

**SOME ECONOMIC IMPLICATIONS
OF LIFE SPAN EXTENSION**

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This paper is concerned with the following question: What would the economy look like if we suddenly discovered the fountain of youth? While this question may seem fanciful, a growing number of contemporary Ponce de Leons with impressive scientific credentials would argue that there is a significant chance of unraveling the mystery of aging in the near future. The search for the famed fountain of youth has moved from the swamps of Florida to the laboratories of biologists, chemists, and physicians. These gerontologists are not, however, searching for some magical elixir; rather they are exploring the biochemical nature of aging with the goal of ultimately stopping, if not reversing, the aging process.

The scientific community appears to differ about the near-term likelihood of discovering a youth drug that would prevent or, at least, retard aging. While the probability of quickly finding such a drug may be small, the socio-economic consequences of such a discovery could be enormous. The expected value of social-scientific research on this type of life span extension may, then, be very large from the perspective of a cost-benefit calculation. Indeed, until some very basic social-scientific research is done on the subject, it will be difficult to judge how much of the nation's pure scientific, as well as social-scientific research support should be devoted to life span extension.

In this paper I concentrate on the implication of lifespan extension for aggregate factor supply and economic welfare. While this is the major focus of the paper, I also devote some space to consideration of life span extension's impact on the economy's skill composition and on existing economic institutions, including the social security system.

The major conclusion I draw from my analysis is that the expansion of working and total life spans should significantly increase economic welfare. The measure of economic welfare to which I am referring is average consumption per year over one's lifetime; increasing the length of one's life, including one's productive life, appears to permit a higher level of consumption in every year that one is alive.

Throughout the paper "life span extension" is taken to mean keeping people young for longer periods of time. This is quite different from what one conventionally means by life span extension, namely, keeping old people alive for longer periods.

The youthful extension of life with which I am here concerned represents a true expansion of the lifetime' leisure and consumption opportunities of individuals. Assuming that both consumption and leisure are normal goods, this increase in individuals' budget sets will lead them to purchase more commodities as well as enjoy more leisure during their elongated lives. The purchase of additional commodities necessitates, however, additional earnings. Hence, at least some fraction of the increased number of years arising from our youth drug will be devoted to additional work.

In the stylized economic models examined below, I consider equal increases in the age of retirement and the age of death, as well as proportionate increases in retirement and death ages. Since the potency of the

youth drug is as much in doubt as the availability of the drug itself, I attempt to distinguish economic consequences of short expansions of life from those of long expansions.

In the first section of this paper I investigate how life span extension affects our per capita output and economic welfare assuming a fixed capital stock in the economy. The section demonstrates that even if output per worker falls due to diminishing returns to increases in the labor force, output per capita and economic welfare may still rise.

Section two considers the impact of longer lives on aggregate capital accumulation and the economy's capital-labor ratio. This analysis indicates that capital intensity is likely to rise or at least not fall as life and work spans are extended. This in turn implies that output per worker and wages per worker will not be adversely affected by longer life spans. Combining the results of sections I and II, I arrive at a fairly optimistic assessment of the economic welfare consequences of the expansion of life.

Section three explores how the skill composition of the labor force and the relative wages of skilled and unskilled workers are likely to change as a result of the youth drug; section four is concerned with life span expansion's impact on the social security system and other economic institutions.

I. Life Span Extension's Impact On Per Capita Output and Economic Welfare Assuming a Fixed Stock of Capital

Assuming that total annual births remain unchanged, and that after a transition period total annual deaths are also unchanged, life span extension will be associated with an increase in total population. While the total stock of people who are alive will rise, the assumptions about births and deaths mean that the long run growth rate of population is

unaffected by life span extension. The discovery of the youth drug will lead initially to a decline in total deaths as the number of physically old people decline. Assuming the drug is potent for only a fixed period of time, the number of physically old people will eventually return to its former level as the early users of the drug reach the limits of its effectiveness. During this transition period the population growth rate will exceed its long term rate and the total population will rise.

Practitioners of the "Dismal Science" have long been concerned with population increases. The type of population increases arising from life span extension has quite a different impact on per capita output and economic welfare than does population growth arising from, for example, higher birth rates.

