The Effect of Income Taxation on the Retirement Age and Lifetime Labor Supply

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Abstract

Cuts in the marginal income tax rates brought about by the 1986 Tax Reform Act have been credited or cursed with numerous supply side effects. The purpose of the present study is to explore what effects, if any, changes in the marginal income tax rates might be expected to have on retirement behavior and lifetime labor supply. A model of tax and retirement behavior is developed in the standard life-cycle mode. A basic proposition of the model is that an increase in the marginal tax rate reduces the planned retirement age if leisure and consumption are substitutes, and increases it if they are complements. The elasticity of substitution is estimated using cross-section data and found to be less than one, implying complementarity between consumption and leisure. It follows that tax increases tend to increase the retirement age and lifetime labor supply, while tax cuts have the opposite effect. The results are shown to hold even after allowing for a bequest motive and uncertain lifetimes.
I. Introduction

There is a growing literature treating the retirement decision as endogenous within a life-cycle model. In the typical model, retirement choice is based on the maximization of an intertemporal utility function subject to a lifetime budget constraint. Since these models are generally too complicated to solve analytically even under restrictive assumptions, there is often a very loose connection between the life-cycle model and the estimation model. A typical empirical model relates the age of retirement to a set of explanatory variables including health status, net social security and private pension benefits, assets, job characteristics, wages, and the like. Sometimes, estimates from the empirical model are fed back into the life-cycle model so that retirement behavior can be simulated under alternative policy regimes.

The focus of this study is the relationship between retirement behavior and changes in the wage. The income tax, by lowering the wage rate, generates a substitution effect favoring earlier retirement and an income effect favoring later retirement if leisure is a normal good. The net result is ambiguous depending on the relative strengths of the two effects.

Empirical studies of the role of the wage in the retirement decision generally find little or no relationship. For example, while Hurd and Boskin (1984) find substantial retirement effects of health status and mandatory retirement provisions, they find little systematic
variation of the wage with retirement probabilities. For some ages, the wage is positively related to the probability of retirement; for other ages, it is negatively related. Likewise, Quinn (1977) finds no evidence that the individual's wage rate is an important determinant of retirement status.

The inability of empirical studies to pick up an association between retirement behavior and the wage may be due to correlation between the wage rate and retirement benefits or may be due to restrictions placed on earnings by the social security retirement test. Further, since retirement and earnings are directly correlated, earnings cannot be used as an explanatory variable in studies that use actual retirement behavior as the dependent variable.  

The present study takes an analytical approach to deriving the relationship between the wage and retirement behavior. The retirement decision is modeled within a life-cycle framework in which the retirement age is set so as to equate desired lifetime consumption with desired lifetime earnings after taxes. The individual maximizes an intertemporal utility function subject to a lifetime budget constraint. The assumption of a constant elasticity of substitution between consumption and leisure allows us to sign the derivative of optimal (planned) retirement with respect to changes in the marginal tax rate. The basic proposition of the model is that an increase in the marginal tax rate reduces the planned retirement age if leisure and consumption are substitutes and increases it if they are complements.
A simple test of the relationship between consumption and leisure is conducted using data extracted from the Michigan Panel Study of Income Dynamics (PSID). The elasticity of substitution between consumption and leisure is estimated from the coefficients of a leisure share equation derived from the structural model.\(^5\)

The model begins with the premise that intertemporal utility depends only on the consumption and leisure paths and that lifetimes are certain. Later versions of the model admit a bequest motive and uncertain lifetimes. The results of the model are shown to hold in the extended model.

Section II describes the life-cycle model and section III reports on the results of a simple empirical test. A bequest motive and uncertain life expectancy are introduced in sections IV and V, and the implications of the results are discussed in section VI.

II. Theoretical Expectations

The model of this study is in the tradition of models developed by Sheshinski (1978) and Crawford and Lilien (1981). Sheshinski develops an intertemporal utility maximization model in which it is assumed that workers work full time or not at all. The individual jointly chooses an optimum consumption path and retirement plan. Crawford and Lilien relax the assumptions of perfect capital markets, certain lifetimes, and actuarially fair pension systems, but assume a zero rate of interest and zero rate of time preference.

