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# *An Aging Society: Opportunity or Challenge?*

AN AMERICAN woman reaching childbearing age in 1960 would expect 3.6 children; an identical woman in 1990 would expect only 1.9 children. That dramatic demographic change makes it almost inevitable that the American population will age rapidly over the next 50 years. By 2025, the share of the American population that is 65 or older will exceed the share of Florida's population that is of retirement age today. The ratio of retirees to workers will have risen by nearly two-thirds. Even more dramatic demographic changes are occurring abroad. The share of the Japanese population that is 65 or over will rise from 11 percent to 19 percent over the next two decades. If current fertility levels in West Germany are maintained until 2050, the population will not only age but shrink more than one-third.

These demographic changes have aroused considerable anxiety in the United States. Economic concerns have focused on the burden that a

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growing elderly population will place on the economy in general and the federal treasury in particular, as well as on a possible loss of dynamism as population growth slows. Those concerns have led to a potentially radical change in American fiscal policy. To ensure that social security taxes will be sufficient to fund benefits over the next 75 years, and to help the nation save in anticipation of increased demographic burdens, the social security legislation enacted in 1983 calls for social security taxes to exceed benefits over the next 30 years. This surplus will be accumulated in a trust fund, which will peak at 29 percent of GNP in 2020 and then be drawn down as the population ages.

This paper steps back from the current political debate over the social security trust fund and examines the more general question of how serious a macroeconomic problem aging is and how policy should respond to it. We focus primarily on issues relating to saving and capital accumulation. We do not consider the broader question of whether the current U.S. national saving rate is too high or too low, but focus on the effect of demographic changes on the optimal level of national saving. In addition, we consider the effects of demographic change on productivity growth and the optimal timing of tax collections.

Our general conclusion is that demographic changes will improve American standards of living in the near future, but lower them slightly over the very long term. Other things being equal, the optimal policy response to recent and anticipated demographic changes is almost certainly a reduction rather than an increase in the national saving rate. Slowing population growth will reduce the investment that must be devoted to equipping new workers and housing new families, while making it easier for the United States to attract foreign capital. Although there are many reasons for arguing that the United States currently saves too little, anticipated demographic change is not one of them.

Our analysis proceeds in five steps. First, we assess the coming dependency burden. While it is true that the share of the population aged 65 or over will increase sharply, it is also true that the share of children in the population will gradually decline, and that the fraction of the labor force that is near peak productivity will increase. Using information on projected fertility, mortality, and labor force participation rates as well as data on health care costs and the spending of different age groups, we assess past and future dependency trends. We find that demographic changes unaccompanied by changes in capital intensity would reduce

per capita incomes by between 7 percent and 12 percent over the next 60 years, but would actually increase incomes over the next 20 years. In only one of the next six decades will demographic changes affect living standards as much as the "peace dividend" is likely to affect them in this decade. The decline in living standards caused by the increased dependence would be fully reversed by a 0.15 percent a year increase in productivity growth.

Second, we consider the consequences of the slower labor force growth that presages the increase in the retired share of the population. Between 2010 and 2060, the labor force is expected to decline slightly, compared with an average increase of 1.5 percent annually between 1950 and 1990. The projected decline in the labor force growth rate will permit a 3–4 percent reduction in the share of net investment in total income without reducing capital intensity. Since reduced labor force growth will occur *before* dependency burdens increase, projected demographic changes raise the short-term consumption path even if the steady-state consumption level declines. We show that in a standard growth model with plausible parameter values, optimal consumption typically rises in response to a demographic shock like that experienced in the United States over the past three decades.

Third, we consider the implications of integrated world capital markets for our analysis. The degree and speed of population aging in other major industrialized countries, particularly West Germany and Japan, is more dramatic than that in the United States. The increase in dependency abroad will coincide with a deceleration in labor force growth rates. Along an optimal path, therefore, the rest of the world will export capital to the United States—thus increasing U.S. consumption and reducing saving in the short run.

Fourth, we go beyond the standard growth theoretic approach and ask whether the coming demographic changes are likely to affect the rate of technical change. With slow labor force growth, labor is scarce; this scarcity may induce more rapid technical change. Such a development would sharpen our conclusion that diminished fertility represents an opportunity rather than a problem. Using international cross-section time series data for 1960–85, we find some evidence that nations with slower labor force growth do experience more rapid productivity growth. The estimates suggest that the reduction in labor force growth projected for the next 40 years may raise productivity growth enough to offset

fully the consequences of increased dependence. This finding, however, is uncertain. A more definitive finding is the absence of any empirical support for the pessimistic view that aging societies suffer reduced productivity growth.

Fifth, we consider the implications of our findings for fiscal policy. Because demographic changes over the next decades are not likely to be associated with reduced private saving, they constitute no argument for reducing the budget deficit. There remains the question of efficiency in tax collection. Maintaining current service levels for the elderly will require an increase in government spending from about 32 percent to 37 percent of GNP. Since the deadweight loss from taxation rises with the square of the tax rate, financing these expenditures on a pay-as-you-go basis will involve higher deadweight losses than maintaining a constant tax rate. We find, however, that these effects are likely to be small, amounting to at most several tenths of a percent of annual GNP.

We conclude by discussing the implications of our results for social security, for intergenerational redistribution more generally, and for population and immigration policy. Our findings suggest that population aging does not constitute a strong argument for accumulating a large social security trust fund, although if national saving is deemed to be inadequate for other reasons, the trust fund may be a convenient way to increase it.

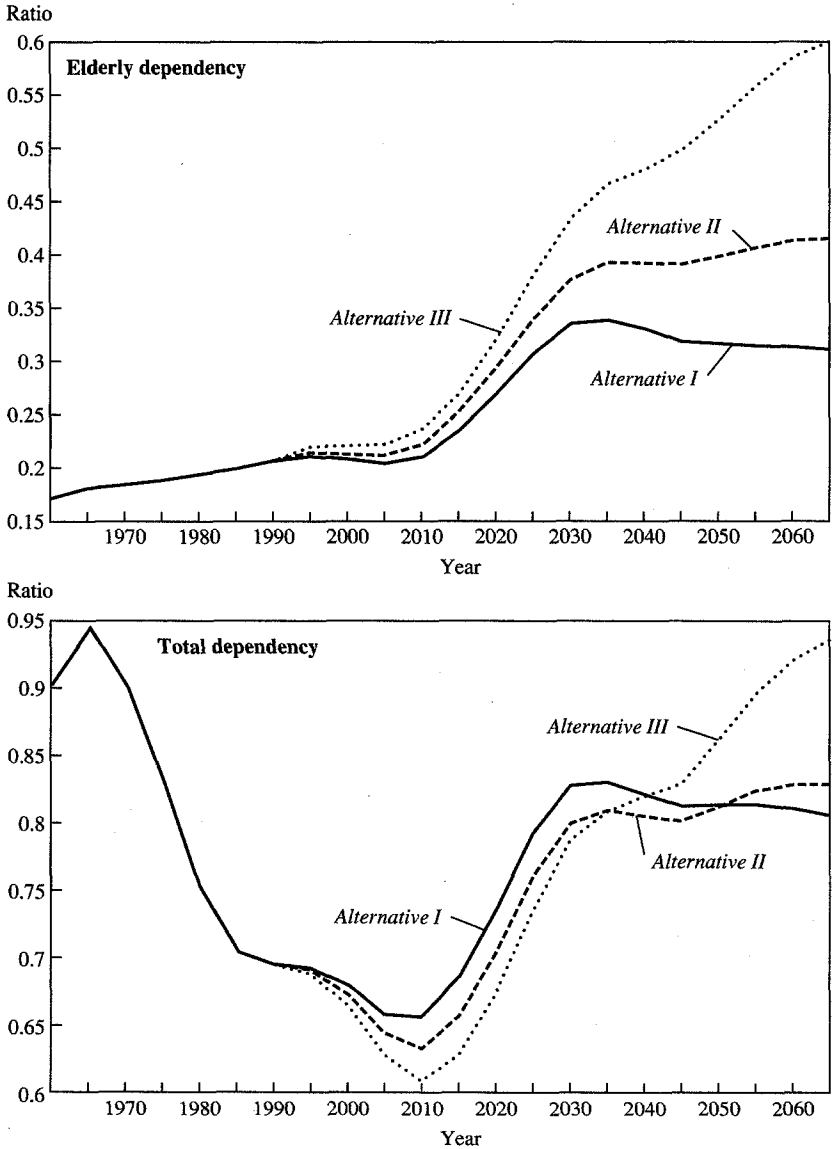
## The Burden of Increased Dependency

The economic consequences of population aging depend on the nature of the underlying demographic change as well as the relationship between the resource needs of individuals at different ages and their capacity for self-support. This section presents our estimates of the economic burden of increased dependency, noting the uncertainties associated with each step in the calculation.

### *Changing Demographic Structure*

Figure 1 plots the Social Security Administration's projections of the elderly dependency ratio, the number of people aged 65 and over as a fraction of the population aged 20–64, and the total dependency ratio,

**Figure 1. Actual and Projected Dependency Ratios, United States, 1960–2065[a]**




Sources: Board of Trustees of the Federal Old-Age and Survivors Insurance and the Disability Insurance Trust Funds (1988, table A1, p. 93) and unpublished data from the Social Security Administration underlying the published projections.

a. Elderly dependency ratio is the population aged 65 and over divided by the population aged 20–64. Total dependency ratio is population aged 65 and over plus the population under 20 divided by the population aged 20–64.

the number of children plus elderly as a fraction of the working-age population, between 1960 and 2065. The figure shows the Social Security Administration's intermediate projections (alternative II) as well as outlying projections making more extreme assumptions about fertility and mortality changes. The projections agree in suggesting that the fraction of the population 65 and over will increase, and the fraction of the population under 20 will decrease, over the next 50 years. There is very little change, however, over the next decade.

Declining fertility is the principal source of the changing demographic patterns.[1] In stable or declining populations, young cohorts account for a smaller share of the total population than they do in rapidly growing populations. In the years following World War II, the total fertility rate in the United States rose from 2.4 in 1945 to a peak of 3.7 in 1957. Fertility declined sharply during the late 1960s and early 1970s, falling to 1.7—well below replacement levels—by 1976. Since then, fertility has increased slightly, averaging 1.8 in the mid-1980s. Preliminary data for 1989 suggest continued increase, to 2.0. These changes have important implications for the demographic structure of the population over the next half-century.

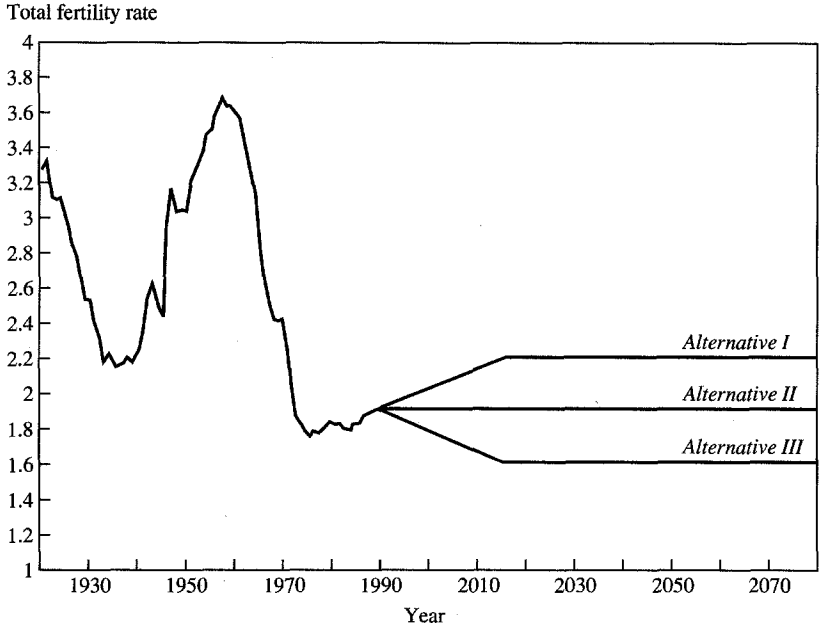
The demographic effects of falling fertility have been reinforced by improvements in old-age mortality. In 1960, life expectancy for a 65-year-old man was 12.9 years, compared with 15.0 years in 1990. The mortality improvement for women has been even more pronounced, with life expectancy at age 65 increasing from 15.9 to 18.9 years during the past three decades. Current projections call for further improvements in life expectancies at age 65, to 18.0 years for men, and 22.1 years for women, in 2060.[2]

Long-term demographic projections like those in figure 1 are uncertain for several reasons. First, fertility forecasts are subject to large standard errors and are notoriously inaccurate, as is illustrated by figure 2, which displays historical total fertility rates and the various Social Security Administration projections for the next half-century. The range of historical experience dwarfs the range between the Social Security

1. The relative importance of fertility declines, mortality improvement, and international migration is discussed in OECD (1988).

2. These data are drawn from Board of Trustees of the Federal Old-Age and Survivors Insurance and the Federal Disability Insurance Trust Funds (1990, table 11). More detailed information on mortality improvements can be found in Poterba and Summers (1987).

**Figure 2. Actual and Alternative Projected Total Fertility Rates, 1920–2080**




Source: Projected data are from Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds (1988, table 11, p. 37). Historical data are from *Social Security Area Population Projections: 1989* (1989, pp. 3–4).

Administration's optimistic and pessimistic projections. Even the factor of two difference between the predicted share of the population 65 or over in 2050 in the optimistic and pessimistic projections shown in figure 1 probably understates the true degree of demographic uncertainty.[3] Postwar fertility projections in the United States anticipated neither the beginning, nor the end, of the baby boom.

A second important source of demographic uncertainty is the future course of immigration. The Social Security Administration's intermediate forecasts assume net immigration of 600,000 people a year until 2065—roughly the annual level of net legal and illegal immigration in the late 1980s. Assuming a constant immigrant flow for the next 75 years ignores potential changes in either immigration policy or the level of

3. The pessimistic case assumes an ultimate fertility rate of 1.6, high for example in contrast to West Germany's current rate of 1.3. On the other hand, figure 2 may be deceptive, in that uncertainty regarding the average fertility rate over a 75-year period may be much less than the uncertainty regarding fertility rates at any point in time.

illegal migration. The age structure of the population is sensitive to the level of immigration because immigrants on average are younger than nonimmigrants. George Borjas reports that only 3.1 percent of those who immigrated to the United States between 1975 and 1979 were 65 or over in 1980, compared with 10.6 percent of the nonimmigrant population.[4] Higher immigration during the next half-century would reduce dependency burdens.

Uncertainty about future mortality gains is a third, but less important, source of randomness in demographic projections. Most of the forecast rise in the number of Americans aged 65 or over is the result of large birth cohorts in the 1950s and 1960s. Even doubling the projected gains in life expectancy at age 65 between 1990 and 2060 would increase the number of elderly in 2060 by less than 20 percent, and change the ratio of the elderly to the working-age population by less than 8 percentage points.

Although there is much uncertainty regarding the future age composition of the U.S. population, the broad trend toward a rising average age, a greater number of dependent elderly, and fewer dependent children is indisputable. Moreover, uncertainty about long-term demographic change should not cloud the relatively certain *short-term* demographic outlook. Labor force growth in the next two decades, for example, is largely forecastable given the fertility experience of the past two decades. Along many dimensions, the near-term effects of demographic change operate in different directions from the long-term changes. To illustrate this we now explore alternative ways to calibrate the shifting burden of demographic change.

### *The Support Ratio*

Demographic shifts affect the economy's consumption opportunities because they change the relative sizes of the self-supporting and dependent populations. We summarize these changes in the *support ratio,* denoted $\alpha$, which we define as the effective labor force, *LF,* divided by the effective number of consumers, *CON*:

$$\alpha = LF/CON. \tag{1}$$

The share of the population aged 65 and over is one, but not the only, determinant of this ratio. The support ratio is also influenced by the

4. Borjas (1990, pp. 41, 46).

relative consumption needs of people of different ages, as well as by changes in the retirement age, labor force participation rates, and the earning power of those who are working. Because there are several approaches to measuring and projecting each of these factors, we present several different measures of the support ratio.