Population growth due to life span extension involves an increase in the ratio of productive to dependent persons. The change in this dependency ratio can potentially reverse the dismal Malthusian prescription that population growth is immiserating. Malthus' argument that population growth reduces economic welfare relies on the law of diminishing returns. For a fixed stock of non-labor inputs, output as a function of labor input is subject to diminishing returns, i.e., the level of output per worker will decline as the number of workers increases.

The interesting feature of life and work span extension is that although output per worker could fall as the total work force rises, output per person in the economy may still rise because the ratio of workers to total population increases.

Per capita output seems to be a good measure of economic well-being because it indicates the level of consumption that each member of society could enjoy for each year of his or her life if output was uniformly distributed. While total lifetime utility would surely rise from the introduction of the drug (this would be evidenced simply by the voluntary purchase of the drug), it seems interesting to inquire whether this lifetime utility increase represents a higher or lower yearly level of economic well-being. Per capita income seems to be a good measure of potential yearly economic welfare.

To examine precisely the changes in per capita income, let us consider a very simply economy in which each person lives D years, is unproductive for C years (reflecting, for example, retirement, childhood, and schooling years), and works for $(D-C)$ years. Let us further assume that conventional population growth is zero and that the number of people at each age equals N . The total population of this economy is then DN , and the work force is $(D-C)N$.

Per capita output, y , may be written as:

$$(1) \quad y = \frac{F((D-C)N)}{D.N},$$

where F is the economy's production function which relates output to labor input. The assumption of positive, but diminishing marginal productivity means that $F' > 0$ and $F'' < 0$. Differentiating y with respect to D yields:

$$(2) \quad \frac{\partial y}{\partial D} = \frac{F'N}{DN} - \frac{F}{D^2N} = \frac{F'DN - F}{D^2N}$$

Equation (2) asks the question how does per capita output respond to equal increases in life and work spans. The technological assumptions that

$F' > 0$ and $F'' < 0$ imply that:

$$(3) \quad F > F'(D-C)N \quad \text{or} \quad F + F'CN > F'DN$$

Condition (3) does not suffice to determine the sign of (2), i.e., whether life span extension increases or decreases per capita output. While nothing definitive can be said about the impact of small increases in life and work span on per capita output, for very large increases in life span the force of diminishing returns holds sway, and per capita output definitely declines. To see this consider the inequality:

$$(4) \quad F/F' > DN$$

While inequality (4) may not hold for small values of D , as D increases the inequality must hold; the right hand side of (4) increases at a rate N as D increases, while the left hand side increases at rate

$$\frac{\partial F/F'}{\partial D} = N - \frac{FF''N}{F'^2},$$

which exceeds N since $F'' < 0$.

For our economy the sign of (2) seems clearly to be positive. Using the conventional Cobb-Douglas description of U.S. production:

$$(5) \quad F = ((D-C)N)^\alpha,$$

where α is labor's share in total output equal to about .7. Using (5) and expressing (2) in terms of the percentage change in per capita output due to a percentage change in life span, I arrive at:

$$(6) \quad \frac{\partial y}{\partial D} \cdot \frac{D}{y} = \left(\frac{\alpha D}{D-C} - 1 \right)$$

In our economy a working period, $(D-C)$, of 45 years from age 20 to age 65 and a life span, D , of 75 years seems to be the norm.

Applying these numbers to (6) yields a value for (6) of .17 suggesting that a 10 percent increase in life span gives rise to a 1.7 percent increase in per capita output. The increase in per capita income would, of course, be much greater if output per worker did not fall. In this case a 10 percent increase in life span would give rise to a 6.7 percent increase in per capita output. One should keep this fact in mind when reading the next section which indicates that output per worker could easily rise when capital accumulation is considered.