The model of the present study extends the earlier work by allowing for variable hours of work prior to retirement and for positive
rates of interest and time preference. It is assumed that the taxpayer has a time-invariant utility function of the constant elasticity of substitution form (CES):

\[ U(t) = a C(t)^b + (1-a) L(t)^b \]

where \( C(t) \) is consumption in period \( t \), \( L(t) \) is hours devoted to leisure in time period \( t \), \( a \) is a constant between zero and one, and \( b \) is a constant less than or equal to one. In the special case when \( b \) is equal to zero, the utility function becomes Cobb-Douglas; as \( b \) goes to one, consumption and leisure become perfect substitutes and as \( b \) goes to minus infinity, they become perfect complements.

The taxpayer seeks to maximize lifetime utility:

\[ U = \int_0^T \left[ a C(t)^b + (1-a) L(t)^b \right] e^{-\rho t} \, dt \]

where \( T \) is the known life-span of the taxpayer and \( \rho \) is the fixed rate of time preference. In the model of this section, there is no bequest motive and no uncertainty. These assumptions are relaxed later.

In the maximization, the taxpayer is constrained by the following budget constraint:

\[ A = S(t) = w (k - L(t)) + r A(t) - C(t) \]

where \( A \) is the change in asset holdings in time \( t \), \( S(t) \) is saving in time \( t \), \( w \) is the after-tax wage rate, \( k \) is the time available each period for work and leisure, \( r \) is the interest rate, \( A(t) \) is the asset level in period \( t \), and \( C(t) \) is consumption in period \( t \). Leisure, \( L(t) \) is less than \( k \) during the working period and equal to \( k \) during the
retirement period. The constraint states that the change in the value of the taxpayer's assets at each instant in time is equal to saving after tax. Inheritances and bequests are ignored for the time being by assuming \( A(0) = A(T) = 0 \).

The Hamiltonian for this optimal control problem is:

\[
H = e^{-\rho t} \left[ a C(t)^b + (1-a) L(t)^b \right] + \lambda(t) \left[ w (k - L(t)) \right] + r A(t) - C(t) + \mu(t) (k - L(t))
\]

where \( \lambda(t) \) and \( \mu(t) \) are multiplier functions associated with the satisfaction of the constraints. Then,

\[
\begin{align*}
(5a) \quad a b e^{-\rho t} C(t)^{b-1} - \lambda(t) &= 0 \\
(5b) \quad (1-a) b e^{-\rho t} L(t)^{b-1} - w \lambda(t) - \mu(t) &= 0 \\
(5c) \quad \lambda(t) &= -\lambda(t) r \\
(5d) \quad A(0) &= A(T) = 0 \\
(5e) \quad \mu(t) (k - L(t)) &= 0
\end{align*}
\]

are the first-order conditions for an extremum. Recognizing that \( \mu(t) \) equals zero when \( t < R \) (the retirement age) and \( \mu(t) \) is positive when \( t > R \), these can be solved for the time paths of consumption and leisure:
(6a) \[ C(t) = C(0) e^{-g t} \]

(6b) \[ L(t) = L(0) e^{-g t} \quad t < R \]
\[ = k \quad t > R \text{ or } R \]

where \( g = (\rho - r)/(1 - b) \).

Since \( L(R) = k = L(0) e^{-gR} \), it follows that \( L(0) = k e^{gR} \). Further, since \( C(0)/L(0) = w s^{(a/(1-a))^s} \), where \( s = 1/(1-b) \), we have

\[ C(0) = w s^{(a/(1-a))^s} k e^{gR} \]

and the time paths for consumption and leisure are seen to depend on the wage rate, the utility parameters, total time available, and the retirement age:

(7a) \[ C(t) = w s^{(a/(1-a))^s} k e^{g(R-t)} \]

(7b) \[ L(t) = k e^{g(R-t)} \quad t < R \]
\[ = k \quad t > R \text{ or } R \]

Consumption and leisure will either increase or decrease over the lifetime depending on the sign of \( g \). If \( r \) is greater than \( \rho \), then \( g \) will be negative, and consumption and leisure will increase over the taxpayer's lifetime.

