Social Security and the Retirement Decision

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*The Quarterly Journal of Economics* is currently published by The MIT Press.
The effect of Social Security and private pensions on individual retirement decisions is modeled, relaxing in turn three commonly maintained assumptions—perfect capital markets, actuarial fairness, and certain lifetimes—which together imply that there is no effect. In each case, raising the contribution level can cause systematic changes (of either sign in general) in individual retirement decisions. For Social Security, the effects associated with forced saving and deviations from actuarial fairness probably tend to advance retirement. But those effects that arise solely from the insurance aspect of Social Security and private pensions are ambiguous in sign, owing to the presence of a substitution effect that tends to delay retirement because the insurance benefits can be fully realized only by working longer.

I. INTRODUCTION

Since 1947, the labor force participation of men 65 years of age and older has fallen from 48 percent to 20 percent. Since 1962 (the first year men were allowed to collect early Social Security benefits at age 62), there has been a similar decline in the participation of men between the ages of 60 and 64, from 80 percent to 62 percent. This trend toward earlier retirement represents one of the most dramatic changes in the labor force of the post-war era.

The most frequently cited explanation for this phenomenon has been the rapid post-war growth of institutionalized retirement plans, particularly Social Security. Today, virtually all workers are covered by either Social Security, private or public pensions, profit-sharing plans, or some combination of these. This nearly universal coverage represents a significant change since 1945, when less than 12 percent of the population over 65 was covered by Social Security and an even smaller fraction was covered by private plans. Social Security and other pension benefits have become the major source of retirement income, providing almost four-fifths of the nonwage income of men over the age of 65. Feldstein [1974] estimates that anticipated Social Security benefits alone represent some 60 percent of other household assets.

Numerous empirical studies support the hypothesis that the trend toward earlier retirement is at least in part the result of increased Social Security and pension coverage. Quinn [1977], for example, finds that for men and unmarried women aged 55–63, eligi-

* We owe thanks for helpful discussions to Franklin Fisher, Mark Machina, and Joel Sobel, and we are especially grateful to Peter Diamond, whose thoughtful comments on an earlier version saved us from making significant errors.
bility for Social Security lowers the probability of labor force participation by 17.5 percentage points, eligibility for private pensions lowers the probability of participation by 7.3 points, and eligibility for both lowers the probability of participation by 30.5 points. Boskin [1977] estimates that the income effect on retirement of Social Security benefits is seven times as large as the income effect of private asset income; he attributes this to the fact that Social Security benefits are both guaranteed for life and indexed against inflation. Lilien [1979] finds that roughly half of the fall in older male participation rates over the last three decades has been due to increased Social Security and pension coverage, with the remaining decline due primarily to the growth of real income.

While the inducement to earlier retirement due to Social Security and other pension plans has been repeatedly demonstrated in the empirical literature, its theoretical foundations are less well established. Several authors (see, for example, Kotlikoff [1979] or Blinder, Gordon, and Wise [1978]) have developed life-cycle models with endogenous retirement decisions. Under the assumptions of certain lifetimes, perfect capital markets, and actuarial fairness in setting retirement benefits, they conclude that pension coverage does not affect the incentive to retire. Under these strong assumptions, pensions are equivalent to other forms of savings. Thus, the only effects of pension coverage on individual behavior are a one-for-one displacement of private (nonpension) savings by pension contributions prior to retirement, and a one-for-one displacement of private dis-saving by pension benefits after retirement. With perfect capital markets, pension coverage cannot even cause forced savings.

In fact, most pensions, particularly Social Security, are essentially different from other forms of savings. The Social Security benefit structure is complex and far from actuarially fair. The average return (in benefits) on Social Security contributions is higher than that of most alternative forms of savings, while the marginal return is less than in most savings plans. (It is, in particular, negative after the age of 65.) Unlike private savings, Social Security savings cannot be drawn upon or borrowed against until retirement; instead, they take the form of a lifetime annuity. As a result, the amount of benefits received by any particular individual is a random variable determined by the individual’s age at death. It is just these differences between Social

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1. These papers were not intended to show the neutrality of Social Security, and it is not their authors' contention that Social Security has no impact on retirement.
Because there are several characteristics of the current Social Security system that affect workers' incentives to retire, it is difficult to identify the separate influences in a comprehensive model. We shall, therefore, adopt the following strategy. In the next section, we construct a model of the effect of social insurance on individual retirement decisions, under the assumptions of perfect capital markets, actuarial fairness, and certain lifetimes. As already indicated, under these assumptions, the presence of social insurance has no effect on retirement decisions. In the remainder of the paper, we modify each of the above assumptions one by one to approximate more closely the environment in which the Social Security program and private pensions actually operate.

II. A Model of Social Insurance with No Effect on Incentives to Retire

In what follows, we shall assume that workers plan consumption, savings, and retirement to maximize expected lifetime utility. The representative individual has a stationary, temporally independent utility function, separable, and strictly increasing in consumption and leisure; it is written as \( U(c_t) + V(l_t) \), where \( U(c_t) \) is the flow of utility from consumption of goods \( c_t \), at time \( t \), and \( V(l_t) \) is the flow of utility from leisure \( l_t \), at time \( t \). \( U \) is assumed to be twice continuously differentiable, with \( U'(c_t) > 0 \) and \( U''(c_t) < 0 \) for all \( c_t \). Individuals are permitted to choose their retirement date, denoted \( N \), but prior to retirement, hours worked are assumed to be institutionally set; we can, therefore, simplify the notation by normalizing \( V(l^w) = 0 \) and \( V(l^r) = v \), where \( l^w \) and \( l^r \) denote hours of leisure while working and retired.

The assumption that hours worked are either \( l^w \) or \( l^r \) precludes any analysis of partial retirement (e.g., stepping down from a full-time job to a part-time job). This assumption makes the model more tractable by allowing us to assume that workers receive retirement benefits only after they stop working. Under the present Social Security system, individuals may receive full benefits at age 65 while

2. Feldstein [1977] develops a life-cycle model where Social Security affects retirement. His results come from dropping the fairness assumption and more realistically modeling the Social Security benefit structure. His analysis, however, differs significantly from Section IV of this paper, where we address the fairness assumption. Blinder, Gordon, and Wise [1978] also provide an extensive discussion of the conditions under which pension neutrality is lost.
working, as long as their income remains under $5,000 a year. Workers earning over $5,000 have their benefits reduced by 50 percent of earnings in excess of $5,000; thus, most workers on full-time schedules receive no benefits until after retirement. Because of our assumption about hours, we cannot model the disincentive to work that Social Security may create for individuals who, in the absence of Social Security, would have earned more than $5,000 and less than the amount where all benefits are taxed away. Since the disincentive to work of a 50 percent tax on earnings is fairly well understood, we do not consider this a major drawback.