The prognosis for per capita output is less sanguine if instead of assuming that the total increase in life span is devoted to work, we assume that a constant fraction of the total life span is spent working as longevity is extended. Per capita output in this case definitely falls. The change in per capita output for this case is given in (7), which from (3) is negative.

$$(7) \quad \frac{\partial y}{\partial D} = \frac{F'(D-C)N - F}{D^2 N} < 0$$

Which type of labor supply response, a year for year increase in the working span, or a smaller, say, proportionate increase in working lives seems most likely to occur? A year for year increase in working span as total life span rises means that there is no desire for additional lifetime leisure as income rises. Evidence about retirement patterns in this century seems to rule out the year to year increase in working span. As real wages have risen, there has been a dramatic increase in early retirement behavior of males. In 1920, 60.1 percent of males over age 65 were in the labor force. The comparable number in 1977 was 20.1 percent. If the real wage were the only thing that had changed during this period, we could unambiguously conclude that lifetime leisure was a normal good, since the

substitution effect of a higher wage leads to more labor supply, the reduction in labor supply must reflect a positive income effect for lifetime leisure. The counter argument to this is that much of the increase in early retirement may reflect Social Security's implicit taxation of the labor supply of older workers (see Kotlikoff 1978). Another potentially important consideration is that this historic increase in lifetime leisure has occurred only for ages when physical stamina and general health is poorest. If the youth drug permits individuals to remain highly energetic for years and years, desired lifetime leisure could actually fall; the preference for leisure appears to be strongly dependent on one's state of physical well-being, even for individuals who are adjudged to be medically healthy relative to their age cohort.

Another factor involved in thinking about changes in (D-C) is that much of C reflects childhood and old age, periods for which work is physically impossible. The fraction of the lifetime that represents non-discretionary leisure will certainly fall with the advent of the youth drug. Hence, even if the period of discretionary leisure increases proportionately with the period of work, the work span as a fraction of total life span will rise.

To summarize this section, I have demonstrated that population growth due to life span extension is special in that it increases the ratio of productive to non-productive people in society, or, equivalently, it increases the fraction of each person's life that he or she is productive. For a fixed stock of capital, population increases lead to a reduction in output per worker because of diminishing returns. Output per capita can, however, still rise if the ratio of productive to non-productive years increases, an event which I perceive as highly likely.

II. Impact of Life Span Expansion on the Capital Stock, Capital Intensity, and Output per Worker

This section considers how life span extension will affect the total stock of capital as well as the capital labor ratio. The capital labor ratio determines output per worker; if the capital labor ratio does not fall as a consequence of life span extension, output per worker will not decline. If the capital labor ratio rises, output per worker will rise as well. The message of this section is that diminishing returns to additional labor input need not occur provided there are concomitant increases in the capital stock arising from life span extension.

To make the analysis as intuitive as possible, I first present a very simplified life cycle model of capital accumulation which ignores intertemporal discounting, conventional population growth, and various types of economic uncertainties. Consider then, an economy in which individuals live for D years and work for the first R years. Letting e stand for the earnings per year of work, lifetime earnings equal eR . I assume equal consumption per year over one's life; consumption per year is then eR/D . Conventional population growth is zero. There are N individuals at each age. The total capital stock for this economy consists of the capital (wealth) owned by workers plus the capital owned by retirees, i.e., those older than R . Each person saves $e(1-R/D)$ per year until retirement; thereafter, he dissaves an amount eR/D each year until death at age D . A pre-retirement worker of age x has saved $e(1-R/D)$ for x years and thus has a net worth of $e(1-R/D)x$. The total assets of workers, A_w , is given by the integral over workers from age zero to age D of assets held at age x times N , the population at each age.

$$(1) \quad A_w = \int_0^R e(1-R/D)N \cdot x \, dx = e(1-R/D)N \frac{R^2}{2}$$

Assets for retirees equal their net worth at retirement age, $e(1-R/D) \cdot R$, less their accumulated dissaving from age R to their current age x . Assets for a retiree age x can thus be written as $e(1-R/D) \cdot R - eR/D \cdot (x-R)$, or $eR - \frac{eR}{D} x$. Total assets of retirees, A_R , equals the integral over ages R to D of retiree's assets at age x .

$$(2) \quad A_R = \int_R^D (eR - \frac{eR}{D} x)N dx = eR(D-R)N - \frac{eR}{D} (\frac{D^2}{2} - \frac{R^2}{2})N$$