Lifetime consumption, \( C \), is found by integrating the discounted value of taxpayer consumption over the lifetime:

(8) \[ C = \int_0^T C(t) e^{-rt} \, dt \]
\[ = w s^{(a/(1-a))^s} k e^{gR} \left[ (1 - e^{-zT})/z \right] \]
where \( z = g + r \). Likewise, lifetime earnings can be calculated by integrating the discounted value of taxpayer earnings over the working lifetime:

\[
(9) \quad M = \int_0^R w (k - L(t)) e^{-rt} \, dt
\]

\[
= w k [(1 - e^{-rR})/r] - w k e^{gR} [(1 - e^{-zR})/z]
\]

Since inheritances and bequests are ruled out of this section, it follows that lifetime consumption must equal lifetime earnings, \( F = M - C = 0 \). Substituting from (8) and (9) gives:

\[
(10) \quad F = w k [(1 - e^{-rR})/r] - w k e^{gR} [(1 - e^{-zR})/z]
\]

\[
- w^s (a/(1-a))^s k e^{gR} [(1 - e^{-zT})/z] = 0
\]

The effect of an earnings tax on the retirement decision is found by differentiating \( F \) with respect to the retirement age, \( R \), and the wage rate, \( w \). After simplification using equation (10), this gives, respectively:

\[
(11a) \quad F_R = -g w k e^{gR} [(1 - e^{-zR})/z]
\]

\[
(11b) \quad F_w = (1-s) w^{s-1} (a/(1-a))^s k e^{gR} [(1 - e^{-zT})/z]
\]

Note that \( F_R \) is always positive as long as \( g \) is negative (which occurs when \( r \) is greater than \( p \)). \(^9\) \( F_w \) is positive if \( s = 1/(1-b) \) is less than one, which occurs if \( b \) is negative (recall that \( b \) is always less than one). If \( b \) is positive, \( F_w \) is negative.
The partial derivative of \( R \) with respect to \( w \) may be found by employing the implicit function rule:

\[
\frac{\partial R}{\partial w} = -\frac{F_R}{F_w}
\]

which is positive if \( b \) is positive and conversely if \( b \) is negative. If \( b \) is equal to zero, \( s \) is equal to one and \( F_w \) is equal to zero so that \( \partial R/\partial w \) is not defined.

Hence, we have the following proposition that an increase in the wage rate increases the retirement age so long as current consumption and leisure are substitutes (\( b \) is greater than zero). If leisure and consumption are complements (\( b \) is less than zero), an increase in the wage rate reduces the retirement age. This implies that an income tax, which reduces the wage rate, reduces the retirement age so long as consumption and leisure are substitutes, and increases the retirement age if they are complements.

The model can also be used to assess the effect of changes in taxation on lifetime labor supply. Following Blinder (1974, p. 76) in defining lifetime labor supply, \( H \), as lifetime earnings, \( M \), normalized by the wage rate, \( w \), we have from equation (9):

\[
H = \frac{M}{w} = k \left[ (1 - e^{-tR})/r \right] - w k e^{gR} \left[ (1 - e^{-zR})/z \right]
\]

Differentiating with respect to \( w \) gives:

\[
\frac{\partial H}{\partial w} = -g k e^{gR} \left[ (1 - e^{-zR})/z \right] \frac{\partial R}{\partial w}
\]

which has the same sign as \( \partial R/\partial w \) as long as \( g \) is negative (\( r \) is greater than \( \rho \)). Hence, the same conclusions apply to lifetime labor
supply as apply to the retirement decision: an increase in the wage rate increases lifetime labor supply so long as current consumption and leisure are substitutes (b is greater than zero). If leisure and consumption are complements (b is less than zero), an increase in the wage rate reduces lifetime labor supply. This implies that an income tax, which reduces the wage rate, reduces lifetime labor supply so long as consumption and leisure are substitutes, and increases lifetime labor supply if they are complements.

