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Demographic Change, Social Security Systems, and Savings[1]

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Abstract

In theory, improvements in healthy life expectancy should generate increases in the average age of retirement, with little effect on savings rates. In many countries, however, retirement incentives in social security programs prevent retirement ages from keeping pace with changes in life expectancy, leading to an increased need for life-cycle savings. Analyzing a cross-country panel of macroeconomic data, we find that increased longevity raises aggregate savings rates in countries with universal pension coverage and retirement incentives, though the effect disappears in countries with pay-as-you-go systems and high replacement rates.

Keywords: Savings, demographic change, population economics, social security systems

JEL numbers: E1, J2.

1. Introduction

Demographics can affect aggregate savings behavior. Most savings models that account for demographics focus on the fact that people at different ages save at different rates. In these models, demographic change affects aggregate savings through changes in the age structure of the population (e.g., Deaton and Paxson 1997, Kelly and Schmidt 1996, Higgins and Williamson 1997, Higgins 1998). However, few savings models consider another fundamental demographic that may affect savings rates: the length of life.

In a simple life cycle model, a longer life span need not affect savings rates; the optimal response to a longer life span can be a corresponding proportional increase in working lifetime, with savings rates while working remaining fairly steady. However, there is empirical evidence at the microeconomic level (Hurd, McFadden, and Gan 1998) and at the macroeconomic level (Bloom, Canning, and Graham 2003) that higher life expectancy increases savings rates. This raises the question of why people who expect to live longer should choose to save more rather than simply retire later.

We discuss four mechanisms through which life expectancy can affect savings: increased sickness in old age may prevent longer working lives; the influence of compound interest and wage growth over a longer working life may produce a wealth effect; imperfect annuity markets may reduce the effective returns to savings in high mortality environments due to the chance of dying before spending one's wealth; and retirement incentives in social security systems may discourage or prevent longer worker lives.

Using a simulation model, Lee, Mason, and Miller (2000) argue that increases in longevity in Taiwan can explain its savings boom over the last 40 years, on the basis that

Taiwan's retirement age has been fixed. Along these lines, the theoretical and empirical analyses in this paper reveal that the major explanation for the cross-country link between longevity and savings is the existence of social security programs that offer incentives to retire at a fixed age.

Gruber and Wise (1998) and Blondal and Scarpetta (1997) show that social security rules in OECD countries create powerful financial incentives to retire at a particular age and that many workers appear to respond to these incentives. This leads to a clustering of retirement at the ages at which retirement incentives are introduced in each country. Similar social security arrangements also exist in many countries outside the OECD. For example, Social Security Administration (2002) reports data on social security in Taiwan. When covered workers reach 60 years of age, they are eligible upon retirement to receive a lump sum payment based on their contributions to the system. A worker receives a sum equal to his or her monthly salary for each of the first 15 years of social security contributions. This increases to two months' salary for the next 15 years of contributions. This lump sum is capped at 45 months of salary, though an extra 5 months worth of salary can be added to the lump sum by continuing to work to age 65. Thus, if one has worked to age 65, benefits no longer increase over time, although contributions continue. Two additional factors may also influence the decision to retire at younger ages. Because productivity declines with age, the average wage on which the lump sum is based may decrease over time,[2] and expected benefits may decrease. In addition, as one gets older, the probability of dying before collecting benefits increases. Thus, Taiwanese workers have an incentive not to extend their working careers past 65.

[2] This is more likely to be true for manual laborers than for skilled laborers insofar as experience is an important element of productivity for the latter group.

This paper explores the hypothesis that the effect of life expectancy on national savings rates depends on key features of the social security system in place. As we show theoretically, with no social security system and perfect capital markets, the optimal response to an improvement in life expectancy is to lengthen of the working life, with no (or possibly a negative) effect on savings rates. However, in countries where social security provisions create strong incentives to retire, the retirement age may effectively be fixed, so that longer life spans lead to longer periods of retirement and greater pre-retirement savings.

We approach the issue first from a theoretical perspective. Our model is similar to Blanchard (1985) in that it considers individual savings decisions over time and aggregates across cohorts to find national savings. Our innovation is to allow retirement decisions, as well as savings decisions, to depend on life expectancy. Aggregation gives us an equation whose parameters we estimate using data for a panel of countries over the period 1960–2000. The aggregate equation includes the usual demographic and economic growth effects on savings found in the literature.

For our empirical analyses, we construct data on key features of the social security system in each country of the world. We summarize each system by four variables. Two dummy variables indicate whether or not the system covers all workers (universal coverage) and whether there is a retirement or earnings test to be eligible for benefits (retirement incentive). We also measure the replacement rate: the proportion of an average worker's wage that a pension plan replaces after retirement. We distinguish the portion of the coverage that is funded (through investments) from the portion that operates as a pay-as-you-go system (which holds claims on the government for future payment). Although funded retirement systems may be similar to private savings, pay-as-you-go systems may displace private savings without generating national savings (Feldstein 1976). As expected, we find that national savings rates are higher with fully funded social security systems than with pay-as-you-go systems.

Our results indicate that higher life expectancy does not increase savings rates in the absence of universal coverage and retirement incentives. We find that with universal coverage and retirement incentives, a longer life span is associated with higher savings rates, but this effect disappears in systems with pay-as-you-go pension finance and high replacement rates.

Institutional incentives are not the only possible explanation of an effect of longevity on savings. As noted, there are three other possible mechanisms to consider. The first relates to the possibility that although individuals are living longer, the years they gain in life expectancy may not be healthy ones. This implies that ill health among the elderly forces retirement at a fairly constant age, so that the increase in life expectancy requires more savings for old age from what remains a fairly steady length of working life. This argument is weakened by strong evidence for the "compression of morbidity," the idea that with increased life spans the relative, or even absolute, length of life spent in chronic ill-health toward the end of life has declined (Fries 1980, Fries 1989, Crimmins, Saito, and Ingegneri 1997, Crimmins 2004, Costa 2002). In our theoretical model we allow for the compression of morbidity by assuming that health status and the disutility of labor depend on age relative to life expectancy.

A second explanation is that, with positive interest rates, a longer working life allows compound interest to operate over a longer period. If there is technological progress and economic growth, a longer working life also allows a worker to earn more when real wages are higher. As a result, the worker at retirement will be wealthier than before. The worker can spend this wealth by taking more leisure (early retirement) or by having a higher level of lifetime consumption (and less savings while working). If both leisure and consumption are normal goods, the worker will do both and the market response to a longer life span will be a lower savings rate (Bloom, Canning, and Moore 2004). Our theoretical model allows for wealth effects associated with compound interest and real wage growth.

A third argument is that mortality is random and thus lowers the effective interest rate by creating the possibility that one might die and leave unintentional bequests. As life expectancy increases, and the mortality rate falls, the effective rate of return to savings goes up, encouraging both savings and earlier retirement (Kalemli-Ozcan and Weil 2002, Zhang, Zhang, and Lee 2003). This effect depends on lack of access to annuity markets, and the substitution effect on savings of higher effective interest rates outweighing the income effect. We assume perfect annuity markets in our theoretical model, ruling out this mechanism. However, it seems likely that this effect plays a role when capital markets are incomplete. Although effects through these alternative mechanisms are plausible, we find no evidence of an effect of life expectancy on savings rates in the absence of social security institutions. We find significant effects when social security arrangements do exist.