We assume that individuals plan to work from time zero to time $N$. While working, they receive income at a constant rate, which we normalize to 1; they privately save at rate $s_t$; and they make social insurance contributions at a constant rate $p$. Thus, $c_t + s_t + p = 1$. $p$ is assumed to be set exogenously by social planners. When retired (i.e., after time $N$), workers earn nothing, but may dissave; in addition, they receive social insurance benefits at a constant rate $d$. Allowing $p$ and $d$ to vary over time would needlessly complicate the analysis without significantly altering the conclusions. For simplicity, we also assume that the price of consumption is constant over time, that savings earn no interest, and that individuals do not discount the future; these assumptions can be relaxed without significantly affecting our results.

Initially, we shall assume that individuals know with certainty that they will die at time $T$, and that individuals may borrow unlimited amounts at a zero interest rate, as long as all debts are repaid by period $T$. Under the above assumptions, the worker's objective function can be written as

$$\int_0^T U(c_t) dt + \int_N^T [U(c_t) + v] dt = \int_0^T U(c_t) dt + (T - N)v.$$

In this example, separability and concavity of the instantaneous utility function, certain lifetimes, and perfect capital markets imply that each individual will set consumption equal in all periods. Thus, the worker's problem can be written as

$$\max_{N,c} TU(c) + (T - N)v$$

3. Further, it can be shown that in a wide variety of environments, constancy of $p$ and $d$ is consistent with optimality of the insurance plan.
subject to

\[ Tc \leq N(1 - p) + (T - N)d. \]

This model purports to describe a worker’s plans. But as Strotz [1955] pointed out, in dynamic models it is not a foregone conclusion that the plans of agents whose expectations are realized will be carried out, if they are later given the opportunity to revise them. This difficulty, which is known as *dynamic inconsistency*, can arise because the relative importance an agent attaches to utility in different periods can shift over time, even if nothing else in the environment changes. Nevertheless, the present model is dynamically consistent, and thus can be viewed as a model either of the worker’s plans or of the realization of those plans. Unanticipated changes in the environment may of course require revision of plans, but our analysis remains equally descriptive in such cases. And the model would remain consistent if exponential discounting at a constant rate and nonnegative interest were introduced (see Strotz [1955, p. 172]).

While an actuarially fair Social Security system would face an aggregate budget constraint, which is irrelevant to the individual, for the current system an individual’s benefits and, therefore, his budget constraint depend significantly on that individual’s retirement age, among other things. The nature of this dependence is discussed in detail in Section IV. In effect, the system treats each individual as a member of a cohort of workers with a given retirement age, and the individual therefore faces a menu of retirement dates and benefit levels. While actuarial fairness better approximates the operation of some private pension plans than the Social Security system, as we discuss in Section IV, this individual dependence of benefit levels on retirement age makes individual actuarial fairness, under our simplifying assumption that workers have identical (or identically distributed) lifetimes, the natural benchmark from which to begin our analysis.

In the present example, benefit determination is fair when total contributions to social insurance, \( Np \), are equal to total retirement benefits received, \( (T - N)d \). Thus, fairness requires that benefits be set conditional on \( p \) and \( N \) such that

(2) \[ d = (pN)/(T - N). \]

As in most private pensions and, to a lesser degree, in Social Security (see Section IV), this schedule implies that benefits per period are greater, the later an individual retires.

Individuals are assumed to know the schedule by which benefits
are determined. We can, therefore, substitute (2) into the constraint of Problem (A), which reduces it to

\[(3) \quad Tc \leq N.\]

It is now clear from (1) and (3) that the retirement plan has no effect on the worker's optimal choice of \(c\) and \(N\), because the parameters of the plan fall out of the worker's problem. The only effect in this example is to replace private savings with public savings; and since \(s_t \equiv 1 - p - c_t\), it follows that this displacement is one-for-one.

The intuitive explanation for this is, of course, simple. In a world of certain lifetimes, actuarially fair social insurance is completely equivalent to private savings. And while social planners may set \(p\) at a level that does not correspond to individuals' desired savings, individuals can counteract this by borrowing or lending in perfect capital markets, when such markets exist. (Note, however, that neutrality will in general be lost if the returns from private and social savings differ.)

### III. Borrowing Constraints

In the preceding example, unlimited borrowing rights guaranteed that individuals could always finance current consumption expenditures, as long as their lifetime budget constraint was satisfied. More realistically, individuals who would like to consume more than their current income, in anticipation of higher future income, typically face liquidity constraints. A more general life-cycle model of consumption, which incorporates the usual profile of lifetime earnings, suggests that workers will wish to borrow during their years of relatively low earning capacity and later repay the resulting debts during their high earning years. Faced with borrowing restrictions, they consume all of current disposable income while young, and do not begin saving until later in life. Increasing the level of social insurance contributions lowers current disposable income, further tightening the constraints on current consumption.

Let \(c^*\) and \(N^*\) be the values that solve problem (A), and note that \(c^* = N^*/T\) and \(U'(c^*) = u\). Individuals were shown in the above example to borrow during their working years if \(c^* > 1 - p\). They then repay their debts from social insurance benefits after retirement. To get an idea of the likelihood that \(c^* > 1 - p\) will hold for the level of \(p\) implicit in the Social Security system, note that \(p\) in 1978, including
both employer and employee contributions, was 0.123. The question is, how many individuals would increase their current consumption if their current income were raised by \( p \) and Social Security benefits were eliminated at the same time? If a significant number would, the borrowing constraints studied here can affect individuals’ optimal retirement decisions.