The first issue in measuring the support ratio concerns the relative consumption needs of people at different ages. One assumption, which we label *CON*1, defines effective consumption as if all people have identical resource needs:

$$CON1 = \sum_{i=1}^{99} N_i, \tag{2}$$

where $N_i$ is the number of people of age $i$. This measure of needs is implicit in the commonly cited total dependency ratio shown in figure 1.

An alternative approach involves differentiating the resource needs of people at different ages. We develop this approach in a second measure of effective consumption needs, *CON*2, which has three parts: private nonmedical expenses, public education expenses, and medical care. For private nonmedical outlays, we follow Edward Lazear and Robert Michael in assuming that all people 20 and older have identical needs, while those under 20 (18 in their work) have needs equal to one-half those of adults.[5] For public education expenses, we assume per capita outlays of $2,553 (1989 dollars) per person under 20, $309 per person aged 20–64, and $84 per person aged 65 and over. These estimates are explained in more detail below. For medical care, we assume that needs are proportional to total spending by age: $1,262 per person per year for those under 64 and $5,360 for those 65 and over.[6] Adding together

5. Lazear and Michael (1980, p. 102) estimate that a child raises equivalent scale consumption for a husband-wife family by 22.2 percent, or by 44.4 percent as much as the average consumption of either parent. There is some evidence that nonmedical consumption needs of the elderly may be lower than those for younger people. For example, the U.S. Department of Agriculture poverty line assumes that food expenditures by the elderly are 90 percent of those for prime-aged individuals. The ongoing trend toward more elderly living in single households, however, suggests that the relative expenditure needs of the elderly may rise in the future.

6. These relative medical costs are based on the current age structure of the elderly population. As the average age of those 65 or over rises, the relative cost of medical care for the elderly will increase. In 1987 total annual per capita health expenditures for people aged 65–69 were $3,728, compared with $9,178 for those aged 85 and over. Holding age-specific expenditure patterns constant at their 1987 level, average spending per person aged 65 and over would be approximately 10 percent higher with the age composition expected in 2060 rather than that in 1990. See Waldo and others (1989).

these three components, we construct a needs-weighted consumption measure, *CON*2, as 0.72 times the number of people under 20, plus the number aged 20–64, plus 1.27 times the number 65 and over.[7]

The relative needs of elderly and nonelderly consumers can be affected by demographic factors such as mortality improvements. Edward Schneider and Jack Guralnik observe that only 3 percent of men and 6 percent of women 65 and over reside in nursing homes, while 15 percent of men and 25 percent of women 85 and over are in such homes. The high cost of nursing home care ($23,600 per resident per year in 1985) makes it an important contributor to the total cost of caring for the aged population.[8]

The appropriate weighting of young and old dependents may depend on more than their consumption demands. Many of the transfers to children take place within the family, while those to elderly dependents are largely mediated by the government. A Scandinavian proverb, brought to our attention by George Akerlof, suggests that "one mother can care for ten children, but ten children cannot care for one mother." Individuals may derive more pleasure from caring for children than from caring for elderly dependents, making the burdens of an increasingly elderly population more onerous than the burdens of caring for a young population.[9]

We also consider two different measures of the effective labor force. The first, *LF*1, assumes that all people aged 20–64 are in the labor force, while individuals 19 and under or 65 and over are not:

$$LF1 = \sum_{i=20}^{64} N_i. \tag{3}$$

Our second measure, *LF*2, recognizes that both human capital and labor force participation rates vary by age. We use data on the average 1989 earnings ($w$) of people of each age (measured in five-year intervals),

7. The needs-weighted consumption measure, *CON*2, is defined as

$$CON2 = \sum_{i=1}^{99} S_i N_i,$$

where $S_i$ is the respective weight for an individual at age $i$.

8. Schneider and Guralnik (1990).

9. Provided the "warm glow" of caregiving does not affect the marginal utility of consuming goods, it should not affect our needs weighting of different-aged households. It will affect the total utility of households.

along with Social Security Administration forecasts of age-specific labor force participation rates, *PR*, to estimate *LF*2:[10]

$$LF2 = \sum_{i=15}^{80} w_i PR_i N_i. \tag{4}$$

This recognizes that the earning capacity of a society with a high fraction of people in middle age is higher than that of a society with many new entrants to the labor force.[11]

### *Support Ratio Projections, 1990–2060*

Because the level of the support ratio is less informative than its changes from year to year, we focus on $\hat{\alpha}_t$, the percentage change in the support ratio between 1990 and year $t$:

$$\hat{\alpha}_t = (LF_t/CON_t)/(LF_{1990}/CON_{1990}) - 1. \tag{5}$$

We report support ratios corresponding to each combination of effective labor force and effective consumption measures.

Table 1 shows the historical and projected changes in *LF* and *CON* and demonstrates that regardless of measurement method, growth in both the labor force and consumption requirements declines during the next half-century. For example, the earnings-weighted labor force grew at a 1.7 percent annual rate during the 1980s, but will *shrink* in four of the five decades between 2010 and 2060. In the nearer term, labor force growth also slows. By the first decade of the next century, labor force growth is only one-fourth its rate during the 1970s. Total needs-weighted consumption, which grew at a 1.1 percent annual rate during the 1980s, rises by less than one tenth of 1 percent a year between 2040 and 2060.

Table 2 and figure 3 show the percentage change in the four alternative measures of the support ratio. Four conclusions stand out. First, because both our measures of the labor force grow more slowly than population

10. These data are from the Bureau of Labor Statistics, *Usual Weekly Earnings of Full-Time Wage and Salary Workers* and *Usual Weekly Earnings of Employed & Part-Time Wage and Salary Workers*. We adjust part-time workers to full-time equivalent employees.

11. This labor force concept includes only market activity, neglecting the value of labor devoted to household production. It may therefore overstate the historical changes in the effective labor force that were partly due to rising *market* labor force participation by women.

**Table 1. Actual and Projected Average Annual Growth in Labor Force and Consumption, United States, 1950–2060**

Percent

| | *Labor force* | | *Consumption* | |
|---|---|---|---|---|
| *Period* | *Population 20–64 (LF1)* | *Earnings-weighted population (LF2)* | *Unweighted (CON1)* | *Needs-weighted (CON2)* |
| 1950–1960 | 0.74 | 1.18 | 1.77 | 1.66 |
| 1960–1970 | 1.25 | 1.19 | 1.23 | 1.28 |
| 1970–1980 | 1.73 | 2.05 | 0.91 | 1.13 |
| 1980–1990 | 1.29 | 1.69 | 0.95 | 1.08 |
| 1990–2000 | 0.83 | 1.07 | 0.70 | 0.75 |
| 2000–2010 | 0.80 | 0.48 | 0.57 | 0.65 |
| 2010–2020 | 0.06 | −0.03 | 0.48 | 0.60 |
| 2020–2030 | −0.26 | −0.10 | 0.29 | 0.42 |
| 2030–2040 | 0.11 | 0.07 | 0.14 | 0.17 |
| 2040–2050 | 0.00 | −0.03 | 0.04 | 0.05 |
| 2050–2060 | −0.06 | −0.02 | 0.03 | 0.05 |

Source: Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds (1988). Projected data for 1990–2060 use alternative IIb. Data show geometric average annual changes in labor force and consumption needs under IIb.

during the next 70 years, there is a long-run decline in the support ratio. The size of the decline is more sensitive to our assumptions about consumption than to our measure of the effective labor force.[12] When consumption needs are assumed to be equal for people of all ages, the support ratio for *LF*1 (*LF*2) declines by 7.4 percent (7.8 percent) between 1990 and 2060. When we adjust consumption using our needs-weighted measure, the decline in the support ratio is more pronounced: 11.5 percent and 11.8 percent for *LF*1 and *LF*2, respectively.

It is difficult to know whether these estimates represent a large or a small burden spread over 70 years. They correspond to between a 0.10 percent and 0.15 percent reduction in the annual productivity growth rate, which is small relative to the uncertainty in secular productivity growth. They represent three to four times as large a cost as the peace dividend that the United States is likely to enjoy over the next decade.

12. For the period 1950–90, the support ratios *are* sensitive to our choice of labor force concept, primarily because of significant changes in labor force participation rates, most notably among women.

**Table 2. Changes in Support Ratio Relative to 1990, United States, 1950–2060**
Percent

| *Year* | *Unweighted population aged 20–64/ unweighted consumption (LF1/CON1)* | *Earnings-weighted population/ unweighted consumption (LF2/CON1)* | *Unweighted population aged 20–64/ needs-weighted consumption (LF1/CON2)* | *Earnings-weighted population/ needs-weighted consumption (LF2/CON2)* |
|---|---|---|---|---|
| 1950 | −1.4 | −11.5 | 1.4 | −9.0 |
| 1960 | −10.9 | −16.5 | −7.4 | −13.2 |
| 1970 | −10.8 | −16.9 | −7.7 | −14.0 |
| 1980 | −3.3 | −7.0 | −2.0 | −5.8 |
| 1990 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2000 | 1.3 | 3.7 | 0.8 | 3.2 |
| 2010 | 3.8 | 2.8 | 2.3 | 1.4 |
| 2020 | −0.5 | −2.3 | −3.1 | −4.8 |
| 2030 | −5.9 | −6.0 | −9.5 | −9.6 |
| 2040 | −6.2 | −6.6 | −10.0 | −10.5 |
| 2050 | −6.5 | −7.3 | −10.4 | −11.2 |
| 2060 | −7.4 | −7.8 | −11.5 | −11.8 |

Source: Same as table 1. The earnings-weighted labor force measure uses contemporaneous and projected labor force participation rates and the 1987 age-earnings profiles for men and women to form effective labor forces.

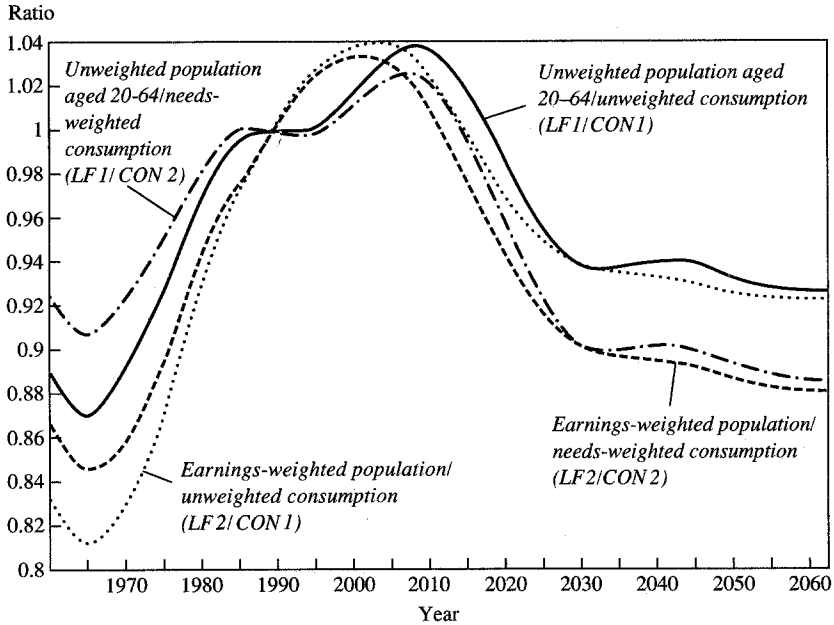
In yet another metric, a three- to four-year increase in the average age at retirement, or a 19 percentage point increase in female labor force participation, would be needed to offset the increase in dependency.

Second, in the next two decades there is a *decline* in economic dependency (a rise in the support ratio) because the declining number of dependent children more than offsets the rising number of dependent elderly. Between 1990 and 2010, when the baby boom generation is part of the labor force and relatively small birth cohorts are retiring, the labor force grows more rapidly than the dependent population. This leads to an improvement in the support ratio by 2010.[13]

Figure 4 provides further detail on the differential burdens of young and aged dependents. It plots the contributions of both children and the elderly to the support ratio defined using *LF*2 and *CON*2. In this case

13. Measures that define effective consumption with less weight on children show smaller gains in the support ratio during the next two decades. If the consumption weight based on needs is set equal to zero for children, the support ratio actually declines by between 1 percent and 2 percent during 1990–2010.

**Figure 3. Actual and Projected Changes in Support Ratio (Relative to 1990), Four Alternative Measures, United States, 1960–2065**




Source: Table 2.

$\alpha = P/(C + P + E)$, where $P$ is the number of prime-aged adults, $C$ the number of effective children, and $E$ the number of effective elderly. Then the percentage change in the support ratio can be written in terms of the percentage change in its components:

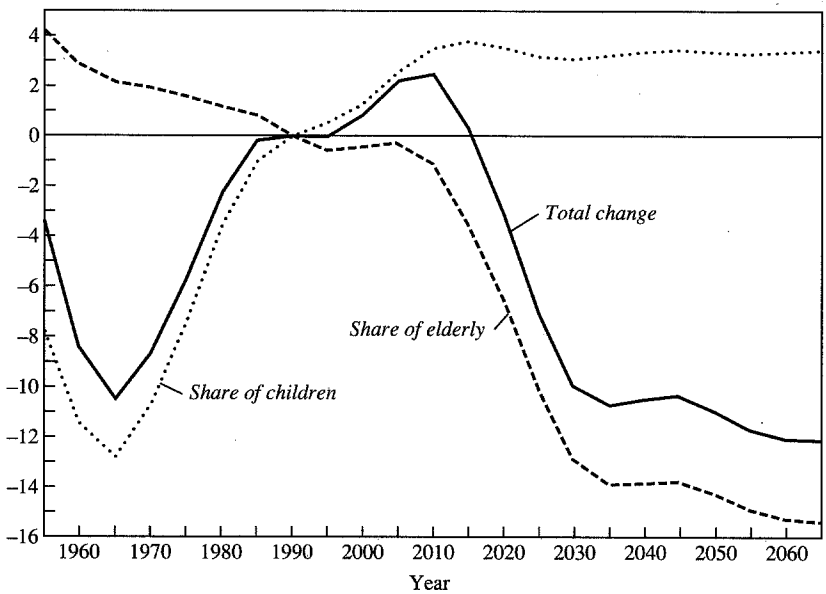
$$(6) \qquad \hat{\alpha} = (\hat{P} - \hat{C})\,[C/(C + P + E)] + (\hat{P} - \hat{E})\,[E/(C + P + E)].$$

The first term is due to differential growth rates of the prime-aged and dependent children populations, the second to the differential growth between the prime-aged and elderly groups. Figure 4 plots these two terms, showing that virtually all the improvement in the support ratio in the near term is from a shrinking share of children in the population. Most of the long-run decline is a result of rising numbers of elderly during 2010–2035.