Adding (1) to (2) gives the total capital stock, K , in this economy:

$$(3) \quad K = Ne \frac{(D-R)R}{2}$$

Let us now consider equal increases in life span D and retirement age R , i.e., we keep the differential $D-R$ constant. The change in the capital stock is thus $Ne \frac{(D-R)}{2}$ which is clearly positive. There appears to be two opposing forces involved here. On the one hand, simultaneously increasing D and R reduces the relative length of the retirement period. This reduces the annual savings of each worker, $e(1-R/D)$, and increases the annual dissaving of each retired person, eR/D . On the other hand, there is an absolute increase in the number of workers, while the number of retirees stays constant. Although each worker saves less, there are so many additional workers that total savings of workers as well as the capital stock rises. To obtain some notion of the magnitude of these capital stock increases, I present the elasticity of the capital stock with respect to this type of life span and work span extension.

$$(4) \quad \frac{\partial K}{\partial D} \frac{D}{K} = \frac{D}{R}$$

Since D exceeds R, this elasticity exceeds unity. Values of D of 55 and R of 45 give an elasticity of 1.22. In our model, a value of 55 corresponds to a real world age of death of 75, since the age at which work begins, e.g., 20, is normalized to zero. An elasticity of 1.22 implies that a 10 percent increase in life span would increase the capital stock by 12.2 percent.

If, rather than assuming that D-R stays constant, we assume that $\frac{D-R}{R}$ stays constant as D increases, the elasticity of capital to D equals 2.

Since the labor force equals NR, the capital labor ratio, K/L, is easily computed:

$$(5) \quad K/L = \frac{Ne(D-R)R/2}{NR} = \frac{e(D-R)}{2}$$

Note that equal increases in life and work spans leave the capital labor ratio unaltered while equal proportionate increases in D and R increases the capital labor ratio by the same percentage.

Proportionate increases in retirement and death ages which increase the absolute length of retirement lead to more capital per worker, while changes in life span which leave the length of retirement unaltered do not alter capital intensity. Equation (5) paints a rosy picture for life span extension's impact on per capita output independent of whether the working period increases year for year with life span or increases proportionally. If work span increases pari passus with life span, output per worker will remain fixed, but per capita output will rise due to the increase in workers per person in the economy. If the extension of the working span is proportionate, per capita output will rise because output per worker increases, although the ratio of workers to the population remains fixed.¹ Since the real wage, e,

¹It can be demonstrated that these per capita output results hold in a model in which there is an initial non-productive period of B years, followed by (R-B) years of work, and (D-R) years of retirement.

is also an increasing function of capital intensity, the same story can be told for yearly consumption which is eR/D . When R/D rises, e remains fixed; when R/D is fixed, e rises. Yearly consumption rises in either case.

The analysis to this point has assumed that each worker is fully employed for each year prior to retirement, I now permit the quantity of labor supplied each year to be chosen by the individual, and ask whether this type of labor supply response to life span extension will alter the economy's capital intensity. To begin, let us assume that each person works for the same fraction of each year. As life span is extended, the increases in potential lifetime resources that I've discussed above might lead individuals to reduce their labor supply, ℓ , during each working year, as well as alter the total number of years, R , spent working. This type of labor supply reduction, by reducing earnings, will reduce savings and the capital stock. Although the capital stock falls, the capital labor ratio is unaffected.²

To see this, write $e = w\ell$, where w is the wage per year. The economy's labor supply, L , in this case is $NR\ell$. Rewriting the capital labor equation (5) for this situation of variable labor supply gives:

$$(6) \quad K/L = \frac{Nw\ell(D-R)R/2}{NR\ell} = \frac{w(D-R)}{2}$$

In (6) it is clear that the capital-labor ratio is independent of annual labor supply ℓ . Intuitively, the yearly labor supply falls by the same percentage as the capital stock falls, leaving the capital labor ratio unaltered. Even if labor supply differs from one period to the next, as long as the percentage reduction in the labor supply in each period is the same, the capital

²Martin Feldstein (1974) investigates the impact of the long run labor supply elasticity on capital intensity. A related paper is Kotlikoff and Summers (1978).

labor ratio will be unaltered. To the extent that labor supply when young falls (rises) by a greater (lesser) percentage than labor supply when old, the capital labor ratio will fall (rise).