If we now rule out borrowing in the example, social insurance is no longer neutral. For \( p \) sufficiently low, so that \( c^* \leq 1 - p \), the problem remains equivalent to problem (A). But if \( p \) is high enough to induce borrowing in our previous example, the worker’s problem becomes

\[
\text{(B)} \quad \max_{N, c^r} NU(1 - p) + (T - N)[U(c^r) + v]
\]

subject to

\[
N(1 - p) + (T - N)c^r \leq N,
\]

where \((1 - p)\) is pre-retirement consumption and \(c^r\) is post-retirement consumption.

At a solution of problem (B),

\[
U(1 - p) - U(c^r) - v + pTU'(c^r)/(T - N) = 0
\]

and

\[
c^r = pN/(T - N).
\]

It follows from (4) and (5) that

\[
\frac{dN}{dp} = \left[ U'(1 - p) - U'(c^r) \right] - \frac{pNT}{(T - N)^2} U''(c^r) \bigg/ \frac{p^2T^2}{(T - N)^3} U''(c^r) < 0.
\]

Thus, increasing the level of social insurance reduces pre-retirement consumption and increases the flow of pension savings. In this example, \( s_t \) is always zero when \( c^* \geq 1 - p \). Post-retirement consumption is greater than in our previous example, because workers are being forced to save more for their retirement than they would otherwise desire to. With declining marginal utility from consumption, they prefer to use some of these forced savings to purchase additional leisure, which they can only do in our model, with fixed hours, by retiring earlier.

Until now, we have assumed that social insurance benefits could be claimed by retired workers at any age. But in fact there is a mini-
mum age, currently 62, at which Social Security benefits can be collected. Thus, for individuals who in the absence of Social Security would retire before 62, consumption in the period between retirement and age 62 must be financed out of private savings. If social insurance savings displace sufficient private savings, individuals may be unable to finance their pre-social insurance level of consumption $c^*$, while retiring at $N^*$.

Let $\bar{N}$ be the minimum age requirement for collecting benefits $d$. The lifetime budget constraint of problem (A) must now be modified to read

$$Tc \leq N(1 - p) + \min (T - N, T - \bar{N})d.$$  

Given $N$, the condition for actuarial fairness in setting $d$ becomes

$$d = \frac{pN}{T - \max(N, \bar{N})}.$$  

If we assume that benefits are set in this fashion and that there are no borrowing constraints, we will again reach the conclusion that social insurance does not affect workers' incentives to retire. With borrowing constraints, however, social insurance may tend to delay, or advance, retirement. Workers who retire before $\bar{N}$ must finance consumption between retirement and $\bar{N}$ out of their private savings. If $S(t)$ represents accumulated private savings at time $t$, then in this example, $S(N) = (1 - c - p)N$. Social insurance will have no real effect on retirement if

$$1 - c^* - p \geq c^* (\bar{N} - N^*),$$  

which is equivalent, given that $c^* = N^*/T$, to $1 - p \geq \bar{N}/T$. If $1 - p < \bar{N}/T$ and $N^* < \bar{N}$, the worker's problem is equivalent to

$$\max_N \bar{N}U\left(\frac{N(1 - p)}{\bar{N}}\right) + (T - \bar{N})U\left(\frac{Np}{T - \bar{N}}\right) + (T - N)v.$$  

If $c_1 = N(1 - p)/\bar{N}$ is pre-$\bar{N}$ consumption and $c_2 = Np/(T - \bar{N})$ is post-$\bar{N}$ consumption, the first-order condition for a solution to this problem is

$$1 - p)U'(c_1) + pU'(c_2) = v.$$  

That is, labor is supplied until the weighted sum of the marginal pre- and post-$\bar{N}$ utilities of consumption is equal to the marginal value of leisure. The weights $1 - p$ and $p$ describe the pre- and post-$\bar{N}$ allocation of earned income.
From (10), it follows that

\[
\frac{dN}{dp} = \frac{[U'(c_1) + c_1 U''(c_1)] - [U'(c_2) + c_2 U''(c_2)]}{(1 - p)c_1 U''(c_1) + pc_2 U''(c_2)},
\]

\(dN/dp\) is ambiguous in sign. The denominator of the right-hand side of (11) is negative. To see what determines the sign of the numerator, note that

\[
U'(c) + c U''(c) = U'(c)[1 + c U''(c)/U'(c)] = U'(c)[1 - \eta],
\]

where \(\eta\) denotes the elasticity of marginal utility. \(\eta\) is a measure of the utility cost of variability in consumption; if \(\eta\) is high, this cost is also high. If \(\eta\) is nondecreasing in \(c\) and less than unity, \(U'(c) + c U''(c) = U'(c)[1 - \eta]\) is decreasing in \(c\), since both components of the product are; this and the fact that \(c_2 > c_1\) imply that the numerator of the right-hand side of (11) is positive, and, since the denominator is negative, that \(dN/dp < 0\). Similarly, if \(\eta\) is nonincreasing in \(c\) and greater than unity, the numerator is negative and \(dN/dp > 0\). Thus, for the constant-elasticity utility function with elasticity less than unity (which is necessary for it to be concave), \(dN/dp < 0\); and for the logarithmic utility function, \(\eta = 1\) and, therefore, \(dN/dp = 0\). For the exponential utility function, the sign of \(dN/dp\) depends on the parameters.

The ambiguity of \(dN/dp\) in this example leads to two possible scenarios, in which the effects of social insurance when there are borrowing constraints differ. We note that for individuals with \(N^* < \bar{N}\), the constraint caused by the need to finance consumption between \(N^*\) and \(\bar{N}\), as described in problem (C), becomes binding before the constraint of financing working consumption, as described in problem (B). However, this is true in our model only with a constant income over the life cycle. In a more realistic model, both types of constraints may be binding. If \(dN/dp\) in equation (11) is negative, then increasing the level of \(p\) eventually leads to an advancement of retirement date. However, if \(dN/dp\) in (11) is positive, we have \(dN/dp > 0\) for \(N^* < \bar{N}\) and \(dN/dp \leq 0\) for \(N^* > \bar{N}\). In this case, increasing the level of social insurance causes the retirement date to approach \(\bar{N}\).

IV. ACTUARIAL FAIRNESS

The assumption of actuarially fair benefit determination is inappropriate as a description of Social Security, whose benefits are determined by an extremely complicated formula that deviates sig-
nificantly from our previous assumption of fairness. In this section, we shall explore the incentives toward earlier retirement created by the Social Security benefit structure’s deviations from actuarial fairness.

