out” career track, in which people must be promoted to a certain grade by a certain age, and if the fraction of workers that can be in the higher grade is fixed, then a slower rate of population growth will mean that a smaller fraction of the eligible population will ever be promoted. Examples of such systems are the promotion of military officers and the tenuring of junior faculty.

4. Aging in a life-cycle model

This section examines the effects of aging in a life-cycle model. The life-cycle model is concerned with how the saving of individuals in order to smooth consumption over the course of their lives in the face of varying income leads to the accumulation of wealth at the individual level and of the capital stock at the national level. Individuals make saving and labor supply choices taking as exogenous aggregate conditions in the economy. Since the life-cycle model predicts that the elderly will be running down their assets, it implies that the aggregate saving rate will fall in response to population aging brought on by lower fertility.²⁸ The section begins by examining the simplest possible life-cycle model, with wage and interest rates taken as exogenous. It then

²⁸ As discussed in Section 2, reduced fertility is the primary driving force behind current population aging. For a discussion of the effects of reduced mortality on saving in the life-cycle model, see Kotlikoff (1981) and Skinner (1985).

expands the model to allow for general equilibrium effects of changes in the capital stock. The last part of this section examines alternative models of saving and how they behave in the face of demographic change.

4.1. Demographic change in a two-period life-cycle model

First, the effect of demographic change in a simple overlapping generations life-cycle model is considered (see Auerbach and Kotlikoff (1987) for a more extensive discussion).²⁹ Individuals are assumed to live for two periods, supplying labor only in the first period of life. They get utility only from consumption in the two periods:

$$U_t = U(C_{y,t}, C_{o,t+1}), \quad (17)$$

where $C_{y,t}$ is the consumption of people who are young in period t and $C_{o,t+1}$ is the consumption of the same people when they are old in period $t + 1$. Individuals take as exogenous their wage during the first period of life, W_t , and the interest rate on saving held between the first and second periods of life, r_{t+1} . Individuals face the lifetime budget constraint

$$C_{y,t} + \frac{C_{o,t+1}}{1 + r_{t+1}} = W_t. \quad (18)$$

The saving of the young is $S_{y,t} = W_t - C_{y,t}$. The consumption of the old in period t is equal to their saving when young plus accumulated interest: $C_{o,t} = (1 + r_t)(W_{t-1} - C_{y,t-1})$. Given that they have earned interest of $r_t(W_{t-1} - C_{y,t-1})$ on the wealth that they put aside when young, the saving of the old in period t is $S_{o,t} = -W_{t-1} + C_{y,t-1}$. Consider first the case where W and r are constant, and thus optimal consumption of the young, C_y , is also constant. To incorporate population age structure into the model, let n be the rate of population growth. Thus the young generation is $(1 + n)$ times the size of the old generation. The aggregate saving rate is

$$s = \frac{n(W - C_y)}{(1 + n)W - r(W - C_y)}. \quad (19)$$

Population aging brought on by a decline in fertility – that is, a decline in n – will lower the saving rate. Further, when n is zero, that is, when the old and young generations are the same size, the saving rate will be zero. Finally, under the assumption that

²⁹ By fixing the number of periods in life and the relative size of working life and retirement, this model constrains us to look only at the effects of fertility-induced demographic change.

W and r are constant, the saving rate in period t depends only on the ratio of old to young in that period.

The assumption of exogenous interest and wage rates is appropriate for a small open economy, but not otherwise. The partial equilibrium model presented here can be closed by assuming that the capital stock in each period is equal to the saving of the current elderly. Capital per worker is then given by $k_t = (W_{t-1} - C_{y,t-1})/(1+n)$. The wage and interest rates are determined by a productive technology using capital and labor.

Allowing for general equilibrium effects, an assessment of the effect of population aging on the saving rate rapidly becomes analytically intractable. An increase in the ratio of old to young people will increase the amount of capital per worker, and thus raise the wage and lower the interest rate. In the special case where preferences are homothetic the saving rate of the young cohort, s_y , will be invariant to the interest rate. In this case, the general equilibrium effect of changes in population age structure on the saving rate in steady state will be the same as the partial equilibrium effect. If preferences are not homothetic, however, then there will be a secondary effect of changes in n on the saving rate of the young. For example, if the interest elasticity of saving is positive, then population aging will reduce the saving rate both by raising the fraction of the population that is old and by lowering the saving rate of the young. A second sort of complication in the general equilibrium model is that saving in period t depends on the interest rate (and thus the ratio of old to young) that will hold in period $t+1$. Thus saving in each period depends on expectations of future population growth rates. Similarly, if one allows more than one period of working life, the saving decision made early in life depends on the expected path of lifetime wages. Finally, changes in the population age structure which change the steady-state level of capital per worker will lead to dynamic adjustments in the levels of capital, wages, and interest rates along the path to a final steady state.