The conclusion that emerges from this very simplified model is that the economy's capital intensity is likely to rise or at least remain constant in response to life span extension.

It is important to determine whether those results hold for a more realistic and, correspondingly, more complex model of economic growth. I, therefore, constructed a more detailed steady state life cycle model which takes into account interest rates, population and productivity growth, and intertemporal optimal consumption choice. Rather than consuming at a constant level each year, individuals choose a consumption path that maximizes an intertemporal utility function, U , of the form:

$$(7) \quad U = \int_0^D \log C_t e^{-\rho t}$$

In (7), ρ is the rate of time preference which indicates the consumer's relative preference for consumption today rather than consumption tomorrow. C_t is consumption at time t . Individuals choose the path of C_t 's which maximizes (7) subject to the lifetime budget constraint:

$$(8) \quad \int_0^D C_t e^{-rt} \leq \int_0^R w_t e^{-rt}$$

Equation (8) indicates that the present value of the consumption path chosen must not exceed the present value of lifetime earnings. The interest rate at which dollar values are discounted back to time zero is r ; R and D are, respectively, ages of retirement and death; and w is the real wage in year t . The

real wage is assumed to grow at a constant rate, g , due to labor augmenting technological change. To make the model somewhat more realistic, I incorporate a 30 percent tax on wage income and a 50 percent tax on interest incomes in the analysis.

Given the optimal consumption and earnings paths, one can compute savings and wealth holdings at each age for a representative individual in this economy. Aggregating the wealth holdings of each person at each age, I arrive at equation (8) which indicates the total supply of capital at time t in the economy, K_t^S , corresponding to different parameter values of the model.

$$(9) \quad K_t^S = \frac{w_t}{rg} [H_1 + H_3 H_4],$$

$$\text{where,} \quad H_1 = \left(\frac{1-e^{(r-u)R}}{u-r} \right) - \left(\frac{1-e^{-nR}}{n} \right)$$

$$H_3 = \left[\frac{e^{zD} - 1}{z} - \frac{1-e^{(r-u)R}}{u-r} \right] - \left(\frac{e^{(r-u)R} - e^{(r-u)D}}{u-r} \right) e^{-\rho D}$$

$$H_4 = \frac{1-e^{(g-r)R}}{1-e^{-\rho D}}$$

$$u = n+g$$

$$z = (r-u) - \rho$$

In (9), n and g are respectively rates of population and productivity growth.

The demand for capital by firms corresponding to given after tax factor prices, w_t and r , is derived from the Cobb-Douglas production function:

$$(10) \quad K_t^D = \frac{\alpha w_t (1-tr)}{(1-\alpha)r (1-tw)} \frac{(1-e^{-nR})}{n},$$

where α is capital's share in total income, taken here to be .3, t_r is the tax rate on interest income (.5), and t_w is the tax rate on wage income (.3).

To investigate how changes in life span D and work span R influence the capital stock in general equilibrium, I first solve for the equilibrium value of K which equates capital supply and demand for initial values of D and R . I then change D and R and compute the new equilibrium value of K . To find equilibrium solutions for (9) and (10), I eliminate K_t/w_t from both equations, leaving an equation in r . This equation was solved using a computer. The solution is unique because in (9) K_t/w_t is a decreasing function of r , while in (10) K_t/w_t is an increasing function of r . Given the equilibrium value of r , equation (8) or (9) may be used to solve for the equilibrium value of K_t/w_t .

Table 1 reports general equilibrium capital labor ratios for a range of different retirement ages and death ages. By general equilibrium, I mean that all changes in the optimal consumption path that arise due to changes in wages and interest rates are taken into account. Since age zero in this model corresponds to the age of entrance into the labor force, an age of death of 50 and a retirement age of 40 should be thought of as corresponding to real world ages of 70 and 60. The table also reports real net wage rates corresponding to the different capital labor ratios, where the net wage for a death age of 50 and a retirement age of 40 is normalized to one.