After this paper was completed, we were informed by a referee that results paralleling some of those in this section had already appeared in Sheshinski [1978]. His model assumes perfect capital markets and certain lifetimes, but is more general than the model of this section in that it allows nonzero interest rates and time discounting of utility and a more general dependence of benefits on contributions and age at retirement. He derives more general versions of the first-order conditions that appear in this section and the comparative statics result that appears in equation (20). He also provides a “benefit-compensated” version of the result in equation (21); this compensation leads to a definite comparative statics result in contrast to our ambiguous one. While Sheshinski, of course, deserves full credit for priority, we have retained our statements of parallel results for ease of exposition.

Workers become eligible for Social Security benefits at age 62, with benefit levels determined by a formula based on average monthly earnings up to age 62. While this formula is too complicated to describe here (a complete description can be found in Munnell [1977]), it is important to note several of its characteristics. First, the formula is highly progressive, giving low-income workers greater expected benefits per contribution dollar than high-income workers and giving single-earner families higher expected benefits per contribution dollar than two-earner families. Since Social Security contributions are the same fraction of earned income up to a maximum taxable amount for all workers, differences in Social Security’s benefit replacement rates provide a good measure of progressivity and deviations from individual fairness.

Table I gives 1976 replacement rates (benefits as a percentage of previous year’s earnings) for a variety of earning histories. In 1976, a 65-year-old male earning 40 percent of the median income, with a nonworking wife, could receive benefits equal to 99 percent of his previous year’s earnings. In contrast, a single male earning the maximum taxable income receives benefits of only 33 percent of his previous year’s earnings.

While the progressivity of base benefits clearly indicates that Social Security is not individually fair, it might still be fair in aggregate. In fact, aggregate cohort benefits have exceeded cohort contributions since the inception of Social Security, so that benefits have
SOCIAL SECURITY AND RETIREMENT

TABLE I
REPLACEMENT RATES

<table>
<thead>
<tr>
<th>Type of beneficiary*</th>
<th>Replacement rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single male earning 40 percent of median income</td>
<td>0.66</td>
</tr>
<tr>
<td>Single male earning median income</td>
<td>0.46</td>
</tr>
<tr>
<td>Single male earning maximum taxable income</td>
<td>0.33</td>
</tr>
<tr>
<td>Male earning 40 percent of median income with nonworking wife</td>
<td>0.99</td>
</tr>
<tr>
<td>Male earning maximum taxable income with nonworking wife</td>
<td>0.49</td>
</tr>
<tr>
<td>Husband and wife each earning 50 percent of maximum taxable income</td>
<td>0.42</td>
</tr>
</tbody>
</table>

* Assumes earnings as described for all years up to retirement.

been more than fair in aggregate. This point is reinforced by the fact that Social Security benefits are not subject to state or federal income tax.

A social insurance plan can fail to be fair on average, as does Social Security, and still be marginally fair. To be marginally fair, an extra year of work must increase the retirement benefit level to reflect both the shorter period of retirement over which benefits will be received and the greater total contributions made into the system. Our current Social Security system also fails to be marginally fair. Between the ages of 62 and 65, an extra month of work increases benefits by 5/9 of one percent. The claim is that this represents an actuarially fair increase in benefits. However, there is only a trivial 1 percent annual increase in benefits for years worked after age 65 and before age 72. Thus, while according to Social Security administrators the system is marginally fair between the ages of 62 and 65, it is clearly less than marginally fair after age 65.

We can modify our earlier assumption about benefit determination to reflect more accurately the current Social Security benefit structure. Suppose that $d$ is determined by $(T - N)d = TA + NBp + NA(B - 1)$ or, equivalently, that

\begin{equation}
(13) \quad d = [(T - N(1 - B))A + NBp]/(T - N).
\end{equation}

For $B = 1$, social insurance is marginally fair, and there is a lifetime transfer of $TA$ to individuals from the social insurance program. This is a reasonable characterization of the Social Security benefit structure for individuals retiring between the ages of 62 and 65. For $B = 0,$
benefits per period are a constant, \( d = A \), independent of \( N \). Social Security has \( B \) slightly greater than zero after the age of 65. In general, given this specification of \( d \), social insurance is more than fair on average when individuals choose \( N \) such that \( N/T < A/[(1 - B)(A + p)] \) for \( B \neq 1 \). This condition is satisfied at retirement age 65 under the Social Security system.

We can now set up the worker's life-cycle problem under our modified benefit structure and the assumption that the borrowing constraints described in the previous section are not binding:

\[
\max_{N, c} TU(c) + (T - N)v,
\]

subject to

\[
Tc \leq N(1 - p) + (T - N)d.
\]

Substituting (13) into the constraint of problem (D) yields

\[
c \leq (N/T)[1 - (1 - B)(A + p)] + A.
\]

Note that for sufficiently high \( A \) or sufficiently low \( B \), individuals choose to retire without working. A necessary condition for the optimal value of \( N \) to be positive is

\[
TU[(N/T)[1 - (1 - B)(A + p)] + A] + (T - N)v > TU(A) + Tv,
\]

which implies that

\[
\omega \equiv 1 - (1 - B)(A + p) > 0.
\]

Note that \( \omega \), as defined above, is the price, net of social insurance, of leisure in terms of consumption. If \( v \geq 0 \), a necessary condition for some work is a positive price of leisure. Assuming an interior solution, the conditions for a solution of \( D \) are

\[
U'(c)\omega = v
\]

and

\[
c = (N/T)\omega + A.
\]

It follows from (17) and (18) that

\[
\frac{dN}{dp} = \left[ \frac{N}{\omega} + \frac{T}{\omega^2} \frac{U'(c)}{U''(c)} \right] (1 - B),
\]

\[
\frac{dN}{dA} = \left[ \frac{N}{\omega} + \frac{T}{\omega^2} \frac{U'(c)}{U''(c)} \right] (1 - B) - \frac{T}{\omega} < 0,
\]
And

\[
\frac{dN}{dB} = -\left[\frac{N}{\omega} + \frac{T}{\omega^2} U'(c)\right] (A + p).
\]

Of the comparative statics results given in (19)-(21), only \(dN/dA\) is unambiguous in sign for \(0 < B < 1\). Raising \(A\) both increases the level of income workers can receive without working and lowers the implicit price of leisure \(\omega\); thus, both the income and substitution effect of a change in \(A\) tend to reduce retirement age.