To handle the complications which arise in the general equilibrium model, one must resort to simulations. This approach is discussed in Section 4.3. Another approach is to ignore the effects of changes in interest and wage rates, and use the observed cross-sectional saving profile in combination with expected changes in population age structure in order to forecast saving. Such an approach, which is discussed in Section 4.2, can be justified by the assumption of an open economy in which factor prices are set at world levels and are unaffected by domestic capital accumulation and population growth.

4.2. Aging and saving in partial equilibrium

Partial equilibrium analyses forecasting the effect of demographics on the saving rate have generally started with household data on saving rates and income levels by age. Saving is forecast by assuming that the age-wage and age-saving profiles will remain

constant while the number of people in each age group varies. The forecast changes in saving from such exercises have been surprisingly small. Wachtel (1984), using saving rates from the 1962–1963 Surveys of Consumer Finances, projects a change in the saving rate between 1985 and 2020 of between -0.5 and 0.2 percentage points, depending on the source of saving data used. Auerbach and Kotlikoff (1990) forecast the effect of demographic change on the saving rate, having first allocated government consumption by age group. Depending on the base year they use, they forecast an increase in the US saving rate between the 1980s and the 2020s of between 2.3 and 2.8 percentage points. Bosworth et al. (1991) argue that demographic changes have not had significant effects on saving rates in the past. They decompose saving changes between 1963 and 1985 into changes in within-age-group saving and income on the one hand and changes in the fractions of the population made up of different age groups on the other. They find that changes in the latter factor had only trivial effects on the saving rate over the period they examine. They also report similar results for Canada and Japan.

A second set of studies has tried to forecast the effect of demographic change on saving using age-saving profiles derived by regressing national saving rates on the fractions of countries' populations in different age groups. The estimated saving coefficients for the elderly from such regressions are negative and large compared to those derived from household level data, and forecasts of the response of saving to changes in demographics are accordingly much more dramatic. Heller (1989), projecting the effect of demographic change on the US private saving rate over the period 1980–2025 reports estimated declines in saving ranging from 3.8 to 10.5 percentage points. Masson and Tryon (1990) report similar results. Weil (1994) suggests that the divergence between the micro- and macro-based forecasts of the effect of demographics on saving may be due wealth transfers between households. When the elderly transfer wealth to their children (through inter vivos transfers, intentional bequests, or accidental bequests), they reduce their children's need to save. Thus the presence of a larger elderly cohort may reduce national saving by reducing the saving rate of the young generation. This approach is discussed further in Section 6.1.

4.3. Aging and saving in general equilibrium

Auerbach and Kotlikoff (1987) present a somewhat realistic, but computationally very complex, simulation model with which one can examine the general equilibrium effects of demographic change. Individuals live for 75 periods, the first 20 as dependent children whose consumption is determined by their parents. The intertemporal utility function for individuals is defined over consumption, leisure, and the utility of dependent children. Labor supply is endogenous, determined by the wage and interest rates and by a lifetime productivity profile that declines in old age, leading to retirement and life-cycle saving. The wage rate and the interest rate are determined by the

Table 9
Behavior of endogenous variables during a baby bust transition

Year	Saving rate	Wage rate	Interest rate
0	7.6	1.00	9.9
1	6.1	1.00	9.9
5	6.6	1.00	10.0
10	7.4	1.00	10.0
20	7.9	1.02	7.4
50	3.0	1.10	7.3
70	0.0	1.11	7.1
110	-1.5	1.11	7.1
∞	0.0	1.11	7.1

Source: Auerbach and Kotlikoff (1987).

supplies of labor and capital, which is in turn composed of life-cycle savings. In each period, individuals make optimizing decisions given the entire future paths of the endogenous variables. The model is solved iteratively to find rational expectations paths of all of the dependent variables. There is no uncertainty.

Auerbach and Kotlikoff consider the effects of a fertility transition in which the birth rate moves from a level consistent with 3% annual population growth to a level consistent with zero population growth. The change in fertility is taken to be unexpected, but as soon as it has taken place the time paths for all variables are recalculated. After the initial shock there is again no uncertainty, and all variables follow the rational expectations paths.