The numerical values in table I support the finding from the more simplified model that proportionate growth in retirement and death ages will raise capital intensity. An increase in retirement age from 40 to 80 concomitant with an increase in the age of death from 50 to 100 raises capital intensity from 6.89 to 9.17 or 34.3 percent. At the same time the real wage rises by

I. General Equilibrium Capital-Labor Ratios and Wage Rates for Various Life Spans and Work Spans*

Age of Retirement	Age of Death										
	50	60	70	80	90	100	110	120	130	150	200
40	6.89	9.24	11.37	13.26	14.89	16.39	17.58	18.83	19.65	21.10	23.70
1	1.10	1.19	1.28	1.35	1.41	1.46	1.52	1.55	1.62	1.73	
50	7.26	9.23	10.95	12.51	13.98	15.27	16.37	17.39	19.20	21.53	
	1.02	1.10	1.18	1.24	1.31	1.36	1.41	1.46	1.54	1.64	
60	7.68	9.16	10.66	12.02	13.18	14.31	15.42	16.98	19.63		
	1.03	1.10	1.16	1.22	1.27	1.32	1.37	1.44	1.55		
70	7.92	9.23	10.36	11.58	12.57	13.66	15.18	17.93			
	1.04	1.10	1.15	1.20	1.25	1.29	1.36	1.48			
80	8.23	9.17	10.19	11.36	11.98	13.55	16.02				
	1.06	1.10	1.14	1.19	1.22	1.29	1.40				
90	8.37	9.30	10.17	10.90	12.20	14.88					
	1.06	1.10	1.14	1.17	1.23	1.34					
100	8.53	9.23	10.04	11.56	13.35						
	1.07	1.10	1.14	1.20	1.28						

*Top number in each cell is capital labor ratio; bottom number is the wage rate. The wage rate for a retirement age of 40 and a death age of 50 is normalized to 1. The table assumes 1 percent growth in population, 2 percent growth in productivity, and a 1 percent rate of time preference.

10 percent and per capita output rises by 13 percent. An interesting feature underlying these proportionate changes is that although the ratio of the retirement age to the death age stays constant, the ratio of productive to non-productive workers rises. This reflects the positive rate of population growth, i.e., there are few people 80 to 100 relative to people under 80 due to population growth. Even at a low 1 percent rate of population growth there are only .37 100 year olds for every 1 year old in the population.

The table indicates some non-linearities with respect to equal increases in retirement and death ages. Holding the retirement period at 10 years, increases in life span from 50 to 100 raises capital intensity from 6.89 to 8.37, the real wage by 6 percent, and per capita output by 19 percent. On the other hand, for a 20 year retirement period, raising the age of death from 60 to 110 leads to very little change in capital intensity; it rises from 9.24 to 9.30. Per capita output rises, however, by 22.5 percent primarily because of the increase in the ratio of productive to non-productive citizens.

III. Life Span Extension and the Skill Composition of the Labor Force

The extension of the age of retirement will affect career choices and human capital investment (training) decisions. Increases in the age of retirement make careers which require an initial period of training relatively more attractive than careers that involve no initial training. The reason for this is that the lengthened work span permits a longer period of amortization on the initial training investment. If there is no change in the length of training received in these careers, an increased number of workers will choose skilled careers; the growth in skilled relative to unskilled workers in the economy will continue until skilled wages are depressed relative to unskilled wages to the

point that marginal workers are again indifferent between unskilled and skilled careers.

This increase in the skill composition of the labor force and fall in the relative wages of skilled and unskilled workers need not, however, occur. The increase in the retirement period makes additional training desirable. If each skilled worker engages in additional training, the returns to the career paths can be realigned with the same proportion of skilled to unskilled workers in the economy, although with an increase in the ratio of effective skilled workers to unskilled workers. By effective skilled workers, I mean the number of skilled workers adjusted for their degree of training. In this scenario the wage per unit of skilled human capital falls although annual earnings of skilled workers could actually rise because of the greater amount of human capital per skilled worker.