Third, the changes in the support ratio between 1990 and 2060 are usually no larger than, and in some cases significantly smaller than,

**Figure 4. Contributions of Young and Elderly Dependents to Percentage Changes in the Support Ratio (Relative to 1990), 1955–2065**

Change in consumption relative to 1990 (percent)

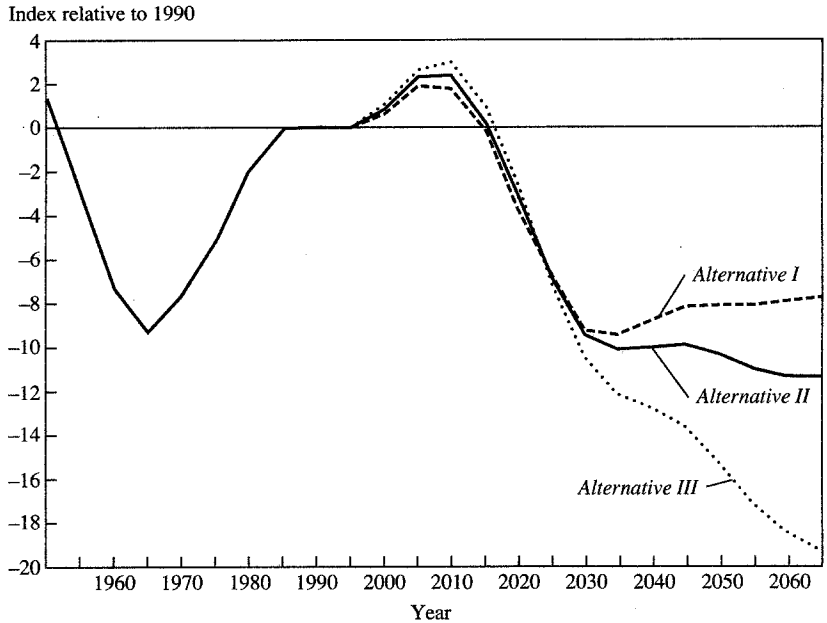



Source: Authors' calculations using equation 6. The earnings-weighted labor force measure (*LF*2) and the needs-weighted consumption measure (*CON*2) are used. See text for details.

those between 1960 and 1990. With our preferred measures, *LF*2 and *CON*2, the support ratio was 14.0 percent lower in 1970 than 1990. By 2060, it is projected once again to be below the 1990 level, this time by 11.8 percent. Our support ratio peaks around 2010. One reason why the slow growth of real wages in the U.S. economy since 1973 has been less burdensome than it might have otherwise been is that the labor force participation rate has risen. The figures show clearly that the gains in sustainable consumption from demographic developments are now nearly exhausted.

Finally, while the decline in the support ratio by the middle of the next century is large, there is still substantial uncertainty about the ultimate burden. Figure 5 presents support ratios using *LF*2 and *CON*2 under the three Social Security Administration demographic forecasts. There are substantial differences in the scenarios, particularly between the more pessimistic alternative III and alternative II, which is our

**Figure 5. Percentage Change in Support Ratio (Relative to 1990), Alternative Demographic Assumptions, 1950–2065**




Source: Authors' calculations using Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds (1988) and the needs-weighted consumption (*CON2*) and earnings-weighted labor force (*LF2*) measures.

standard case. The decline in the support ratio is almost twice as large in the pessimistic scenario as in our benchmark. Even in the optimistic alternative I, the support ratio still declines by almost 8 percent between 1990 and 2060.

## Capital Accumulation and Shifting Dependency Burdens

This section explores how the demographic shifts described above affect the economy's sustainable level of consumption, and how society should plan for these changes. We find that sustainable consumption increases for the next several decades and that an economy with otherwise optimal national saving would reduce its saving in response to the coming demographic changes.

*Steady-State Consumption Opportunities*

Demographic change has two effects on consumption opportunities. First, an increase in dependency lowers output per person, thus reducing consumption per capita. Second, slower labor force growth reduces investment requirements, thus reducing the need for saving and increasing consumption per capita.

To examine the importance of these two changes for consumption opportunities, we assume that output per worker, $f(k)$, where $k$ is the capital-labor ratio, is divided between consumption and investment. Maintaining constant capital intensity requires investment of $nk$, where $n$ is the labor force growth rate.[14] For expositional ease, we have assumed away depreciation and technical change.[15] When the labor force and the population are not the same, consumption per capita is only a fraction of output net of investment per worker. This fraction is the ratio of the number of workers to the size of the population, precisely the support ratio ($\alpha$) defined above. The resulting equation for per capita consumption is:

$$c = \alpha[f(k) - nk]. \tag{7}$$

This expression can be rewritten to find the change in steady-state consumption for changes in $\alpha$ and $n$:

$$\Delta c/c = \Delta\alpha/\alpha - [\alpha(k/c)\,\Delta n + \Delta\alpha\,(k/c)\,\Delta n], \tag{8}$$

with $c$, $k$, and $\alpha$ evaluated at the initial steady state.[16] Equation 8 illustrates the two steady-state effects of demographic change. A decline in the labor force-population ratio ($\alpha$) reduces the level of per capita consumption that is feasible given the economy's capital stock. At the same time, a decline in the growth rate of the labor force ($n$) permits more consumption for a given capital-output ratio. Society receives a "consumption dividend" when it is able to invest less and still maintain

14. A substantial part of the U.S. capital stock is residential capital. The natural steady-state condition for housing requires investment at the rate of population growth, not the rate of labor force growth. In steady state, these two growth rates will coincide.

15. We incorporate both in our numerical simulations below.

16. We have arbitrarily assigned the second-order term to the second effect in our decomposition. We have also assumed that the capital-labor ratio, and thus the capital-consumption ratio, do not change with demographic change. The model we present below justifies this assumption.

**Table 3. Shifting Steady-State Per Capita Consumption from Demographic Shocks, 1960–2065**[a]

Percent

| | *Unweighted consumption (CON1)* | | | *Needs-weighted consumption (CON2)* | | |
|---|---|---|---|---|---|---|
| *Year* | *Effect of dependency* | *Effect of labor force growth* | *Total change in per capita consumption* | *Effect of dependency* | *Effect of labor force growth* | *Total change in per capita consumption* |
| | | | *Population 20–64 as effective labor force (LF1)* | | | |
| 1960 | −10.9 | 0.4 | −10.6 | −7.4 | 0.4 | −7.1 |
| 1970 | −10.8 | −1.8 | −12.6 | −7.7 | −1.8 | −9.5 |
| 1980 | −3.3 | −2.4 | −5.7 | −2.0 | −2.4 | −4.5 |
| 1990 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2000 | 1.3 | 0.0 | 1.3 | 0.8 | 0.0 | 0.8 |
| 2010 | 3.8 | 1.0 | 4.8 | 2.3 | 1.0 | 3.4 |
| 2020 | −0.5 | 3.0 | 2.5 | −3.1 | 2.9 | −0.2 |
| 2030 | −5.9 | 2.5 | −3.4 | −9.5 | 2.4 | −7.1 |
| 2040 | −6.2 | 1.8 | −4.3 | −10.0 | 1.8 | −8.3 |
| 2050 | −6.5 | 2.5 | −4.0 | −10.4 | 2.4 | −8.0 |
| 2060 | −7.4 | 2.1 | − 5.3 | −11.5 | 2.0 | −9.4 |
| 2065 | −7.4 | 2.2 | −5.2 | −11.5 | 2.1 | −9.4 |
| | | | *Earnings-weighted labor force (LF2)* | | | |
| 1960 | −16.5 | 1.1 | −15.4 | −13.2 | 1.2 | −12.1 |
| 1970 | −16.9 | −0.4 | −17.3 | −14.0 | −0.4 | −14.4 |
| 1980 | −7.0 | −1.9 | −9.0 | −5.8 | −2.0 | −7.8 |
| 1990 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2000 | 3.7 | 2.2 | 5.9 | 3.2 | 2.2 | 5.4 |
| 2010 | 2.8 | 3.5 | 6.3 | 1.4 | 3.5 | 4.9 |
| 2020 | −2.3 | 4.4 | 2.1 | −4.8 | 4.2 | −0.6 |
| 2030 | −6.0 | 3.7 | −2.3 | −9.6 | 3.6 | −6.0 |
| 2040 | −6.6 | 3.6 | −3.0 | −10.5 | 3.5 | −7.0 |
| 2050 | −7.3 | 3.9 | −3.5 | −11.2 | 3.7 | −7.5 |
| 2060 | −7.8 | 3.6 | −4.1 | −11.8 | 3.5 | −8.3 |
| 2065 | −7.8 | 3.7 | −4.2 | −12.0 | 3.5 | −8.4 |

Source: Authors' calculations.

a. The table shows the steady-state change in consumption relative to the 1990 base if demographic change were to reach a steady state at the level of the indicated year.

a given level of per capita output. This "Solow effect" offsets the long-run dependency effect on per capita consumption.

Table 3 reports the size of these two effects. For each year, we show the steady-state consumption change associated with changes in $\alpha$ (first column), $n$ (second column), and the combined effect (third column). The consumption changes due to the dependency increase are the same

as the changes in the support ratio shown in table 2; the other columns show the extent to which changing investment needs offset this effect.

Two results emerge from table 3. First, the consumption benefits from reduced investment requirements are substantial. During the next two decades, the benefits of slower labor force growth will be about a 1 percent to 3.5 percent increase in per capita consumption, using the 1990 base. Since the labor force was growing more rapidly in the 1970s and 1980s than in 1990, the effect of reduced investment requirements is even larger relative to earlier years. By the middle of the next century, the benefits of slower labor force growth will be between 2.1 percent and 3.7 percent of per capita consumption. This is between one-quarter and one-half of the adverse dependency effects of the changing population mix.

Second, while the investment effect offsets a substantial part of the long-term dependency increase, it magnifies the short-run effect of rising support ratios. Reduced dependency and slowing labor force growth both increase consumption possibilities so that by 2010, society will be between 3.4 percent and 6.3 percent richer, depending on the combination of labor force and needs measures. Only after 2020 does the increase in dependency outweigh the decline in investment needs and reduce consumption below its 1990 level.

The steady-state consumption decline between 1990 and 2060 is estimated at between 4.2 percent (with effective consumers set equal to total population and the earnings-weighted labor force) and 9.4 percent (with effective consumers computed using our needs-weighted measure and the unweighted labor force). As with the support ratios, this finding is more sensitive to our definition of consumption needs than to our definition of the effective labor force. For almost all cases, however, society is richer in the new steady state than in 1970 or 1980.

### *Demographic Change and Optimal Capital Accumulation*

The results presented so far suggest that in the short run, demographic changes will raise the level of consumption that can be sustained while maintaining the level of capital intensity. In the long run, they will reduce the sustainable level of consumption. The question then becomes how society should adjust its saving policy to these developments. To study this question, we use the standard Ramsey optimal growth model.

We assume that a social planner seeks to maximize

$$V = \int_0^\infty e^{-\rho t} P_t U(c_t)\, dt, \tag{9}$$

where $P_t$ denotes the number of individuals alive in period $t$, $c_t$ is per capita consumption in period $t$, and $\rho$ is the social time preference rate. We denote the current period as time zero. This social welfare function weights the utility, denoted as $U$, of a representative individual in each generation by the generation's size.[17] Using our earlier notation, $P_t = N_t/\alpha_t$, where $N_t$ is the labor force in period $t$ and $\alpha_t$ is the support ratio.

Our analysis abstracts from the overlapping generations structure of the actual population. Calvo and Obstfeld formally justify this procedure by demonstrating that if age-specific transfer programs like social security are available, and if individual utility functions are additively separable, then "the Cass-Koopmans-Ramsey framework can be used to evaluate paths of *aggregate* consumption even in models where different generations co-exist. . . . the planning problem facing the government can be decomposed into two subproblems, a standard problem of optimal aggregate capital accumulation and a problem of distributing consumption optimally on each date among the generations alive then."[18] The social planner maximizes equation 9 subject to a capital accumulation constraint analogous to equation 7:[19]

$$\dot{k}_t = f(k_t) - c_t/\alpha_t - n_t k_t. \tag{10}$$

If $\alpha_t = 1$, equation 10 reduces to the standard resource constraint in neoclassical growth models. The consumption profile that solves this problem satisfies:

$$\dot{c}_t/c_t = \sigma\,[f'(k_t) - \rho], \tag{11}$$

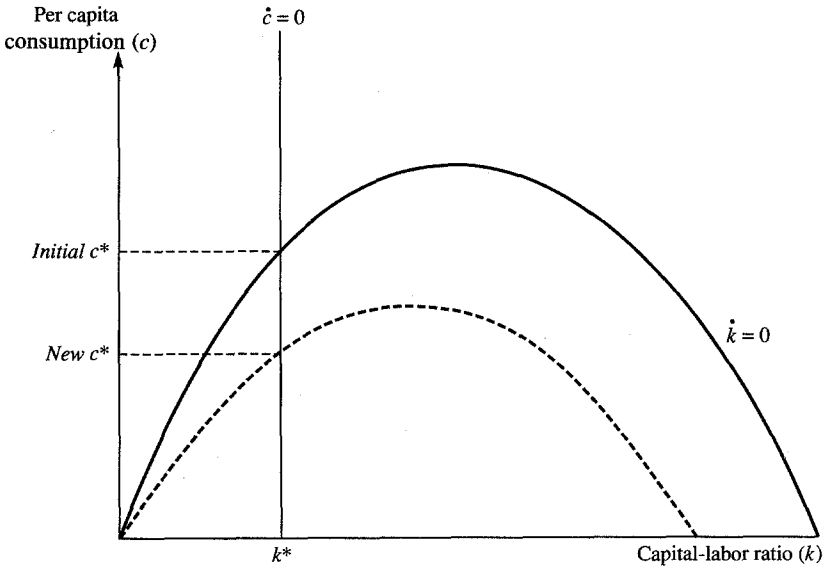
where $\sigma = [-U'(c_t)/c_t]\,[U''(c_t)]$, the elasticity of substitution in consumption.

17. Some might argue for using an alternative objective function that does not weight the average utility of different generations by the number of people in the generation. This will lead the social planner to raise average consumption in small cohorts relative to that in larger cohorts, because the aggregate resource cost of raising the average consumption of people in small cohorts is less than that for large cohorts. We see no compelling ethical argument for weighting people in different sized cohorts differently.

18. Calvo and Obstfeld (1988, p. 163).

19. The optimal plan must also satisfy transversality conditions noted for example by Blanchard and Fischer (1989).

**Figure 6. Steady-State Consumption Response to an Increase in Dependency (Decline in α)**




In steady state with no technical progress, per capita consumption and the capital-labor ratio must be constant. From the Euler equation 11, we find that constant consumption requires

$$k^* = f'^{-1}(\rho). \tag{12}$$

This locus, a vertical line in $(c, k)$ space, is drawn in figure 6. Constancy of the capital-labor ratio given in equation 7 yields the second locus depicted in figure 6 as the solid line $\dot{k} = 0$.

Permanent reductions in $\alpha$, the support ratio, scale back the feasible level of per capita consumption for each $k$, shifting the $\dot{k} = 0$ locus as shown by the dashed line in figure 6. The steady-state capital-labor ratio is unaffected by this change, so the only effect of this shock is an immediate and permanent decline in consumption per capita. Reductions in $n$, the labor force growth rate, would have the opposite effect, shifting the $\dot{k} = 0$ frontier *out*. The steady-state consumption effect of a demographic shift such as a fertility decline, which reduces both $\alpha$ and $n$, depends on which of these effects may be larger. Reductions in $n$ would

unambiguously reduce the optimal steady-state saving rate while increases in $\alpha$ would have no effect on steady-state savings.[20]

The actual demographic projections for the United States are more complex than an immediate shift in either $\alpha$ or $n$, however. For the next several decades, the net effect of demographic change is an outward shift in the $\dot{k} = 0$ locus, followed by a period of inward shift that terminates with the locus below its current level. When consumers have perfect foresight and recognize the complex nature of the demographic transition, the initial consumption response to news of the demographic transition is theoretically ambiguous.

This ambiguity suggests the need for explicit numerical simulations to address the optimal consumption response. We assume that the utility function in equation 9 has the form

$$U(c_t) = (c_t^{1-1/\sigma} - 1)/(1 - 1/\sigma), \tag{13}$$

where $\sigma$ is the elasticity of substitution in consumption. We also assume a constant elasticity of substitution production function:

$$f(k_t) = [ak_t^{1/1-\beta} + b]^{1-\beta}. \tag{14}$$

The elasticity of substitution in production is $\beta$. To find the transition path between one steady state and another, we discretize differential equations 10 and 11 and employ a grid-search algorithm to find the initial consumption level that will lead the economy to the new steady state.[21]

Our simulations also allow for labor-augmenting technical change ($g$) and depreciation ($\delta$), which are introduced into equations 10 and 11 in the standard way.[22] Although consumption grows over time when there is technical progress, the consumption numbers we report are *relative* to the consumption that would have been possible without demographic change. We assume that technical change is equal to 1.4 percent a year, the Social Security Administration's steady-state projection.[23] The depreciation rate is set equal to 4.1 percent, the U.S. average during 1952–

20. This is easily seen from the Harrod-Domar condition $k/f(k) = s/n$, where $s$ is the saving rate out of national income, and the observation that neither changes in $\alpha$ nor changes in $n$ affect optimal steady-state capital intensity in the Ramsey model.