The organization of this paper is as follows: Section 2 presents our theoretical model, Section 3 describes our data, Section 4 presents regression results, and Section 5 concludes.

2 (i) Theory – Individual Consumption and Retirement

We examine the optimizing problem of agents deciding their lifetime labor supply and consumption and take the real wage rate, w, and interest rate, r, to be exogenous. We assume that the interest rate is fixed over time, but that real wages grow at the rate σ, reflecting long-run economic growth.

As in Blanchard (1985) we assume an exogenous, constant death rate. Given the constant death rate, λ, the probability of being alive at age t is $e^{-\lambda t}$. For an agent at birth, the probability of dying at exact age t therefore follows a Poisson distribution and is $\lambda e^{-\lambda t}$. Life expectancy is given by

$$z = \int_0^\infty t(\lambda e^{-\lambda t})dt = \frac{1}{\lambda}. \qquad (1)$$

Blanchard (1985) takes the time path of labor income to be fixed and focuses on the effect of a changing life span on the decision to save. We treat both savings and retirement decisions as endogenous. Agents compare the real wage earned to the disutility of working to determine if they will work. A major innovation of our model is the disutility of labor schedule, $v(z,t)$, which we assume rises with age, t, due to failing health promoting retirement as individuals age. We postulate that the disutility of working at age t depends on life expectancy, z. Higher life expectancy is assumed to go hand in hand with improved health, reducing the disutility of working at each age.

If health status at each age improves proportionately with life expectancy (the relative compression of morbidity), then the disutility of labor, $v(z,t)$, satisfies

$$v(\alpha z, \alpha t) = v(z,t) \qquad (2)$$

In other words, the health status and disutility of someone working at age 45 who has a life expectancy of 60 is the same as the health status and disutility of someone working at age 60 who has a life expectancy of 80.

We assume that at age t the agent gets the instantaneous utility $\left[u(c(t))-\chi_t v(z,t)\right]$, where $u(c(t))$ is the utility of consumption; $v(z,t)$ is the disutility of working at age t given life expectancy z; and χ is an indicator function that takes the value 1 when working and 0 when retired. We consider only full-time work or retirement and rule out part-time employment.

Agents make consumption and work decisions for each time t and lifetime expected utility is given by

$$U=\int_0^{\infty} e^{-(\delta+\lambda)t}\left[u(c)-\chi v(z,t)\right]dt\,, \tag{3}$$

where future utility is discounted at the subjective rate of time preference, δ, and is conditional on the probability of being alive at time t. Lifetime expected utility is maximized subject to the budget constraint

$$\frac{dW}{dt}=\chi_t w+\left(\lambda+r\right)W-c\,, \tag{4}$$

where W is the state variable, wealth. If the agent works at time t, he or she earns the wage $w(t)$, which adds to wealth, while consumption, $c(t)$, reduces wealth. We assume that wealth can be transferred from one period to another by saving or borrowing from the financial sector. This competitive financial sector can borrow or lend freely at the interest rate *r*.

Agents are paid an effective interest rate $r+\lambda$ on their savings. This rate is larger than *r*, to compensate agents for the risk that they may die before withdrawing their savings. Similarly, agents who borrow pay the rate $r+\lambda$ to compensate the bank for the risk that they may die before repaying their borrowing. This is equivalent to treating all savings as taking the form of annuity purchases, while all borrowing is accompanied by an actuarially fair life insurance contract for the amount of the loan. Provided that a continuum of agents exists, the financial sector can avoid all risk by aggregating over individuals and earning zero profits.

The transversality condition is that $\lim_{t\to\infty} W_t \geq 0$. Note that agents may plan to hold positive wealth indefinitely, because they do not know how long they will live.[3] The control variables for the agent's optimization problem are c and χ. Agents must decide when to work and when to retire and what their consumption stream should be.

The Hamiltonian for this problem is

$$H = e^{-(\lambda+\delta)t}\left[u\left\{c(t)\right\} - \chi_t v(z,t)\right] + \phi\left[\chi_t w(t) + (\lambda + r)W(t) - c(t)\right]. \quad (5)$$

The following are the first-order conditions for a maximum in c and χ:[4]

$$\dot{\phi} = -\frac{\partial H}{\partial W} = -\phi(r+\lambda), \quad (6)$$

$$\frac{\partial H}{\partial c} = e^{-(\lambda+\delta)t}u'(c) - \phi = 0, \text{ and} \quad (7)$$

$$\begin{aligned} \frac{\partial H}{\partial \chi} &= -e^{-(\lambda+\delta)t}v(Z,t) + \phi w(t) \geq 0 \text{ when } \chi = 1 \\ \frac{\partial H}{\partial \chi} &= -e^{-(\lambda+\delta)t}v(Z,t) + \phi w(t) \leq 0 \text{ when } \chi = 0 \end{aligned} \quad (8)$$

These conditions can be shown to yield the following:

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[3] The transfer of the wealth of those who die to the financial sector exactly compensates deposit-taking institutions for the fact that they pay an interest rate $r+\lambda$ on deposits that exceed the risk free rate *r*, and rules out the need to consider unintended bequests.

[4] Berck and Sydaeter (1992) give sufficient conditions for a maximum. Checking that these conditions are satisfied is straightforward.

$$\dot{c} = \left(r - \delta\right) \frac{u'\left(c\right)}{-u''\left(c\right)} \tag{9}$$

$$\chi_t = 1 \Leftrightarrow u'(c)w(t) \geq v(z,t) \tag{10}$$

.

The first condition implies a rising consumption level over time if the interest rate is high, though this effect may be small if the utility function is highly concave. If the marginal utility of consumption falls quickly with the level of consumption (that is, if $-u''(c)$ is large) the agent will want to smooth consumption over time. The second condition implies that agents work at time t so long as the utility gain from the consumption purchased by the wage they earn (the marginal utility of consumption multiplied by the wage) exceeds the disutility of working.

To investigate the agents' choices in a simple model, we assume the agent has log utility:

$$u(c) = \log(c) \tag{11}$$

We also assume the following simple explicit form for the disutility of work that obeys our homogeneity of degree zero assumption

$$v(z,t) = de^{t/z} = de^{\lambda t} \tag{12}$$

The parameter *d* measures the intensity of the disutility of work and potentially may vary as the nature of employment changes. Our utility function implies that marginal utility is $u'(c) = 1/c$ and that the optimal growth rate of consumption is

$$\frac{\dot{c}}{c} = (r - \delta), \tag{13}$$

so that individual consumption is given by $c(t) = c_0 e^{(r-\delta)t}$. The initial level of consumption, c_0, can be calculated from a re-parameterization of the budget constraint as follows:

$$\int_0^{\infty} e^{-(\lambda+r)t} c(t)dt = \int_0^{R} e^{-(\lambda+r)t} w(t)dt \tag{14}$$

Using the result that the wage grows at the rate σ while consumption grows at the rate $r-\delta$ gives us

$$\int_0^{\infty} e^{-(\lambda+r)t} c_0 e^{(r-\delta)t} dt = \int_0^{R} e^{-(\lambda+r)t} w_0 e^{\sigma t} dt \tag{15}$$

or

$$c_0 \left[\frac{e^{-(\lambda+\delta)t}}{-(\lambda+\delta)} \right]_0^{\infty} = w_0 \left[\frac{e^{(\sigma-(\lambda+r))t}}{\sigma-(\lambda+r)} \right]_0^{R}, \tag{16}$$

and so

$$\frac{c_0}{w_0} = \frac{(\lambda+\delta)}{(\lambda+r-\sigma)} \left(1 - e^{(\sigma-\lambda-r)R}\right). \tag{17}$$

For the model to make sense, we require that $\sigma < r + \lambda$. If this is not the case, the net present value of lifetime wage earnings can be infinite and the budget constraint shown in equation (15) is not well defined. Because we want to examine outcomes as the death rate, λ, varies, we assume that $\sigma < r$ so that the finite budget constraint holds for any death rate.