Table 9 shows the paths of the key endogenous variables in the initial steady state (year zero), along the transition path, and in the final steady state. Comparing the initial and final steady states, the wage rate rises and the interest rate falls, reflecting the increase in the capital-labor ratio as the number of high capital retirees rises relative to the number of workers. The saving rate falls to zero in the new steady state, since there is no population growth (see Section 4.1). Interestingly, the time paths of the endogenous variables are not monotonic along the transition path. The saving rate falls in the initial years of the transition not because of an increase in the number of old people, but because working-age people expect a rising wage profile, and thus save less in order to smooth consumption. Twenty years after the reduction in fertility occurs, the saving rate is higher than in the initial steady state, but following this point it falls, as the ratio of retirees to workers rises.

4.4. Limitations of the life-cycle model

Although it provides a good benchmark from which to begin analysis of demographic

change, there are a number of problems with the life-cycle model – both with its ability to fit the data and with the assumptions it uses.

One of the most salient empirical problems with the life-cycle model is the “failure” of the old to dissave to the extent predicted in the model. Explanations for this phenomenon are discussed in Chapter 16 of this *Handbook*. The low rates of dissaving by elderly households explain why partial equilibrium predictions of how changes in demographics will affect saving (that is, taking the observed age–saving profile as constant) lead to smaller predicted reductions in saving than do simulations such as those by Auerbach and Kotlikoff (1987) which impose life-cycle preferences on agents.

Comparing the life-cycle model’s predictions about wealth holding to what is observed in the economy, two problems arise. First, simulating the model for reasonable sets of parameters, life-cycle saving does not produce a ratio of wealth to income as high as that observed in the economy (White, 1978). Second, observed saving does not accord well with the predictions of the life-cycle model: Carroll and Summers (1991) find that lifetime consumption patterns of individuals closely match lifetime income profiles, rather than being smoother than income, as the model predicts. A number of authors (Carroll and Summers, 1991; Deaton, 1991) have argued that observed saving of most households is far lower than would be implied by a life-cycle motive. Deaton proposes a buffer stock model of saving, in which households smooth consumption over a very short time horizon. Complicating this analysis, the economic environment in which most households in developed countries find themselves, most importantly the existence of Social Security and employer-mandated private pension schemes, means that it may not be optimal for these households to be doing any saving anyway. Whether these households would react to a change in their environment such as a reduction in future Social Security benefits due to changing demographics by raising saving, as predicted by the life-cycle model, or by keeping saving constant, as predicted by the buffer stock model, is hard to know.

The extreme skewness of the wealth distribution greatly complicates the analysis of how an aging population will affect capital accumulation. We know little about the saving motives of wealthy households – although we do know that their fertility experience has paralleled that of the population as a whole³⁰ – and so it is hard to know how their saving will be affected by demographic change.

Another line of criticism of the life-cycle model has been that the time horizon over which it assumes optimization – individuals’ own lifetimes – is too short. This is a view associated with Barro’s (1974) model of Ricardian equivalence, in which changes in the timing of tax collections that hold the present value of taxes constant do not affect consumption. If decision-makers are altruistic toward the members of generations that follow, then the impact of shocks that affect birth cohorts differentially will be smoothed away. In the extreme case, family dynasties can be treated as

³⁰ Russell (1982).

single individuals solving an infinite horizon optimization problem. This approach to the determination of optimal saving in the face of demographic change is explored by Cutler et al. (1990) and Auerbach et al. (1991). Proponents of intergenerational altruism point to the large size of bequest flows as evidence of the presence of a bequest motive. Section 6.1 of this chapter discusses how demographic change will affect the role of bequests in capital formation.

5. Social security and other government programs

5.1. Dependency ratios for government programs

Table 10 shows relative government social expenditures (including transfers) by age among the G-7 countries. Per capita expenditures on the elderly range between 3.5 and 5.7 times as high as expenditures on working-age adults. The US has the highest relative expenditures on the elderly because, unlike the other members of the group, it publicly funds health care only for the old. Expenditures on children range between

Table 10
The effect of demographic change on social expenditures^a

	Per capita social expenditures in 1980 relative to 15–64 age group		Impact of projected demographic change on			
			Social expenditure (1980 = 100)		Financing burden per head of 15–64 age group (1980 = 100)	
	0–14	65+	2010	2040	2010	2040
Canada	1.4	3.7	141	187	109	145
France	1.9	5.1	116	128	104	132
West Germany	1.7	5.3	104	97	113	154
Italy	0.9	3.5	108	107	106	139
Japan	2.3	5.3	141	140	137	154
United Kingdom	1.9	4.0	101	110	96	111
United States	1.5	5.7	125	165	99	131

^aThe first two columns show 1980 government social expenditures per capita on the 0–14 and 65+ age groups relative to those on the 15–64 age group. Social expenditures are spending on health, education, unemployment compensation, family benefits, and old age, survivor, and disability pensions. The next two columns show the effect of projected demographic change on total social expenditure, holding social expenditure per capita constant within age groups. The final two columns show the effect of projected demographic change on total social expenditure divided by the population aged 15–64.