21. Because the Social Security Administration forecasts population in every fifth year, we interpolate annual observations using a smooth interpolator. The results are not sensitive to the frequency of the data.

22. Following Blanchard and Fischer (1989), we express capital per "effective worker," where effective workers grow at $n + g$. Consumption is expressed per "effective person." In equation 11, the discount factor becomes $(\rho + \delta + g/\sigma)$.

23. Our results are insensitive to the choice of $g$.

87.[24] Finally, we use data for this period on payments to labor and capital to estimate capital's share in gross output—33.2 percent. Over this same period, the capital-output ratio averaged 2.3.[25] These two numbers imply a steady-state marginal product of capital of 14.4 percent. From equation 11, this implies an effective discount rate ($\rho + g/\sigma$) of 10.3 percent: that is, the steady-state marginal product of capital less depreciation.

We present results using two values of $\sigma$, a benchmark case of unit elasticity ($\sigma = 1$) and an alternative elasticity of substitution of one-tenth ($\sigma = 0.1$). We also choose two values for the elasticity of substitution in production, a benchmark of unit elasticity ($\beta = 1$) and an alternative elasticity of one-half ($\beta = 0.5$). When the elasticity of substitution in consumption is low, consumption today is not a good substitute for consumption tomorrow, and we expect more consumption smoothing. When the elasticity of substitution in production is low, saving does not get a high return since the extra capital does not substitute well for the smaller labor force, and we expect less consumption smoothing.

Demographic change has occurred gradually over the past 25 years, as the baby boom has given way to the baby bust. It is not obvious how best to model these changes as a single shock. Initially, we assume the economy is in steady state with values of $\alpha$ and $n$ corresponding to those prevailing in 1990, and ask how consumption and saving should evolve henceforth. Because some of the consequences of demographic change were already known by 1990, we go on to examine how consumption and saving should have responded in 1970 and 1980 if news of demographic change had suddenly arrived.

For all our simulations, we use the trajectories of $\alpha$ and $n$ implied by the Social Security Administration's alternative IIb forecasts, and further assume that the predicted values for 2065 persist as the economy's final steady state.[26] The resulting consumption changes are thus the

24. Our depreciation rate is estimated as capital consumption allowances divided by the aggregate capital stock. We define aggregate capital stock as national assets minus consumer durables minus one half of the value of land. Consumer durables are excluded since they are not included in output. One half of land is included in capital to allow for natural resource values to change.

25. Capital's share in output is total output less wages and salaries, two-thirds of proprietors' income (the estimated labor compensation), and indirect business taxes, divided by output less indirect business taxes.

26. Alternative IIb projections embody the alternative II forecasts regarding demographic change, as well as an intermediate set of economic forecasts.

**Table 4. Optimal Consumption Response to Demographic Shocks, United States, 1990–2060[a]**

| Item | Static expectations | Perfect foresight with alternative elasticities[b] | | | |
|---|---|---|---|---|---|
| | | $\beta = 1$ $\sigma = 1$ | $\beta = 1$ $\sigma = 0.1$ | $\beta = 0.5$ $\sigma = 1$ | $\beta = 0.5$ $\sigma = 0.1$ |
| *Case 1. Labor force population 20–64 and unweighted consumption* | | | | | |
| Initial steady state | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Initial adjustment | 100.0 | 100.6 | 101.1 | 100.4 | 101.0 |
| Time path | | | | | |
| 2000 | 101.3 | 101.4 | 101.3 | 101.4 | 101.3 |
| 2010 | 104.8 | 103.3 | 101.7 | 103.8 | 102.1 |
| 2020 | 102.5 | 102.3 | 101.4 | 102.5 | 101.7 |
| 2030 | 96.6 | 98.3 | 100.3 | 97.7 | 99.8 |
| 2040 | 95.7 | 96.2 | 99.0 | 95.9 | 98.1 |
| 2050 | 96.0 | 95.9 | 98.1 | 95.9 | 97.1 |
| 2060 | 94.7 | 95.1 | 97.3 | 95.0 | 96.2 |
| New steady state | 94.8 | 94.8 | 94.8 | 94.8 | 94.8 |
| *Case 2. Earnings-weighted labor force and needs-weighted consumption* | | | | | |
| Initial steady state | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Initial adjustment | 100.0 | 102.3 | 102.8 | 101.9 | 102.8 |
| Time path | | | | | |
| 2000 | 105.4 | 104.1 | 103.0 | 104.5 | 103.3 |
| 2010 | 104.9 | 104.1 | 102.8 | 104.5 | 103.0 |
| 2020 | 99.4 | 100.4 | 101.5 | 100.2 | 101.1 |
| 2030 | 94.0 | 95.7 | 99.6 | 95.0 | 98.3 |
| 2040 | 93.0 | 93.5 | 97.8 | 93.2 | 96.0 |
| 2050 | 92.5 | 92.7 | 96.3 | 92.6 | 94.5 |
| 2060 | 91.7 | 92.0 | 95.1 | 91.8 | 93.4 |
| New steady state | 91.6 | 91.6 | 91.6 | 91.6 | 91.6 |

Source: Authors' calculations.

a. Each column is the simulated path of consumption in response to a demographic shock like that which the United States will experience between 1990 and 2060. The static expectations column is the change in consumption if agents in each period assume that the current level of $\alpha$ and $n$ will persist forever. The perfect foresight columns assume current knowledge of the entire path of demographic change. The initial steady state is the 1990 value of $\alpha$ and $n$.

b. $\beta$ is the substitution elasticity in production; $\sigma$ is the substitution elasticity in consumption.

optimal response to the demographic transition that the United States will undergo over the next seven decades, assuming these changes were unforeseen as of 1990.

The results of these simulations are shown in table 4. The level of per capita consumption in the 1990 steady state is normalized to 100. The first column, the static expectations response, is the change in consump-

tion if consumers have no foresight about demographic change but rather assume at each date that current conditions will persist forever. It thus corresponds to the consumption path in table 3. The other four columns assume that consumers in 1990 have perfect foresight regarding future demographic changes.

For all the parameter values, consumption rises initially in response to the demographic transition, by up to 2.8 percent relative to the steady state implied by 1990 demography. This result is insensitive to the parameter choices we present.[27] Consumption remains above its 1990 level until 2020 or later. Thus, demographic shifts during the next half-century optimally *raise* present consumption. The initial effect is more pronounced when consumption is less substitutable over time ($\sigma$ is small) and less pronounced when production is less substitutable over time ($\beta$ is small).

Figure 7 shows the movements of consumption and capital for the simulations using unit elasticities of substitution in production and consumption. The corresponding saving rate is shown in figure 8. Consumption initially rises by 2.3 percent. This is followed by a period when capital per effective worker declines, during which consumption continues to increase. The shifting opportunity locus due to the decline in labor force growth ultimately causes an increase in saving and thus in capital intensity, even at the higher level of consumption. After the period of capital deepening, consumption begins to decline. Finally, when the increase in dependency overtakes the favorable effects of the slowing labor force growth, both consumption and capital decline to the new steady state, and saving remains low.

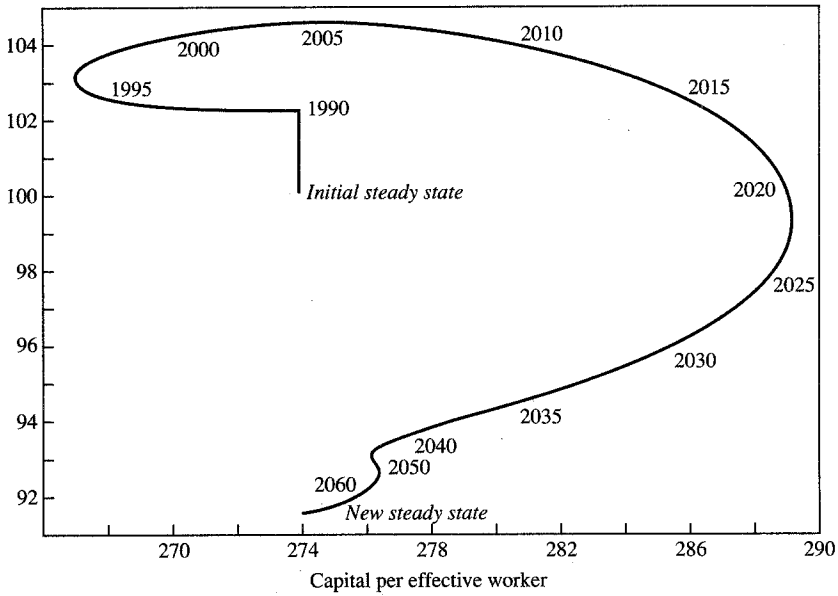
As figure 8 demonstrates, the saving rate falls almost 2 percentage points during the 1990 initial adjustment. It then increases for a few years, though it never attains its initial steady-state value. This increase is due to the increase in the support ratio, which allows both consumption per person and the saving rate to increase. Finally, the saving rate begins to fall toward its new long-run level, equal to the amount of saving necessary to equip the more slowly growing labor force.

We also ran the simulations using the Social Security Administration's alternative I and alternative III, with no substantive changes in results.

27. In addition to the parameter values reported, we have experimented with elasticities in substitution and production up to 10. For none of these cases is there an initial increase in savings.

**Figure 7. Optimal Consumption and Capital-Labor Trajectory Following Demographic Shock, 1990–2060**

Consumption per effective person (index, 1990 = 100)



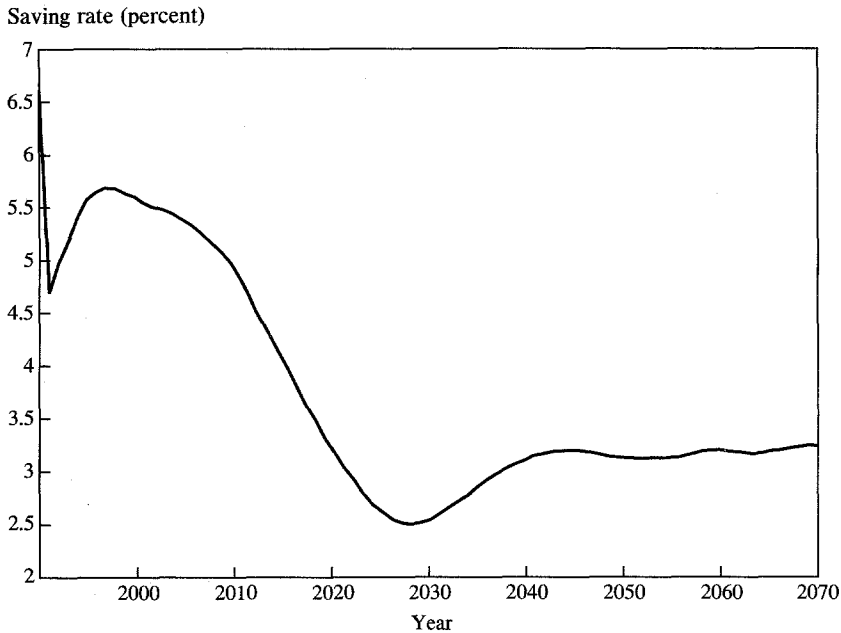

Source: Authors' calculations. Elasticities used are $\beta = 1$, $\sigma = 1$. Labor force measure is earnings-weighted (*LF2*); consumption measure is needs-weighted (*CON2*). Consumption at the initial steady state is normalized to 100. The resulting index yields capital per effective worker equal to 274 in the initial steady state.

Consumption rises less with the alternative I assumptions than with our benchmark alternative II assumptions, because the number of dependent children does not decrease as quickly, and more with the alternative III assumptions, where there is an even larger short-run benefit. In all three cases the response to the demographic news is a decrease in saving. We have also experimented with changing capital's share or the assumed initial level of capital intensity in order to vary the discount rate.[28] Even with a pure discount rate as low as zero, our conclusion that consumption rises following a demographic shock remains valid.

Finally, we explored how consumption would change if we began the simulations in 1970 or 1980. As table 2 demonstrated, consumption

28. Because the discount factor must equal the marginal product of capital in steady state, and the marginal product of capital is the ratio of capital's share in output to the capital-output ratio, changes in the discount factor have to be accompanied by changes in either capital's share or the capital-output ratio.

**Figure 8. Optimal Saving Rates in Response to Demographic Shock, 1990–2070**




Source: Authors' calculations. Elasticities used are $\beta = 1$, $\sigma = 1$. The consumption measure is needs-weighted (*CON2*); the labor force measure is earnings-weighted (*LF2*).

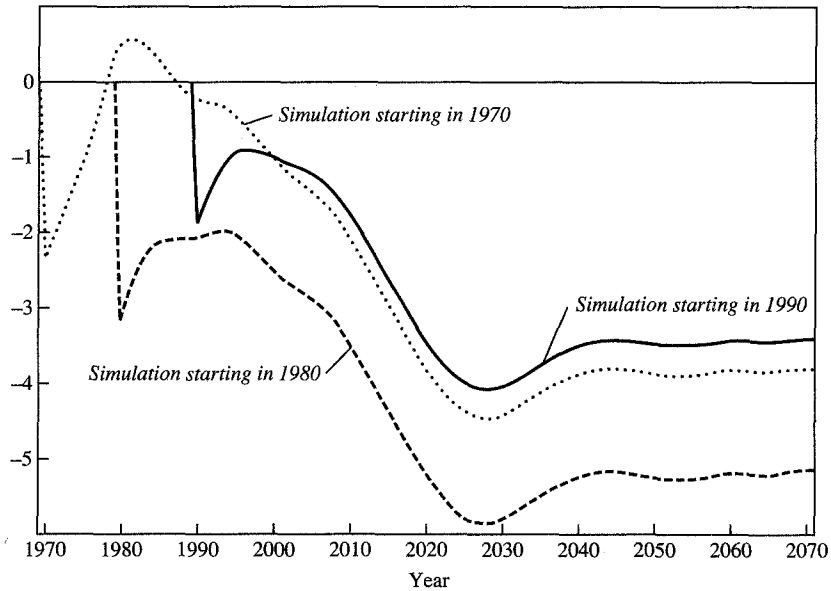
possibilities are higher in 1990 than in any of the three previous decades. Figure 9 shows the deviation of the saving rate from its initial steady-state level after the demographic news. In all of the simulations, saving falls immediately following the demographic news, and is always falling by 2000. Even in the cases where saving begins to increase in the 1990s—when we begin the simulation in 1980 or 1990—the saving rate is lower throughout the 1990s than the original steady state, and it begins a period of prolonged decline by 2000.

While these figures help to develop perspective on the recent decline in U.S. saving and investment rates, the actual decline in U.S. national saving from an average of 7.1 percent in the 1970s to about 2 percent in the late 1980s is considerably more than our demographic analysis can justify.

The analysis in this section reaches a clear conclusion. For an economy choosing its consumption path in accord with a standard optimal growth model, the right response to the upcoming U.S. demographic change

**Figure 9. Optimal Saving Responses to Demographic Change: Sensitivity to Date of Demographic Discovery**[a]

Difference in saving rate from steady state (percent)




Source: Authors' calculations using Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds (1988).

a. This figure presents the percentage point difference in saving rates from the initial steady state following a demographic shock. The three lines represent saving paths when the simulations are run starting in 1970, 1980, and 1990. These saving paths come from simulations using needs-weighted consumption (*CON2*) and the earnings-weighted labor force (*LF2*), and unit elasticities of substitution in both production and consumption ($\beta = 1$, $\sigma = 1$).

would be an increase in consumption and a reduction in national saving. For all plausible combinations of parameter values, the effects of reduced labor force growth and reductions in the number of children exceed the effects of increases in long-run dependency.