III. Empirical Results

The purpose of the empirical model is to test whether consumption and leisure are substitutes or complements. The estimation model for nonretired taxpayers is obtained by dividing equation (7b) by (7a):

\[ \frac{L(t)}{C(t)} = \left(\frac{a}{(1-a)}\right)^{s} w^{-s} \]  

or in log form:

\[ \ln \frac{L(t)}{C(t)} = -s \ln \left(\frac{a}{(1-a)}\right) -s \ln w \]

Since \( s = 1/(1-b) \) is always positive, the model states that the leisure-consumption ratio is negatively related to the wage rate (i.e., people with higher wage rates have lower leisure-consumption ratios). By estimating \( s \) using ordinary least squares regression analysis, we obtain an estimate of \( b = (s-1)/s \) which is unbiased and efficient. A standard \( t \)-test can then be used to determine whether \( b \) is greater than or less than zero and thereby determine whether leisure and consumption are substitutes or complements.
The problem in estimating equation (16) using data from a standard cross-section of households is that generally information on consumption is not available in those data sets that are rich in information on labor supply. Fortunately, the Michigan Panel Study of Income Dynamics (PSID) contains both consumption and labor supply information. This study utilizes the 1986 panel for the 1984 interviewing year. Nonretired households whose family head is between the ages of 20 and 60 were selected for the estimation. Further, unmarried persons, families on welfare or social security, and families with an unemployed household head were excluded from the estimation sample. This provides a subsample of households for which wage rate data are available and whose work/consumption decisions are not biased by high implicit marginal tax rates (as with AFDC recipients, say). The estimation subsample includes 1,675 households.

Hours of leisure, L(t), are calculated for the head of the household by subtracting hours worked per year from total time available, k (assumed to equal 8,760 = 24 hours per day times 365 days per year). Since the unemployed were excluded from the subsample, no adjustment for time spent seeking employment was necessary.

The consumption variable, C(t), was constructed by summing those items of consumption available in the PSID data. These included annual food expenditures at home and away from home, annual rent for renting families, annual property taxes and mortgage payment for homeowning families, and total federal income taxes. Hence, most tax, shelter, and food costs were included in the consumption variable. Other items of consumption such as transportation, entertainment, and
clothing were not available in the data set and could not be included in the consumption variable.

The wage rate was put on an after-tax basis by multiplying by one minus the household's marginal tax rate. The marginal tax rate was imputed based on the household's taxable income, number of exemptions, and the tax table used. Taxpayers were either assigned the standard deduction (zero-bracket amount) or an average itemized deduction for their taxable income bracket depending on whether or not the family itemized deductions. For families itemizing deductions, the amount of the itemized deduction was calculated by applying an average fraction of income determined from the 1982 Statistics of Income -- Individual Tax Returns to the family's taxable income. The deduction for married couples when both work was calculated by subtracting from gross income 10% of the earned income of the lesser-earning spouse, regardless of whether or not the couple itemized deductions.

The results of the estimation were:

\[
\ln \left[ \frac{L(t)}{C(t)} \right] = 1.084 - 0.814 \ln w \\
R^2 = 0.3573 \quad \text{Adj } R^2 = 0.3570 \quad F = 925.782
\]

where the numbers in parentheses are t-ratios. The estimated coefficients both test significantly different from zero at the .99 confidence level. The $R^2$ and adjusted $R^2$ statistics indicate good explanatory power for a cross-section regression, and the $F$ statistic confirms the explanatory power of the wage variable at the .99 confidence level.
The estimated coefficients in equation (17) can be used to derive estimates of the model parameters, \( s = 1/(1-b) \) and \( a \). From equation (16) and the estimated parameters from equation (17), we have:

\[
(18a) \quad -s \ln (a/(1-a)) = 1.084 \\
-\ln s = -0.814
\]

Working backward, since \( s = 0.814 \), \( b = (s-1)/s = -0.228 \). Further, since \( \ln (a/(1-a)) = 1.084/(-0.814) = -1.332 \), \( a/(1-a) = 0.264 \) and \( a = 0.209 \). Gustman and Steinmeir (1986) estimate \( s \) and \( b \), respectively, as \( 0.87 \) and \( -0.15 \).