An increase of \(B\) raises the implicit price of leisure, with an ambiguous effect on \(N\). There is a substitution effect, \(-TU'(c)(A + p)/\omega U''(c)\), which tends to delay retirement; and an income effect, \(-N(A + p)/\omega\), which acts to induce earlier retirement. If we make the usual labor supply assumption (albeit in a somewhat different setting) that the substitution effect of a shift in wages dominates the income effect, then \(dN/dB > 0\).

The assumption of a dominating substitution effect also implies that \(dN/dp\) has the same sign as \(B < 1\). When \(B < 1\), an increase in the level of social insurance, as measured by \(p\), causes a larger increase in lifetime contributions than in lifetime benefits; a marginal period of work, therefore, buys less consumption the higher is \(p\). Again, if the substitution effect of the fall in the price of leisure dominates, \(dN/dp < 0\) when \(B < 1\).

These results have several implications for Social Security's effect on the incentives to retire. That Social Security benefits are calculated so that \(A\) is significantly positive creates a strong influence that tends to make workers retire earlier. Further, since Social Security is highly progressive (low-income families have higher \(A\)'s than high-income families), our analysis suggests that low-income workers will tend to retire earlier than high-income workers. As can be seen in Table II, this is confirmed by the records of the Social Security system. Finally,
because the Social Security system sets $B$ very close to zero after age 65, there is a strong substitution effect created by Social Security coverage that tends to encourage earlier retirement up to the age of 65. This last effect is sometimes referred to as the "earnings-tax" effect of Social Security, because individuals who work beyond age 65 have their current benefits taxed away without any corresponding increase in future benefits.

V. UNCERTAIN LIFETIMES

To this point we have not attempted to model the insurance effects of social insurance. Above, the worker's life-cycle consumption and labor-supply decisions were made under conditions of perfect certainty. In this section, we shall examine another important aspect of Social Security: insurance against longevity.

In the absence of Social Security or other annuities, individuals who are uncertain about their lifetimes must maintain sufficiently high private savings to finance, at some level of consumption, a long and variable retirement period. In our earlier life-cycle models, individuals were assumed to know their death dates with certainty, and proper planning guaranteed that savings would be exhausted precisely at that date. With an uncertain date of death, individuals will generally have to maintain positive savings at and beyond their expected death date to insure against the possibility of unusual longevity. Because Social Security benefits take the form of a lifetime annuity, they reduce the need for holding large amounts of private savings.

The extension of our model considered in this section is based on the assumption that individuals cannot privately purchase alternative forms of actuarially fair lifetime annuities. While this assumption may seem restrictive, it should be remembered that Social Security and some private pensions are indexed annuities, guaranteeing constant real benefits for the remainder of life. We are unaware of any form of private savings that takes this form and, therefore, feel our assumption is a reasonable approximation. The results of this section would require considerable modification if individuals had access to indexed private annuities.

We shall now modify our certain-lifetime model to take account of uncertainty about the date of death.\(^4\) Let $T$ be the latest possible

\(^4\) The present model is superficially similar to the one developed by Diamond and Mirrlees [1979, Sections 5–8] to study the effects of social insurance when individuals are uncertain about their ability to work in future periods and can choose when to retire. Being unable to work in their model is formally analogous to being dead in our model, except that the analog of their assumption that the marginal utility of consumption is independent of ability to work is highly unnatural in our model. Since that assumption is used heavily, no useful analogies are available.
death date, and let $F(t)$ be the probability that the representative individual will still be alive at age $t$. $F$ is assumed to be differentiable and strictly decreasing in $t$ for all $t \in [0, T]$\textsuperscript{5} with $F(0) = 1$ and $F(T) = 0$. Individuals are assumed to know $F$ and to set $N$ and $|c_t|$ so as to maximize expected lifetime utility. Given these modifications of our earlier assumptions, the worker’s objective function can be written as

\begin{equation}
\int_0^N F(t)U(c_t)dt + \int_N^T F(t)[U(c_t) + v]dt
= \int_0^T F(t)U(c_t)dt + v \int_N^T F(t)dt.
\end{equation}

Like the models studied above, the present model is dynamically consistent. Even if the stochastic process that determines time of death is not temporally independent, the fact that death occurs only once means that Bayesian updating, after surviving an additional period, leaves unchanged all ratios of the form $F(t)/F(t')$ where $t$ and $t'$ are dates that have not yet occurred, provided that no learning about $F$ takes place. Thus, a surviving worker whose environment is as anticipated will never wish to revise the plans made at the beginning of his or her lifetime.

To highlight the effect of social insurance on retirement decisions under uncertainty, we shall return to the assumption that $d$ is set conditional on $N$ and $p$ in a way that is individually actuarially fair. To avoid trivialities, assume that $p \in (0, 1)$. We shall also continue to simplify by assuming that all workers have identically distributed death dates (although they need not die at the same time); this assumption can be relaxed with some effort. Given this assumption, actuarial fairness requires that

$$\int_0^N pF(t)dt = \int_N^T dF(t)dt$$

or, equivalently, that

\begin{equation}
d = pG(N),
\end{equation}

where

\begin{equation}
G(N) \equiv \int_0^N F(t)dt / \int_N^T F(t)dt.
\end{equation}

\textsuperscript{5} We use the standard notation for closed and open intervals. For example, “$x \in [a, b]$” means $a \leq x \leq b$, and “$x \in (a, b)$” means $a < x < b$.\)
Before the worker's problem can be written simply, we require additional assumptions about the constraints on his or her consumption and retirement plans, which are somewhat more complex than in the certain lifetime model. Following Yaari [1965], we shall assume that the worker has access to a perfect capital market, except for a prohibition against dying with negative net worth. As we have assumed that \( F \) is strictly decreasing, which implies that death occurs with positive probability in any interval, this prohibition implies that the worker's savings must be nonnegative at every instant. Alternatively we could assume as above that the worker is simply unable to borrow against future earnings and benefits.