For a fixed retirement age, R* lower than the optimal R, we can use equation (17) to determine the initial consumption wage ratio and equation (13) to set the growth rate of consumption. This determines the time path of consumption. If there is mandatory retirement at age R*, equation (17) immediately implies that with $r = \delta > 0$ and $\sigma = 0$, the effect of an increase in life expectancy is to lower the initial consumption-wage ratio; the income earned before the fixed retirement date now has to be spread over a longer life. Thus, under mandatory retirement longer life spans require higher savings rates. As long as wage growth is not too rapid this intuition will continue to hold.[5]

For endogenous retirement the situation is more complex. The optimal retirement age *R* is given by the marginal condition where the disutility of working just equals the utility of the consumption from the wage earned:

$$v(R) = w(R)u'(c(R)) \tag{18}$$

which can be written as

$$de^{\lambda R} = w_0 e^{\sigma R}\left[c_0 e^{\frac{(r-\delta)}{\beta}R}\right]^{-1}. \tag{19}$$

Equations (17) and (19) give two marginal conditions with two unknowns, the retirement age and the initial level of consumption (together with equation (13) this determines the time path of consumption), highlighting the joint nature of these decisions. The first-order conditions for optimal lifetime consumption and savings generate the initial consumption level, given by equation (17). Equation (17) gives a positive relationship between retirement and consumption because later retirement allows for a higher level of lifetime consumption (the consumption level converges to the constant wage level w as the retirement age rises). However, the first-order condition for optimal retirement given by equation (19) gives a downward-sloping relationship between the retirement age and consumption level; the agent works longer only if the marginal

[5] At very high rates of wage growth, longer life spans can potentially create a wealth effect that leads to early retirement.

utility gained from the additional consumption enabled by working longer is sufficiently high, implying that the consumption trajectory must be lower. The intersection of the two curves gives the optimal retirement–consumption choice.

Substituting for the initial level of consumption in equation (19) gives us

$$de^{\lambda R} = \left[\frac{(\lambda + r - \sigma)}{(\lambda + \delta)}\right] \frac{e^{(\sigma+\delta-r)R}}{(1 - e^{(\sigma-\lambda-r)R})}, \tag{20}$$

which is an implicit function of the retirement age *R* alone.[6] Similarly, we substitute out the retirement age in equation (19) and derive an equation that is an implicit function of c_0, the initial level of consumption, alone:

$$c_0 = w_0 \frac{(\lambda + \delta)}{(\lambda + r - \sigma)} \left(1 - \left(\frac{w_0 c_0^{-1}}{d}\right)^{\frac{\sigma-\lambda-r}{\lambda-\delta-\sigma+r}}\right) \tag{21}$$

We now have a set of equations that could provide the solution to the agent's maximization problem. Equation (20) can be solved to give the retirement age, *R*. Equation (21) can be solved to give the initial level of consumption, c_0, which together with equation (13) gives us a complete solution for the agent's labor supply and consumption decisions.

Although we have a potential solution, solving the implicit functions (20) and (21) for *R* and c_0 is complex, and we do not have a complete closed-form solution. Our approach is to use the implicit function theorem to obtain an approximation around a special case for which we do have a complete closed-form solution. This special case is where the rate of time preference, rate of interest, and growth rate of wages are all zero ($\delta = r = \sigma = 0$).

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[6] If the rate of wage growth is extremely high while the disutility of labor grows slowly, this equation may have no finite solution. However, provided that $\sigma < \lambda + r - \delta$, the growth rate of the disutility of labor dominates and the agent will eventually retire.

The implicit function theorem implies that the optimal retirement age and initial consumption, for $r, \delta, and\ \sigma$ small, can be approximated by:

$$R = \log\left(\frac{1+d}{d}\right)z + \left[\frac{(1+d)\log(\frac{1+d}{d}) - 1}{(1+d)}\right](\sigma - r)z^2 - \left[\frac{1-\log(\frac{1+d}{d})}{(1+d)}\right]\delta z^2 \qquad (22)$$

$$\frac{c_0}{w_0} = \frac{1}{1+d} + \frac{1}{(1+d)^2}(\sigma - r)z + \frac{1+d\log(\frac{1+d}{d})}{(1+d)^2}\delta z \qquad (23)$$

When $\delta = r = \sigma = 0$, the retirement age is proportional to life expectancy and the consumption-wage ratio does not change with variations in life expectancy. Individuals "stretch" their working lives to finance the same level of consumption over a longer life span. However, assuming $r = \delta > 0$ and $\sigma \geq 0$, our results imply that the initial consumption-wage ratio rises, and savings falls, when life expectancy increases. The intuitive rationale for this result is that an increase in life expectancy magnifies the compounding effects of wage growth, interest rates, and time preference. For example, suppose that the interest rate is positive and that the agent keeps to the proportionality result that holds in the case of $r, \delta,$ and σ all being zero when life expectancy rises. In this scenario, when life expectancy rises, the agent will have greater wealth upon reaching retirement age because of the increased effects of compound interest and wage growth over a longer working life. The higher level of accumulated assets allows a higher level of consumption (spread over the entire life span). This induces a lower marginal utility of consumption, reducing the incentive to work and encouraging earlier retirement. The wealth effect generated by compound interest and wage growth over a longer life span leads to both an increase in consumption and an increase in leisure (early retirement).

Let us assume that interest rates and time preference are fixed across countries and over time. Taking equations (17) and (23) we can write the initial consumption ratio as

$$\frac{c_0}{w_0} = g(z, \sigma, R^*) \quad (24)$$

where we expect consumption to be rising with life expectancy when there is no mandatory retirement (or the mandatory retirement age is above the optimal age when people actually retire) but to be falling with life expectancy when the mandatory retirement constraint, R*, is binding.

