**Should America Save for its Old Age?**
**Population Aging, National Saving, and Fiscal Policy**

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**Abstract**

While popular wisdom holds that the United States should save more now in anticipation of the aging of the baby boom generation, the optimal response to population aging from a macroeconomic perspective is not clear cut. Indeed, Cutler, Poterba, Sheiner, and Summers ("CPSS",1990) argued that the optimal response to the coming demographic transition was more likely to be a *reduction* in national saving than an increase. In this paper we reexamine the appropriate response of national saving and fiscal policy to the aging of the population. We focus on the intuition behind the determinants of the optimal response to aging, and explore the robustness of the CPSS conclusion. In particular, we ask how the optimal saving response depends on the openness of our economy, on how we view the consumption of children, and on the existence of pay-as-you-go transfer programs like Social Security and Medicare.

We find that, if the United States were a small open economy and world interest rates were fixed at their current level, the desire to smooth consumption as our population aged would lead us to increase saving today. But the optimal response in a closed economy is much less clear cut, as slower growth of the labor force will push down the rate of return on capital and real interest rates and diminish desired saving. For reasonable parameter values, the optimal response to our aging population in a closed economy is likely to be small--either a small decline in national saving or a small increase. We also explore the role of the government in creating and addressing the problem of population aging. Government programs can influence consumption paths in optimal growth models if the programs affect the capital-labor ratio or the relative weight that society places on the consumption of the elderly.

## 1. Introduction

The approaching retirement of the baby boom generation is one of the most dramatic, yet predictable, events to affect our economy in many years. The financial pressures associated with population aging have been well publicized, and concern about the future solvency of Social Security and Medicare is widespread. Popular wisdom holds that the United States should save more now in anticipation of the coming increase in the share of elderly in our population, and both the government and private individuals are urged to set aside resources today to meet the inevitable demands of the decades ahead. Indeed, it can be argued that the recent turnaround in the federal government's budget balance--from years of deficits to the now-predicted years of surpluses--stems, in part, from a desire to prepare for the retirement of the baby boomers.

Yet, the appropriate saving response to population aging is not clear cut. Cutler, Poterba, Sheiner, and Summers (1990) (hereafter CPSS) argued that the optimal response to the coming demographic transition was more likely to be a *reduction* in national saving than an increase. Moreover, Schieber and Shoven (1994) claimed that baby boomers' sale of accumulated assets during their retirement could lead to a collapse in the prices of those assets.

In this paper we reexamine the appropriate response of national saving and fiscal policy to the aging of the population. We focus on the intuition behind the determinants of the optimal response to aging, and explore the robustness of the CPSS conclusion. In particular, we ask how the optimal saving response depends on the openness of our economy, on how we view the consumption of children, and on the existence of pay-as-you-go transfer programs like Social Security and Medicare.

We find that, if the United States were a small open economy and world interest rates were fixed at their current level, the desire to smooth consumption as our population aged would lead us to increase saving today. But the optimal response in a closed economy is much less clear cut, as slower growth of the labor force will push down the rate of return on capital and diminish desired saving. For reasonable parameter values, the optimal response to our aging population in a closed economy is likely to be small--either a small decline in saving or a small increase. We also explore the role of the government in creating and addressing the problem of population aging. Government programs can influence consumption paths in optimal growth models if these programs affect the capital-labor ratio or the relative weight that society places on the consumption of the elderly.

The next section of the paper sets the stage by documenting the expected changes in demographic structure in the United States and by placing those changes in historical context. It also reviews long-term forecasts of the federal government's spending and revenue. Then we turn to a theoretical analysis of the effect of population aging, exploring a simple model of aggregate income and consumption for both a small open economy and a closed economy. After developing this intuition, we simulate optimal consumption and saving in the United States in light of the expected changes in demographic composition. Finally, we compare the effects of demographic change on the federal government and on the nation as a whole, and discuss the optimal fiscal response to our population aging.

## 2. Changing Demographics in the United States

The retirement of the baby boom generation is part of a dramatic reshaping of the demographic composition of the U.S. population, with important implications for sustainable fiscal policy.[1]

*Population Aging*

When the first baby boomer turns 65 in 2011, there will be about 4½ adults of working age for every person 65 and over, and the elderly will constitute 13 percent of the population. When the last baby boomer turns 65 in 2029, there are projected to be fewer than 3 working-age adults per older person, and the elderly are expected to be almost 20 percent of the population.

Moreover, this pronounced aging of the population is not a temporary phenomenon. The solid line in the top panel of Figure 1 plots the ratio of the working-age to elderly population. The number of potential workers available to support each retiree is expected to fall further after the boomers' retirement, albeit at a much slower pace. This continued aging of the population stems from two factors: the decline in fertility following the end of the baby boom in 1964, and an expectation of increasing longevity (falling mortality rates for older Americans) over the next century.[2] The drop in fertility is the more important factor quantitatively, as can be seen by comparing the solid line with the dotted line, which plots the ratio of workers to elderly assuming

[1] The demographic projections in this paper are drawn from the intermediate (baseline) projections in the 1999 Annual Report of the Social Security Board of Trustees (Social Security Administration, 1999). Lee and Carter (1992), Lee and Tuljapurkar (1994, 1998) and Lee and Skinner (1999) argue that mortality rates are likely to fall faster than predicted by the Trustees, which would accentuate the aging of the population and the associated financial stresses on the federal government.

[2] The temporary surge in fertility during the baby boom deferred population aging but will make it more sudden and pronounced. Weil (1997) provides a more detailed discussion of how changes in fertility and mortality affect population aging.

that future mortality is held constant.[3]

As we will see, aging caused by declining fertility has different economic effects than aging caused by increasing longevity. One source of difference is that decreasing fertility reduces the number of children who need to be supported, while increasing longevity does not. The dashed line in the top panel shows that the ratio of the working-age population to the child population started climbing around 1970, and it is expected to continue increasing slowly over the next 75 years. We will discuss the extent to which a reduction in the burden of children may offset the increased burden of the elderly.

A more important economic difference between population aging caused by decreasing fertility and that caused by increasing longevity is that falling fertility leads to slower growth of the labor force, and rising longevity does not. The bottom panel of Figure 1 plots the past and projected growth rates of the working-age population. Labor force growth is expected to fall to an unprecedented level, which will make it difficult (as we show later) to absorb large increases in saving without significantly reducing the rate of return.

*Fiscal Policy*

The aging of the U.S. population will place great demands on government resources. When the baby boom generation enters retirement, spending on Social Security, Medicare, and Medicaid (which pays for a large share of nursing home expenditures) will likely climb sharply. Moreover, continued increases in health spending per older person make population aging that

[3] We thank the actuaries at the Social Security Administration for providing us with this alternative projection.

much more expensive for the government.

One way to gauge the impact of aging on fiscal policy is to examine the projected financial stresses on specific government programs. Social Security and Medicare Part A (which pays for hospital services) are intended to be self-financing, in the sense that promised benefits should be paid by those programs' dedicated taxes and any assets that have been accumulated in the programs' trust funds. Yet, the current official projections are for Social Security to become insolvent in 2037 and Medicare Part A in 2025. The projections also imply that achieving solvency for the next 75 years would require an immediate 1.89 percentage point increase in the payroll tax for Social Security and a 1.21 percentage point increase in the payroll tax for Medicare (or equivalent cuts in promised benefits). Beyond 2075, support ratios are projected to remain constant, or even decline somewhat more as life expectancy continues to rise. Thus, reaching projected solvency for perpetuity would require significantly larger tax increases or benefit cuts.

Programmatic solvency is a very narrow lens through which to examine the impact of aging on our economy. Programs like Medicaid and Medicare Part B (which pays for physician services) will also face increased demands from population aging, but because they are financed out of general tax revenue, calculations of their long-term solvency are not informative. Instead, we need to ask whether overall fiscal policy is on a sustainable path; that is, is our current tax structure sufficient to finance our current spending promises? Despite significant improvements in recent years, many analysts still conclude that fiscal policy is on an unsustainable trajectory, as the projected increases in spending for Social Security, Medicare, and Medicaid will eventually outstrip revenue.[4]

Perhaps the most appropriate perspective for thinking about the impact of population aging is for the economy as a whole. The optimal response to the fiscal imbalance depends on the effect of population aging on overall consumption opportunities. Thus, we begin our analysis at an aggregate economic level and return later to focus on the government.