More formally, let \( S(t) \) denote private savings at time \( t \). If the worker begins life with no assets, \( S(0) = 0 \). Our assumptions imply that

\[
S(t) \equiv \begin{cases} 
(1 - p)t - \int_0^t c_i dt & \text{if } t \in [0,N), \\
S(N) + (t - N)pG(N) - \int_N^t c_i dt & \text{if } t \in [N,T]; 
\end{cases}
\]

and it follows that

\[
\dot{S}(t) \equiv \begin{cases} 
1 - p - c_t & \text{if } t \in [0,N), \\
pG(N) - c_t & \text{if } t \in [N,T]. 
\end{cases}
\]

Once more following Yaari [1965], we can express the \( S(t) \geq 0 \) constraint as follows: for all \( t \in [0,T] \), \( \dot{S}(t) \geq 0 \) whenever \( S(t) = 0 \), where the right-hand derivative, \( pG(N) - c_t \), is taken for \( \dot{S}(N) \). It should also be clear from monotonicity at the solution to the worker's problem, that \( S(T) = 0 \).

Finally, assuming the Inada condition, \( \lim_{c \to 0} U'(c) = \infty \), we can ignore the nonnegativity restrictions on \( c_t \). As we are assuming that \( S(0) = 0 \), so that positive consumption is impossible without working, this Inada condition also rules out the possibility that \( N = 0 \) at the solution.

Yaari's [1965, Case A] analysis yields conditions for the solution of the worker's problem in the present model. He shows that, in our notation, the optimal consumption plan must satisfy

\[
F(t)U'(c_t) \equiv \begin{cases} 
\lambda & \text{if } t \in [0,N), \\
\lambda' & \text{if } t \in (N,T], 
\end{cases}
\]

when the \( \dot{S}(t) \geq 0 \) whenever \( S(t) = 0 \) constraint is not binding; otherwise
Equation (27) states that expected marginal utility from consumption should be constant over time, along the interior part of the plan, except possibly for a jump at $t = N$. The possibility that $\lambda \neq \lambda'$, and the implied discontinuity in $|c_t|$ at $t = N$, cannot be ruled out at this stage, but we shall argue below that $\lambda = \lambda'$ at the solution and that the optimal consumption path is, in fact, continuous everywhere.

Before discussing the first-order condition associated with the worker’s choice of $N$, we make a number of simplifying observations:

(i) A worker never saves after retirement. This follows because (27) and (28) and the concavity of $U$ imply that after retirement, $|c_t|$ is nonincreasing. Thus, if a worker ever saved, he would continue to save until $T$, given the constancy of post-retirement income $pG(N)$. Since $S(t) \geq 0$, this would imply that $S(T) > 0$, which is incompatible with optimality.

(ii) If a worker ever saves (privately), it must be before retirement, and he or she must continue to save until retirement. This follows immediately from (i), an argument like that used to establish (i), and the constancy of pre-retirement income. (It would remain valid if pre-retirement income were rising, but not necessarily if it were falling or followed the typical “hump-shaped” pattern.)

(iii) No worker who ever saves plans to retire at $T$, since then (ii) would imply that $S(T) > 0$, a contradiction.6 (Even a worker who never saves will never plan to retire at $T$, provided that $u$ is not too negative; that is, if he or she is not an extreme workaholic.)

6. That the optimal $N$ is always strictly less than $T$ may seem puzzling in view of the fact that, by l'Hôpital’s Rule,

$$\lim_{N \to T} (T - N)pG(N) = p \lim_{N \to T} \left[ (T - N)F(N) - \int_0^N F(t)dt \right] = + \infty.$$

This follows from actuarial fairness and the fact that a worker who planned to retire near $T$ and happened to live that long would be in a position to reap the benefits of the social savings of almost all other members of his or her cohort. Nevertheless, it can be shown that even though a worker who plans to retire near $T$ enjoys large consumption possibilities after retirement, the fact that he cannot borrow against them, coupled with the diminishing marginal utility of consumption, means that the expected utility of such plans is not abnormally high. More precisely, if the Inada condition $\lim_{c \to \infty} U'(c) = 0$ is satisfied, the limit of expected utility as $N \to T$, given optimal consumption conditioned on $N$, is just expected utility when $N = T$. 
(iv) If a worker ever saves privately, private cumulative savings are exhausted exactly once, at a point \( Q \in (N^*, T) \), where asterisks again denote optimal values. That \( Q \) is well-defined and that \( Q > N^* \) follows immediately from (i), (ii), and (iii). To see that \( Q < T \), assume the contrary. Then, by (27), 
\[ F(t)U'(c_t) = \lambda' > 0 \quad \text{for all } t \in (N, T]. \]
But \( U''(\cdot) < 0 \), and, by (i), \( c_t \geq pG(N) \) for all \( t \in (N, T] \), so
\[
\lim_{t \to T} F(t)U'(c_t) \leq \lim_{t \to T} F(t)U'(pG(n)) = U'(pG(N)) \lim_{t \to T} F(t) = 0,
\]
a contradiction. (Intuitively, \( Q < T \) because the relative advantage of social over private savings grows without limit as \( F(t) \) approaches zero.)

Given observations (i)–(iv), for an individual who ever saves, cumulative savings \( S(t) \) are strictly positive throughout an interval \( (R, Q) \), where \( 0 < R < N^* < Q < T \). From now on, we shall confine our discussion to the case where \( R = 0 \), that is, where the worker saves throughout his or her working lifetime. The case where the worker is forced to save for a while by high social-insurance payments was analyzed, in the certainty case, in Section III. Little additional insight would be gained by generalizing that analysis to allow an uncertain lifetime.

It follows from observations (i)–(iv) and the fact that \( S(t) \) is continuous that \( S(t) > 0 \) throughout a neighborhood of \( N^* \); thus, a simple argument establishes that \( \{c_t\} \) is continuous near \( N^* \), and that \( \lambda = \lambda' \) in (27). Since \( c_t \leq pG(N) \) for all \( t \in (Q, T] \), and the optimal \( \{c_t\} \) is interior throughout \( [0, Q) \) given observations (i)–(iv), this implies that discontinuities in the optimal \( \{c_t\} \) can occur, if at all, only at \( Q \).