## Open-Economy Aspects of the Demographic Shift

Our analysis thus far has focused on the demographic change in the United States. When capital markets are integrated, however, the demographic shift in the United States must be measured not only in absolute terms but *relative* to the coincident shifts in our major trading partners. This section compares the degree of population aging in

different nations and extends our earlier simulation model to consider the United States in relation to the other countries in the Organization for Economic Cooperation and Development (OECD). Our earlier finding that, other things being equal, demographic changes justify a reduction in optimal saving is reinforced when we allow for international capital flows, because demographic change is less pronounced in the United States than elsewhere in the OECD.

### *Relative Rates of Population Aging*

To compare rates of population aging, we use projections by the OECD.[29] These projections differ in two important ways from the Social Security Administration projections for the United States. First, the OECD treats the 15–19 age group as workers rather than dependents. Second, and more important, the OECD assumes that fertility rates in all countries will converge to the replacement level of 2.1 by 2050. Because U.S. fertility rates are currently well above those in most of the OECD, this understates the likely contrast between the future U.S. and foreign demographic experiences.

Figure 10 shows the historical and projected elderly dependency ratio for the United States, Japan, and the European Community.[30] The elderly dependency ratio increases substantially in all countries, with the most rapid increase in Japan. By 2050, even with a 19 percentage point increase in the elderly dependency ratio from 1950, the U.S. ratio will be roughly 5 percentage points lower than those of the other countries.

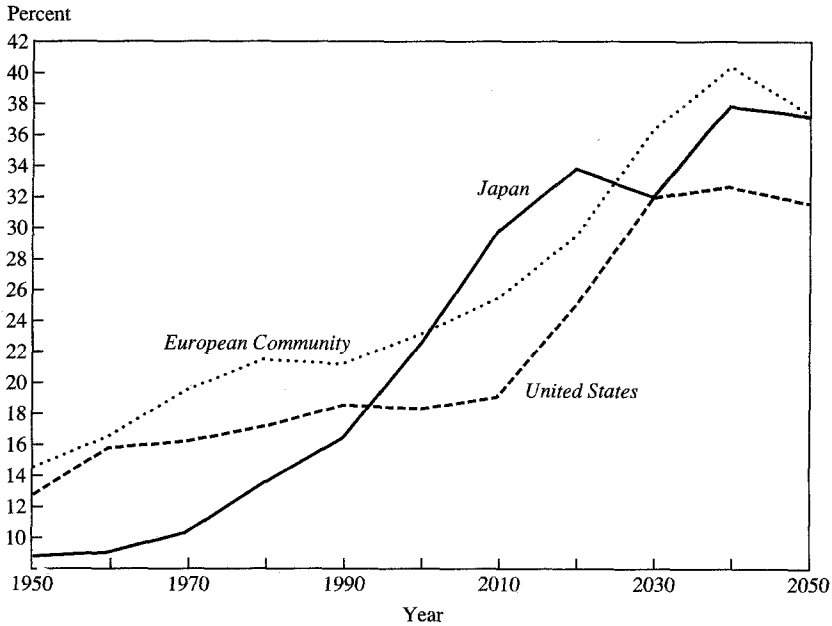
Figure 11 shows the path of support ratios corresponding to the *LF*1 and *CON*1 assumptions. The broad outlines for all three regions are similar. All have higher support ratios in 1990 than in 1960, and all will have much lower support ratios by the middle of the next century than they do today. The ultimate level of U.S. dependency will be lower than that abroad.

Two differences in these indexes are notable, however. First, the United States will be better off for the next two decades than it is now, while the other countries experience declines in the support ratio

29. OECD (1988).

30. The multicountry index is a GDP-weighted average of the indexes for the individual countries.

**Figure 10. Actual and Projected Elderly Dependency Ratios, United States, Japan, and European Community, 1950–2050**



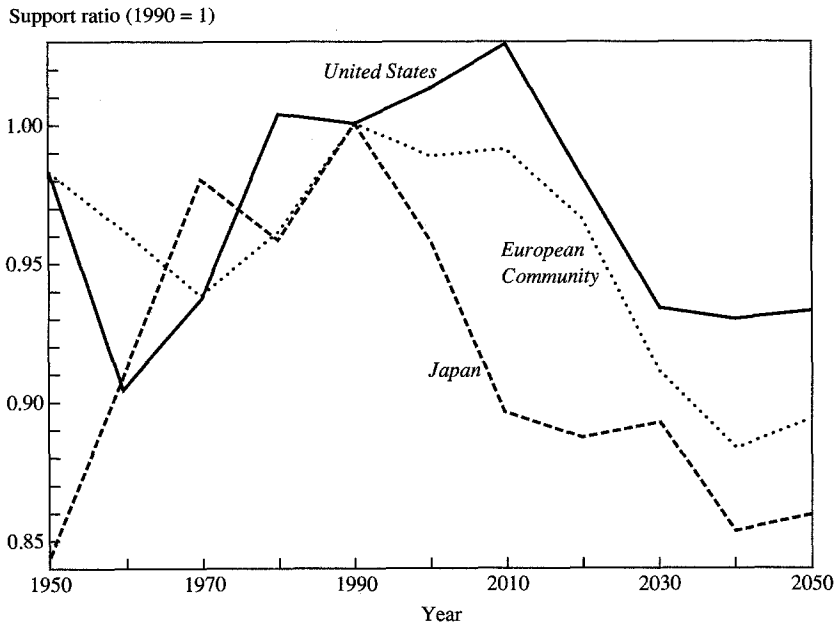

Source: OECD (1988). Working-age population includes all those aged 15–64.

beginning in 1990. Second, the U.S. and EC dependency ratios are driven principally by fertility changes, while the Japanese changes are driven to a much larger extent by reductions in mortality.[31] The decline in the support ratio in the 1950s in the United States and in the 1960s in the EC is due to increased numbers of children; the rise in the support ratio throughout the postwar period in Japan, in contrast, is caused by reduced mortality at middle and older ages. Because the labor force grows faster when fertility is higher, the reduction in labor force growth over the next several decades, and thus the consumption dividend from reduced investment requirements, will be larger in the United States and the European Community than in Japan.

To evaluate the size of the demographic transition abroad, table 5 reports the optimal consumption and saving responses to projected

31. OECD (1988) presents evidence on the importance of fertility and mortality declines for the different countries.

**Figure 11. Actual and Projected Support Ratios, United States, Japan, and European Community, 1950–2050**




Source: OECD (1988) The consumption measure is total population (*CON*1). The labor force measure is the population 15–64 (*LF*1).

demographic changes in the United States, Japan, the European Community, the non-U.S. OECD, and the total OECD.[32] These consumption paths are simulated using the model of the previous section. For the United States, consumption rises only slightly initially, continues increasing until 2010, and then declines to the new steady state. This consumption increase is accompanied by an increased saving rate, however, since the relative increase in the working-age population increases output per person by more than consumption per person.

For Japan, the coming demographic changes reduce optimal con-

32. The table uses the case of unit elasticities of substitution and production. We assume that depreciation rates and rates of labor-augmenting technical progress are equal in all countries and are the same as the Social Security Administration forecasts for the United States. The assumption of equal productivity growth is obviously wrong but probably does not have a large impact on estimates of the change in saving due to changes in demographic structure.

**Table 5. Autarky Response of Consumption and Saving to Demographic Shocks, United States and Various Nations, 1990–2050[a]**

| Item | Country | | | | |
|---|---|---|---|---|---|
| | *United States* | *Japan* | *European Community* | *Non-U.S. OECD* | *Total OECD* |
| | *Consumption response* | | | | |
| Initial steady state | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Initial adjustment | 100.1 | 99.2 | 100.1 | 100.0 | 100.1 |
| Time path | | | | | |
| 2000 | 100.6 | 97.2 | 99.7 | 99.3 | 99.8 |
| 2010 | 101.5 | 92.2 | 98.8 | 97.8 | 99.2 |
| 2020 | 99.1 | 89.0 | 97.1 | 95.5 | 97.0 |
| 2030 | 94.4 | 88.5 | 92.8 | 92.1 | 93.0 |
| 2040 | 92.0 | 86.3 | 89.1 | 88.8 | 89.9 |
| 2050 | 92.1 | 84.8 | 88.2 | 87.9 | 89.1 |
| New steady state | 92.3 | 84.4 | 87.9 | 87.8 | 89.0 |
| | *Saving rate response* | | | | |
| Initial adjustment | −0.1 | 0.7 | −0.1 | 0.0 | 0.0 |
| Time path | | | | | |
| 2000 | 0.1 | −1.4 | −0.9 | −1.0 | −0.6 |
| 2010 | 0.5 | −3.0 | −0.7 | −1.1 | −0.5 |
| 2020 | −1.4 | −2.6 | −1.5 | −1.8 | −1.6 |
| 2030 | −2.4 | −1.3 | −2.8 | −2.5 | −2.5 |
| 2040 | −1.5 | −3.1 | −2.9 | −2.9 | −2.3 |
| 2050 | −1.4 | −1.5 | −0.8 | −1.2 | −1.3 |
| New steady state | −1.5 | −1.3 | −0.7 | −1.1 | −1.3 |

Source: *OECD (1988)* and authors' calculations.

a. The values in the table are the optimal consumption and saving paths for each country without international capital flows. We use needs-weighted consumption (*CON2*) and the unweighted labor force (*LF1*). Consumption is relative to the initial steady state, which is normalized to 100. Saving paths are defined as the percentage point difference between the saving rate along the path and the initial steady state. The elasticities of substitution in production and consumption both equal unity.

sumption initially by just under 1 percent, and consumption continues to decline throughout the next 60 years, even as the saving rate declines. For the European Community, there is also a slight increase in consumption, but by 2000 consumption is lower, and continues to decline throughout the next half-century. This pattern of declining consumption after a small increase in initial consumption carries over to the non-U.S. OECD and total OECD simulations.

The initial decrease in the saving rate in the United States and the increase in the non-U.S. OECD imply that in an open economy, capital would initially flow from the non-U.S. OECD to the United States. After the initial change in saving, however, capital flows are more difficult to

predict. In addition to the change in saving rates in the autarky case, the countries also have different changes in labor force growth rates, and thus in investment requirements. Because the desired capital inflow depends on the difference between saving and investment requirements, looking at saving rates or consumption alone does not indicate whether each country would borrow or lend. To address this issue, we turn next to simulations that allow for capital mobility.

### *A Two-Country Simulation Model*

Our open-economy simulations aggregate the European Community, Japan, and the other countries of the OECD to form a non-U.S. OECD index. Figures 12 and 13 show the support ratio and labor force growth rates for the United States and this aggregate. The support ratios are consistent with those in figure 11. The United States has a 5 percentage point higher support ratio in 2050 than the non-U.S. OECD, and unlike the rest of the OECD has a rising support ratio over the next two decades. By 2050 the labor force in both areas is projected to stabilize, not grow. Between now and then they fluctuate, but with U.S. labor force growth always higher.

To assess the optimal response of U.S. saving in an open-economy context, we extend the model of the previous section to allow for capital mobility. We distinguish asset ownership from asset location by denoting period $t$ asset ownership per person in country 1 by $a_{1,t}$. Asset accumulation is given by

$$\dot{a}_{1,t} = w_t + a_{1,t}(r_t - n_{1,t}) - (c_{1,t}/\alpha_{1,t}), \tag{15}$$

where the wage, $w_t$, and the interest rate, $r_t$, are equalized across countries. The labor force growth rate, the support ratio, and the level of per capita consumption can differ across countries and therefore have both time and country subscripts.

The common capital-labor ratio is a weighted average of asset holdings in the two nations:

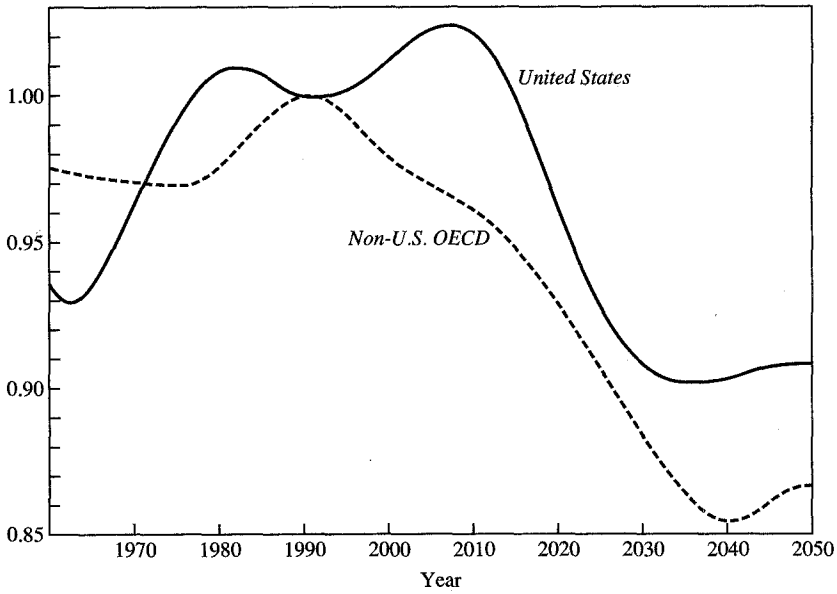
$$k_t = \theta_{1,t}\, a_{1,t} + (1 - \theta_{1,t})\, a_{2,t}, \tag{16}$$

where $\theta_{1,t}$ is country 1's share of world population. From equation 16 we derive the capital accumulation constraint for the two-country model:

$$\dot{k}_t = \dot{\theta}_{1,t}(a_{1,t} - a_{2,t}) + \theta_{1,t}\,\dot{a}_{1,t} + (1 - \theta_{1,t})\,\dot{a}_{2,t}. \tag{17}$$

**Figure 12. Actual and Projected Support Ratios, United States and Non-U.S. OECD, 1960–2050**

Support ratio (1990 = 1)




Source: Authors' calculations based on data in OECD (1988). Non-U.S. OECD includes all OECD countries except the United States, weighted by GDP. The consumption measure is needs-weighted (*CON2*), with the same weights as for the United States. The labor force is the population 15–64 (*LF1*).

This constraint replaces equation 10 in the one-country model. The optimal consumption profile (equation 11) and the steady-state saving-investment relation (equation 12) are identical to those in the one-country case.

We calibrate the two-country model assuming that both countries have Cobb-Douglas production functions and logarithmic utility functions. We assume that one nation is the United States and the other is the non-U.S. OECD, and set the relative labor force in the United States at four-tenths of the two-country total, roughly the value of the productivity-weighted U.S. labor force share for 1990. In addition, we begin the simulations assuming no net foreign investment position.[33] We also assume equal rates of technological progress and equal discount rates in the two countries.

33. This corresponds to the average U.S. net foreign asset position during the 1980s, but understates foreign holdings of U.S. assets at the beginning of the 1990s.