## 3. Aggregate Income and Consumption with an Aging Population

Two distinct approaches have been used to study the optimal fiscal response to population aging. Most analysts have focused on the financial pressures facing government transfer programs like Social Security and Medicare. As we just noted, without significant pre-funding, the solvency of these programs will require sizable cuts in benefits or boosts in taxes. And real pre-funding, as opposed to mere paper transactions with the trust funds, requires an increase in government saving.[5] On the other hand, CPSS focused on aggregate saving and consumption using the Ramsey model, and made no explicit reference to government programs like Social Security or Medicare. They concluded that the optimal response to the coming demographic change is to reduce national saving, not raise it. A primary goal of this paper is to clarify the differences between these approaches and resolve their opposing recommendations for fiscal policy. To do so, we use both the Ramsey model and Diamond's (1965) overlapping-generations model.

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[4]See Congressional Budget Office (1999).

[5] For example, see Group of Ten (1998) and Aaron, Bosworth, and Burtless (1989).

*The Aggregate Budget Constraint*

We use a simple macroeconomic framework to characterize feasible consumption paths in terms of the dependency rate and the labor force growth rate. We include workers and old people but wait to include children until we have gained intuition in this simpler situation. We assume that demographic shocks occur instantaneously: An increase in longevity is modeled as a sudden increase in the number of old people, and a decrease in fertility is modeled as a sudden decrease in the number of workers.

Aggregate income $Y$ is the sum of labor and capital income:

$$Y = W N_w + r A \quad , \tag{1}$$

where $w$ is the wage, $N_w$ is the number of workers, $r$ is the interest rate, and $A$ is the stock of assets. In steady state, aggregate saving $S$ must be exactly sufficient to maintain a constant amount of assets per worker, implying that $S = nA$, where $n$ is the growth rate of the labor force. Then, steady-state aggregate consumption $C$ is:

$$C = Y - S = W N_w + (r - n) A \quad . \tag{2}$$

Following CPSS, we define the "support ratio" as:

$$\alpha = \frac{N_w}{N_w + N_o} = \frac{N_w}{P} \quad ,$$

where $N_o$ is the number of old people and $P$ is total population. Decreases in the support ratio correspond to increases in the more familiar dependency ratio.[6] Let $a$ be assets per worker, or $A/N_w$. Then, we can write steady-state consumption per capita as:

[6] Specifically, $\alpha = 1/(1+d)$, where $d$ is the dependency ratio $N_o/N_w$.

$$c = \frac{w N_w + (r - n) A}{P} = \alpha \ (w + (r - n) a) \quad . \qquad (4)$$

That is, consumption per person equals the number of workers per person times the sum of labor income per worker and capital income per worker in excess of the need for new saving to maintain the same assets for each member of the next generation.[7]

Equation (4) shows that demographic shifts can affect steady-state consumption possibilities (for given $w$, $r$ and $a$) by changing the support ratio α, the labor force growth rate $n$, or both. Recall that population aging will result from either an increase in longevity or a decrease in fertility. An increase in longevity reduces the share of workers in the population. This drop in the support ratio α lowers sustainable consumption through what CPSS label the "dependency effect." A decrease in fertility has two opposing effects on steady-state consumption. First, like an increase in longevity, it reduces α and thereby sustainable consumption. Second, it reduces the labor force growth rate, which lowers the amount of saving needed to maintain a given level of assets per worker. This drop in *n raises* sustainable consumption through what CPSS call the "Solow effect."

*Optimal Consumption*

In addition to the steady-state consumption possibilities described by equation (4), we are interested in the optimal *path* of consumption as well--a path that will depend on expected

[7] In an economy with labor-augmenting technical change, these variables should be interpreted as consumption per "effective person," and wages and assets per "effective worker," where effective people and workers grow at the rate of the population and labor force (respectively) plus the rate of technical progress. We generally abstract from technical change in our analysis.

demographic shifts as well as shifts that have already occurred. We will not calculate precise consumption paths until we turn to the simulations, but even characterizing those paths qualitatively requires a specification of preferences. We describe the Ramsey planner here and discuss the overlapping generations model later.

We assume that a social planner maximizes:

$$V = \int_t^\infty U(c_t)\ P_t\ e^{-\rho t}\ dt \quad , \tag{5}$$

where ρ is the time preference or discount rate. This social welfare function weights average utility at a point in time by the number of people alive at that time, and we find it more compelling than the common alternative welfare function that omits the $P_t$ term.[8]

## 4. Small Open Economy

We explore the effect of population aging in both a small open economy, which we describe here, and a closed economy, which we discuss in the following section.

### *A Ramsey Planner*

In a small open economy, the wage and the interest rate are fixed exogenously. A social

[8] This social welfare function is the one used by CPSS (1990) and Romer (1996). Others, such as Blanchard and Fischer (1989), use a utility function that does not weight by population. We find this alternative utility function much less compelling, because it implies that individuals in large cohorts will have lower consumption, as it takes more resources to raise average consumption in such cohorts. See Arrow and Kurz (1970) for a discussion. In addition to allocating total consumption over time, the Ramsey planner also allocates consumption across individuals at each point in time. Calvo and Obstfeld (1988) show that these decisions can be made independently under certain conditions, including the existence of lump-sum taxation.

planner maximizes equation (5) subject to an intertemporal budget constraint that sets the present discounted value of aggregate consumption equal to the present discounted value of aggregate wages plus the value of initial assets:

$$\int c_t P_t e^{-rt} dt = \int w_t N_{w_t} e^{-rt} dt + A_0 \quad . \tag{6}$$

The consumption path that solves this problem satisfies the Euler equation

$$\frac{\dot{c}}{c} = \sigma (r - \rho) \quad , \tag{7}$$

where σ is the intertemporal elasticity of substitution in consumption. We assume that the world interest rate $r$ equals the rate of time preference ρ, so that the country is not accumulating or decumulating assets forever. Then, $\dot{c}$ equals zero, and the planner chooses the level of sustainable consumption and maintains it forever; if the demographic shock occurs instantaneously, the implied level of assets per worker will be stable as well.

Figure 2 shows the optimal consumption response to two types of population aging, with the top panel treating a one-time increase in longevity and the bottom panel a one-time decrease in fertility. The solid line in each panel shows the consumption possibilities frontier before the demographic shock; the dashed lines show the frontiers after the shock.

As we noted above, an increase in longevity reduces α and shifts the consumption frontier down. If the shift occurs without warning, optimal consumption drops immediately to $c_2$ and assets per worker are unchanged. If the shift is foreseen, optimal consumption will stop drop immediately upon discovery to its new, permanent level--but that level, $c_2$ ‘, is somewhat higher than $c_2$. The additional saving in advance of the boost in longevity raises assets per worker, and the larger assets finance the ultimate higher consumption level.

A unexpected decrease in fertility is more complicated. First, the drop in α pushes the frontier down. Second, the reduction in *n* increases the slope of the frontier (dominating the impact of smaller α, which tends to flatten the frontier). These changes represent the dependency and Solow effects defined above. But there is a third effect as well: the smaller number of workers causes an immediate jump in assets per worker (from $a_1$ to $a_2$), although aggregate assets obviously remain unchanged.[9] The net effect on consumption depends on the level of initial assets. At some asset level, the increased dependency is just offset by the reduction in required investment and jump in assets per worker, and steady-state consumption is unchanged. This is the case at $a_1$, as depicted in the bottom panel of Figure 2.[10] Because the Solow effect increases with assets, while the dependency effect is unchanged, more initial assets increases the relative size of the Solow effect. Thus, for initial assets below $a_1$, a reduction in fertility lowers consumption; for initial assets above $a_1$, a reduction in fertility increases consumption.

A decrease in fertility that is expected in advance would cause consumption to move in the same direction as if the same shock had hit without warning, but not to move as far. The planner uses the advance warning to smooth consumption, as one would expect.

It is useful for later comparison to determine the initial assets at which an unexpected fertility shock has no effect on consumption. Expressing the support ratio in terms of *n*,

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[9] There is no jump in assets per old person. However, the approach followed here creates a more natural transition to the closed economy case, where capital per worker determines the wage and interest rate.