These points are illustrated in the following simple model. I assume that the economy's output, F , can be described by a Cobb-Douglas production function in effective skilled labor, S^* , and unskilled labor, U :

$$(1) \quad F(S^*, U) = S^{*\alpha} U^{1-\alpha}$$

where α is the share of effective skilled labor in total income. I let W_S denote yearly earnings per skilled worker and W_U yearly earnings per unskilled worker; competitive choice of career paths will insure an equalization of lifetime earnings in both careers:

$$(2) \quad W_S(R-E) = W_U R$$

The effective stock of skilled labor is related to the number of skilled workers, S , by:

$$(3) \quad S^* = S \cdot H(E).$$

In (3), $H(E)$ is the human capital production function which indicates the number of effective skill units of labor provided by a worker with E years of training. I assume that $H'(E) > 0$ and $H''(E) < 0$. W_S and W_U are determined in competition factor markets and equal, respectively, the marginal products of skilled and unskilled workers.

$$(4) \quad W_S = \frac{\alpha F}{S}; \quad W_U = (1-\alpha) \frac{F}{U}$$

Equation (2) and (4) imply:

$$(5) \quad \frac{\alpha}{1-\alpha} \frac{R-E}{E} = \frac{S}{U}$$

If one holds E , the length of training, constant, then increases in R definitely raise the economy's skill composition. However, this need not occur because E will increase with R .

The length of training is chosen to maximize lifetime earnings in a career as a skilled worker:

$$(6) \quad W_S(R-E) = W_{S*} H(E)(R-E)$$

In (6) W_{S*} is the wage per unit of skilled human capital. Individuals take W_{S*} as given by the market when they determine their optimal amount of training, E . Optimal choice of E satisfies:

$$(7) \quad H'(E)(R-E) = H(E)$$

It is also immediate that:

$$(8) \quad \frac{dE}{dR} = - \frac{H'(E)}{H''(R-E) - 2H'(E)} > 0.$$

Equation (8) indicates that the length of training unambiguously rises with increases in the age of retirement, R . The greater the age of retirement,

the longer is the period of time that a skilled worker can amortize his training investment. Hence, increases in the retirement age make additional training more desirable. The skill composition, S/U , determined in (5) may, however, remain unchanged. If the elasticity of the training period, E , with respect to the retirement age, R , is unity, E will rise in the same proportion as R , and S/U will be unaltered. In every case, the wage per unit of skilled human capital, W_{S^*} , falls relative to the unskilled wage, W_U .

$$(9) \quad \frac{W_{S^*}}{W_U} = \frac{R}{H(E)(R-E)}$$

and:

$$(10) \quad \frac{dW_{S^*}/W_U}{dR} = -\frac{H(E)E}{H(E)^2(R-E)^2} < 0.$$

In the case of zero population growth, the ratio of trainees, T , to skilled workers, S , is:

$$(11) \quad T/S = E/R-E.$$

Taking N to be the population at each age, the total labor force, RN , is divided between trainees, skilled workers, and unskilled workers:

$$(12) \quad RN = S + U + T$$

If E and R move in equal proportions, equations (5), (11), and (12) dictate a proportionate growth in the number of skilled workers, unskilled workers, and trainees. If E rises less than in proportion to R , the skilled work force will rise relative to the unskilled work force, and the number of trainees will fall relative to the number of skilled workers.

While I know of no empirical study which has investigated the elasticity of the training period with respect to the age of retirement, my own impression

is that this elasticity is likely to be less than unity. This impression is based on the observation that in many areas there is a fixed body of knowledge which can be digested in a few years, and that additional training time will be subject to severe diminishing returns.

In addition to influencing the skill mix, the length of training, and relative wages of skilled and unskilled workers, life span extension is very likely to increase the number of people choosing to have multiple careers during their lifetimes. Within the simple model of human capital investment that I have been discussing, multiple careers always dominate a single career. This reflects diminishing returns to human capital investment in any one career. By engaging in a number of careers during one's life and, therefore, participating in a number of different training programs, one can raise the average marginal return from human capital investment, where by "average," I mean average over the different human capital production functions. If there were no fixed costs to human capital investment, this line of argument would imply that every individual would optimally spend some part of his working life in each and every career. This obviously is not what we observe in the real world, suggesting that fixed costs of switching careers are important. Another possibility is that the human capital production technology is not smooth. For example, there appears to be a minimum length of training time required for entry into certain careers. These minimum time constraints could easily lead to corner solutions in terms of career choice, i.e., only one career would be pursued in a lifetime.