2 (ii) Theory – Aggregate Consumption

We consider an economy with a fixed life expectancy z and constant rate of growth of wages σ. The mandatory retirement age R, if there is one, is also fixed. This implies that each cohort will have the same initial consumption-wage ratio (c_0 / w_0) and the same rate of growth of consumption, $r-\delta$, though later cohorts will be richer if there is wage growth. As in Sheshinski (2005), aggregate consumption at time T comprises the consumption of the members of each cohort born at $s \le T$ that have survived to T and is given by

$$C_T = \int_{-\infty}^{T} B_s e^{-\lambda(T-s)} c_0(s) e^{(r-\delta)(T-s)} ds \quad (25)$$

where B_s is the number of births at time s and $c_0(s)$ is the initial consumption of the cohort born at time s. Suppose we have a constant birth rate b; population growth is then given by $n = b - \lambda$ and we have

$$C_T = \int_{-\infty}^{T} bP_T e^{-(n+\lambda)(T-z)} w_T e^{-\sigma(T-z)} \frac{c_0}{w_0} e^{(r-\delta)(T-z)} dz \qquad (26)$$

where P_T is population at time T, and we drop the dependence of the initial consumption-wage ratio on the cohort birth year because it is independent of the cohort. Integrating this equation gives aggregate consumption as

$$C_T = \left(\frac{c_0}{w_0}\right)\left(\frac{bP_T w_T}{b+\sigma+\delta-r}\right) \qquad (27)$$

Now let us assume that the total wage bill $w_T L_T$ is a share $(1-\alpha)$ of total GDP at time T (for example this will occur if the production function is Cobb-Douglas with a capital share of α). Hence,

$$\frac{C_T}{Y_T} = \left(\frac{c_0}{w_0}\right)\left(\frac{b(1-\alpha)}{b+\sigma+\delta-r}\right)\frac{P_T}{L_T} \qquad (28)$$

It follows that aggregate consumption depends on three components. The first is the initial consumption-wage ratio. The second component contains terms that depend on the birth rate and the rate of wage growth. The third term is the ratio of population to workers. Equation (28) is multiplicative. Taking $r=\delta$ we can derive a simple linear form for savings by taking logs and using the approximation $\log(1+x) \approx x$ for x small:

$$\frac{S_T}{Y_T} = -\log(g(z,\sigma,R^*)) + \frac{\sigma}{b} - \frac{Old_T}{WA_T} + \log\left(\frac{L_T}{WA_T}\right) + \log(1-\alpha) \qquad (29)$$

where *Old/WA* is the old age dependency rate and *L/WA* is the participation rate of the working age population in the labor force. The variable *Old* refers to those aged above some threshold (we use a threshold of 65 years of age) and the working-age population, *WA*, are adults whose age is below the threshold (we take working age to be those aged 15–64). The aggregation effects in (29) are similar to the equations usually estimated in the literature. Our theory supports a negative effect of the old age dependency rate on savings as in Leff (1969). We also find a positive effect of economic growth on savings, particularly when birth rates are low, a variant on the “variable rate of growth effect” proposed by Fry and Mason (1982).

The simple theory we set out in sections (i) and (ii) allows us to separate out the effects of individual decision making on aggregate consumption. However, the model given in (28) has a number of weaknesses.

The first is that the theory considers only adults. The population numbers in (28) refer to the adult population, and the “birth rate” is the rate of creation of new adults. The youth dependency rate may also matter. Given that parents are altruistic and try to smooth household per capita (or adult equivalent) consumption, total household consumption will have to be higher when there are children present. Rather than incorporate a theory of intra-household transfers into the life cycle framework, we simply add a youth dependency rate to mirror the old age dependency rate in the empirical formulation.

A second weakness relates to the assumption of logarithmic utility. In the case of a fixed mandatory retirement age, the initial consumption-wage ratio is independent of the level of income. However, when the retirement age is endogenous and optimally chosen, our finding that the consumption-wage ratio is independent of the level of income is dependent on the assumption that we have a logarithmic utility function. Logarithmic utility means that the income and substitution effects of higher wages on retirement cancel out, making the retirement age and initial consumption wage ratio independent of the wage level.

Bloom, Canning, and Moore (2004) show that, given a constant coefficient of relative risk aversion of 2, with a higher wage rate, the income effect tends to dominate. With higher levels of wages, workers will want to retire earlier, increasing their savings rates while working to fund a longer retirement. This suggests that the wage rate should appear in the individual's initial consumption-wage ratio decision. Making these two additions to our aggregate equation gives[7]

$$\frac{S_T}{Y_T} = h(z,\sigma,w_T,R^*) + \frac{\sigma}{b} - \frac{Old_T}{WA_T} + \phi\frac{Young_T}{WA_T} + \log\left(\frac{L_T}{WA_T}\right) + \log(1-\alpha) \qquad (30)$$

A third shortcoming is that few systems actually have mandatory retirement at a fixed age R*. However, other institutional characteristics of social security systems may affect retirement behavior and aggregate savings in a similar way. A retirement test refers to a situation where drawing social security depends on not having labor income. Although it is possible to keep working where there is a retirement test, the implicit incentives to retire may be very large. Certain features of a social security system can also affect aggregate savings. A fully funded pension system will tend to displace an equal amount of private savings; however, it may increase aggregate savings if contribution levels exceed the private savings that people desire

[7] Including the youth dependency rate causes no problems in this aggregate equation. However, adding the level of wages to the individual's demand for savings does cause problems. In this case, when there is economic growth, the wage level of cohorts born in the distant past will have been lower, which will tend to reduce their initial savings rate relative to current cohorts. Our aggregation does not allow for this and so the model is an approximation that will hold only when the effect of wage levels on initial saving rates is small or the rate of economic growth is low.

and if there are borrowing constraints. A pay-as-you-go pension system will tend to reduce aggregate savings because it displaces private savings, but the system does not itself lead to wealth holding.[8] In the empirical work we include a range of features of the pension system, instead of focusing solely on an explicit mandatory retirement age.

3. Data

We construct annual data for a panel of countries over the period 1960 to 2000. We use as a measure of savings the gross domestic savings rate (savings divided by GDP) from the World Bank's *World Development Indicators* (2002). This combines individual and household savings with corporate and government savings, but we assume that corporate and household savings are part of household wealth. *World Development Indicators* also provides our measure of life expectancy. Life expectancy data are available about four times per decade for most countries in *World Development Indicators*. We interpolate over intervals of up to two years to get an annual series. In our theory, the relevant variable for individual decision making is cohort life expectancy; we proxy this with period life expectancy.[9] Data on age structure and the young, working-age, and old-age populations (the populations aged 0 to 14, 15 to 64, and 65 and over) are also from *World Development Indicators*.

Data on real GDP per capita in purchasing power parity terms come from version 6.1 of the Penn World Tables (Heston, Summers, and Aten 2002). We take the log difference between current and ten-year lagged GDP per capita divided by ten (giving the annual average growth

[8] This assumes that people do not save against the future taxes needed to finance a pay-as-you-go pension system. In other words, we do not have complete Ricardian equivalence.
[9] Period life expectancy is the expected life span applying current age specific death rates while cohort life expectancy depends on the future death rate of the cohort as it ages.

rate) as our measure of economic growth. We define the “birth rate” of adults as one fifth of the population aged 15 to 19 divided by the total population aged 15 and over, using data taken from the United Nations’ *World Population Prospects* (2004). This approximates the annual rate of inflow of new adults. Data on labor force numbers before 1980 come from the International Labor Organization (1997), and after 1980, from International Labor Organization (2005).

Data on social security systems come from the Social Security Administration’s *Social Security Programs Throughout the World* (various years 1961–2002). The raw data consist of the responses of various countries to a survey sent out by the Social Security Administration. These systems are often very complex, with a large number of conditions and caveats not fully explained in the responses. It is difficult to create a set of variables that accurately captures the elements of the various systems and is consistent across countries.