When \( R = 0 \), the worker’s problem can now be written as
\[
(E) \quad \max_{\{c_t\}, N} \int_0^Q F(t)U(t)dt + U(pG(N)) \int_Q^T F(t)dt + v \int_N^T F(t)dt
\]
subject to
\[
\int_0^Q c_t dt = N(1 - p) + (Q - N)pG(N).
\]
The constraint, which is a translation of \( S(Q) = 0 \), is the only one that is now relevant, since all others have already been substituted out.

In addition to the constraint, solutions of problem (E) must satisfy the first-order conditions,

\[
F(t)U'(c_t) \equiv \lambda, \quad t \in [0, Q],
\]

\[
-F(N)v + U'(pG(N))pG'(N) \int_0^T F(t)dt + \lambda[1 - p \{1 + G(N) - (Q - N)G'(N)\}] = 0,
\]

and

\[
F(Q)[U(c_Q) - U(pG(N))] - \lambda[c_Q - pG(N)] = 0,
\]

which are derived from the Lagrangian expression in the usual way, making use of the fact that all solutions of the problem expressed in this form must be interior by observations (i)–(iv). If the Inada condition \( \lim_{c \to \infty} U'(c) = 0 \) is satisfied, the existence of a solution is easily established by making use of the results of Yaari [1964]; weaker conditions also suffice.

To avoid unnecessary technicalities in deriving an expression for \( dN/dp \) as much as possible, we proceed as follows. First, note that, given (29) for \( t = Q \) and the fact that \( U''(\cdot) < 0 \), the first-order condition (31) is satisfied if and only if \( c_Q = pG(N) \). (It can be shown that the implied value of \( Q \) is, in addition to satisfying the first-order condition, optimal for given values of \( N \) and \( p \).) Since \( c_t \equiv pG(N) \) for \( t \in (Q, T] \), this implies that the optimal \( \{c_t\} \) is continuous at \( Q \). This continuity condition makes good economic sense and completes our proof that the optimal \( \{c_t\} \) is continuous everywhere.

Now define \( \lambda^*(N, Q, p) \) and \( \{c_t^*(N, Q, p)\} \) as the values of \( \lambda \) and \( \{c_t\} \) that satisfy both (29) and the constraint of problem (E). Given our assumptions, it is clear that these functions are well defined and differentiable. Total differentiation reveals that

\[
\frac{\partial \lambda^*}{\partial N} = \frac{1 - p[1 + G(N) - (Q - N)G'(N)]}{I},
\]

\[
\frac{\partial \lambda^*}{\partial Q} = \frac{pG(N) - c_Q^*(N, Q, p)}{I},
\]

and

\[
\frac{\partial \lambda^*}{\partial p} = \frac{(Q - N)G(N) - N}{I},
\]
where \( I \) denotes \( \int_0^T [F(t)U''(c_t(N,Q,P))]^{-1} dt \).

Given the definition of \( \lambda^*(N,Q,P) \), and remembering that (31) is equivalent to \( c_Q = pG(N) \), it follows from (29) and (30) that at a solution to the worker's problem,

\[
-F(N)v + U'(pG(N))pG'(N) \int_Q^T F(t)dt + \lambda^*(N,Q,p)[1 - p[1 + G(N) - (Q - N)G'(N)]] = 0,
\]

and

\[
F(Q)U'(pG(N)) - \lambda^*(N,Q,p) = 0.
\]

When the appropriate second-order conditions are satisfied, the system (35)–(36) characterizes the optimal values of \( N \) and \( Q \) for a given value of the parameter \( p \), and can, therefore, be used to derive the comparative statics properties of the model. The Jacobian of the system can be written as

\[
J = \begin{pmatrix}
\alpha & \beta \\
F(Q)U'(pG(N))pG'(N) - \frac{\partial \lambda^*}{\partial N} F'(Q)U'(pG(N)) - \frac{\partial \lambda^*}{\partial Q}
\end{pmatrix},
\]

where

\[
\alpha = -F'(N)v + p[G''(N)U'(pG(N)) + pG'(N)^2U''(pG(N))]
\]

\[
\int_Q^T F(t)dt + \lambda^*(\cdot)p[(Q - N)G''(N) - 2G'(N)]
\]

\[
+ \frac{\partial \lambda^*}{\partial N}[1 - p[1 + G(N) - (Q - N)G'(N)]]
\]

and

\[
\beta = \frac{\partial \lambda^*}{\partial Q}[1 - p[1 + G(N) - (Q - N)G'(N)]]
\]

\[
+pG'(N)[\lambda^*(\cdot) - F(Q)U'(pG(N))].
\]

By (33), (36), and the fact that \( c_Q(N,Q,P) = pG(N) \) at a solution, \( \partial \lambda^*/\partial Q = 0 \) and \( \beta = 0 \).

The derivative \( dN^*/dp \) can now be computed by solving the system of equations obtained by totally differentiating (35) and (36)
with respect to $p$:

$$J\left[ \frac{dN^*/dp}{dQ^*/dp} \right] = \left[ -\left[ U'(pG(N)) + pG(N)U''(pG(N)) \right]G'(N) \right. \\
\times \int_Q^T F(t)dt + \lambda^* \left[ G(N) - (Q - N)G'(N) \right] \\
- \frac{\partial \lambda^*}{\partial p} \left[ 1 - p \left[ 1 + G(N) - (Q - N)G'(N) \right] \right] \\
\left. - F(Q)U''(pG(N))G(N) + \frac{\partial \lambda^*}{\partial p} \right].$$