A standard t-test can be used to test whether \( b \) is significantly different from zero (or equivalently whether \( s \) is significantly different from one). It is easily confirmed that indeed \( s \) is less than one and \( b \) is less than zero. This implies that leisure and consumption are complements and that an increase in the wage rate reduces the retirement age. This in turn implies that an income tax, since it reduces the wage rate, increases the retirement age and increases lifetime labor supply.

IV. Adding a Bequest Motive

The model to this point assumes no bequest motive. To test the sensitivity of the results to that assumption, a bequest motive is introduced into the model in this section.

The lifetime utility function, previously a function of lifetime consumption and leisure, must be modified to account for bequests and their utility to the individual. A standard practice is to augment
the lifetime utility function with a utility bequest function, \( B[A(T)] \):

\[
U = \int_0^T [a C(t)^b + (1-a) L(t)^b] e^{-\rho t} dt + B[A(T)]
\]

where \( B \) is an increasing function of assets in time \( T \). The terminal condition for the model is no longer \( A(T) = 0 \), but depends on the optimal bequest set so as to maximize \( U \).

The optimal bequest is determined by solving the following the following transversality condition for \( A(T) \):

\[
\lambda(T) = B'[A(T)]
\]

where \( \lambda(T) \) is the shadow price of wealth in period \( T \) and \( B'[A(T)] \) is the marginal utility of the bequest. The transversality condition states that the optimal bequest is determined by equating the marginal utility of the bequest with its shadow price.

The shadow price, \( \lambda(T) \), is also equal, by equation (5a), to:

\[
\lambda(T) = a b e^{-\rho T} C(T)^{b-1}
\]

which in turn can be rewritten, after substitution from equation (7a), as:

\[
\lambda(T) = a b e^{-\rho T} [w^S (a/(1-a))^S k e^{g(R-T)}]^{b-1}
\]

Assuming that the utility bequest function has the same general form as the lifetime utility function, \( B[A(T)] = d_1 A(T)^{\beta}/\beta \), where \( \beta < 1 \), we get by differentiation:
(23) \[ B'[A(T)] = d^{1-\beta} A(T)^{\beta-1} \]

Then, substituting from equations (20), (22), and (23), simplifying by setting \( \beta = b \), and solving for \( A(T) \), gives the optimal bequest:

(24) \[ A(T) = d b^{-s} (1-a)^{-s} w^s k e^{gR} e^{rsT} \]

The assumption that \( \beta = b \) is not appealing since it restricts the bequest and utility functions to have the same elasticity. It is shown in footnote 11 that the results carry through if \( b \) and \( \beta \) are unequal but have the same sign.

To find the effect of a wage change on the retirement age, the \( F \) function of equation (10) must be rewritten to recognize that lifetime income now equals lifetime consumption plus bequests, so that \( F = M - C - A(T) = 0 \). Substituting from equation (24) gives:

(25) \[ F = w k \left[ (1 - e^{-rR})/r \right] - w k e^{gR} \left[ (1 - e^{-zR})/z \right] \]
\[ - w^s \left( a/(1-a) \right)^s k e^{gR} \left[ (1 - e^{-zT})/z \right] \]
\[ - d b^{-s} (1-a)^{-s} w^s k e^{gR} e^{rsT} = 0 \]

The effect of a wage change on the retirement decision can be found, as we did before, by differentiating \( F \) with respect to \( R \) and \( w \). This gives, respectively:

(26a) \[ F_R = -w k g e^{gR} \left[ (1 - e^{-zR})/z \right] \]

(26b) \[ F_w = (1-s) \left\{ w^{s-1} \left( a/(1-a) \right)^s k e^{gR} \left[ (1 - e^{-zT})/z \right] \right\} \]
\[ + d b^{-s} (1-a)^{-s} w^{s-1} k e^{gR} e^{rsT} \} \]
As before, $F_R$ is always positive as long as $g$ is negative (which occurs when $r$ is greater than $\rho$). $F_w$ is positive if $s = 1/(1-b)$ is less than one, which occurs if $b$ is negative (recall that $b$ is always less than one). If $b$ is positive, $F_w$ is negative.