We constructed four variables from the Social Security Administration data. We begin by defining a dummy variable for universal coverage. We consider a system universal when all employees are reported to be covered by the system. We code a system as not universal when one or more groups of employees, for example agricultural workers, informal sector workers, those in small firms, or the self employed, are excluded. We count as universal those systems where some workers in particular sectors, for example public employees, are excluded but are reported to be covered by a different system. This approach ignores the possibility that actual coverage in “universal” systems may be low when there is an unrecognized informal sector.

Our second variable is a dummy that indicates the presence of a retirement incentive in the system. A retirement incentive occurs when benefits are only payable on retirement, or if benefits are conditional on an earnings test. Gruber and Wise (1998) show that in OECD countries retirement spikes at ages where retirement incentives begin. In some cases the retirement test is strict: retirement prompts pension benefit eligibility that would be lost if work continued. In others systems there is a partial reduction in pension benefits if earned income continues, and there are incentives to delay retirement in the form of higher pension payouts. We set the retirement test equal to one where there are any retirement incentives reported in the system; in other cases we set it to zero. For example, until 2001 the United States' social security system had an earnings test that reduced pension benefits for those below age 70 who continued to work (the earnings test now only applies to those who take early retirement, available from age 62, and are below age 65). In our data, this counts as having a retirement incentive.

We also calculate the replacement rate for each observation. This is the size of the annual pension, as a percentage of the recipient's pre-retirement income, for a worker of average income (which we take to be income equal to two thirds of GDP per worker) who works from age 17 to the reported normal retirement age in the system, under the system's current rules. The replacement ratio depends on three components: any basic flat-rate pension, any pension that is related to earnings, and any lump sum of accumulated contributions.

For a flat-rate pension we take this flat rate relative to average earnings as its replacement ratio. For earnings-related pensions, there is usually a formula that depends on the number of years of contributions. For countries with defined-contribution schemes, we assume the worker earns a constant amount and contributions start at 17 and run to the normal retirement age; for example, when the normal retirement age is 65 workers have 48 years of contribution. We assume that the contributions in the fund earn a real rate of return of 3% a year. We assume that upon retirement the accumulated fund is used to finance a single life annuity that guarantees the same payout, in real terms, over the life of the pensioner. We take the annuity to pay out a real rate of 5.25% per annum for the lifetime of the annuitant, based on current rates for indexed linked (i.e. adjusted in line with the retail price index to keep their real value) annuities in the United Kingdom.[10] Calculating the accumulated value of the pension fund at retirement, this implies that each 1% of salary contributed to the fund over the working life should generate 5.7% of earnings as a pension.

In many particular cases the calculation of the value of pension rights is not straightforward. For example, in the United States the benefit rate depends on earnings and contributions in a highly non-linear way that favors low-income workers. Our data source does not report the details of the annual formula, though it does report the maximum benefit. Due to the highly progressive nature of the system, this maximum benefit is close to the benefit of a worker with average wages who works his whole life, and we use this to calculate replacement rates.[11]

In countries that introduce new systems, workers are sometimes allowed to remain in the old system; when this occurs we use the characteristics of the new system if it is compulsory for new workers. In other cases, workers have a choice of which system to enter. For example, 1993 pension reforms in Colombia and Peru gave workers a choice between a defined-contribution private pension and a defined-benefit public pension. The system in Peru makes enrollment in the defined-contribution system the default when entering employment, with no switching thereafter, and this system dominates the private sector; we treat Peru as having a defined-

[10] Compulsory purchase of annuities in the United Kingdom diminishes the adverse selection that appears to be common in the United States, though it is still present.

[11] In this way, we calculate the replacement ratio in the United States to be roughly 40%. This figure is close to the number calculated based on more detailed information.

contribution system after 1993. In Colombia, switching between the systems is allowed for all workers and occurs frequently, and take-up of the defined-contribution system has been slow; we treat the Colombian system as a defined-benefit system throughout. Another difficult case is Denmark. The occupational pension system is "quasi-mandatory" in that membership is compulsory for those working in the occupation, and has wide coverage. We treat these occupational pension schemes as mandatory and include them in the replacement rate.

We split the replacement rate into two portions. One is pay-as-you-go, where the government pays the benefits. The second is funded, where a fund holds financial assets to meet the future claims of the pensioners. Although funded pensions are common in defined-contribution schemes while pay-as-you-go is common in defined-benefit programs, the alignment is not perfect. For example, defined-contribution schemes can invest the contributions or can be notional schemes where repayment is drawn from general government funds. We take a system to be funded when the assets are held either by an independent provident fund or private companies that invest freely in a portfolio of assets.[12] We count as pay-as-you-go systems those, such as the Sri Lankan system, where the social security fund is limited to hold only government debt, on the grounds that this debt reflects an accounting rule within the government rather than real funding of the liability. Some countries, such as Switzerland, have a two-pillar system in which there is a basic flat-rate pension funded by pay-as-you-go and an earnings-related contribution system that is fully funded.

This distinction between fully funded and pay-as-you-go systems allows for the effect of a high replacement rate on aggregate savings to depend on the system of pension finance.

[12] We include as funded systems countries like Chile, where pension companies are restricted in buying foreign assets. We exclude countries like Argentina, where the bulk of private pension company assets must be held in government securities (which have defaulted).

Table 1 shows some illustrative data. For each country we report the universal coverage dummy, the retirement incentive dummy, and the replacement rate (funded and pay-as-you-go) for 1961, 1981, and 2002. The data set we use contains data for all the years 1961, 1964, 1967, 1969, 1971, 1973, 1975, 1977, 1979, 1981, 1983, 1985, 1987, 1989, 1991, 1994, 1995, 1997, 1999, and 2002. For intervening years we use data from the latest available year up to two years back; the social security systems are fairly stable over time with only a small number of changes, so this interpolation seems reasonable.[13]

We report descriptive statistics on the data set we use in table 2. The very high maximum replacement rate for funded systems is from Singapore in the 1970s, when reported annual social security defined-contribution rates (employee and employer combined) exceeded 50% of income. Table 3 shows the evolution of the social security variables over time. Comparisons should be treated with caution, as the number of countries reporting is larger in later years. It nonetheless appears that the portion of systems offering universal coverage is increasing over time while the proportion with a retirement incentive is fairly constant at around 50%. Pay-as-you-go schemes have a replacement rate of around 50% on average. The largest change is the rise in the average fully funded replacement rate over the period, a reflection of the number of countries, particularly in Latin America, that have introduced fully funded defined-contribution schemes as part of pension reform.

4. Estimation and Results

[13] There are a number of cases where reported characteristics of a system change slightly over time with no reference to a change in the social security law. We treat these as real changes, though it may be that it is reporting accuracy rather than the actual system that has changed.

We wish to estimate equation (30) based on data from a panel of countries. We include measures of each of the variables in the relationship except the interest rate and the share of labor in national income $(1-\alpha)$, which we assume to be constant across countries.