**Table 6. Effect of Demographic Shock on Consumption and Foreign Capital Ownership, United States and Non-U.S. OECD, 1990–2050[a]**

| | *United States* | | *Non-U.S. OECD* | |
|---|---|---|---|---|
| *Item* | *Consumption* | *Foreign capital ownership (percent)* | *Consumption* | *Foreign capital ownership (percent)* |
| Initial steady state | 100.0 | 0.0 | 100.0 | 0.0 |
| Initial adjustment | 101.0 | 0.0 | 99.4 | 0.0 |
| Time path | | | | |
| 2000 | 100.8 | −5.5 | 99.2 | 3.7 |
| 2010 | 100.2 | −6.4 | 98.7 | 4.7 |
| 2020 | 97.9 | −3.5 | 96.4 | 2.6 |
| 2030 | 93.9 | −4.7 | 92.4 | 3.7 |
| 2040 | 91.0 | −7.9 | 89.6 | 6.7 |
| 2050 | 90.5 | −8.7 | 89.1 | 7.7 |
| New steady state | 90.5 | −8.7 | 89.1 | 7.7 |

Source: OECD (1988) and authors' calculations.

a. The table shows the results from the open-economy demographic simulation. We use the needs-weighted measure for consumption (*CON2*) and the unweighted labor force (*LF1*). Consumption is normalized to 100 in the initial steady state. Foreign capital ownership is the percentage of assets in each country owned by foreigners. It is initially zero in both countries. The elasticities of substitution in production and consumption both equal unity.

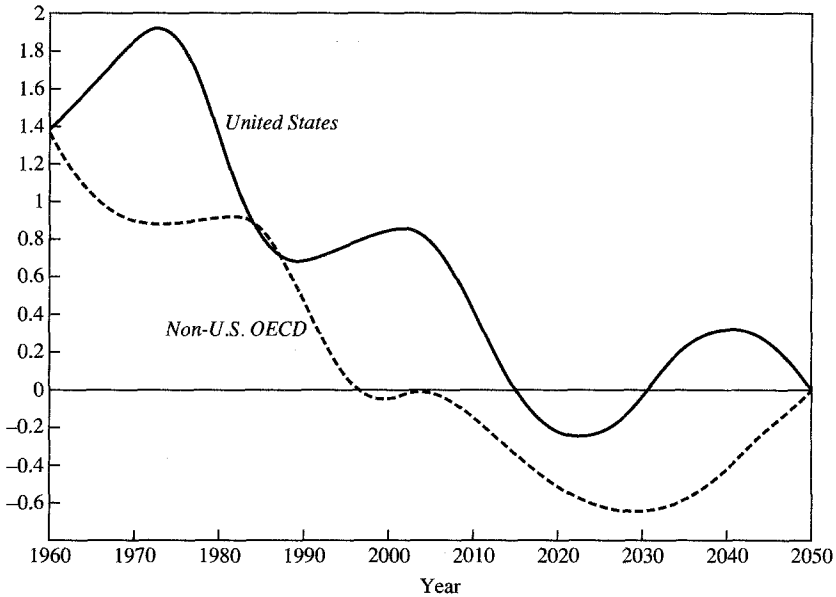
To finance the additional consumption indicated in the simulations, the United States runs a current account deficit. Figure 14 shows the path of net national saving and net investment, and, as residual, the current account. For about 15 years, the United States runs current account deficits, so that more than 6 percent of U.S. assets are owned by foreigners in 2010. High saving for the subsequent 15 years results in current account surpluses and reduces foreign capital ownership to 3.5 percent. Past 2020, however, with the rapid increase in the number of elderly, the United States again runs current account deficits, so that in the steady state almost 9 percent of U.S. assets are owned by foreigners.

For the non-U.S. OECD, consumption declines 0.6 percent when trade with the United States is permitted. The availability of investment projects in the United States means that higher saving in the short run will not depress rates of return by as much as in the closed-economy case.

The open- and closed-economy cases yield different consumption levels in both the short run and the steady state. In the open-economy

**Figure 13. Actual and Projected Growth Rate of Labor Force, United States and Non-U.S. OECD, 1960–2050**

Annual growth rate (percentage points)



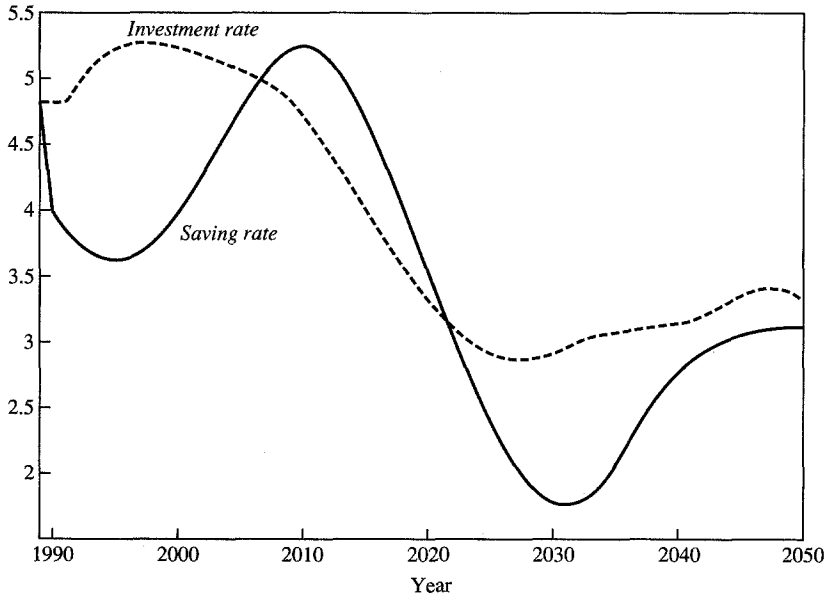

Source: Same as figure 12.

Table 6 presents the two-country simulation results. We normalize consumption to be 100 initially in both countries. While the shape of the consumption response is similar in the open- and closed-economy cases, the size of the responses is different. For the United States, the closed-economy analysis suggests a 0.1 percent consumption increase relative to the 1990 steady state. With capital flows between the relatively slowly aging United States and the more rapidly aging rest of the OECD, however, the U.S. consumption increase is 1 percent of the 1990 benchmark. Consumption in the United States increases more in the open-economy case because high saving elsewhere in the world reduces the rate of return to capital, inducing a positive shock to the value of human wealth.[34]

34. Although we assume that utility is logarithmic, the interest elasticity of saving is positive. When interest rates increase, holding wealth constant, saving is unaffected. However, with interest rates higher, the present discounted value of labor income decreases, and hence consumption falls. Wages in the United States also increase in the short run.

**Figure 14. Net Saving and Investment Rates, United States, from Two-Country Simulations, 1990–2050**

Percent of GNP




Source: Authors' calculations and OECD (1988).

case, U.S. consumption is higher in the early stage of the transition because of the availability of foreign capital. The resulting decrease in asset accumulation translates into a 1.8 percentage point reduction in steady-state consumption from the closed-economy simulation. For the non-U.S. OECD, the effect is reversed: greater capital accumulation along the transition path leads to steady-state consumption 1.3 percentage points higher than in the autarky steady state.

These results suggest two conclusions. First, the pattern of demographic change in other developed nations can have a large effect on the optimal consumption response to demographic change in the United States. The importance of these effects depends critically on the degree of capital market integration. Second, because the United States is aging more slowly than other OECD nations, the optimal consumption response in the open economy entails higher initial consumption than in the autarky case and thus a current account deficit.

## Demographic Change and Productivity Growth

The foregoing calculations assume that demographic changes affect productivity only by causing changes in capital intensity. The rate of technical change, or equivalently of total factor productivity, is assumed to be independent of demographic developments. But if demographic factors affect technical change, the implications could be quite significant, both for living standards and for optimal capital accumulation.

There are several potential links between demographic developments and the rate of technological change. One argument, stressed recently by Julian Simon and Ben Wattenberg, holds that slow population growth reduces the rate of technical progress.[35] The argument has two strands. First, a rapidly growing population enlarges the market for capital goods (the Solow effect noted above), making innovation more profitable by permitting greater spreading of fixed costs. As population growth slows, innovation becomes less profitable. Second, as the share of the population that is young and innovates declines, the aging society loses some of its "dynamism" and experiences slower technical change. As described by French demographer Alfred Sauvy, such a future would hold "a society of old people, living in old houses, ruminating about old ideas."[36]

A more optimistic argument, advanced by H. J. Habakkuk, is that incentives to innovate are strongest when labor is scarce.[37] Habakkuk argued that industrialization proceeded faster in America than in England because attractive agricultural opportunities raised the price of labor in the United States relative to that in England, where labor was abundant and less expensive. Paul Romer has formalized this argument and used it to explain the apparent tendency for abnormally rapid U.S. productivity growth in periods of relatively slow labor force growth.[38]

The relative importance of these mechanisms can only be assessed empirically. Unfortunately, there are no ideal experiments for considering the effects of demographic change on productivity growth. Below we draw on the differing demographic experiences of relatively high-

35. Simon (1981) and Wattenberg (1987).
36. Wattenberg (1987, p. 65).
37. Habakkuk (1962).
38. Romer (1990).

income countries to assess the likelihood that an aging population will lead to economic stagnation.

### *Evidence on Productivity and Demographic Composition*

Our empirical work uses the 1960–85 international comparison data of Robert Summers and Alan Heston.[39] Unfortunately, data on total factor productivity are not available for a wide sample of countries. Instead, we study the relation between labor force growth and labor productivity growth.[40]

We selected countries with 1960 labor productivity at least 30 percent of U.S. productivity (we use income per worker as our productivity measure) and excluded the OPEC countries, thus generating a sample of 29 countries. Selecting on initial income avoids the bias of including only countries that have experienced large productivity growth, as Bradford DeLong highlights.[41] We omit countries with very low initial productivity because the role of labor force growth may be very different in pre-industrial societies. Japan is omitted because its productivity was only 25 percent of U.S. productivity in 1960.

Figure 15 plots annual productivity growth and annual labor force growth during 1960–85. The data show a strong negative correlation. Slower-growing countries, including most European nations, exhibit above-average productivity growth, while more rapidly growing countries such as Canada and Australia have lower productivity growth.

To control for additional factors affecting growth, we estimate cross-section regressions of the form:

$$\ln (y_{1,i}/y_{0,i})/T = \alpha_0 + \alpha_1 \ln (LF_{1,i}/LF_{0,i})/T + \alpha_2 \ln (y_{0,i}) + \alpha_3 (I/Y)_i + \epsilon_i, \tag{18}$$

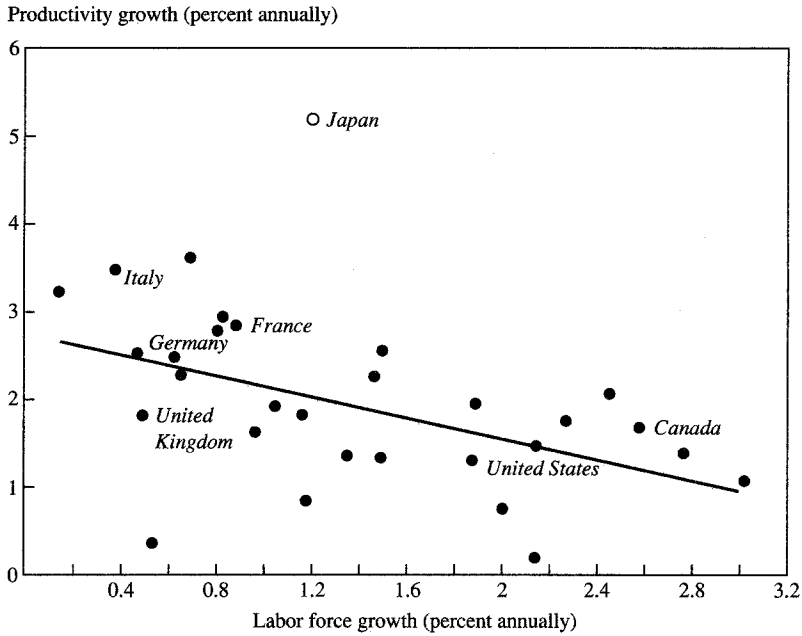
where $y_{1,i}$ and $y_{0,i}$ are, respectively, final and initial output per labor force member; $LF_{1,i}$ and $LF_{0,i}$ are the final and initial labor force; $(I/Y)_i$ is the average investment rate during the sample period; $i$ denotes the country; and $T$ is the length of the sample period. The investment rate is included to control for changes in capital that affect labor productivity but not

39. Summers and Heston (1990).

40. We present limited evidence below suggesting that the difference between labor productivity and total factor productivity does not have a large effect on our results.

41. DeLong (1988).

**Figure 15. Productivity Growth and Labor Force Growth, Selected Countries, 1960–85**[a]




Source: Authors' calculations based on data in Summers and Heston (1990). The G-7 countries are labeled on the figure.

a. Japan is included in the figure but not in the regression line.

total factor productivity. Initial income is included to capture the possibility that lagging countries grow more rapidly as they converge toward leading ones. Productivity growth and labor force growth are expressed at annual rates.

The upper panel of table 7 reports ordinary least squares estimates of equation 18. The coefficients in the bivariate regressions, analogous to figure 15, imply that a 1 percentage point decrease in the annual labor force growth rate raises productivity growth by 0.62 percentage point a year. Controlling for the initial level of productivity and investment rates has little effect on the labor force growth coefficient, with the estimates still negative (−0.64) and large. The data also suggest that more rapid investment leads to faster productivity growth, although there is no evidence of productivity convergence for this sample.

We estimated equation 18 with other samples of countries, with similar results. If we include the six OPEC countries with 1960 produc-

**Table 7. Demographic Change and Productivity Growth, 1960–85, Various Periods[a]**

| | *No controls* | | *With controls* | | | |
|---|---|---|---|---|---|---|
| *Period* | *Labor force growth* | $\bar{R}^2$ | *Labor force growth* | *Logarithm of initial productivity* | *Investment rate* | $\bar{R}^2$ |
| *Ordinary least squares estimates* | | | | | | |
| 1960–85 | −0.617 | 0.281 | −0.637 | −0.346 | 0.063 | 0.421 |
| | (0.179) | | (0.161) | (0.434) | (0.022) | |
| 1960–73 | −1.061 | 0.389 | −1.044 | −0.730 | 0.064 | 0.460 |
| | (0.245) | | (0.232) | (0.647) | (0.028) | |
| 1973–85 | −0.258 | 0.025 | −0.295 | 0.154 | 0.075 | 0.175 |
| | (0.198) | | (0.195) | (0.546) | (0.031) | |
| Fixed effects | −0.903 | 0.085 | −0.446 | −6.290 | 0.032 | 0.600 |
| | (0.477) | | (0.355) | (1.177) | (0.057) | |
| *Instrumental variables estimates* | | | | | | |
| 1960–85 | −0.711 | ... | −0.742 | −0.337 | 0.064 | ... |
| | (0.216) | | (0.189) | (0.438) | (0.022) | |
| 1960–73 | −0.977 | ... | −0.956 | −0.763 | 0.064 | ... |
| | (0.297) | | (0.272) | (0.651) | (0.028) | |
| 1973–85 | −0.436 | ... | −0.610 | −0.150 | 0.085 | ... |
| | (0.272) | | (0.296) | (0.610) | (0.033) | |
| Fixed effects | −0.840 | ... | 0.332 | −7.273 | −0.017 | ... |
| | (1.151) | | (1.440) | (2.174) | (0.107) | |

Source: Authors' calculations based on data in Summers and Heston (1990).

a. The dependent variable is the annual productivity growth rate. The labor force growth rate and investment rate are both annual rates. The sample consists of the 29 non-OPEC countries with 1960 income per worker above 30 percent of the U.S. level. The upper panel reports ordinary least squares estimates. The lower panel instruments for the growth rate of the labor force with the growth rate of the population. Standard errors are in parentheses; $\bar{R}^2$s are adjusted for degrees of freedom.

tivity above 30 percent of the U.S. level, the coefficient in the multivariate regression rises to −0.517 (0.144). If we limit the sample to countries with 1960 productivity at least 50 percent of that in the United States, the coefficient becomes −0.263 (0.192). If we consider the current OECD countries, the coefficient is −0.372 (0.161). Finally, if we include all 114 countries in the Summers and Heston data with at least 20 years of data, the coefficient becomes −0.507 (0.159).