[10] Because of the jump in assets per worker, $a_1$ is less than the level of assets around which the budget constraint pivots, which is where the Solow and dependency effects are exactly offsetting.

$$\alpha = \frac{N_w}{N_w + N_o} = \frac{(1+n)\,N_o}{(1+n)\,N_o + N_o} = \frac{1+n}{2+n} \quad , \tag{9}$$

and remembering that $a = A/N_w = A/(N_o(1+n))$, consumption can be written as:

$$c = \frac{(1+n)}{(2+n)}\, w + \frac{(r-n)}{(2+n)}\, \frac{A}{N_o} \quad . \tag{10}$$

This implies:

$$\frac{dc}{dn} = \frac{w}{(2+n)^2} - \frac{(2+r)}{(2+n)^2}\, \frac{A}{N_o} \quad , \tag{11}$$

and the level of assets per worker at which $dc/dn = 0$ is:

$$a^* = \frac{A^*}{N_w} = \frac{A^*}{N_o(1+n)} = \frac{w}{(2+r)(1+n)} \quad . \tag{12}$$

*Overlapping Generations*

Now suppose that the small open economy consists of overlapping generations of lifecycle consumers who live for two periods. When people are young, they work, pay Social Security taxes, and receive a bequest from the old. When people are old, they are retired, and they finance their consumption and bequests through their savings and Social Security benefits. We assume for now that the Social Security system is entirely unfunded or pay-as-you-go, so total taxes equal total benefits. We also assume for now that bequests are exogenous, and that, in steady-state, each successive generation of workers receives the same size bequest as the previous. As a result, each successive retired generation must leave a larger bequest than it received when young because of population growth. One might also think of these bequests as government programs that transfer resources from the old to the young, such as property tax payments for schools. Therefore:

$$c_w = w - s - t + q \quad , \textit{ and} \tag{13}$$

$$c_o = s(1+r) + t(1+n) - q(1+n) \quad , \tag{14}$$

where $c_w$ and $c_o$ are consumption when working and when old, $s$ is saving, $t$ is taxes paid, and $q$ is the bequest received. We assume that individuals' time preference rate equals the interest rate (as for the Ramsey planner), so they set consumption when working equal to consumption when old:[11]

$$s = \frac{w - (t-q)(2+n)}{2+r} \quad , \text{ and} \tag{15}$$

$$c_w = c_0 = c = \frac{(1+r)}{(2+r)}w - \frac{(r-n)}{(2+r)}(t-q) \quad . \tag{16}$$

We cannot analyze longevity formally at this point because of our simple model of preferences, but we return to this topic later. It is clear intuitively that, just as in the Ramsey model, an increase in longevity reduces consumption, as unchanged lifetime income is spread over more years of consumption.

A decrease in fertility has no effect on consumption if there are no bequests and no taxes or benefits. The wage and interest rate are fixed exogenously, and everyone saves for his or her own retirement; the size of previous or subsequent generations is simply irrelevant to each individual. More formally, a change in fertility has no impact on budget constraints or

[11] We later allow for the utility from consumption to depend on people's age, so that $c_o$ might differ from $c_w$ even if the interest rate equals the time preference rate. This complication does not affect the intuition relating the overlapping generations model to the Ramsey model.

preferences, and therefore no impact on optimal consumption in equation (15). This conclusion may seem puzzling in light of the various effects at work in the Ramsey model. However, one can easily show that assets per worker in this economy equal the assets at which consumption in the Ramsey model is unaffected by a fertility shock. Specifically, using equation (15) with $t = q = 0$:

$$a = \frac{A}{N_w} = \frac{sN_o}{N_w} = \frac{s}{(1+n)} = \frac{w}{(2+r)(1+n)} \quad , \tag{17}$$

which is the formula for $a^*$ in equation (11) above.[12]

A decrease in fertility *will* affect consumption if there are bequests or a pay-as-you-go Social Security system, which are exactly the situations where assets per worker differ from $a^*$. An unfunded Social Security system decreases desired saving, and bequests have the opposite effect. If $t > q$, the net effect is to push assets per worker below $a^*$, so a fertility decrease will reduce consumption; if $t < q$, the reverse is true. Intuitively, the presence of Social Security or bequests means that people do care about the size of other generations. A decrease in fertility means that the previous generation is larger relative to one's own than it would be otherwise. From the perspective of a worker, this implies larger Social Security taxes (for any given amount of benefits) but also larger bequests received (for any given amount of total bequests given).[13]

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[12] Our discussion of the Ramsey model included the dependency effect, the Solow effect, and the initial jump in assets per worker. Because these effects apply to the economy as a whole rather than any individual, it is not immediately obvious that the effects are exactly offsetting under these circumstances. Nevertheless, it is straightforward to show that this is true.

[13] Weil (1994) showed that the existence of bequests means that countries with a large elderly share of the population may not have low saving rates, because the high dissaving of the elderly may be offset by higher saving on the part of those receiving bequests.

Whether the net effect on consumption is positive or negative depends on whether the net transfer to the worker is positive or negative: if taxes are larger, then a decrease in fertility will depress consumption, but if the bequest is larger, the reverse is true.

We can extend this basic story in several ways. First, suppose that the government is running a fully funded Social Security system. In this situation, people are essentially saving for their own retirement (albeit through the government), and our formulas can be easily modified to show that the system is irrelevant for the impact of changing fertility on consumption. Second, suppose that there is no Social Security system but that the government has issued debt. As shown by Auerbach, Gokhale, and Kotlikoff (1991), the implicit debt of an unfunded Social Security system is equivalent to explicit debt of the government. Thus, government debt plays the same role as unfunded Social Security in determining the impact of lower fertility on consumption.

## 5. A Closed Economy

In a closed economy, the dependence of the wage and interest rate on demographic composition and saving decisions fundamentally alters the Ramsey planner's decisions. It also means that overlapping generations are linked even in the absence of pay-as-you-go transfers or bequests.

### *A Ramsey Planner*

The wage and interest rate are now determined by the amount of capital per worker, so we substitute the concept of "capital" for "asset" from the small open economy. The steady-state national budget constraint can be rewritten in per capita terms as:

$$c = \alpha(f(k) - nk) \quad , \tag{18}$$

where $k$ is the capital-labor ratio and $f(k)$ is the production function, which we assume exhibits diminishing returns to scale. A social planner maximizes the social welfare function (5) subject to a capital accumulation constraint analogous to equation (6):

$$\dot{k}_t = f(k_t) - \frac{c_t}{\alpha_t} - n_t k_t \quad , \tag{19}$$

choosing a consumption path that satisfies the Euler equation:

$$\frac{\dot{c}_t}{c_t} = \sigma \; (f'(k_t) - \rho) \quad . \tag{20}$$

*The Special Case When Consumption is Not Substitutable Over Time*

In the case of $\sigma = 0$, the planner will maintain a constant level of per capita consumption, so the consumption path will be unaffected by the relative price of consumption in different periods.[14] This situation is quite similar to the small open economy, where the relative price of consumption is fixed. Figure 3 depicts the optimal response to population aging, with the top panel again dealing with an increase in longevity and the bottom panel a decrease in fertility. The consumption possibilities frontiers are curved rather than straight (as in the small open economy) because of the diminishing returns to capital.

An increase in longevity lowers the share of workers in the population ($\alpha$), shrinking

[14] This is a Leontief utility function, where an increase in consumption in one year that is not accompanied by an increase in consumption in every year does not raise social welfare.

consumption at every level of capital. Without forewarning, consumption will simply jump down from $c_1$ to $c_2$. With forewarning, consumption will drop somewhat less and stay at $c_3$ permanently, and the extra saving before the longevity shock boosts the capital stock to $k_3$. In an open economy, an increase in saving receives a fixed return equal to the world interest rate. In a closed economy, increases in saving that raise capital per worker cause a reduction in the rate of return. Hence, a longevity increase leads to a bigger reduction in consumption in a closed economy than in an open economy because of diminishing returns.

A decrease in fertility lowers both α and *n*. For larger *k*, the Solow effect of reducing the investment required to equip the next generation of workers becomes more important relative to the dependency effect of reducing the share of workers in the population, and the consumption frontiers eventually cross. As we show in our calculations below, a decline in fertility will lower steady-state consumption at the current U.S. capital stock. Thus, an unexpected drop in fertility causes a jump in capital per worker from $k_1$ to $k_2$, and a drop in consumption from $c_1$ to $c_2$. Forewarning of a fertility decline depresses consumption by less, to $c_3$, and extra saving before the shock followed by the jump in capital per worker eventually leaves the economy at $k_3$.

*The General Case When Consumption is Substitutable Over Time*

In the previous examples, the social planner effectively chose to increase the capital-labor ratio following many demographic shocks, even though the increase in that ratio diminished the marginal product of the additional capital. This insensitivity to the return to saving does not hold when $\sigma$ differs from 0 and the planner chooses the capital stock so that $f'(k) = \rho$.[15] In this general closed-economy case, changes in fertility or longevity will *not* affect the *steady-state* capital-labor ratio, which is pinned down by the social rate of time preference, although they will usually alter the capital-labor ratio along the transition path. Figure (4) depicts the optimal consumption response to population aging in this situation; the vertical line in both panels is the locus $\dot{c} = 0$, which is the level of $k$ such that $f'(k) = \rho$.