The first nine variables are the factors that affect individual decisions on savings in a laissez-faire world. We include the wage level (proxied by two thirds of income per capita), life expectancy, and the growth rate of the economy. Because the functional form may be non-linear, we perform a Taylor series expansion to the quadratic terms. This leads us to include the square of each of the three variables and the three interaction terms between them. This gives us the approximation

$$h(z,\sigma,w) \approx \phi_1 z + \phi_2 \sigma + \phi_3 w + \phi_4 z^2 + \phi_5 \sigma^2 + \phi_6 w^2 + \phi_7 z\sigma + \phi_8 w\sigma + \phi_9 zw$$

for the initial consumption: wage ratio when there is no mandatory retirement. The next four variables – the growth rate divided by the "birth rate," the old and young age dependency ratios, and the log of the labor force participation rate – are the result of aggregation across cohorts. We then add our four variables that describe the social security system: a dummy for universal coverage, a dummy variable for a retirement incentive, the fully funded replacement ratio, and the pay-as-you-go replacement ratio. Finally, each of these institutional social security variables is interacted with life expectancy.

The savings variable ranges from around zero to 0.5 with an average of about 0.2. To ensure that the scale of the independent variables matches the scale of savings (so as to avoid very small coefficients, particularly on the interaction terms), we measure income per capita in units of $10,000 and life expectancy in units of 100 years.

We begin with an ordinary least squares regression, which is reported in column 1 of table 3. In column 2 we report a fixed effect specification. A Wald test of the restriction that all of the fixed effects are zero has a value of 35.64, which is distributed as F(56, 1685) under the null that the fixed effects are all the same. This is a decisive rejection of the null, leading us to infer that fixed effects are important.

While the fixed effects regression is more robust than simple ordinary least squares, a problem of autocorrelation is still present. A test for serial correlation in the fixed effects regression using Drukker's (2003) approach to estimating the test proposed by Wooldridge (2002) gives a value of 51.7, which is distributed as F(1, 56) under the null of no autocorrelation; this gives a decisive rejection. One approach would be to estimate the regression allowing for serial correlation. However, the serial correlation is likely to be due to misspecification of the dynamic nature of the model.

Our theory suggests a relationship between certain variables and the desired aggregate savings rate. For example, changes in any exogenous variables will change steady-state savings rates. However, people may not jump immediately to the new consumption level. Habit formation and persistence in consumption may mean a gradual move to the new consumption level. We can model this as a partial adjustment process. Let *y* be the savings rate and *x* be the set of variables determining y; a partial adjustment process has the form

$$y_t - y_{t-1} = \lambda(\beta(x_t) - y_{t-1}) + \varepsilon_t$$

where $y_t* = \beta x_t$ is the optimal level of savings given the exogenous variables x_t. Rearranging gives

$$y_t = (1-\lambda) y_{t-1} + \beta x_t + \varepsilon_t$$

This suggests that we should include the lagged savings rate in the regression to correct for the dynamic adjustment in the time path of savings.

The inclusion of a lagged dependent variable to create a dynamic fixed effects panel model results in biased estimates of all parameters under the usual dummy variable estimation, even if the number of countries is large. This is because the lagged dependent variable cannot be regarded as independent of the current error (Nickell, 1981). We overcome this problem by using the bias correction methods for unbalanced dynamic panels developed by Bruno (2005). We take a first-order approximation to the bias (Bruno shows that this usually accounts for 90% of the bias using Monte Carlo studies), using a generalized methods of moments estimator to get an initial consistent estimate of the coefficient on the lagged dependent variable to initiate the bias correction. We undertake 50 repetitions of the procedure to bootstrap the estimated standard errors.

The results for the general model allowing for fixed effects and dynamic effects are reported in column 3 of table 4. Removing insignificant variables sequentially,[14] we arrive at the regression shown in column 4 of table 3. A joint test that the 14 coefficient restrictions implied by the parsimonious model gives a value of 18.97, which is distributed $\chi^2(14)$, and so does not reject the null hypothesis that these coefficients are all zero. The regression shown in column 4 of table 4 is our preferred specification and is robust to country fixed effects and allows for a dynamic process by which savings adjusts towards its steady state.

According to the results reported in column 4 of table 4, higher income per capita promotes savings, but this effect becomes less marked as income rises due to the negative

[14] We keep all variables that are significant at the 10% level.

coefficient on the income per capita squared. A high old-age dependency rate tends to lower the savings rate.

All of the life expectancy terms that do not involve interactions with the social security system in the general regression have been eliminated in the parsimonious regression reported in column 4 of table 4. This implies that in the absence of a social security system the model predicts no effect of life expectancy on savings rates. However, if there is universal coverage and a retirement test, an increase in life expectancy tends to push up savings rates, as we would expect from the need to finance a longer retirement under conditions of an institutionally fixed retirement age. This effect is reduced if there is a pay-as-you-go system with a high replacement rate. In this case the need for income in retirement is provided by the defined benefits usually found in pay-as-you-go systems.

The ratio of economic growth to the birth rate is not significant and is dropped from our final specification. Our theory predicts these variables should have effects on aggregate savings rates; our finding of a lack of effect is probably due to measurement error. The correct measure of growth rate is the long-run rate of growth over the lifetimes of those consuming, whereas our 10-year average may be only loosely connected to the long-run average due to the volatility in short-run growth rates (Easterly, Kremer, Pritchett, and Summers 1993). Similarly, our measure of the log of the male participation rate was statistically insignificant and was dropped from regression 4 in table 3. The participation rate is included to capture the work-versus-retirement decisions of the working-age population, but participation rates vary for many reasons in addition to early retirement.

Several of the social security variables, and their interaction with life expectancy, remain in our final specification. We find higher life expectancy is associated with higher savings rates when there is universal coverage and a retirement incentive, though the effect is reduced in the presence of pay-as-you-go funding.

The coefficients in columns 3 and 4 of table 4 are not directly comparable with the earlier regressions because of the dynamic structure introduced into the model. In table 5 we report the long-run effect of a number of variables on steady-state savings rates based on the estimates reported in column 4 of table 4. The long-run effect of a higher old-age dependency rate is negative and not statistically different from -1, which is consistent with our theory. We estimate that when life expectancy rises by 10 years, the savings rate will rise by about 4 percentage points when there is a universal pension system and a retirement incentive test in a fully funded system. This effect declines as more of the replacement rate is funded through a pay-as-you-go system and disappears when the pay-as-you-go replacement rate reaches about 50% of earnings. Note that this effect of a higher life expectancy on steady-state savings is temporary and will dissipate in the long run when the higher life expectancy increases the ratio of old to working-age population.

Retirement incentives increase the steady-state savings rate by between 2 and 3 percentage points depending on the level of life expectancy. The effect of moving from a pay-as-you-go to a fully funded system is negligible at a life expectancy of 66 years (the sample mean) but can increase steady state savings rates by 13 percentage points, a very large effect, at a life expectancy of 81 (the maximum life expectancy in the sample).

5. Conclusion

Demographics can influence aggregate savings not only via accounting effects associated with the age structure of a population, but also via behavioral effects associated with expected longevity. The response to a longer life span can take the form of a longer working life or increased savings. The response we see in practice depends on social security arrangements. When there are incentives to retire at particular ages, the labor supply response may be muted, leading to increased savings for a longer retirement. In terms of life cycle behavior, our model only looks at the retirement decision and savings. A possible extension would be to examine the effect of life span extensions on schooling decisions as well. Further analysis of the effect of expected longevity on life cycle behavior using individual- and family-level data observed under different social security systems also seems promising.