Dividing the period 1960–85 into two shorter intervals, 1960–73 and 1973–85, shown in the second and third rows of the upper panel, allows us to examine the importance of the productivity slowdown in the mid-1970s. The results from these regressions are consistent with those from the full sample, although the evidence is stronger in the 1960–73 period. In the earlier period, the coefficient (−1.044) is much larger and still statistically significantly different from zero. In the post-1973 period, the coefficient falls to −0.295 and is no longer statistically significant.

The fourth row of the table presents the results of treating the two sample periods as a panel and estimating a fixed-effects regression. This specification controls for other factors that can explain persistent differences in growth rates across countries but that are not included in our set of explanatory variables. The results are qualitatively similar to those without the fixed effects. The coefficient in the multivariate regression (−0.446) is within the range of the estimates for the two sample periods, although the coefficient is not statistically significantly different from zero when we control for initial income and the investment rate.

The lower panel of the table reports instrumental variables estimates of the same equations, using the population growth rate as an instrument for labor force growth. If rapid productivity growth leads to less rapid increases in labor force participation, the ordinary least squares estimates will be biased, but the instrumental variables regressions will not. The instrumental variables estimates strongly confirm the ordinary least squares estimates. In the 1960–85 regression, the coefficient on labor force growth becomes more negative in the instrumental variables regression (−0.742) and is still statistically significant. The coefficients on the other variables, in contrast, change little.

As the second and third rows of the bottom panel suggest, this is principally due to a more pronounced negative relation between labor force growth and productivity growth during 1973–85. This is consistent with Richard Freeman's claim that the decline in productivity growth in post-1973 Europe discouraged labor force participation, leading to a positive bias in the coefficient on labor force growth rates.[42]

The final row presents the results for the instrumental variables regression with the fixed-effects specification. While the coefficient in the bivariate regression is similar to the ordinary least squares estimate, the coefficient in the multivariate regression is positive. In both cases, the coefficients on labor force growth are not statistically different from zero.

Because reductions in the labor force growth rate tend to increase capital intensity, one would expect them to be associated with increases in labor productivity growth even if they had no impact on technical change.[43] We doubt that the equations in table 7 are primarily picking up

42. Freeman (1988).

43. Mankiw, Romer, and Weil (1990) explore this possibility with particular attention to the role of human capital accumulation.

this effect for two reasons. First, its theoretical magnitude is much smaller than the effects implied by the cross-country equations. Over a 25-year period, a 1 percentage point reduction in labor force growth holding the saving rate constant would raise labor productivity by at most 0.17 percentage point assuming a Cobb-Douglas production function with a 67 percent labor share.[44] Second, for a small sample of OECD countries with available data (18 countries) we estimated productivity growth equations using both labor productivity and total factor productivity and found only negligible differences in the results.[45]

These regressions imply substantively large effects of demographic change on future growth. Because the annual labor force growth rate is predicted to fall by about 1 percentage point between 1990 and 2050, with most of the change occurring between 1990 and 2010, our estimates imply an increase of about 0.6 percentage point in annual productivity growth. Such effects are large enough to offset the decline in living standards that we presented above. Even a 0.2 percentage point increase in annual productivity growth between 1990 and 2040 would offset the roughly 10 percent decrease in per capita consumption as a result of rising dependency burdens over that period. Thus, even if the effects are much smaller than those from our regressions, they are likely to have a large impact on future living standards.

The regressions thus far present little evidence for the more pessimistic view of demographic change. It may be, however, that part of the effect of demographic change occurs through the investment rate. If slower labor force growth reduces the rate of innovation because of decreased demand for capital goods, that will show up as a positive effect of investment rates on productivity growth, rather than as an effect of labor force growth.

To consider this hypothesis, we reestimated the equations in table 7 without controlling for the rate of investment. The results change little from those reported. For the full time period, for example, the coefficient

44. The predicted effect is this large only if the base year for our observations (1960) is the first year of the new labor force growth rates. If the countries were already in steady state with different labor force growth rates, there would be no predicted effect on productivity from this explanation.

45. Without controls for initial productivity and investment rates, the coefficient on the growth rate of the labor force is −0.788 (0.207) in the equation for labor productivity and −0.696 (0.257) in the equation for total factor productivity. In the multivariate regression, the coefficients are −0.305 (0.216) and −0.259 (0.324) in the two equations.

on labor force growth falls only slightly, from −0.637 (0.161) to −0.617 (0.182). In no case does the coefficient on labor force growth fall substantially, and in many cases it becomes more important.

It is also possible that our measure of demographic change is not the best measure for examining the productivity consequences of changes in the population structure. The argument that older work forces are less innovative than their younger counterparts suggests that a variable like the average age of the work force is a more direct measure of demographic conditions. Our measure of labor force growth rates is only partly correlated with this type of demographic variable.

We explored this possibility by adding the average age of the labor force to the equations in table 7.[46] In the basic specification in the first row of the table, when the average age variable is included, the coefficient on the labor force growth rate declines to −0.483 (0.225), and that on the average labor force age is 0.135 (0.138). Neither the coefficient on initial productivity nor that on the investment rate changes substantially. Similar conclusions emerge for the other specifications.[47]

To the extent that the labor scarcity hypothesis is correct, it reinforces our conclusion that the maturing of the labor force expands society's opportunities. Faster productivity growth has a theoretically ambiguous effect on the level of current consumption, however. It tends to increase consumption today because of the income effect of increased output, but this effect can be offset by a substitution effect from the increased investment return as the effective supply of labor grows more quickly.

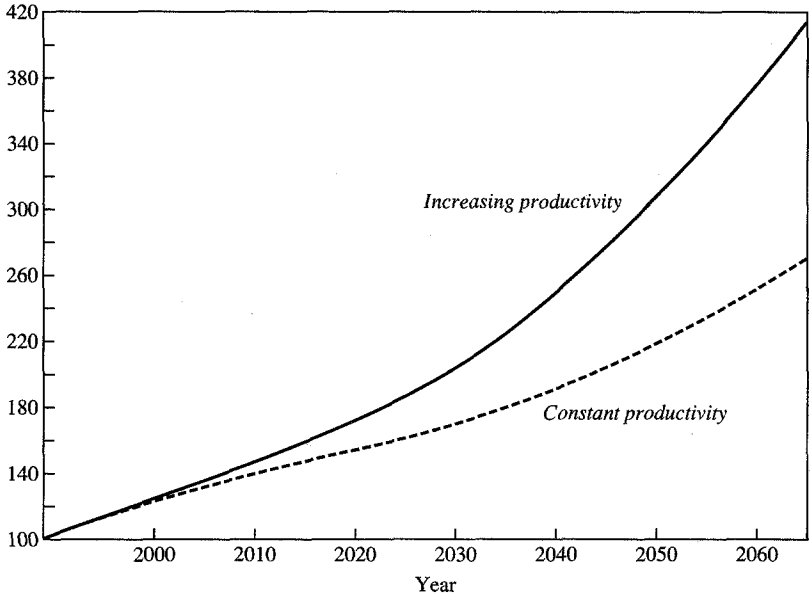
To evaluate these effects for current consumption decisions, we calculated the optimal consumption path when productivity growth changes over time. We assumed that each percentage point decrease in labor force growth increases productivity growth by 0.5 percentage point, a number in the range of those in table 7. Figure 16 shows the resulting consumption path, as well as the consumption path without the

46. To account for changes in the average age of the labor force over the time period of our productivity growth measurements, we defined the average labor force age over any period as the mean of the average age at the endpoints of the period.

47. We intend to explore these issues further in subsequent work. Preliminary results suggest that the evidence for beneficial effects of slow labor force growth is much weaker for the 1870–1960 period than for the post-1960 period. This may be a consequence of the simultaneity caused by much larger immigration flows in the early period. At this point, it seems fair to conclude that there is no international evidence for the dynamism hypothesis that more rapid population growth or a younger population raises productivity, and some evidence for the contrary labor scarcity hypothesis.

**Figure 16. Consumption Response with Induced Productivity, United States, 1990–2065**

Per capita consumption (index, 1990 = 100)




Source: Authors' calculations. For increasing productivity, it is assumed that productivity grows 0.5 percent for each 1 percent decline in annual labor force growth. The consumption measure is needs-weighted (*CON2*), and the labor force is earnings-weighted (*LF2*). The simulations assume unit elasticities of substitution in production and consumption.

productivity effects, following a demographic shock like those examined in the previous sections.[48] The effect of increased productivity growth is to increase current consumption even more, by an additional 0.2 percent. Further, because most of the productivity benefits occur in the next several decades, when the labor force grows slowly, consumption remains above its initial level throughout the transition path to the new steady state.

## Demographic Change and Fiscal Policy

The preceding section suggests that, other things being equal, the optimal response to recent and projected demographic changes is a

48. We use the support ratio defined with the earnings-weighted labor force and needs-weighted consumption measure. We also assume unit elasticities of substitution in production and consumption.

decline in the national saving rate. The implications for fiscal policy depend upon how the private saving rate responds to demographic changes. Tax-smoothing considerations may also imply particular patterns of optimal fiscal policy. This section examines these issues.

The effect of the population's aging on private saving has been the subject of a number of analyses, but no firm conclusion has yet emerged. From the standpoint of the life-cycle hypothesis, slowing population growth and an aging society should be associated with reductions in the private saving rate. As the aged share of the population increases, the ratio of dissavers to savers rises and so the private saving rate falls. David Weil has recently pointed out that this effect may be reinforced by an increase in expected bequests per member of the adult population.[49] On the other hand, many analysts have argued that the maturing of the baby boom generation will raise personal saving because people borrow when young and save as they approach middle age. Increases in personal saving may also result from people having fewer children.

Summers and Carroll explore the impact of demographic changes on saving behavior by assuming constant age-specific saving rates.[50] Figure 17 uses the age-specific saving rates from their analysis, as well as Social Security Administration population forecasts, to project personal saving rates over the next 30 years. The results suggest that the maturing of the population will be associated with a small increase in saving rates during the next three decades. Calculations by Alan Auerbach and Laurence Kotlikoff reach similar conclusions.[51]

A near-term increase in private saving provides a further reason why an economy with an initially optimal saving rate should loosen fiscal policy in response to changing demographic conditions.

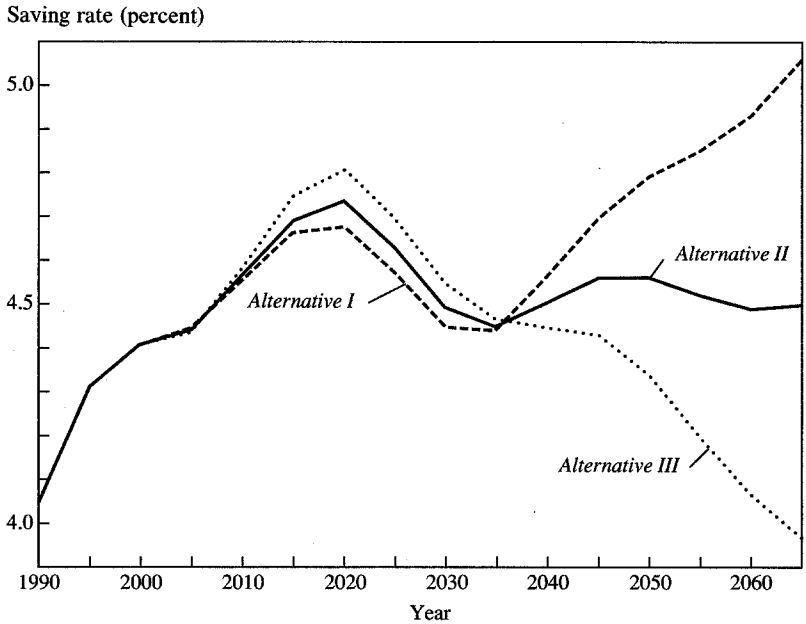
There is, however, a different argument for a tight fiscal policy. Projected demographic changes imply significant fluctuations in the level of government spending over the next century, since transfers to the

49. Weil (1989).

50. Summers and Carroll (1987).

51. Auerbach and Kotlikoff (1989). Both sets of calculations are flawed in ignoring pension saving, which may change as the age structure of the population changes. They also take no account of changes in the number of children or in the number of people supporting aged parents, although these factors may affect age-specific saving rates. David Weil (1990) uses aggregate data on OECD countries to study saving, recognizing these effects. His results suggest that private saving in the United States may rise about 1 percent in the next decade as a result of demographic factors.

**Figure 17. Projected Private Saving Rate, United States, 1990–2065**[a]




Source: Summers and Carroll (1987); Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds (1988).

a. The calculations assume that the saving rate is held constant by age.

elderly are much larger than those to any other group. Efficiency considerations argue for higher current taxes to fund foreseeable increases in government outlays. Because the deadweight loss of taxation increases with the square of the tax rate, financing the anticipated rise in government outlays on a pay-as-you-go basis, with lower tax rates during the next few decades and higher ones in the middle of the next century, entails a larger deadweight burden than a constant tax rate policy.[52] This argument parallels the traditional justification for using debt to finance wars and other transitory shocks to government spending.

To evaluate the empirical significance of tax-smoothing considerations, we begin by describing the age-specific pattern of government outlays. We then present a simple framework for evaluating the efficiency

52. Barro (1979) describes the "tax-smoothing" view of optimal government financial policy.

**Table 8. Per Capita Government Spending, by Age, United States, 1989**
1989 dollars

| Age group | Social security and disability | Health care | Education | Total |
|---|---|---|---|---|
| 0–4 | 132 | 872 | 674 | 1,678 |
| 5–14 | 132 | 690 | 3,353 | 4,175 |
| 15–19 | 132 | 298 | 2,930 | 3,360 |
| 20–24 | 16 | 298 | 1,112 | 1,426 |
| 25–44 | 83 | 298 | 233 | 614 |
| 45–64 | 811 | 218 | 84 | 1,113 |
| 65 and over | 6,138 | 3,526 | 84 | 9,748 |
| Total | 925 | 824 | 873 | 2,622 |

Sources: Social Security Administration (1987); Waldo and others (1989); Board of Trustees of the Federal Supplementary Medical Insurance Trust Fund (1988). For details regarding construction of the data, see notes to table 9.

gains from tax smoothing and report suggestive calculations. These findings imply relatively small efficiency improvements—on the order of 1 percent of one year's GNP—from stabilizing tax rates throughout the next half-century.

### *Age-Specific Patterns of Government Spending*

Governments spend different amounts on individuals of different ages. Outlays on education, for example, benefit primarily children, while the elderly are the principal beneficiaries of most government spending on health care and social security. Even without changes in the structure of government programs, demographic shifts can therefore affect the level of government spending.

Table 8 presents age-specific government expenditure patterns for the United States, focusing on the three largest social expenditures: social security, health care, and education. The first column shows spending on Old-Age and Survivors and Disability Insurance. Virtually all such expenditures are directed to individuals aged 65 or over, with average outlays in 1986 of $6,138 per person. The second column shows analogous age-specific spending patterns for health care, with average expenditures per person aged 65 and over ($3,526) more than four times larger than outlays for any other age group. The third column reports

**Table 9. Projected Government Expenditures, United States, 1990–2060**
Percent of GNP

| *Year* | *Social security and disability* | *Health care* | *Education* | *Other* | *Total* |
|---|---|---|---|---|---|
| 1990 | 4.7 | 4.1 | 4.7 | 18.0 | 31.8 |
| 2000 | 4.5 | 5.3 | 4.9 | 18.0 | 32.9 |
| 2010 | 4.6 | 5.9 | 4.9 | 18.0 | 33.4 |
| 2020 | 5.6 | 6.5 | 4.8 | 18.0 | 35.0 |
| 2030 | 6.5 | 7.4 | 4.9 | 18.0 | 36.7 |
| 2040 | 6.5 | 7.8 | 4.9 | 18.0 | 37.1 |
| 2050 | 6.5 | 7.8 | 4.9 | 18.0 | 37.1 |
| 2060 | 6.5 | 7.8 | 4.9 | 18.0 | 37.0 |

Sources: Social security and disability spending are predicted from projected population growth rates. For the 1989 distribution of spending, we projected the year-end 1986 distribution from the Social Security Administration (1987) to 1989, using the GNP deflator. Spending at below retirement ages is the sum of OASDI payments to the disabled, payments to early retirees, and payments to surviving children and spouses. Spending on all persons below 20 years of age was treated as applying uniformly to the members of this group.