Source: OECD (1988).

0.9 and 2.3 times as high as expenditures on working-age adults. Comparing these expenditure weights to the overall consumption needs weights presented in Section 2 (0.72 for children and 1.27 for the elderly) it is clear why an increase in old-age dependency that is approximately equal to the decrease in youth dependency seems so much more problematic when one takes the perspective of the government than when one takes the perspective of society as a whole.

The second two columns of Table 10 show the effect of projected demographic change on total social expenditures, holding per capita social expenditures constant at their 1980 levels. The table shows, for example, that holding spending per member of each age group constant, total social expenditures would have to rise by 41% between 1980 and 2010 in rapidly-aging Japan. The final two columns of the table show the change in the financing burden of social expenditures per member of the 15–64 age group – that is, the size of total social expenditures divided by the size of the part of the population that pays for them. The increase in the projected financing burden can be read in either of two ways: if the real level of benefits remains constant, then the table gives the increase in social expenditures that each worker would have to fund. Under this interpretation, the effect of demographic change is not particularly threatening: in Japan, for example, total social expenditures per worker over the period 1980–2010 would only rise by 1.1% per year, well below the expected rate of income growth. An alternative interpretation of the table, however, is more alarming: if the level of social expenditures per capita grows at the same rate as output per working-age adult, then the last two columns of the table show the increase in the fraction of output that will have to be devoted to social expenditures. In Japan, the financing burden rises by 37% between 1980 and 2010. In the US, the financing burden per worker is unchanged between 1980 and 2010, but then rises by 32% between 2010 and 2040, as the Baby Boom generation retires.

5.2. Interaction of age structure, social security, and life-cycle saving

To the extent that individuals anticipate the amount of government transfers that they will receive, government policies can be expected to affect individual saving behavior. This perspective is applicable to any program of spending on the elderly. But because they are so large, and because they transfer resources in the form of cash rather than services, special attention has been focused on public pensions (in the US, Social Security).

The age structure of the population interacts with the Social Security system in several ways. Most importantly, the ratio of elderly to young people in the economy determines the tradeoff between the level of Social Security taxes paid by the young and the size of the benefits received by the old. In addition, the age structure of the population affects the way in which Social Security interacts with the saving rate. Increases in pay-as-you-go Social Security will reduce national saving by reducing the

private saving of the young. The ratio of the elderly to the young determines the nature of this tradeoff.

These two effects are demonstrated in a simple overlapping generations model: Individuals live for two periods, working and paying Social Security taxes in the first period of their lives, receiving Social Security benefits in the second period. The level of pre-tax wages in the first period, W , and the real interest rate, r , are assumed to be constant. Let τ be the fraction of their income that the young pay in Social Security taxes and let the young generation be $(1+n)$ times as large as the old generation. The Social Security replacement rate (the fraction of after-tax income that is returned in the form of benefits) is

$$R = \frac{(1+n)\tau}{1-\tau}. \quad (20)$$

Let utility from consumption be Cobb–Douglas:

$$U = C_y^\pi C_o^{1-\pi}. \quad (21)$$

The lifetime budget constraint is

$$C_y + \frac{C_o}{1+r} = W(1-\tau) + \frac{(1+n)\tau W}{1+r}. \quad (22)$$

Maximizing Eq. (21) subject to Eq. (22) gives optimal consumption in each period. Young people will consume a constant fraction π of their full lifetime income, that is, their after-tax income when young plus the discounted value of their future Social Security benefits:

$$C_y = \pi W \left(1 + \frac{n-r}{1+r} \tau \right). \quad (23)$$

Assuming that $r > n$ (see Abel et al., 1989), an increase in τ will lower first-period consumption and lifetime utility. The reason is that the rate of return that a person receives on money “invested” in the Social Security system, n , is less than the rate received if the person invested the money elsewhere.