Table 1
Retirement and Pension Provision

Country	YEAR	Universal Coverage	Replacement rate: fully funded	Replacement rate: pay as you go	Retirement Incentive
Argentina	1961	1	0.00	0.82	1
Argentina	1981	1	0.00	0.70	1
Argentina	2002	1	0.00	0.92	0
Australia	1961	1	0.00	0.11	1
Australia	1981	1	0.00	0.19	1
Australia	2002	1	0.46	0.20	0
Austria	1961	1	0.00	0.84	1
Austria	1981	1	0.00	0.80	1
Austria	2002	1	0.00	0.80	0
Belgium	1961	1	0.00	0.60	1
Belgium	1981	1	0.00	0.60	1
Belgium	2002	1	0.00	0.60	0
Bolivia	1961	0	0.00	0.96	0
Bolivia	1981	0	0.00	0.76	0
Bolivia	2002	1	0.57	0.00	0
Brazil	1961	0	0.00	1.00	1
Brazil	1981	1	0.00	0.95	0
Brazil	2002	1	0.00	1.00	0
Burkina Faso	1961				
Burkina Faso	1981				
Burkina Faso	2002	0	0.00	0.51	1
Canada	1961	1	0.00	0.13	0
Canada	1981	1	0.00	0.38	0
Canada	2002	1	0.00	0.37	0
Chile	1961	0	0.00	0.70	0
Chile	1981	1	0.57	0.00	0
Chile	2002	1	0.57	0.00	0
Colombia	1961				
Colombia	1981	0	0.00	0.85	1
Colombia	2002	0	0.00	0.85	0
Denmark	1961	1	0.00	0.24	1
Denmark	1981	1	0.00	0.25	0
Denmark	2002	1	0.68	0.24	1
Dominican Republic	1961	0	0.00	0.70	1

Country	YEAR	Universal Coverage	Replacement rate: fully funded	Replacement rate: pay as you go	Retirement Incentive
Dominican Republic	1981	0	0.00	0.67	1
Dominican Republic	2002	1	0.40	0.00	0
Ecuador	1961	0	0.00	1.00	1
Ecuador	1981	1	0.00	0.85	1
Ecuador	2002	1	0.00	0.85	1
Egypt, Arab Rep.	1961	0	0.00	0.75	1
Egypt, Arab Rep.	1981	1	0.00	0.80	1
Egypt, Arab Rep.	2002	1	0.00	0.80	0
Finland	1961	1	0.00		0
Finland	1981	1	0.00	0.81	1
Finland	2002	1	0.00	0.83	1
France	1961	0	0.00	0.20	0
France	1981	1	0.00	0.25	0
France	2002	1	0.00	0.50	1
West Germany	1961	1	0.00	0.72	0
West Germany	1981	1	0.00	0.69	1
Germany	2002	1	0.00	0.83	0
Ghana	1961				
Ghana	1981	0	0.79	0.00	0
Ghana	2002	1	0.00	0.80	0
Greece	1961	0	0.00	1.00	1
Greece	1981	1	0.00	1.00	1
Greece	2002	1	0.00	1.00	1
Hong Kong, China	1961				
Hong Kong, China	1981	1	0.00	0.05	0
Hong Kong, China	2002	1	0.57	0.00	0
India	1961	0	0.71	0.00	1
India	1981	0	0.78	0.00	1
India	2002	0	0.96	0.00	1
Indonesia	1961				
Indonesia	1981	0	0.14	0.00	0
Indonesia	2002	0	0.32	0.00	0
Ireland	1961	0	0.00	0.17	0
Ireland	1981	1	0.00	0.15	0
Ireland	2002	1	0.00	0.11	0
Israel	1961	1	0.00		1
Israel	1981	1	0.00	0.66	1

Country	YEAR	Universal Coverage	Replacement rate: fully funded	Replacement rate: pay as you go	Retirement Incentive
Israel	2002	1	0.00	0.66	1
Italy	1961	1	0.00	0.80	0
Italy	1981	1	0.00	0.80	1
Italy	2002	1	0.00	0.68	1
Jamaica	1961				
Jamaica	1981	1	0.00	0.13	1
Jamaica	2002	1	0.00	0.21	1
Japan	1961	1	0.00	0.34	1
Japan	1981	1	0.00	0.71	1
Japan	2002	1	0.00	0.51	0
Kenya	1961				
Kenya	1981	1	0.51	0.00	1
Kenya	2002	1	0.45	0.00	1
Korea, Rep.	1961				
Korea, Rep.	1981				
Korea, Rep.	2002	1	0.00	0.64	1
Madagascar	1961				
Madagascar	1981	1	0.00	0.40	1
Madagascar	2002	1	0.00	0.53	1
Malaysia	1961	0	0.45	0.00	0
Malaysia	1981	1	0.59	0.00	1
Malaysia	2002	1	1.04	0.00	0
Mali	1961				
Mali	1981	1	0.00	0.51	1
Mali	2002	1	0.00	0.63	1
Mexico	1961	0	0.00	0.72	1
Mexico	1981	1	0.00	0.88	1
Mexico	2002	1	0.27	0.00	1
Morocco	1961	0	0.00	0.40	1
Morocco	1981	0	0.00	0.70	1
Morocco	2002	0	0.00	0.70	1
Netherlands	1961	1	0.00	0.32	0
Netherlands	1981	1	0.00	0.68	0
Netherlands	2002	1	0.00	0.58	0
New Zealand	1961	1	0.00	0.13	0
New Zealand	1981	1	0.00	0.28	0
New Zealand	2002	1	0.00	0.26	0

Country	YEAR	Universal Coverage	Replacement rate: fully funded	Replacement rate: pay as you go	Retirement Incentive
Nigeria	1961				
Nigeria	1981	0	0.54	0.00	1
Nigeria	2002	0	0.00	0.65	1
Norway	1961	1	0.00	0.14	0
Norway	1981	1	0.00	0.51	1
Norway	2002	1	0.00	0.42	1
Panama	1961	0	0.00	0.96	1
Panama	1981	0	0.00	1.00	1
Panama	2002	0	0.00	1.00	1
Peru	1961	1	0.00	0.60	0
Peru	1981	1	0.00	1.00	1
Peru	2002	1	0.46	0.00	0
Philippines	1961	1	0.00	0.41	1
Philippines	1981	1	0.00	1.00	1
Philippines	2002	1	0.00	0.91	1
Portugal	1961	0	0.00	0.80	0
Portugal	1981	1	0.00	0.70	1
Portugal	2002	1	0.00	0.80	1
Senegal	1961				
Senegal	1981	1	0.00	0.31	1
Senegal	2002	1	0.00	0.40	1
Singapore	1961				
Singapore	1981	1	2.55	0.00	0
Singapore	2002	1	1.62	0.00	0
South Africa	1961				1
South Africa	1981				1
South Africa	2002	1	0.00	0.20	1
Spain	1961	0	0.00	0.00	1
Spain	1981	1	0.00	1.00	1
Spain	2002	1	0.00	1.00	1
Sri Lanka	1961				
Sri Lanka	1981	1	0.00	0.90	1
Sri Lanka	2002	1	0.00	0.90	1
Sweden	1961	1	0.00	0.77	0
Sweden	1981	1	0.00	0.66	0
Sweden	2002	1	0.00	1.43	0
Switzerland	1961	1	0.00	0.15	0