My sense is that these fixed costs of job switching and minimum training requirements will become much less important if life span is substantially in-

creased. I would expect to see a marked increase in the percentage of the work force which engages in multiple careers.

IV. Impact of Life Span Extension on the Social Security System and Other Economic Institutions

The past two decades have witnessed an enormous growth in the social security system and old age health insurance. During this period the number of Social Security recipients has more than doubled, and benefits -- including retirement, disability, and old age health insurance payments -- have almost quadrupled in real terms. Since 1960 the combined employee and employers Social Security tax rate has doubled from 6 percent to 12.1 percent. 1977 Social Security legislation calls for even higher Social Security taxes in the near future. Between 1978 and 1982, Social Security taxes for a middle income worker will rise in real terms by about 52 percent, about \$1000 1978 dollars. Even these massive tax increases may prove quite insufficient to finance the program through the first half of the twenty-first century. A. Robertson (1978: 21-36), the Chief Actuary of the Social Security Administration projects that if the current law is maintained up to the year 2025, tax rates will have to increase by more than 8 percent to meet scheduled benefit payments. Projecting far into the future is, of course, a hazardous business; still, forecasts of a 23 percent or greater Social Security tax in 2025 do not augur well for Social Security's future.

A large part of recent increases in the Social Security tax burden reflects healthy legislated increases in real Social Security benefits for the elderly. Much of the problem down the road reflects the enormous recent reductions in fertility rates; in 1957 the fertility rate reached a post-World War II high of 3.7 children born per woman; in 1976 the figure was 1.8. The

lower fertility rates imply that the ratio of workers to retired beneficiaries will fall from a current level of 3.2 to about 2 by the middle of the next century.

Increases in life and work years could greatly relieve our Social Security problems. Our system is set up on a pay as you go, or chain letter basis, in which young workers pay taxes which are handed over to old people as retirement benefits. If, through life span extension, we can markedly increase the ratio of workers to retired people, the tax burden per worker will be greatly alleviated.

Certain features of the Social Security program will have to be changed to permit the expansion of life to improve the Social Security morass; if these structural changes in the program are not implemented, life span extension could greatly exacerbate our Social Security problems. The main change that would need to be made is to eliminate Social Security's implicit taxation of the work efforts of the elderly. Prior to age 72 (age 70 after 1981, under the new law), the Social Security earnings test reduces or eliminates benefits for many working aged. Not only do aged workers lose their benefits by working, but they also receive, in most instances, little return on the Social Security taxes they continue to pay. The earnings test represents an implicit 50 percent tax rate for the elderly over a wide range of potential earnings.

If we maintain the earnings test in its current form in the face of expanded life spans, we could quickly run into a situation where most physically young people were induced by Social Security to retire because they were old in calendar time and ran into the Social Security tax bite. Surely, we will want to either eliminate the earnings test altogether, or raise the minimum age at which benefits can be received. If we are responsive to the need for institu-

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tional change in Social Security when the youth drug is discovered, the extension of life will undoubtedly greatly relieve our Social Security problems.

There are other economic institutions which would be dramatically affected by life span extension. Certainly the medical profession and health delivery system would suffer a relative if not an absolute decline as the percentage of physically old people declines. Insurance companies and pension funds with annuity obligations would face severe financial problems if their beneficiaries suddenly stopped dying for say, 40 years. The economy would, presumably, become much more youth oriented with corresponding increases in the demand for physical recreational activities.

The list of potential changes in the structure of the economy is, indeed, a long one. I have certainly focused on just a few, although important, economic issues involved in life span extension. My analysis leads me to be highly optimistic about the economic gains from life span extension. Life span extension is likely to raise per capita income and the economic welfare of the vast majority of people. In addition, life span extension can greatly relieve the financial crunch of our Social Security and Old-Age Health Insurance programs.