Before presenting the expression for $dN^*/dp$, it is useful to examine the "budget" constraint of problem (E), because the effects of social insurance on the worker's behavior are transmitted mainly through this constraint. Let $D(N,Q,p) \equiv N(1 - p) + (Q - N)pG(N)$, the right-hand side of the constraint in (E). It is easily verified that

$$\frac{\partial D}{\partial N} \equiv 1 - p \left[ 1 + G(N) - (Q - N)G'(N) \right],$$

$$\frac{\partial^2 D}{\partial N \partial p} = - \left[ 1 + G(N) - (Q - N)G'(N) \right],$$

and

$$\frac{\partial D}{\partial p} \equiv (Q - N)G(N) - N.$$

Note that $\partial D/\partial N$ is the implicit price of leisure in terms of planned pre-$Q$ consumption, $\int_0^T c_i \, dt$. The effect of changes in $p$ on the relative price of leisure is measured by $\partial^2 D/\partial N \partial p$, and the effect on the feasible level of pre-$Q$ consumption (for given $N$ and $Q$) is measured by $\partial D/\partial p$. Both $\partial^2 D/\partial N \partial p$ and $\partial D/\partial p$ are generally nonzero, but ambiguous in sign. The ambiguity comes from the fact that increasing $p$ both raises total feasible planned consumption and increases the amount that is accessible only after $N$. We can, however, sign both $\partial^2 D/\partial N \partial p$ and $\partial D/\partial p$ if an additional plausible restriction is met. Note that, by (42) and the definition of $G(N)$, $\partial^2 D/\partial N \partial p$ can be ex-
pressed as

\[ \frac{\partial^2 D}{\partial N \partial p} = -\frac{\int_0^T F(t)dt}{\int_N^T F(t)dt} \left[ \frac{1}{\int_N^T F(t)dt} - \frac{(Q - N)F(N)}{\int_N^T F(t)dt} \right], \]

which is positive if and only if \( \int_N^T F(t)dt < (Q - N)F(N) \). This condition, which we shall call "condition A," is not implied by our assumptions, but as Figure I suggests, it is likely to be satisfied at solutions of the worker's problem for realistic values of \( p \); it requires that \( Q \) and \( N^* \) be such that the vertically shaded area is larger than the horizontally shaded area in the figure. Since \( Q = T \) for \( p = 0 \), and since Social Security contributions are a relatively small fraction of workers' incomes, condition A is likely to be satisfied for most workers under the Social Security system.

Condition A is also sufficient to sign \( \partial D/\partial p \). Since \( \partial D/\partial p = 0 \) when \( N = 0 \) and is increasing in \( N \) because \( \partial^2 D/\partial N \partial p > 0 \), it follows that \( \partial D/\partial p > 0 \) when \( N > 0 \) and \( \int_N^T F(t)dt < (Q - N)F(N) \). Using (32)-(34), (41)-(43), and Cramer's Rule applied to (40) yields

\[ \frac{dN^*}{dp} = \left( -\frac{\partial D}{\partial p} \frac{\partial \lambda^*}{\partial N} - \frac{\partial^2 D}{\partial N \partial p} \lambda^*(Q,N,p) - \frac{\partial^2 \gamma}{\partial N \partial p} \right) / \alpha, \]

where \( \gamma \) denotes the objective function of problem (E) and it has been assumed that \( \alpha < 0 \).

Needless to say, \( dN^*/dp \) is generally ambiguous in sign. The denominator \( \alpha \) can be expressed as the sum of two nonpositive terms.
The first,
\[
\]
\[
\times \int_Q^T F(t)dt + \lambda^*(N,Q,p)p[(Q - N)G''(N) - 2G'(N)],
\]
is the second derivative with respect to \( N \) of the Lagrangian associated with problem (E) and must, therefore, be nonpositive at a solution. The second,
\[
\frac{\partial \lambda^*}{\partial N} 1 - p[(1 + G(N) - (Q - N)G'(N))],
\]
is nonpositive by (32).

The first term in the numerator of the right-hand side of (45) is analogous to an income effect. Under condition A, increasing \( p \) increases feasible planned consumption and leisure and, thus, recalling that \( \alpha < 0 \), tends to encourage earlier retirement. The second term on the right-hand side of (45) is like a substitution effect, in that it reflects the effect of \( p \) on \( N^* \) transmitted by the change in the marginal rate of transformation between leisure and pre-\( Q \) consumption. This term encourages later retirement when condition A is satisfied because then, raising \( p \) makes available additional insurance benefits to the worker, raising the amount of pre-\( Q \) planned consumption that can be had by working an additional period. The positive substitution effect follows because in our model, the worker can take advantage of these benefits only by working longer.

To understand the third term, which pertains to post-\( Q \) consumption and is a hybrid of income- and substitution-like effects, recall that
\[
\frac{\partial^2 \gamma}{\partial N \partial p} = [U'(pG(N)) + pG(N)U''(pG(N))]G'(N)\int_Q^T F(t)dt.
\]
Given that \( \alpha < 0 \) and \( G'(N) > 0 \), this term tends to favor later retirement if and only if the term in brackets is positive; this is true if and only if the elasticity of marginal utility is less than unity. The effect of raising \( p \) that is transmitted through the third term is completely analogous to the effect of an increase in the wage in simpler models of retirement: if the marginal utility of consumption falls off rapidly enough, the "income" effect dominates the "substitution" effect and the worker retires earlier, otherwise, he or she retires later.
VI. Conclusion

In this paper we have modeled the effect of Social Security, pensions, and other forms of social insurance on individual retirement decisions. Three strong assumptions—perfect capital markets, actuarial fairness, and certain lifetimes—have been maintained in many analyses of the effects of social insurance to date. While these assumptions together imply that social insurance has no effect on individuals’ incentives to retire, we have argued above that any departure from the above assumptions implies that there is such an effect, which is often systematic.

In particular, when capital markets do not permit consumption loans, benefits are actuarially fair and available at retirement, however early, and lifetimes are certain, raising the level at which workers are required to participate in the social insurance plan advances retirement. If there is an earliest age at which benefits can be collected (as in the current Social Security system, where this age is 62), this effect is ambiguous a priori for workers who would otherwise wish to retire before that age, but likely to tend to delay retirement.

If benefits are not actuarially fair, lifetimes are certain, and capital markets are perfect, there are a number of possible effects on retirement decisions. It is argued, for example, that the deviations from fairness built into the current Social Security system tend to advance retirement for most workers, particularly low-income workers.

Finally, if lifetimes are uncertain, it is shown that actuarially fair social insurance creates an “income” effect that tends to advance retirement and a “substitution” effect that, surprisingly, tends generally to delay retirement. These effects arise solely as a consequence of the uncertainty about length of life that social insurance insures against, and are entirely absent from models with certain lifetimes. The substitution effect in our model tends to delay retirement because under our assumptions, the benefits of social insurance can be fully realized only by working longer. These effects would both be diluted somewhat if other annuities were available.

In conclusion, we have isolated a number of apparently realistic influences that Social Security and some private pension plans might have on workers’ retirement decisions. It is our hope that the theoretical framework outlined here will aid attempts to measure the empirical importance of these influences.

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