If longevity increases without warning, consumption falls from $c_1$ to $c_2$ with no change in the capital-labor ratio, as in the cases we have examined so far. If a longevity increase is anticipated, $c$ falls and $k$ rises until the shock hits. Then $k$ moves back to its initial level and $c$ continues to fall to $c_2$. The forewarning helps the social planner smooth consumption but does not affect the long-run equilibrium.

If fertility decreases without warning--a case not shown in the figure--the capital-labor ratio jumps up and the rate of return on capital falls. The optimal consumption response is ambiguous: *Consumption may increase or decrease* as necessary to lie along the transition path. Over time, the economy moves along the transition path back to the original value of $k$. If a fertility drop is anticipated--the case shown in the figure--the ultimate steady state is the same but the transition path is different. When the news is revealed, consumption jumps. The jump must be such that when the shock hits and capital per worker jumps up, and the economy must be on the transition path to the new steady state. This jump in consumption may be up or down; we

[15] This statement is true in a small open economy as well. However, in that case, we assumed that the world interest rate was equal to the rate of time preference. In an economy with technical progress at rate $g$ and depreciation at rate $\delta$, the steady state condition is $f'(k) = \rho + \delta + g/\sigma$.

have drawn the figure so that consumption moves up initially.

Why might the planner raise consumption in the short run? On one hand, the planner wants to smooth consumption, and since ultimate consumption is lower than current consumption, this tends to reduce consumption immediately. On the other hand, the slower expected growth of the labor force depresses the return to capital, which tends to boost consumption. Which effect dominates depends on the size of the shock, the substitutability of consumption over time, and the substitutability of capital for labor in production (which determines how quickly $f'(k)$ falls with increasing $k$). For example, if the intertemporal elasticity of substitution is larger, the planner is more sensitive to the declining rate of return and the optimal response is more likely to be a temporary increase in consumption.[16]

*Intuition from the Overlapping Generations Model*

In a small open economy, increases in longevity always require a drop in consumption, but reductions in fertility affect consumption only if there are intergenerational transfers. In a closed economy, reductions in fertility affect consumption even without intergenerational transfers, because generations are linked by the dependence of the return on capital on the size of the labor force. Consider an economy with no bequests or pay-as-you-go programs, so that each individual saves for his own retirement. If this economy is small and open, a drop in fertility raises assets per worker, but does not affect the level of feasible consumption. If this economy is closed, however, the boost in capital per worker lowers the return to saving, which forces a change in consumption.

[16] The extent of forewarning affects the size of the consumption change but not its sign.

If the capital stock is larger than in a no-bequest/no-pay-as-you-go economy, the Solow effect would be larger than the dependency effect, potentially offsetting the impact of diminishing returns. Thus, at some capital stock, $k^*$, a reduction in fertility might not *require* a change in consumption. However, unless consumption is invariant to interest rates ($\sigma = 0$), the optimal response to a fertility shock at $k^*$ would still be to raise current consumption and lower future consumption.

## 6. The Needs of the Elderly and the Needs of Children

The social welfare function in equation (5) depends on consumption per person, and it leads the social planner to equalize consumption across individuals. Modifying that welfare function to allow people of different ages to have different consumption levels is straightforward. For example, if

$$v = \int [N_{w_t} U(c_{w_t}) + \gamma N_{o_t} U(c_{o_t}/\gamma)]\, e^{-\rho t}\, dt \quad , \tag{22}$$

the social planner will set the marginal utility of consumption by each worker equal to that of each older person, which requires that the consumption of an older person be $\gamma$ times that of a worker. If the elderly consume less because of lower lifetime income, $\gamma$ would be less than 1; on the other hand, if the elderly consume more because of higher medical needs, then $\gamma$ would be greater than 1. Substituting this welfare function for equation (5) has no effect on our analysis except that the support ratio $\alpha$ is no longer simply the number of workers relative to the population, but the number of workers relative to a population total that gives the elderly a weight of $\gamma$.

Children can be included in the social welfare function in two ways. First, children's consumption can be viewed as one item in their parents' consumption basket, which implies that consumption of children is perfectly substitutable for other consumption. When a decrease in fertility leads to fewer children per worker, workers simply substitute some other consumption item, and their total consumption is unaffected. With this approach, the social welfare function is still equation (20), but the $\gamma$ weight on the elderly reflects the consumption needs of the elderly relative to the joint consumption needs of parents and their children.

Alternatively, the consumption of children may not be perfectly substitutable for their parents' consumption. In this case, the social planner responds to a decline in fertility by raising the consumption of both workers and older people. The appropriate social welfare function is:

$$v = \int [N_{w_t} U(c_{w_t}) + \gamma N_{o_t} U(c_{o_t}/\gamma) + \varphi N_{k_t} U(c_{k_t}/\varphi)] \, e^{-\rho t} \, dt \quad , \tag{23}$$

where $N_k$ is the number of children and $\varphi$ is the consumption weight of children. Here, $\varphi$ reflects the consumption needs of the elderly relative to the consumption needs of parents *not* including their children.

How do these different formulations of the social welfare function affect our analysis? The first version corresponds quite closely to our analysis, as long as bequests are interpreted as the flow of resources from the elderly to workers *and* their children. The second version implies that a given decline in fertility would have a smaller effect on the support ratio than we previously discussed, because the runup in elderly dependency is partly offset by a drop in youth dependency. For example, we found that a decrease in fertility in a small open economy with no transfers or bequests would have no effect on consumption.[17] Yet, if we include children separately in the social welfare function, a decline in fertility would allow a boost in consumption for both workers and the elderly.[18] Under this view of children, the *inter vivos* transfers that support children are like bequests; a change in fertility would have no effect on consumption only if these “bequests” were offset by a transfer from workers to older people.[19]

## 7. Responding to Demographic Change in the United States

With these theoretical results and intuition in hand, we now turn to a quantitative exploration of the optimal consumption response to population aging in the United States.

### *Characterizing the Demographic Shocks*

In the real world, demographic change is much more gradual and irregular than the one-time shocks to $\alpha$ and $n$ that we have analyzed so far. Figure 1 summarizes the demographic shifts projected for the United States over the next seven decades. The implications of these shifts are summarized in Table 1, which shows the changes in steady-state consumption given the *current* capital-labor ratio and *projected* levels of $\alpha$ and $n$; thus, it traces the movement of the consumption possibilities frontier over time but does not show the optimal capital-labor ratio or

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[17] While the total amount of consumption would be unchanged, workers would shift their consumption basket away from the goods used to support children in favor of other goods.

[18] It is important to distinguish between increases in consumption and increases in utility. Having fewer children may raise consumption, but it could still lower utility.

[19] Lee (1995) explores how the direction of transfers in a society affects the impact of demographic change.

optimal consumption.

The table uses four alternative measures of dependency, or support ratios. The first column is based on a "separate children" support ratio, which assumes that children's consumption is not perfectly substitutable for their parents'. We estimate that a child consumes 62 percent as much as a worker, and an older person consumes 137 percent as much, so that $\varphi$ and $\gamma$ from equation (23) are is .62 and 1.37, respectively.[20] The second column is based on a "family" support ratio, in which children's consumption *is* a perfect substitute for parents' consumption and only total family consumption matters. For this case, we use Gokhale, Kotlikoff, and Sabelhaus's (1996) estimate that consumption per old person is 106 percent of consumption per worker including a worker's children ($\gamma$ in equation (22) is 1.06).

The third and fourth columns repeat the initial support ratios from the first and second columns, but they incorporate a gradual rise in the cost of medical care that pushes down the support ratios over time. The Health Care Financing Administration (1999) projects that Medicare spending per beneficiary will increase about one-half percent faster, on average, than real wages over the next 25 years and will rise roughly in line with wages thereafter. By assuming that national per-capita health spending follows the same contour, the weight on the elderly increases from 1.37 to 1.45 by 2040 in the third column, and from 1.06 to 1.10 by 2040 in

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[20] To calculate relative needs for medical care and education, we used data on the age distribution of health spending from Waldo et al (1987) and of education spending from CPSS (1990), updated to reflect growth in national spending on health and education. For all other goods, we assumed that children consume half as much as a working-age adult. Combining these assumptions with the data in Gokhale, et. al. (1996) about the consumption of the elderly relative to workers and their children, we calculated the ratio of consumption of the elderly to workers alone. The resulting support ratio is conceptually the same as that considered by CPSS (1990), although they used slightly different weights.

the fourth column.[21] Allowing the weight on the elderly to increase with medical costs presumes that we want the overall consumption of the elderly to rise relative to that of workers and children. If, instead, we expect the elderly to consume more medical care but less of other goods, then the relevant columns in the table are the first two, regardless of whether medical spending increases.