The partial derivative of $R$ with respect to $w$, found as before according to $\partial R/\partial w = -F_R/F_w$, is positive if $b$ is positive and conversely if $b$ is negative. Hence, the conclusions of the earlier section carry through: an increase in the wage rate increases the retirement age so long as current consumption and leisure are substitutes ($b$ is greater than zero). If leisure and consumption are complements ($b$ is less than zero), an increase in the wage rate reduces the retirement age. This implies that an income tax, which reduces the wage rate, reduces the retirement age so long as consumption and leisure are substitutes, and increases the retirement age if they are complements. Adding a bequest motive in no way affects the expectations of the theoretical model.\textsuperscript{11}

V. Uncertain Lifetime

Until now, the model has been based on the assumption of a definite time horizon. Relaxing that assumption, we assume that the individual's lifetime is unknown. Let $D(t)$ be the probability of dying by time $t$, $D'(t)$ the associated probability density function, and $T$ be an upper bound on possible lifetimes ($D(T) = 1$).

Following Kamien and Schwartz (1981), the individual's lifetime utility function must now be rewritten:
which can be shown to be equivalent to:

\[
U = \int_0^T \left[ [a C(t)^b + (1-a) L(t)^b] e^{-\rho t} \right. \\
+ B[A(t))] \frac{D(t)}{1-D(t)} dt
\]

where \([1-D(t)]\) is the probability of living at least until \(t\) and \(D'(t)\) is the probability of dying at \(t\). All the previous results carry through except that now \(g = (\rho + m - r)/(1 - b)\) where \(m = D'(t)/[1-D(t)]\) is the conditional probability density of dying at \(t\) given survival until then. Hence, the effect of the uncertainty is the same as an increase in the time preference, \(\rho\).

The conclusions of the model are not affected so long as \(g\) remains negative. If \(m\) is sufficiently large to make \(g\) positive, then \(F_R\) is negative, and all conclusions are reversed. However, we would also in this case observe consumption decreasing over the lifecycle and the retirement phase occurring at the beginning of the life cycle. Hence, we will continue to assume that \(g\) is negative although larger (in absolute value) than in the certain time horizon case.

VI. Policy Implications and Conclusions

The first generation models of labor supply and taxation generally found backward-bending labor supply functions for male heads of households. Hence, they would predict that an increase in taxes, by
reducing the disposable wage, moved workers down their backward-bending labor supply functions and resulted in an increase in work effort.

The present study extends the earlier models to adopt a lifetime perspective and focus on the retirement and lifetime labor supply decisions. Yet it arrives at a conclusion similar to those of the older, static models; namely that an increase in taxes leads to an increase in the retirement age and an increase in lifetime labor supply. This conclusion resulted from the empirical finding that consumption and leisure are complementary goods and is independent of the no-bequest motive and definite time horizon assumptions.

This study treats the effect of the personal income tax as a pure wage effect. In practice, the tax is nonlinear and taxes interest as well as wage income. Further, various provisions of the income tax such as Keoghs and IRAs may affect saving and retirement. The Tax Reform Act of 1986 (TRA) introduced a new two-tier tax rate system, 15% and 28%, with 33% applying to many taxpayers in the middle income area. Under TRA, IRAs and Keoghs are still available, but on a restricted basis. As Kendall (1988) points out, a key to analyzing the impact of these changes is whether or not taxpayers view them as temporary or permanent. An interesting extension of the present model would be to allow for uncertainty with respect to future tax rates and provisions.

In order to simplify the problem and focus on income tax effects, this study disregarded the potential impact of social security on the retirement decision. While this may be acceptable in a simple model, more realistic models of retirement behavior need to incorporate the
social security system. To do so introduces many complications that are beyond the scope of this study. For example, while workers between the ages of 62 and 64 lose benefits to the earnings test, they recoup most or all of them through an actuarial adjustment of future benefits. Blinder, Gordon, and Wise (1980) believe that on balance, if the social security law were understood by the public, work disincentives would only affect a small minority of the population.  