Country	YEAR	Universal Coverage	Replacement rate: fully funded	Replacement rate: pay as you go	Retirement Incentive
Switzerland	1981	1	0.00	0.32	0
Switzerland	2002	1	0.63	0.18	0
Taiwan	1961				
Taiwan	1981				
Taiwan	2002	0	0.00	0.20	1
Tanzania	1961				
Tanzania	1981	0	0.45	0.00	1
Tanzania	2002	0	0.90	0.00	1
Tunisia	1961				
Tunisia	1981	0	0.00	0.80	1
Tunisia	2002	1	0.00	0.80	1
Turkey	1961	0	0.00	0.35	1
Turkey	1981	0	0.00	0.60	1
Turkey	2002	1	0.00	0.79	0
Uganda	1961				
Uganda	1981	0	0.39	0.00	1
Uganda	2002	0	0.68	0.00	1
United Kingdom	1961	1	0.00	0.19	1
United Kingdom	1981	1	0.00	0.22	1
United Kingdom	2002	1	0.00	0.41	0
United States	1961	1	0.00	0.32	1
United States	1981	1	0.00	0.44	1
United States	2002	1	0.00	0.45	1
Uruguay	1961	0	0.00	1.00	0
Uruguay	1981	1	0.00	0.70	1
Uruguay	2002	1	0.38	0.22	1
Venezuela, RB	1961				
Venezuela, RB	1981	0	0.00	0.62	0
Venezuela, RB	2002	1	0.00	0.60	0
Vietnam	1961				
Vietnam	1981				1
Vietnam	2002	0	0.00	0.75	0
Zambia	1961				
Zambia	1981	0	0.39	0.00	1
Zambia	2002	0	0.00	0.40	1
Zimbabwe	1961				
Zimbabwe	1981				

Country	YEAR	Universal Coverage	Replacement rate: fully funded	Replacement rate: pay as you go	Retirement Incentive
Zimbabwe	2002	0	0.00	1.00	0

Table 2
Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Savings Rate	0.218	0.085	-0.146	0.509
Annual Wage	9360	0.749	424	33300
Life Expectancy	66.3	10.4	37.8	81.1
Wage Growth	0.021	0.019	-0.058	0.095
Wage Growth/Birth Rate	0.840	0.764	-1.545	4.063
Ratio of old to Working Age	0.122	0.065	0.039	0.276
Ratio of young to Working Age	0.572	0.238	0.211	1.076
Log labor participation rate	-0.094	0.086	-0.317	0.234
Universal Coverage	0.695	0.460	0	1
Retirement Incentive	0.584	0.493	0	1
Replacement rate: pay as you go	0.507	0.331	0	1.232
Replacement Rate: fully funded	0.121	0.333	0	3.068

Data are based on the 1763 observations from 57 countries over the period 1961–2000 used in the regression analysis.

Table 3
Averages of the Retirement and Pension Variables over Time

Year / Variable	1961	1970	1980	1990	2000
Universal Coverage	0.538	0.607	0.607	0.724	0.767
Retirement Incentive	0.538	0.569	0.696	0.621	0.500
Replacement rate: pay as you go	0.452	0.448	0.499	0.497	0.487
Replacement Rate: fully funded	0.019	0.081	0.099	0.122	0.175
Number of Countries	39	51	56	58	60

Table 4
Regression Results: Dependent Variable Savings Rate

	1	2	3	4
Constant	-0.137	Fixed Effects	Fixed Effects	Fixed Effects
	(1.23)			
Lagged savings rate			0.758	0.784
			(37.07)	(48.49)
Wage	0.300	0.642	0.133	0.059
	(4.43)	(6.27)	(1.78)	(5.85)
Life Expectancy	0.968	0.305	0.035	
	(2.40)	(0.64)	(0.08)	
Growth Rate	2.212	3.234	0.989	
	(2.21)	(4.82)	(1.59)	
Wage Squared	-0.032	-0.037	-0.006	-0.012
	(5.77)	(4.83)	(0.83)	(4.68)
Life Expectancy Squared	-0.701	0.075	0.066	
	(1.91)	(0.16)	(0.16)	
Growth Rate Squared	11.174	2.743	0.872	
	(4.07)	(1.17)	(0.48)	
Wage times life expectancy	-0.211	-0.564	-0.130	
	(2.08)	(3.78)	(1.12)	
Wage times growth rate	-0.189	0.039	0.146	
	(0.72)	(0.17)	(0.79)	
Life expectancy times growth rate	-7.320	-4.960	-1.524	
	(4.45)	(4.26)	(1.50)	
Growth Rate divided by birth rate	0.090	0.008	0.000	
	(9.04)	(0.82)	(0.06)	
Ratio of old to working-age	-0.621	-0.891	-0.209	-0.289
population	(13.01)	(7.53)	(2.32)	(4.04)
Ratio of young to working-age	0.010	-0.054	-0.018	
population	(0.45)	(1.75)	(0.86)	
Log labor force participation rate	-0.091	0.301	0.012	
	(3.17)	(5.24)	(0.24)	
Retirement Incentive	-0.166	-0.082	0.034	
	(5.44)	(2.46)	(1.20)	
Replacement rate: fully funded	-0.206	-0.264	0.005	
	(2.79)	(3.34)	(0.08)	
Replacement rate: pay as you go	-0.040	0.408	0.116	0.119
	(0.58)	(6.29)	(2.35)	(4.83)
Universal Coverage	-0.082	-0.058	-0.051	-0.048
	(2.27)	(1.23)	(1.28)	(1.84)
Retirement Incentive times life	0.229	0.106	-0.039	0.008
expectancy	(5.30)	(2.23)	(0.98)	(2.18)
Replacement rate (fully funded)	0.336	0.395	-0.002	
times life expectancy	(3.31)	(3.50)	(0.02)	
Replacement rate (pay as you go)	0.013	-0.590	-0.168	-0.182
times life expectancy	(0.13)	(6.08)	(2.23)	(4.76)
Universal coverage times life	0.091	0.114	0.088	0.084
expectancy	(1.63)	(1.53)	(1.42)	(2.16)
R^2	0.495	0.768	0.889	0.889

t statistics in parenthesis (based on robust standard in columns 1 and 2 and bootstrap standard error estimates in columns 3 and 4).
Based on 1763 observations from 57 countries over the period 1961–2000.

Table 5
Effects on Steady-State Savings Rate

	Effect on Steady-State Savings Rate (percentage points)
Old/ Working Age Ratio rises by 0.01	-1.336 (4.07)
Life expectancy rises by 1 year with universal coverage, mandatory retirement, and a fully funded system	0.424 (2.27)
Life expectancy rises by 1 year with universal coverage, mandatory retirement and a pay-as-you-go system with replacement rate of 0.5	0.003 (0.02)
Life expectancy rises by 1 year with universal coverage, mandatory retirement and a pay-as-you-go system with replacement rate of 1.0	-0.418 (1.90)
Effect of introducing a retirement incentive with life expectancy at 66 years	2.489 (2.23)
Effect of introducing a retirement incentive with life expectancy at 81 years	3.055 (3.48)
Effect of moving from a pay-as-you-go system (replacement rate 1.0) to a fully funded system with life expectancy 66 years	0.005 (0.16)
Effect of moving from a pay-as-you-go system (replacement rate 1.0) to a fully funded system with life expectancy 81 years	13.148 (2.93)

Based on the regression results in column 4 of Table 4.

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