In the first column of Table 1, the long-term reduction in feasible consumption owing to population aging is more than offset in the next two decades by the reduction in youth dependency. In terms of our previous theoretical discussion, this corresponds to the $\dot{k} = 0$ curve in Figure 4 shifting up for 20 years and then down thereafter. In the second column, the use of the family support ratio produces a much smaller upward shift in the consumption frontier and a larger ultimate decline. The third and fourth columns show that the consumption outlook is more pessimistic if one allows the projected increase in health spending to raise the overall consumption of the elderly.

*Estimating Optimal Paths*

To simulate the optimal response of consumption to population aging, we assume that the economy's current capital-labor ratio represents a steady state with regard to the current levels of

[21] Projections for Medicare spending have been substantially reduced in the past few years, owing to program changes introduced by the Balanced Budget Act of 1997, a successful crackdown on fraud and abuse within the program, and other factors. As a result, the projected rise in the consumption weight on the elderly is relatively small. Using the Medicare projections from 1997 would raise the weight on the elderly to 160 percent by 2040, compared with 145 percent using the 1999 projections. The current projections may be overly optimistic, especially in light of the political pressures to expand benefits. On the other hand, Cutler and Sheiner (1998) explore the extent to which improvements in health might reduce health expenditures below the level assumed by the Medicare Trustees.

$\alpha$ and $n$. Then we let demographic conditions evolve as projected, and calculate the path of optimal consumption and the implied levels of saving, the capital-labor ratio, and the rate of return on capital.

We perform some simulations assuming that the United States is a closed economy and some assuming that it is open and that world interest rates are fixed. By comparing the results, we can determine the quantitative importance of diminishing returns to capital as the capital-labor ratio is pushed up by slower labor force growth and a desire to smooth consumption. Moreover, which of these scenarios is more relevant for the United States is not clear. On one hand, net capital flows are much smaller than one might imagine, given the apparent mobility of capital and the growing amount of gross capital flows.[22] In addition, most of the other developed countries are aging more rapidly than the United States, so the prospective increases in their capital-labor ratios are likely to push down world interest rates.[23] On the other hand, it is conceivable that large amounts of U.S. capital could flow to developing countries over the next several decades, which would enable us to do more saving without depressing the rate of return.

When we model the United States as a closed economy, the extent to which a given increase in the capital-labor ratio will depress the return to capital depends on the elasticity of substitution between capital and labor in the production function. We use a Cobb-Douglas production function, which imposes a unitary elasticity; a smaller elasticity would lead to more rapidly diminishing returns. When we model the United States as an open economy, we

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[22] See Feldstein and Horioka (1980) and Mussa and Goldstein (1993).

[23] CPSS analyze a two-country simulation model representing the United States and other developed countries.

substitute the concept of assets for that of capital, and hold the return to assets constant as assets per worker increase. Because receipts of factor income from the rest of the world are roughly equal to payments of factor income to the rest of the world, we set the initial value of $a$ equal to $k$.[24]

*Optimal Response in a Small Open Economy*

We showed earlier that the optimal response to an expected demographic shock in a small open economy is a one-time jump to the new sustainable level of consumption. Table 2 shows that, if the United States can be viewed as a small open economy, the projected aging of the population should cause an immediate drop in consumption. When medical cost increases do not affect the overall needs of the elderly, and children's consumption is considered separately from their parents', the reduction in consumption is quite small--only 0.8 percent. If we expect the needs of the elderly to increase between now and 2025, and we view children's consumption as part of their parents' consumption, the optimal response is a much larger decline in consumption: -2.7 percent. This range translates into an increase in current saving of $50 billion to $175 billion per year.

Although consumption is constant over time in a small open economy, assets per worker

[24] We parameterize the model by updating the calculations in Elmendorf and Mankiw (1999). During 1960 to 1997, the average capital-output ratio was 3.2 and the average net return to capital was 5.8 percent. Our results are sensitive to the return to capital: the smaller the discount rate, the lower is optimal consumption today. However, the results are completely insensitive to the rate of technical progress, except that consumption values must be interpreted as consumption per "effective" person, where effective people increase at the rate of technical progress. Finally, we assume that demographic composition remains constant after 2075, the last year of the official projections.

are not.  The bottom rows of the table show that assets per worker increase between 46 percent and 52 percent in response to the aging of the population.  These extra assets would all be invested abroad, as our own capital-labor ratio is fixed by the world interest rate.

*Optimal Response in a Closed Economy*

The results for the closed economy differ from those for the small open economy in two related ways.  First, diminishing returns to capital in a closed economy reduce the additional future consumption that can be supported by a given increase in saving.  Second, changes in the return to capital generally induce the social planner to adjust the time profile of consumption.

Table 3 focuses on the first of these differences by assuming that consumption is not substitutable over time, so that the social planner chooses a constant consumption level regardless of the path of interest rates.  The optimal decline in consumption ranges from 1.5 percent, for the separate children support ratio with unchanged elderly needs, to 3.7 percent, for the family support ratio with a rising weight on the elderly.  Comparing these results with those for a small open economy shows that the diminishing returns to capital in a closed economy reduce initial consumption by an extra 0.7 percent to 1.0 percent, depending on which support ratio is used.  The bottom rows of the table show that the increase in capital per worker required to sustain the new level of consumption causes a dramatic drop in the return to capital.  Under this scenario, the rate of return in 2070 will be only a half (or a little over half) what it is today.

If consumption has any degree of intertemporal substitutability, such a steep decline in the return to saving would lead to greater consumption in the near term and less consumption in the distant future.  Table 4 shows how the extent of substitutability affects the path of optimal consumption, presenting alternative results for the intertemporal elasticity of substitution equal to 0 (reproduced from Table 3), 0.3, and 0.7.[25]

The top panel addresses our first support ratio, for which there is no increase in elderly dependency over time and children are treated separately. For this measure of dependency, even a moderate degree of intertemporal substitutability makes the optimal response to expected population aging an initial *increase* in consumption. In fact, this was the support ratio used by CPSS, and this is the conclusion they reached.[26] As shown in the third panel, accounting for rising medical costs does not alter this conclusion (although using the more pessimistic Medicare projections of just a few years ago would). Using the family support ratio--viewing the consumption of children as an item in their parents' consumption basket--does change the conclusion, however. The second and fourth panels show that, with a moderate intertemporal elasticity of substitution, the optimal change in initial consumption is a small decline. However, the decrease is much smaller than would be optimal in a small open economy or a closed economy with $\sigma = 0$. Thus, in determining the appropriate response to population aging, it is crucial to consider the general equilibrium effects on the rate of return.

Figure 5 presents the time paths of the interest rate and wage under four alternative simulations. Even with a high degree of intertemporal substitutability, slower labor force growth raises the capital-labor ratio temporarily, which depresses the return to capital and boosts the

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[25] Elmendorf (1996) reviews the empirical evidence regarding this elasticity and concludes that a value of one-third is reasonable.

[26] CPSS also used a much higher discount rate in their simulations--10.3% vs our 5.8%. Because population aging presents a future problem, a higher discount rate makes it less likely that the optimal response will be a reduction in current consumption.

return to labor. With $\sigma = 0.7$, which has the highest initial consumption and thus the lowest saving, the interest rate falls about one-half percentage point from its initial value by 2025, and the wage rises between 3 and 5 percent. After about 2025, both variables move back toward their starting values. With a lower degree of substitutability, and therefore more saving, interest rates fall much more and wages increase much more.[27]

## 8. The Role of the Federal Government

To what extent is the reduction in future consumption *caused* by pay-as-you-go transfer programs? Is population aging a bigger problem for the government or for the nation as a whole? And, what is the optimal fiscal response to population aging? We address these questions in turn.

### *Did Pay-As-You-Go Transfers Cause the Problem?*

Although Social Security and Medicare are not included explicitly in the Ramsey model, they affect the analysis in two important ways. First, as we showed, a decline in fertility has a more negative effect on steady-state consumption if the capital stock is smaller. To the extent that pay-as-you-go programs have reduced saving and the capital stock (for example, see Feldstein 1974), they have increased the challenge of an aging population.

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[27] Abel and Blanchard (1983) analyze the dynamic effects of various shocks on rates of return and asset prices. The empirical evidence relating asset prices and rates of return to demographic composition is mixed. Mankiw and Weil (1989) found that housing prices were sensitive to demographic changes in the United States, but Engelhardt and Poterba (1991) showed that such a relationship did not exist in Canada. Poterba (1999) reviewed the evidence relating demographics and financial asset returns.