The fraction of the (pre-tax) wages of the young that is saved is

$$s_y = (1-\tau) - \pi \left(1 + \frac{n-r}{1+r} \tau \right). \quad (24)$$

Fig. 7 graphs both the saving rate of the young generation and the Social Security replacement rate as functions of the Social Security tax rate (τ) and the population

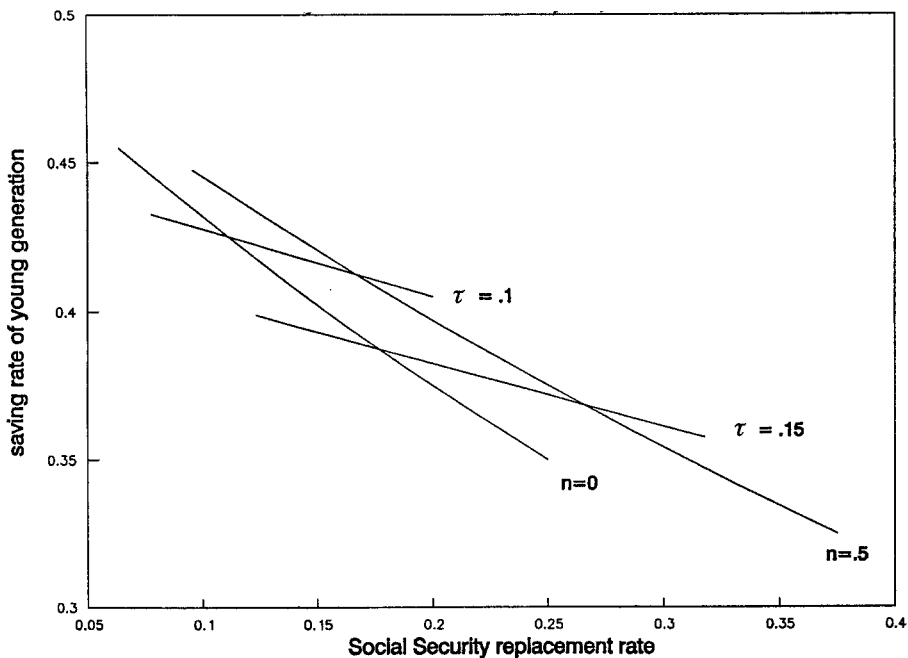


Fig. 7. Effects of tax and population growth rates on saving and Social Security replacement rates.

growth rate (n).³¹ Holding the tax rate constant, a decrease in the population growth rate (which is consistent with population aging) reduces the replacement rate but raises the saving rate. The reason for this effect is that when population growth falls, the rate of return to Social Security contributions must also fall. Since this does not affect the rate of return on marginal saving, there is a pure income effect, which lowers the consumption of the young. More generally, reducing n worsens the tradeoff between the saving rate of the young and the replacement rate: either the replacement rate or the saving rate (or both) must fall. The choice of the Social Security tax rate, τ , determines which of these will occur.

5.3. The response of social security to demographic change

In the face of population aging due to a fertility reduction, the response of the Social Security system can have large effects on shifting welfare between different birth co-

³¹ The values of the other parameters used in creating the figure are $\pi = 0.5$ and $r = 1$.

horts.³² Among the options facing Social Security planners are keeping the level of benefits to retirees constant (and allowing the tax rate on workers to adjust), keeping the tax rate on workers constant (and allowing the benefit levels to adjust), and building up a trust fund in order to smooth the paths of both benefits and taxes.³³

Policy with regard to fertility transitions (as well as to the more complicated actual pattern of declining fertility interrupted by a Baby Boom) has implications for both the level of saving in the economy and for the differential impact on different birth cohorts. Current policy in the US calls for the accumulation of a trust fund which will peak at 30% of GNP in 2030 (Hambor, 1987). Such a policy, if carried out (and if not offset by similarly large deficits in the rest of the federal budget) would lead to the Baby Boom cohort funding part of its own Social Security benefits. Compared to the policy of keeping benefits constant and funding the system on a pay-as-you-go basis (with tax rates adjusting in response to changes in the dependency ratio), the trust fund policy raises the burden on the Baby Boom generation and lowers the burden on its children.

Boskin and Puffert (1988) look at the rate of return of the "investment" that workers make in Social Security, and how this return varies across birth cohorts in response to different Social Security financing policies. The analysis is partial equilibrium, holding constant the real interest rate, the path of real wages, and the labor force participation rate.³⁴ The first column of Table 11 shows the projected average real rates of return to members of different birth cohorts who survive to retirement age under the post-1983 Social Security rules. Early birth cohorts received extremely high rates of return, due mostly to the massive expansion of the Social Security system in the post-war period (and only slightly to demographic factors). Cohorts born after World War II will get a much lower return.³⁵

The large trust fund that the Social Security system is projected to build up is widely viewed as a dangerously tempting target for politicians. The rest of Table 11 considers two scenarios in which the trust fund projected to be accumulated under the current law does not materialize. The second column, labelled "PAYG tax rates", con-

³² For theoretical discussions of the welfare effects of Social Security in the face of shifting demographics and of optimal policy responses, see Blanchet and Kessler (1991), Boadway et al. (1991), and Peters (1991).