For health care spending, we combined four types of spending. We obtained 1987 estimates of Medicare and Medicaid per capita spending on the elderly for hospital care, physicians' services, nursing home care, and other personal health care from Waldo and others (1989). For the nonelderly population, we calculated government spending on each of these categories as the difference between the Division of National Cost Estimates, Office of Actuary, Health Care Financing Administration (1987) estimate of 1987 total government spending for that category and the implied spending on the elderly. This estimate includes both Medicaid spending for the nonelderly and medical care spending for government employees. We distributed this spending by age on the basis of Medicaid spending, as presented in Public Health Service (1989). All of the estimates were converted to 1989 dollars using category-specific projections of 1987–1990 inflation in Division of National Cost Estimates, Office of Actuary, Health Care Financing Administration (1987).

We forecast spending using estimates of inflation rates for the four categories of spending and projections of the age distribution of the population. Hospital care estimates are from the Board of Trustees of the Federal Supplementary Medical Insurance Trust Fund (1988). They imply a steady-state inflation rate above general inflation but below the growth rate of output. Inflation rates for the other three categories were projected to 2000 using the Division of National Cost Estimates, Office of Actuary, Health Care Financing Administration (1987) estimates, and were assumed to grow at the rate of hospital price inflation after that.

Finally, for age-specific spending on education, we obtained 1986 age-specific enrollment rates in school as well as the aggregate amounts spent on primary and secondary education, and higher education. We assumed that all persons under 17 who were enrolled in school were in primary and secondary schools, and all persons 18 and over who were enrolled were in higher education. Spending per person was then the weighted average of the population in each age group and the share of each age group in the two types of education. Our projections assume that education spending would grow at the rate of GNP growth, so that changes in the share of GNP devoted to education change only with changing numbers of young people.

the age profile of education spending. Per capita expenditures on schools for the younger cohorts are substantial, reaching $3,353 a year for children between the ages of 5 and 14. For the three programs combined, spending on the elderly is more than double that of any other group.

Demographic shifts can significantly alter government outlays. Table 9 reports projections of total government outlays as a share of GNP under the assumption that age-specific expenditure patterns remain at 1989 levels for the next 60 years. Primary government spending is assumed to equal a constant fraction of GNP. In these projections,

government spending rises from 31.8 percent of GNP in 1990 to 37.0 percent of GNP in 2060, with nearly all the increase due to changes in medical expenditures and transfer programs to the elderly. Our tax-smoothing calculation assesses the efficiency gains from smoothing the time path of revenues needed to collect this variable expenditure stream.

### *The Efficiency Gains from Tax Smoothing*

We evaluate the efficiency gain from tax smoothing by assuming that the deadweight burden of raising $\tau$ percent of national output in taxes is given by

$$DWL_t = \epsilon\tau_t^2 Y_t/2. \tag{19}$$

The parameter $\epsilon$ depends on the elasticities of aggregate supply and demand and $Y_t$ is national income.[53] The marginal deadweight loss per dollar of revenue raised is $\epsilon\tau_t$. We calibrate $\epsilon$ by setting the marginal deadweight loss from raising one dollar equal to 30 cents, the upper-bound estimate in Charles Ballard, John Shoven, and John Whalley's general equilibrium analysis of the U.S. tax system.[54] Their calculation employs 1973 data, when federal and state-local taxation in the United States was 31 percent of GNP, and therefore implies $\epsilon \cong 1.0$.

We assume that a government planner seeks to minimize the present discounted value of the deadweight losses from taxation over a $T$ period horizon:

$$V = \sum_{t=1}^{T} \left[ \prod_{i=1}^{t} (1 + r_i)^{-1} \right] \epsilon\tau_t^2 Y_t/2, \tag{20}$$

where $r_i$ denotes the one-period nominal interest rate in period $i$. This minimization is subject to an intertemporal budget constraint linking taxes and spending as a share of GNP ($\tau_t$ and $h_t$, respectively) with government debt as a share of GNP ($d_t$). For each period, this constraint is:

$$d_t = d_{t-1}[(1 + r_t)/(1 + \gamma_t)] + h_t - \tau_t, \tag{21}$$

53. If governments set taxes to minimize deadweight loss, the marginal deadweight burden per revenue dollar should be equal across tax instruments. The aggregate tax-to-GNP ratio is then a simple proxy for the level of tax burdens. This convenient assumption neglects the voluminous public finance literature suggesting that marginal deadweight losses vary across tax instruments.

54. Ballard, Shoven, and Whalley (1985).

where $r_t$ is the interest rate and $\gamma_t$ is the rate of output growth.

Summing this forward yields a budget constraint of the form:

$$\sum_{t=1}^{T} \tau_t \delta_t = \sum_{t=1}^{T} h_t \delta_t + d_0 - d_T \delta_T, \tag{22}$$

where $\delta_t = \prod_{s=1}^{t} (1 + \gamma_s)/(1 + r_s)$. Minimizing equation 20 subject to equation 22 yields first-order conditions of the form

$$\epsilon \tau_t = \lambda, \tag{23}$$

so the optimal policy calls for equal tax rates in each period.

In the case where $r_t = \gamma_t$, the benefits of tax smoothing take a particularly simple form. The budget constraint is

$$\sum_{t=1}^{T} \tau_t = \sum_{t=1}^{T} h_t + d_0 - d_T. \tag{24}$$

If, further, $d_T = d_0$, then with a pay-as-you-go policy, taxes just cover government spending: $\tau_t = h_t$. Under the constant period-by-period debt-to-GNP policy, the deadweight loss is

$$DWL_1 = (Y_0 \epsilon/2) \Sigma h_t^2. \tag{25}$$

The constant tax rate satisfying the government budget constraint is just the average value of government spending, so that

$$DWL_2 = Y_0 \epsilon/2 \cdot T (\Sigma h_t/T)^2. \tag{26}$$

Thus, the relative deadweight loss from the optimal tax-smoothing policy is:

$$DWL_2/DWL_1 = (\Sigma h_t/T)^2/(\Sigma h_t^2/T). \tag{27}$$

For the expenditure path in table 9, the deadweight loss reduction in equation 27 is 0.3 percent.

The incremental deadweight loss from time-varying tax rates depends on the precise time path of taxes, hence on the government's choice of debt policy. We consider two such policies. The first assumes a constant debt-to-GNP ratio in every year, and the second assumes a constant primary surplus (equal to its value in 1989 of 0.5 percent of GNP) in each year.

Table 10 presents our estimates of the efficiency gains from tax smoothing. The upper panel presents results assuming a constant debt-

**Table 10. Efficiency Gains from Smoothing Taxes, United States, 1990–2050[a]**
Percent

| Tax rate | Year 1990 | 2010 | 2030 | 2050 | Average deadweight loss as percent of average GNP |
|---|---|---|---|---|---|
| *Constant debt-GNP ratio*[b] | | | | | |
| Variable rate | 32.6 | 33.5 | 36.8 | 37.1 | 6.23 |
| Constant rate | 35.3 | 35.3 | 35.3 | 35.3 | 6.22 |
| *Constant primary surplus*[c] | | | | | |
| Variable rate | 32.3 | 33.9 | 37.2 | 37.6 | 6.52 |
| Constant rate | 35.7 | 35.7 | 35.7 | 35.7 | 6.51 |

Source: Authors' calculations based on sources described in table 9.
a. For each spending category, total government expenditures are projected to 2060, as described in table 9. The two cases are described in more detail in the text.
b. Constant debt-GNP ratio is fixed at 1989 level of 50.2 percent.
c. Constant primary surplus assumes that a federal and state-local surplus equals its 1989 share of GNP throughout 1990–2000.

to-GNP ratio, fixed at its 1989 level of 50.2 percent. In this case the pay-as-you-go tax rate rises from 32.6 percent of GNP in 1990 to 37.1 percent by 2050. The average deadweight loss from this policy, shown in the last column, is 6.23 percent of the average value of GNP. The constant tax rate that achieves the same debt-to-GNP ratio of 50.2 percent in 2050 is 35.3 percent. Under this plan, taxes would rise by 3 percent of GNP—roughly $150 billion—in 1990. Despite this large change in the debt trajectory, however, the change in excess burden is small. The average value of deadweight loss is 6.22 percent of average GNP when tax rates are smoothed. The improvement in deadweight loss averages 0.017 percent of GNP annually, or less than $1 billion a year in 1990 dollars. The change in the *present value* of deadweight losses between 1990 and 2060 equals 1.1 percent of 1990 GNP, or approximately $55 billion.

The lower panel in table 10 shows parallel calculations assuming the combined federal and state-local primary surplus equals its 1989 share of GNP value throughout the 1990 to 2050 period. The results indicate that the average excess-burden-to-GNP ratio under this scenario is 6.52 percent, compared with 6.51 percent if the tax rate is smoothed. The difference between these two efficiency costs is similar to that in our first case, 0.017 percent of GNP. Plausible variations in our assumptions

about the debt-to-GNP trajectory therefore do not appear to have large effects on the efficiency gains from tax smoothing. The general conclusion of these calculations is that there is only a weak tax-efficiency case for prepaying the costs of the future dependency burden.

## Conclusions

Demographic changes currently in progress do not appear likely to worsen economic performance in the United States, at least during the next several decades. While increased dependency will reduce living standards by 5–10 percent in the long run, demographic changes will be beneficial over the next 20 years. In the short run, demographic change will have two important effects. First, slowing population growth will permit a smaller share of national output to be devoted to investment in plant, equipment, and housing. Second, the share of the population that is working will rise, largely as a result of the falling relative population of children. These positive effects of demographic change may be reinforced by increased foreign capital inflows and accelerating technical change as firms respond to an increasing scarcity of labor.

Recent and prospective demographic changes do not appear to warrant increasing the national saving rate. These changes increase wealth in the short run, reduce the rate of return to saving, and attract foreign capital. Holding all else equal, their net effect would be a *reduction* in the optimal national saving rate. Nor do tax-smoothing factors represent an important argument for trying to prepay the government's prospective liability to support a dependent population. There is little efficiency loss in following a pay-as-you-go policy with variable tax rates.

Our conclusion departs from analyses, such as that of Henry Aaron, Barry Bosworth, and Gary Burtless, that recommend accumulation of a large social security trust fund to bolster U.S. national saving.[55] These positions are not necessarily inconsistent, however. A first line of reconciliation would hold that apart from demographic considerations, American national saving is much too low right now and that the social security trust fund provides a politically convenient way of reducing the

55. Aaron, Bosworth, and Burtless (1989).

federal government's absorption of private saving.[56] The decline in the private saving rate from an average of 7.1 percent during the 1970s to about 3 percent during 1986–89 is greater than what our analysis suggests can be justified by demographic factors. There are even some reasons for advocating an increase in the U.S. national saving rate to levels above those observed historically, particularly in light of the emerging need for capital in Eastern Europe and the signs that saving is declining outside of the United States.

A second potential reconciliation of these views involves questions of optimal intergenerational redistribution. Some argue for using the social security trust fund to raise the national saving rate in order to avoid unfairly burdening our children. The primary thrust of this argument—that we need to prepare for the anticipated burden of increased dependency—is exactly what our support ratio calculations reject. This is because the dependency burden is remote, and because slower labor force growth means more rapidly diminishing returns to additional saving. Admittedly, our approach focuses on the economy's year-by-year consumption level, rather than the welfare of individual cohorts. It is therefore poorly suited to addressing arguments that certain cohorts will be greatly disadvantaged without additional capital accumulation. However, we do not find compelling the claim that our children will be unfairly burdened unless we increase capital accumulation today.

Two arguments militate against the intergenerational equity case for trust fund accumulation. First, if the aforementioned fears of inequity were correct, the appropriate response should be an adjustment in the level of prospective intergenerational transfers, not a change in capital accumulation policy. Just as concerns about the income distribution at a particular time are better addressed through transfer policies than through changes in the mix of products produced, transfers are the right way to respond to concerns about intergenerational equity.[57]

Second, other considerations operate to make the baby boom generation less well off than its successors. The baby boomers systematically lose because of their large cohort size. During their working years, wage growth is slow because of low capital-labor ratios. During their retirement years, the number of potential purchasers of capital will fall, thereby

56. See, for example, Hatsopoulos, Krugman, and Summers (1988).
57. This is the central point made by Calvo and Obstfeld (1988).

reducing the rate of return on saving.[58] Moreover, given productivity growth, the next generation will be considerably more affluent than the current one. If slower population growth or foreign capital inflows accelerate this tendency, the case for intergenerational redistribution is reduced. Even with our estimates of the path of optimal consumption, along which a declining support ratio reduces consumption, the lifetime utility of a person who lives for eighty years *rises* for those born from 1990 until 2020. Only after 2020 does the lifetime utility of new cohorts fall below that of those who lived before the demographic change.

Our aggregate analysis cannot resolve policy debates about raising the birth rate or increasing immigration, since these debates often focus on microeconomic effects and distributional consequences. Moreover, there is a fundamental political difficulty of deciding "who is us." How should the welfare of immigrants be treated in deciding whether or not to accept more of them? How should the utility of an otherwise unborn child be treated? Policy recommendations are impossible without a clear philosophical resolution of these questions.

Our analysis does, however, cast some doubt on the view that in narrow economic terms, higher fertility is helpful in reducing the burden of dependency in old age. Dependency at the beginning of the life cycle is between 50 percent and 100 percent as costly as dependency at the end of the life cycle. It also comes 60 years earlier. Furthermore, the weak available evidence suggests that slower population growth is more likely to raise than to reduce productivity growth.

For the set of issues captured by our analysis, there is a stronger case for increased immigration as a way of reducing dependency. Most immigrants arrive as young adults and so begin working without being dependents first. To the extent that they immediately start paying taxes for the support of the elderly, they may increase economic welfare of the preexisting population, even if they are ultimately eligible for transfer payments in old age.

We have only scratched the surface in assessing the macroeconomic implications of demographic change. Among the main priorities for future research, we would include the following. First, any effects of

58. Mankiw and Weil (1989) predict that real house prices will fall by almost 50 percent over the next 20 years because of demographic changes. While their results may overstate the coming decline, even small reductions in house prices would transfer large amounts of wealth to people who are very young today.

demography on the rate of technical change are likely to dwarf its other consequences. It would be valuable to refine our estimates by considering data spanning longer periods and by experimenting with alternative control variables. Second, how demographic changes affect private saving remains uncertain. Investigating the international experience on this question seems worthwhile, particularly if long-term data can be located. Third, our calculations have assumed that the nonmedical care needs of the elderly are equal to those for the nonelderly. Whether this assumption is correct, and whether it will remain correct as the aged population ages, needs to be investigated. Fourth, it would be useful to analyze more systematically the impact of demographic changes on the welfare of different cohorts. This would require a life-cycle analysis of the questions we address with an infinite horizon setting.[59]

It would also be useful to explore the microeconomic implications of changing demography. For example, our aggregation of capital may well be inappropriate if demographic change alters the relative demands for housing and nonhousing capital. Similarly, demographic changes may have important implications for the labor market position of aged workers and for the relative demands for workers in different occupations.

Further research on these and other related topics is likely to refine the conclusions about demographic change reached here. We doubt that it will alter our primary conclusion that demographic change provides opportunities as well as challenges.

59. Auerbach and Kotlikoff (1987) and Auerbach and others (1989) use a life-cycle model to consider demographic issues, but they assume counterfactually that consumers actually vary their saving rates as the model would predict and do not use the model for normative analysis.

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