Second, Social Security and Medicare have probably increased the perceived consumption needs of the elderly relative to the needs of workers and children. Gokhale et al (1996) showed that the consumption of the elderly increased dramatically relative to the consumption of the working-age population between 1960 and 1990, a period that includes the introduction of Medicare and Medicaid in the 1960s and substantial increases in Social Security benefits in the 1970s. A greater dependency burden of each older person increases the total burden imposed by population aging.

*Is Aging a Bigger Problem for the Government or for the Nation?*

One might expect that the imbalance in fiscal policy caused by an aging population is bigger than the imbalance in national consumption. After all, the government bears some of the cost of aging--the need to provide Social Security and Medicare to an elderly population that is growing relative to the number of workers--but none of the benefit--the reduced cost of providing for young children at home and adult children through bequests. Yet, the government bears only *part* of the cost of aging, because Social Security, Medicare and Medicaid represent about 60 percent of the elderly's total consumption. Thus, determining whether population aging is a bigger problem for the government or the nation is an empirical question.

Table 5 quantifies the long-term federal fiscal imbalance from these programs. Spending on the elderly is projected to rise from 7.5 percent of GDP in 2000 to around 13 percent by 2070.[28] The health programs roughly double as a share of GDP, while Social Security expands

[28] The government financial projections are drawn from the 1999 Annual Reports of the Social Security and Medicare Boards of Trustees and the U.S. Government Budget (1999).

by about half; this comparison shows that the total increase in government spending on the elderly stems partly from population aging and partly from rising health expenditures per older person.

One way to gauge the relative magnitude of the government's problem and the nation's problem is to compare the required changes in consumption under the simplifying assumption of fixed interest rates. Incorporating the anticipated decline in interest rates would make both problems worse, and would substantially complicate the calculations. Table 2 showed that, if interest rates are fixed, the optimal national response to population aging would be to lower consumption by 0.8 percent to 2.7 percent. For the federal government's problem, suppose that taxes were increased by a fixed percentage of consumption, so that the stream of new taxes was sufficient, in present value, to finance the additional spending on the elderly associated with population aging. We calculate that the necessary tax increases would represent roughly 3 percent of consumption.

This simple comparison suggests that, in present value, the federal government's problem is larger than the nation's problem, so the focus on the future imbalances in the pay-as-you go programs is not misplaced.[29] For the private and state and local sectors, the positive effects of aging on consumption appear to outweigh the negative effects in present value. The comparison

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[29] This comparison should be viewed as a rough approximation. The likely decline in the return on capital that we have discussed could have differential effects on the nation's problem and the government's problem because those problems have different time profiles. In addition, our calculation is derived from government spending as a share of GDP, and ignores the change in consumption as a share of GDP that would arise when the capital-labor ratio increases and saving declines. Lastly, projected government spending incorporates the increase in the Social Security retirement age that will be phased in over the next several decades, so future consumption is already being cut somewhat.

does not show how different the national problem might be in the absence of pay-as-you-go programs. Suppose that the existence of these programs, and the resulting large transfers to the elderly, has boosted the size of bequests. Then, in the absence of pay-as-you-go programs, the public problem would be smaller than we have estimated, but the private problem would be larger.

*Optimal Fiscal Response to Population Aging*

Determining the appropriate response of fiscal policy to population aging is much more complicated than determining the appropriate response by a Ramsey planner who can directly choose each person's consumption. For the government to target national saving, it needs to understand how government policies affect private saving and how people will respond on their own to changing demographic forces. In addition, as shown in Figure 5, population aging may lead to large swings in wages and interest rates, and the government may want to offset some of these swings to ensure a desirable distribution of consumption. For example, if older Americans are hurt by declining interest rates but do not benefit from rising wages, then the optimal response to aging would be a larger increase in taxes on workers and a smaller reduction in benefits than would be the case in the absence of these general equilibrium effects.

Despite these complications, our comparison of the nation's problem and the federal government's problem is instructive. If population aging does not strengthen the case for increasing national saving, then it is less important to address the imbalances in Social Security, Medicare, and Medicaid in ways that increase saving. These findings suggest that a drastic reduction in benefits or increase in taxes is probably not warranted at this time. The government clearly needs to achieve fiscal balance, but the reduction in consumption that this requires can take place gradually, with the burden borne by future taxpayers as well as current taxpayers.[30] It is also important for society to consider the extent to which advances in medical technology should raise the elderly's share of national consumption. Under our current Medicare system, the relative consumption of the elderly will increase in coming decades. Yet, some Medicare reforms--such as the voucher approach proposed by Aaron and Reischauer (1995)--would limit the growth in Medicare costs, reducing the government's problem and potentially the national problem.[31]

Finally, we should emphasize that the appropriate levels of government saving and national saving depend on many factors besides the demographic forces we have examined in this paper. Some analysts believe that U.S. national saving has been too low for some time, distorted by pay-as-you-go transfer programs, distortionary taxes on capital income, or simply individual behavior that is inadequately forward-looking. Moreover, to the extent that the economy has performed extraordinarily well in recent years, it is sensible to increase our current saving to smooth the benefits of these good times over many years to come. In sum, even if the optimal response to the aging of the U.S. population is only a small increase in government saving, tighter fiscal policy may still be warranted for other reasons.

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[30] One argument against a gradually increasing tax rate is that such a policy would involve more deadweight loss than one in which tax rates were constant. However, CPSS showed that this factor is not important quantitatively. Further, the amount of deadweight loss may be smaller if the balance is restored by trimming benefits rather than raising taxes.

[31] From an economic perspective, it makes little difference whether increased government saving is couched in terms of protecting Social Security and Medicare or not. As a political matter, however, pre-funding those programs would make it more difficult to reduce benefits in the future, which would make it more likely that the elderly's share of national consumption will rise.

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## Table 1

**Consumption Possibility Frontiers**
**(Relative to Consumption in 2000)**

| | Alternative Support Ratios | | | |
|---|---|---|---|---|
| | Medical Cost Increases Do Not Affect Elderly Dependency | | Medical Cost Increases Raise Elderly Dependency | |
| | Separate Children | Family | Separate Children | Family |
| 2000 | 0.0% | 0.0% | 0.0% | 0.0% |
| 2010 | 2.20% | 0.5% | 1.9% | 0.3% |
| 2020 | 0.7% | -1.5% | 0.0% | -1.9% |
| 2030 | -5.9% | -7.6% | -7.1% | -8.3% |
| 2040 | -7.5% | -9.6% | -9.0% | -10.5% |
| 2050 | -6.5% | -8.8% | -8.1% | -9.7% |
| 2060 | -8.1% | -10.2% | -9.6% | -11.2% |
| 2070 | -9.3% | -11.4% | -10.9% | -12.4% |

**Table 2**

**Optimal Response to Population Aging in a Small Open Economy**

| | **Alternative Support Ratios** | | | |
|---|---|---|---|---|
| | **Medical Cost Increases Do Not Affect Elderly Dependency** | | **Medical Costs Increases Raise Elderly Dependency** | |
| | **Separate Children** | **Family** | **Separate Children** | **Family** |
| **Permanent Change in Consumption** (relative to 2000) | -0.8% | -2.3% | -1.4% | -2.7% |
| **Evolution of Assets per Worker** (relative to 2000) | | | | |
| 2000 | 0% | 0% | 0% | 0% |
| 2010 | 7% | 9% | 8% | 10% |
| 2020 | 22% | 25% | 25% | 27% |
| 2030 | 34% | 38% | 39% | 41% |
| 2040 | 36% | 40% | 41% | 44% |
| 2050 | 38% | 43% | 44% | 55% |
| 2060 | 44% | 48% | 50% | 47% |
| 2070 | 46% | 50% | 52% | 52% |

**Table 3**

**Optimal Response to Population Aging in a Closed Economy: Consumption Not Substitutable over Time**

| | Alternative Support Ratios | | | |
|---|---|---|---|---|
| | Medical Cost Increases Do Not Affect Elderly Dependency | | Medical Cost Increases Raise Elderly Dependency | |
| | Separate Children | Family | Separate Children | Family |
| **Permanent Change in Consumption** (relative to 2000) | -1.5% | -3.2% | -2.3% | -3.7% |
| **Rate of Return to Capital** | | | | |
| 2000 | 5.8% | 5.8% | 5.8% | 5.8% |
| 2010 | 5.3% | 5.1% | 5.1% | 5.0% |
| 2020 | 4.4% | 4.2% | 4.2% | 4.1% |
| 2030 | 3.8% | 3.6% | 3.5% | 3.4% |
| 2040 | 3.7% | 3.5% | 3.4% | 3.3% |
| 2050 | 3.5% | 3.3% | 3.3% | 3.2% |
| 2060 | 3.3% | 3.1% | 3.1% | 3.0% |
| 2070 | 3.3% | 3.1% | 3.0% | 2.9% |