³³ Aaron et al. (1989).

³⁴ Since fluctuations in Social Security taxes and benefits produced by demographic changes will have large effects on saving rates and labor force participation, and these will in turn affect interest rates and wages, partial equilibrium analysis may be inappropriate. Auerbach and Kotlikoff (1987) use their general equilibrium model to simulate the welfare effects of different Social Security funding policies in the face of a demographic transition. Their results turn out to be qualitatively similar to those of Boskin and Puffert. See also Auerbach et al. (1989) and Jensen and Nielsen (1992).

³⁵ The rate of return to Social Security contributions is not, of course, a full measure of the financial effect of the program, since the size of contributions changes over time. Later cohorts, which earn low rates of return on their contributions, also make larger contributions as a fraction of wages.

Table 11
Rates of return to Social Security under alternative scenarios

Birth cohort	Base case	PAYG tax rates	PAYG benefits
Before 1912	11.61	11.61	11.62
1913–1922	5.74	5.74	5.94
1923–1932	3.72	3.73	4.16
1933–1942	2.75	2.84	3.18
1943–1952	1.96	2.17	1.96
1953–1962	2.31	2.56	1.89
1963–1972	2.18	2.37	1.56
1973–1982	2.22	2.26	1.54
1983–1992	2.28	2.09	1.54

Source: Boskin and Puffert (1988).

siders a scenario in which for each year after 1990, tax rates are set at exactly the level which covers that year's benefits. In this scenario, the tax rate falls below its currently legislated level until 2025 (it reaches its minimum rate in 2008). The third column, labelled "PAYG benefits", considers the scenario of holding Social Security *taxes* constant at their 1990 rates, and allowing benefits to adjust on a PAYG basis. In comparison to the base case, both of these scenarios favor the Baby Boom cohorts at the expense of those that follow them. Under PAYG benefits, the winners are those cohorts that have finished receiving their benefits by 2025 (that is, cohorts born 1923–1942). Under PAYG taxes, the winners are a younger group: those who retire before 2025. In this case the losers are those not shown in the table: the small cohorts born after 1992 who will have to bear higher tax rates. Hagemann and Nicoletti (1989) offer a similar analysis of the options for financing public pensions in the face of demographic transition for four OECD countries. Keyfitz (1988) also performs similar calculations, and explores the effects of deviations of fertility from its currently-projected path.

5.4. Political economy of social security benefits and of increased aged population

In a simple forward-looking model, as long as the interest rate is greater than the growth rate of output, Social Security reduces lifetime consumption. This can be seen in the model of Section 5.2, and in particular the lifetime budget constraint, Eq. (22). Why, then, do such programs exist? One explanation is that individuals are not sufficiently forward-looking to save for their own retirement, and so the government has to do it for them. But whatever the initial impetus for the creation of public pension sys-

tems, their structure and size is determined in a democratic system in which both contributors and beneficiaries have a voice.

Preston (1984) points out that there are three constituencies in favor of government aid to the elderly: the elderly themselves; working-age adults with elderly relatives, whose burden of family support would be lessened by government transfers to the elderly; and working-age adults who anticipate becoming elderly, and thus stand to benefit from government largesse to the elderly. In the case of support for the other demographic group to receive government support – children – there is only one constituency: working-age adults with children. The effect of population aging due to a reduction in fertility is to expand the first two constituencies supporting transfers to the elderly, while reductions in mortality expand the size of all three constituencies.

Auerbach and Kotlikoff (1992) argue that the political effects of a larger elderly population have already been seen: they attribute the increases in the size of Social Security benefits over the course of the 1970s to the increased share of the elderly in the population. They point out that the fraction of the voting-age population that is over 55 will rise from 28% in 1991 to 36% in 2010 and 42% in 2040. Thus, even as the burden of transfers to the elderly borne by the working-age population becomes more onerous, the likelihood that a majority of the electorate would favor reducing Social Security benefits will fall.