The present study is in no way meant to be a direct test of the effect of the income tax on retirement behavior. Important variables such as health status and job characteristics do not enter the model. The model provides only an indirect test of the impact of the wage on planned retirement behavior using a single cross-section of data. On the other hand, it succeeds, where more sophisticated models fail, in shedding light on the relationship between retirement and tax-induced changes in the wage.
FOOTNOTES

1. See Killingsworth (1983), chapter 5, for a description of dynamic labor supply models.

2. Burtless and Moffitt (1984) provide an example of this type of study. They find that retirement depends on age dependent preferences, but that the age of retirement is rather insensitive to social security benefit levels.


4. A study by Hall and Johnson (1980) is one of the few to focus on the planned retirement age rather than the actual retirement decision.

5. The approach of this study contrasts with that of some recent empirical studies such as Hanoch and Honig (1983) and Hurd and Boskin (1984), which treat the retirement decision as a labor force participation decision of the elderly. By contrast, the present study estimates a model of current consumption and labor supply and uses the estimation results to infer retirement behavior.

6. Two goods are substitutes if an increase in the price of one leads to a decrease in quantity demanded of the other. Two goods are complements if the opposite holds.

7. Social security taxes and benefits are ignored in the model. This is legitimate so long as the social security system is actuarially fair, there are no borrowing constraints, and lifetimes are certain. Some recent studies have found it possible to relax these assumptions. Kahn (1988), for example, investigates the effect of social security on the retirement decision within a life-cycle model incorporating liquidity constraints.

8. This assumption is relaxed in section IV.

9. The assumption that g is negative is consistent with the observation that workers take retirement at the end of their working career rather than at the beginning. A positive g would indicate the reverse.

11. When $\beta$ is not equal to $b$, the expression for $F_R$ is unaffected, but the expression for $F_w$ must be rewritten as follows:

$$F_w = (1-s) \left( w^{-1} \frac{a}{(1-a)^s} k e^{gR} \left[ (1 - e^{-zT})/z \right] \right)$$

$$+ (\beta/b) \left[ (1-\beta)/(1-b) \right] d w^{-1} \left[ b^{-s} w^{s} (1-a)^{-s} e^{gR} e^{-rsT} \right] \left[ (b-1)/(\beta-1) \right]$$

$F_w$ is positive if both $b$ and $\beta$ are negative, negative if both $b$ and $\beta$ are positive, and of indeterminate sign if $b$ and $\beta$ are of opposite sign. Hence, $\partial R/\partial w = -F_R/F_w$ is positive if both $b$ and $\beta$ are positive, negative if they are both negative, and of indeterminate sign if $b$ and $\beta$ are of opposite sign. Adding a bequest motive does not change the expectations of the theoretical model if $b$ and $\beta$ are unequal but of the same sign.

12. Hubbard (1984) estimates an extended life-cycle model on cross-section data. His results indicate that IRAs and Keoughs stimulate saving and that the increase depends positively on the marginal tax rate. He does not consider retirement effects.

13. Empirical evidence of the impact of social security on the retirement decision is mixed. For example, Diamond and Hausman (1984 a and b) find that the presence of pension and social security benefits have a significant effect on retirement decision, with pre-age 65 social security benefits explaining about "half the story" of early retirement; on the other hand, Kotlikoff (1979) finds little or no relationship between social security and the retirement decision, although social security appears to significantly reduce private saving. Likewise, an empirical cross-section study of retirement decisions by Gordon and Blinder (1980) casts serious doubt on previous claims that the social security system induces many workers to retire earlier than they otherwise would.

14. There is considerable controversy in the economics literature over the effect of health status on retirement. While Hall and Johnson (1980) found that health influences planned retirement, Boskin (1977) found that current health status, measured by annual hours ill, is not significant to the retirement decision. The effect of job characteristics on the age of retirement was explored by Filer and Petri (1988). Their results support the hypothesis that jobs that are differentially difficult for older workers to perform appear to be those from which workers retire early.
REFERENCES