**Table 4**

**Optimal Response to Population Aging in a Closed Economy: Consumption Substitutable over Time**

| Support Ratio | Intertemporal Elasticity of Substitution in Consumption | Consumption Relative to 2000 | | | |
|---|---|---|---|---|---|
| | | Initial Change | In 2020 | In 2050 | In 2070 |
| **Medical Cost Increases Do Not Affect Elderly Dependency; Separate Children** | 0.0 | -1.5% | -1.5% | -1.5% | -1.5% |
| | 0.3 | +0.7% | -0.3% | -5.5% | -7.7% |
| | 0.7 | +1.0% | -0.0% | -6.4% | -8.5% |
| **Medical Cost Increases Do Not Affect Elderly Dependency; Family** | 0.0 | -3.2% | -3.2% | -3.2% | -3.2% |
| | 0.3 | -0.5% | -1.9% | -7.5% | -9.8% |
| | 0.7 | +0.0% | -1.8% | -8.6% | -10.7% |
| **Medical Cost Increases Raise Elderly Dependency; Separate Children** | 0.0 | -2.3% | -2.3% | -2.3% | -2.3% |
| | 0.3 | 0.4% | -0.9% | -6.8% | -9.3% |
| | 0.7 | +0.8% | -0.6% | -7.9% | -10.1% |
| **Medical Cost Increases Raise Elderly Dependency; Family** | 0.0 | -3.7% | -3.7% | -3.7% | -3.7% |
| | 0.3 | -0.7% | -2.3% | -8.3% | -10.7% |
| | 0.7 | -0.1% | -2.2% | -9.5% | -11.6% |

**Table 5**

**Projected Government Spending**
**(Share of GDP)**

| | **2000** | **2010** | **2020** | **2050** | **2070** |
|---|---|---|---|---|---|
| Social Security | 4.5% | 4.8% | 5.9% | 6.8% | 7.0% |
| Medicare | 2.6% | 3.0% | 3.9% | 5.3% | 5.4% |
| Medicaid Spending on Elderly | 0.5% | 0.5% | 0.7% | 0.9% | 0.9% |
| **Total** | 7.5% | 8.2% | 10.3% | 12.9% | 13.3% |

Figure 1

## Demographic Change in the United States

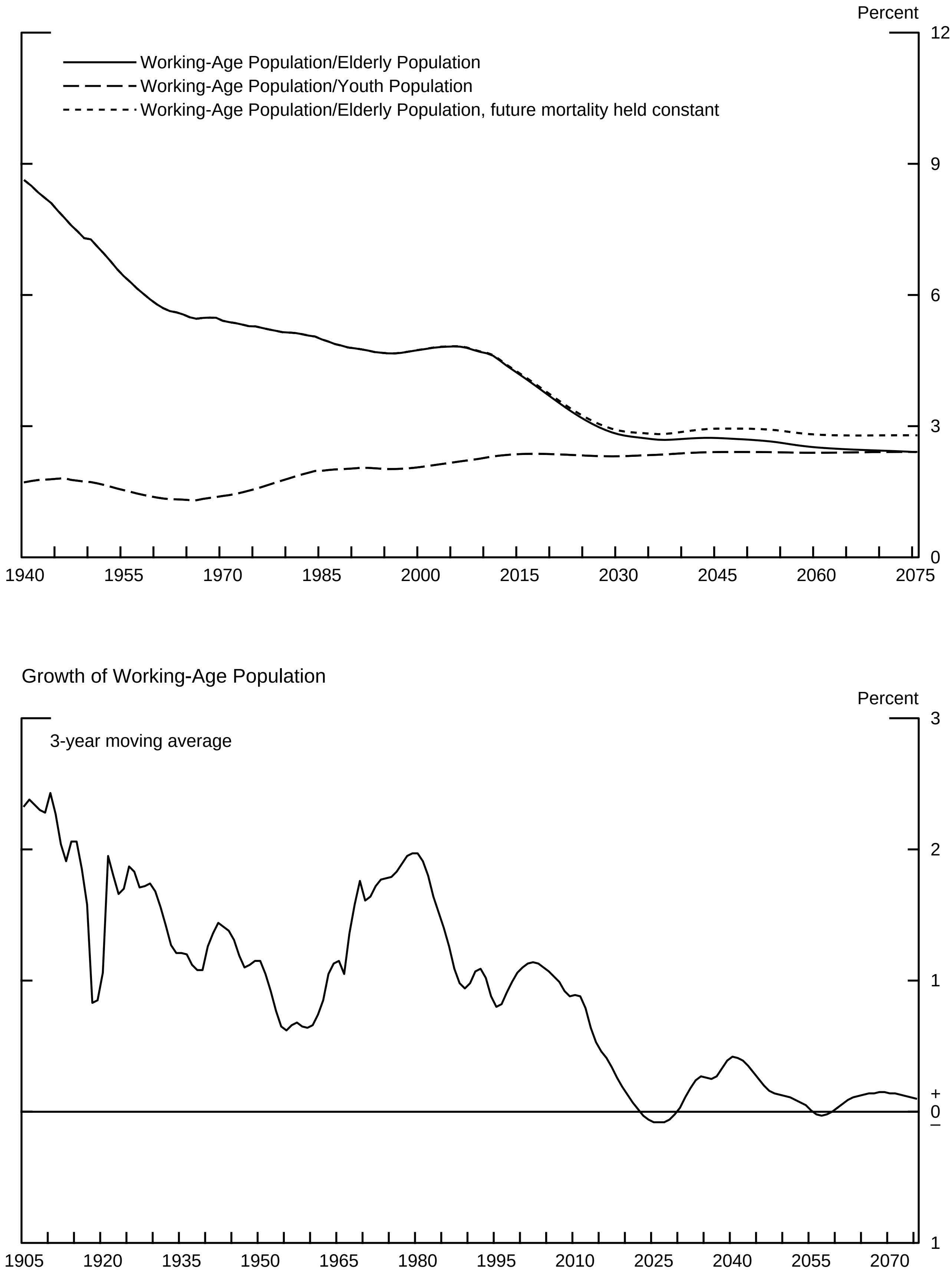
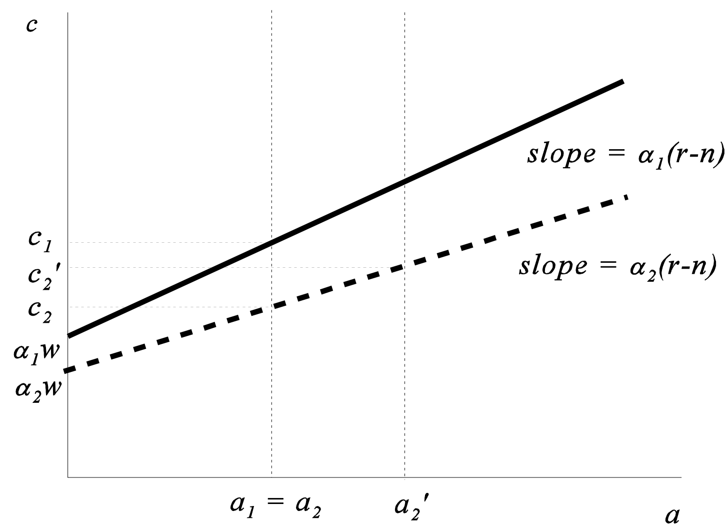