6. Within-family intergenerational relations and aging

Chapters 4 and 5 of this *Handbook* lay out the flows of resources between members of families in different generations, both within and between households.³⁶ The family is one of the two major institutions (the other being the government) that transfers resources to dependent members of society. Since population aging will affect the relative numbers of people on the different sides of these flows – the average number of children per parent, the average number of siblings per adult, the average number of living parents per adult – it should be expected to change the size of the flows. In the face of population aging generated by reduced fertility, for example, it is possible for the average size of intergenerational transfers given by parents to all of their children to be constant, or for the average size of intergenerational transfers received by each child to remain constant. But it is not possible for both these magnitudes to be constant. Where the change will come, in turn, depends on the model underlying the transfers. And changes in the size of transfers will in turn affect both the need for government intervention and the saving of individuals.

Intergenerational resource flows can take the form of direct transfers of money, the provisions of services, and shared living arrangements. Often, it may be hard to isolate a single direction of resource flow: Crimmins and Ingegneri (1990) find that in the

³⁶ See also Lee and Lapkoff (1988).

case of an elderly person co-residing with one of his or her children (the likelihood of which is a positive function of the number of children that the elderly person has), there are benefits which flow in both directions.

Intra-family transfers need not be altruistically motivated. Kotlikoff and Spivak (1981) model such relationships as annuity contracts undertaken by non-altruistic life-cycle agents. Resource flows between parents and children may be payments for services little different than what is observed in markets (Bernheim et al., 1985). Finally, flows such as bequests may be accidental.

6.1. Parent to child transfers

As discussed in Section 4.4, intergenerational transfers from parents to children – and in particular bequests – have played a central role in attempts to understand saving and capital accumulation. Whether or not bequests represent transfers by altruistic parents who get utility from their children's consumption is a central question in evaluating the Ricardian equivalence proposition of Barro (1974). The problems of the life-cycle model in explaining the size of the capital–output ratio have directed further attention to bequests. Kotlikoff and Summers (1981) find that only a small fraction of existing wealth can be attributed to the accumulated difference between the income and consumption of people currently alive – most of the capital stock is not life-cycle wealth, but accumulated bequest wealth.³⁷

The effect of changes in the ratio of children to parents on the size of intergenerational transfers, and in particular on bequests, depends on the motivation which generates these bequests. This motivation has, in turn, been widely debated among macroeconomists. In the extreme case where bequests are completely accidental, reductions in fertility will dramatically raise the size of bequests per child by reducing the number of siblings among whom they are shared.³⁸ In many models of bequests, the increase in the total parental resources available per child will be divided up between larger bequests per child and larger non-bequest consumption by parents. This will be the case, for example, if parents get marginal utility from giving bequests that decreases in the size of bequests per child (Blinder, 1974).

Increases in the size of bequests received by children will in turn affect their saving and the economy's level of capital. The anticipation of future bequests may lower the saving of the young (Weil, 1994). Blinder suggests that bequests have a negative effect on the labor supply of the young.

In addition to potentially changing the size of bequests, population aging will change their timing. Since changes in mortality have not been accompanied by a delay

³⁷ See also Modigliani (1988), Kotlikoff (1988b), and Gale and Scholz (1994).

³⁸ Smith and Orcutt (1980).

in the average age at which children are born,³⁹ children will be receiving bequests ever later in life. Wolf (1988) in a simulation discussed further below, finds that a reduction in mortality leading to a 5% increase in life expectancy is accompanied by an increase from 32% to 44% in the fraction of the population aged 55–59 that has a living mother. Galor and Stark (1993) suggest that delaying the point in life at which a bequest is received will increase the propensity of children to invest in human capital.

6.2. *Child to parent transfers*

The effect of changes in the age structure of the population on child-to-parent transfers has generally been analyzed in terms of the prospective burden of government support for the elderly. Particularly in the case of support for the elderly, government transfers and private transfers may be substitutes. Although the role of family in providing support (and in particular income) for the elderly has greatly diminished, children still play a large role in support. Disabled elderly women aged 75–84, for example, receive 38% of their days of care from children, and only 15% from formal caregivers. (US Senate, 1991). In countries without well-developed social security systems, private transfers between households bulk much larger than in the US (Cox and Jimenez, 1990).

Cutler and Sheiner (1994) find that the number of children has a significant negative effect on the probability of being in a nursing home, controlling for health, age, marital status, and economic status. They find that having one fewer child raises the probability of being in a nursing home by more than having one additional limitation in an Activity of Daily Living.⁴⁰

Wolf (1988) uses a micro-analytic simulation to explore the effects of population aging on individual family structures. He simulates family trees, which can then be sampled to show changes in the cross-sectional pattern of kinship. Wolf uses his simulation to examine stable populations. The base population is that of the Netherlands in 1970. He then simulates two variants: one with the total fertility rate reduced from 2.65 to 1.6 (the actual drop in fertility in the Netherlands between 1970 and 1980), and one with age-specific mortality rates reduced by 25% (in turn increasing life expectancy at birth by 5%).