**Figure 2**

**Population Aging in a Small Open Economy**

**Increase in Longevity ($\alpha_2 < \alpha_1$)**




**Decrease in Fertility ($n_2 < n_1$)**

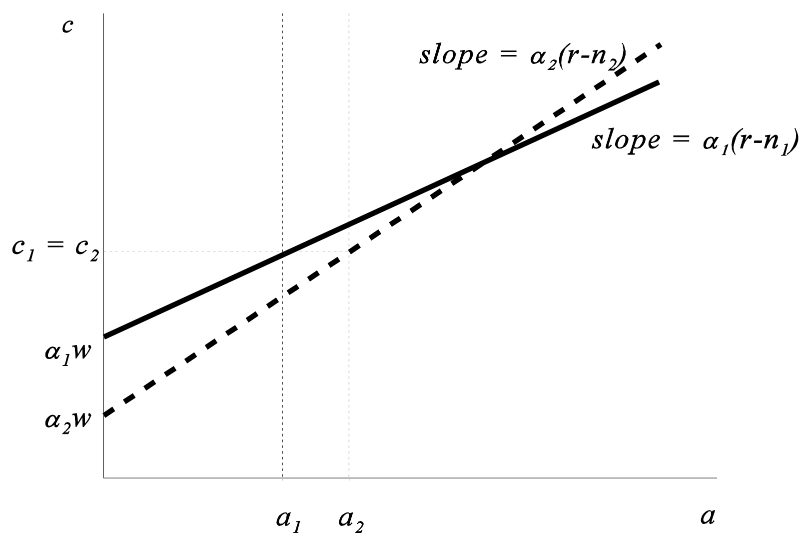
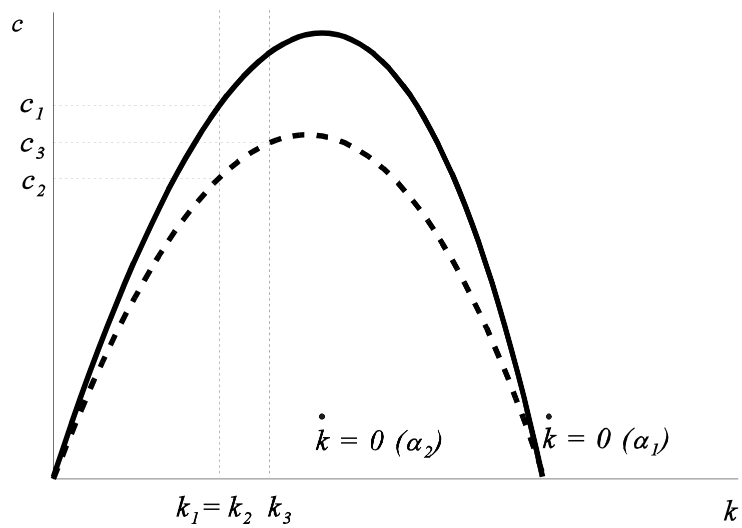


**Figure 3**

**Population Aging in a Closed Economy with σ = 0**

**Increase in Longevity ($\alpha_2 < \alpha_1$)**




**Decrease in Fertility ($n_2 < n_1$)**

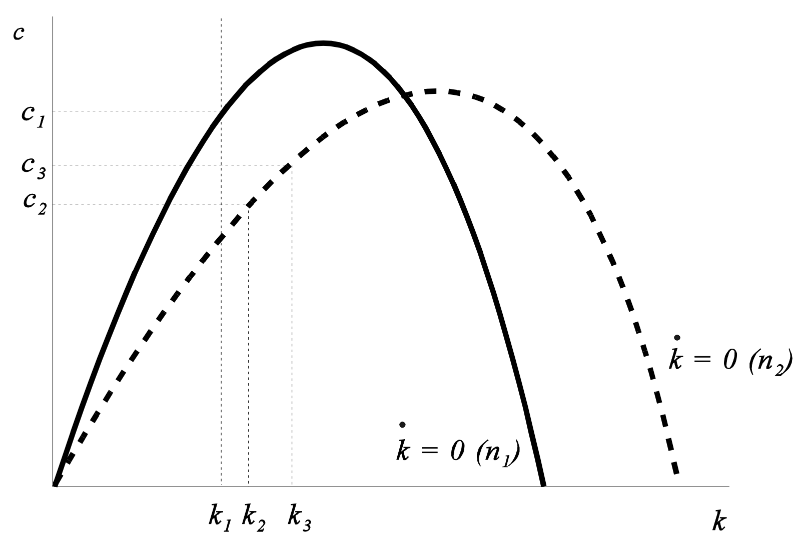
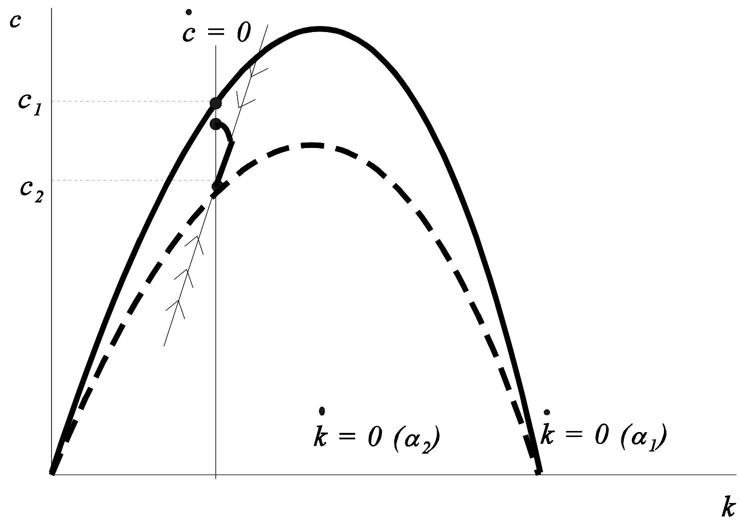


**Figure 4**

**Population Aging in a Closed Economy with σ ≠ 0**

**Increase in Longevity ($\alpha_2 < \alpha_1$)**




**Decrease in Fertility ($n_2 < n_1$)**

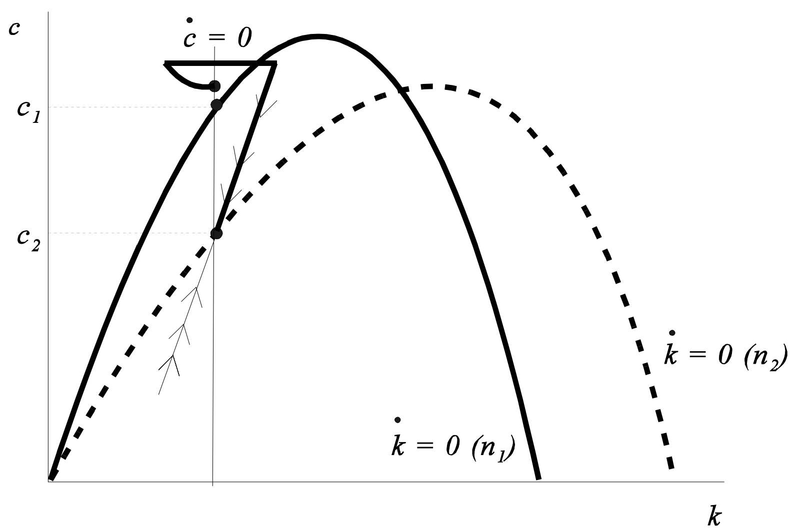
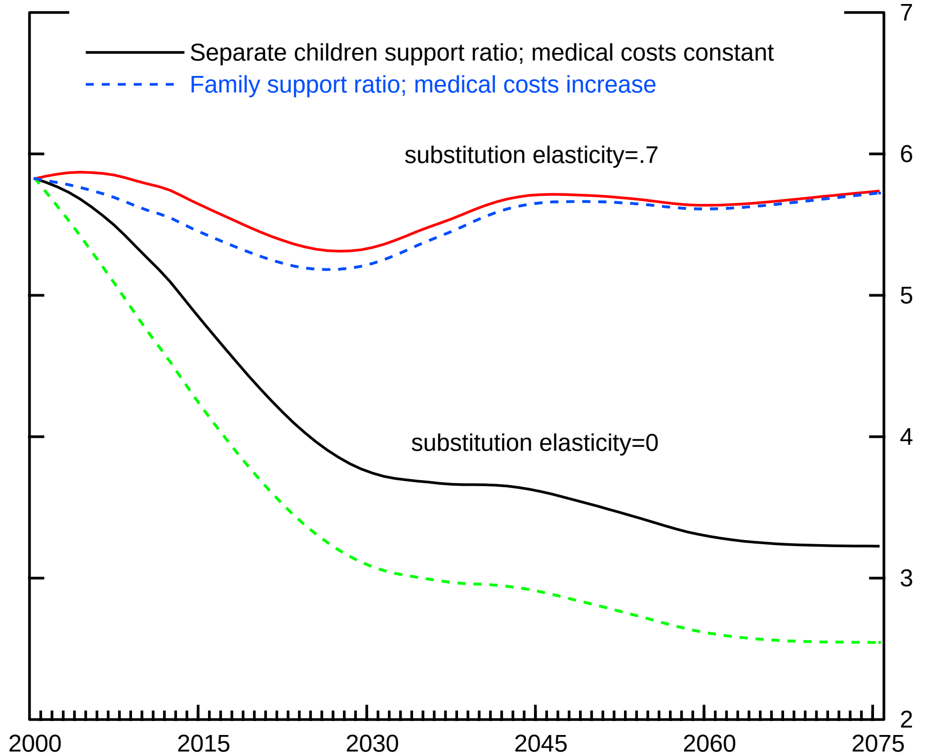


Figure 5

# Simulation Results

Interest Rate Paths




Wage Paths