Wolf shows that reducing either mortality or fertility raises the fraction of the elderly who do not have living children, although the fertility change has a much larger effect. Reduced mortality raises the fraction of the aged without working-age offspring from 4% to 5%, while reduced fertility raises the fraction to 17%. The fraction

³⁹ Glick (1977) reports that comparing 1905 to 1975, married women's median age at the birth of first children fell by 0.3 years, and the median age at the birth of last children fell by 3.3 years.

⁴⁰ These are indicators of the ability to undertake commonly-impaired functions, such as dressing, bathing, or eating.

of 75–79 year olds without living daughters rises from 27% to 42% when fertility is reduced.

At the same time that the availability of family members to supply support falls for the elderly, there will be an increase in the burden of old-age dependency as viewed from the perspective of working age adults. Reduced mortality will raise the fraction of working-age adults with living parents. Reduced fertility will raise the burden of caring for the elderly faced by working age adults by sharply reducing the average number of siblings with whom the burden can be shared. From both the elderly and the working age, then, there will be pressure to increase care for the elderly by the government.

7. Conclusion

One of the salient themes of this chapter is that the “costs” of population aging currently in prospect are to a large extent simply the passing of the transitory benefits of reduced fertility. Resources no longer needed in caring for dependent children and supplying new workers with capital are being transferred toward caring for dependent elderly. The costs of these two dependency burdens are roughly equal. But in the period in which the population age structure changed in response to the fertility decline, there was a window of roughly fifty years in which the overall burden of dependency on society was lower than it had been or would be again. Over the period 2010–2030, during which the negative effect of aging on consumption in the US will be growing most rapidly, the effect of aging will be to reduce needs-adjusted consumption by a total of approximately 10.5%, or 0.5% per year (see Table 7). Similarly, over the period 1970–1990, when the burden of caring for the young and supplying capital to new workers was falling, the effect of aging was to raise needs-adjusted consumption by 0.45% per year. It is precisely the fact that this window will be closing, and that the burden of caring for dependents will be rising in the near future, that has led to population aging being viewed as such a costly phenomenon. If one takes a longer view, and acknowledges the benefits that have been reaped from aging, the situation looks less alarming, or at least less unjust.

A natural yardstick against which to assess the effects of population aging on the standard of living is the process of long-term economic growth. Output per capita in the US grew at an average rate of 2.0% per year over the period 1948–1991. By this standard, the effects of aging on aggregate consumption – half a percent per year over the worst two decades – will be large, but not overwhelming. A second comparison is to the post-1973 productivity slowdown. The growth rate of output per capita in the US fell from 2.2% per year over the period 1948–1972 to 1.7% per year over the period 1973–1991. This is roughly the same magnitude as the projected effect of aging on consumption in the 2010–2030 period. But while the duration of aging’s effects are limited, the duration of the productivity slowdown is unknown.

A second theme of this chapter is that although aging will not appreciably change the overall burden of transfers that society makes to dependents, it will greatly change the channels through which these transfers flow. Families, which make the largest fraction of transfers to children, will see the direct burden of such transfers eased. A larger fraction of transfers to dependents will end up flowing through the government – although, of course, the source of these transfers is still originally incomes of families.

Population aging has a larger effect on individual transfer schemes considered in isolation than on the net flow of transfers taken together. As shown in Section 3.2, the effect of a change in population growth on the quantity of a resource flow depends on the difference between the average age of the flow's recipients and the average age of its providers. In the case of the total resource flow to dependents, the average age at which resources are received and at which they are provided are not very different. This is a consequence of the dependent groups being found on both sides of the age continuum, while the group that provides net transfers is in the middle. But the same analysis can be applied to individual components of the resource flow – that which goes through the government and that which goes through the family. In this case, the average ages at which transfers are provided and received are quite different. In Western, industrialized countries, the burden of caring for children has remained in the family, while the burden of caring for the aged has been substantially shifted to the government. The average age of receiving benefits from one's family is substantially lower than the average age of providing benefits to other family members. Thus reductions in fertility ease the burden of direct transfers on families. In the case of government transfer schemes to dependents, which focus particularly on the elderly, the average age of providing is younger than the average age of receiving – and thus population aging enlarges the burden of such transfer schemes.

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