Heath and Life Span Effects

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East-West Center, Hawaii
June 18-June 22 2007

Health and Life Span Effects

- Value of Health/Lifespan Improvements
- Health and Worker Productivity
- Life spans and life cycle behavior
  - retirement
  - Consumption/savings
  - Institutions
- Health lifespan and education

Value of Health Improvements

- Welfare Gain from Lifespan Improvement
- Value of life span gain in money units.
- Vale of a statistical life
- What money gain would give the same welfare benefit as the gain in life expectancy?

Individual Utility

Life time welfare

$$U(C, S) = \max \int_0^\infty \exp(-\rho t)\, S(t)\, u(c(t))\, dt$$

Budget constraint

$$\int_0^\infty \exp(-rt)\, S(t)\, c(t)\, dt = \int_0^\infty \exp(-rt)\, S(t)\, y\, dt$$

Indirect Utility

- Assuming $r = \rho$

$$\text{V (Y, S)= u(y)} \int_0^\infty \text{exp(-rt) S(t) dt} = u(y)A(S)$$

- Annuity of \$1 for life has value

$$A(S) = \int_0^\infty \text{exp(-rt) S(t) dt}$$

Equivalent Variation

- Survival rates rise from S_0 to S_1 while income rises from y_0 to y_1
- The equivalent variation e (rise in annual income) of the health improvement solves

$$V(y_1 + e, S_0) = V(y_1, S_1)$$

- Or

$$u(y_1 + e)A(S_0) = u(y_1)A(S_1)$$

Approximation of EV

- Using a Taylor series expansion

$$e \approx \frac{u(y_1)}{u'(y_1)}\left(\frac{A(S_1)-A(S_0)}{A(S_0)}\right)$$

- The equivalent variation depends on the discounted growth in survival and the level of income

Value of Life Span Increases

- We can estimate the equivalent variation if we know the age specific survival function before and after, the level of income and the shape of the utility function.
- The utility function needs to be determined both in terms of its slope (higher order terms may be important as well) and its intercept – notice we implicitly take the utility of being dead to be zero.
- U(c) is the utility of being alive and having consumption c. We can find the intercept from value of life studies.

Health and Full Income

- Health adds directly to welfare as well as acting as an input into production.
- Value of Life studies put a high monetary valuation on small risks of death.
- Over 50% of welfare gain in US from 1900 has been lifespan (Nordhaus).
- Calibration of utility function as in Becker, Philipson and Soares (2005).

Full Income in China

	GDP per Capita	Life Expectancy	Full Income Gain
1973	$870	61.4 years	
1982	$1210	68.8 years	
2000	$3750	71.1 years	
Value of Increase 1973-2000	$2880	$704	$3584
Value of increase 1982-2000	$2540	$202	$2742

Full Income in India

	GDP per Capita	Life Expectancy	Full Income Gain
1965	$927	42.6 years	
1980	$1160	52.4 years	
2000	$2480	62.4 years	
Value of Increase 1965-2000	$1553	$1224	$2777
Value of increase 1980-2000	$1320	$574	$1894

Health and Worker Productivity

Issues

- No consensus on how to define health
- Health status indicators have large measurement errors.
- Effect is bi-directional – we cannot infer causality from correlation.

Measuring Health Capital Multiple Indicators of Health

- Self assessed health status
- Morbidity Rates
- Physical function limitations
- Physical growth outcomes

Health Human Capital

- We are interested in health that comes as a result of health and other investments – controlled health.
- Uncontrolled health , e.g. due to genetic differences will affect productivity but is not health capital.
  - Compare with IQ and schooling as human capital.
- Ideally we would measure the effect of a health input on health status and then trace out the effect of the improved health status on productivity –but this is rare.

Feedbacks from Income to Health

- Model has three functions which occur simultaneously.
- Health is a function of health and other inputs (including shocks).
- People decide, based on their income, on inputs and activities that affect health.
- Health affects productivity and income

Analytical Framework

- Health production function
  - Health H
  - Health inputs I
  - Exogenous health factors (genetic etc.) g usually unobserved
  - Random error e1

$$H = h(l, g, e1)$$

Input determination

- The level of inputs depends on household characteristics, such as wage earnings W, and the availability of inputs X
- We "solve out" for the effect of current health h on input demands.

$$l = d(X, W, g, e2)$$

Productivity

- Wages W depend on health H, education E, other factors Z and an error term

$$W = w(H, E, Z, e3)$$

Estimation Problems

- We have measurement error in health – biases results downwards.
- Health affect wages but wages also affect health via their effect on health inputs – we have reverse causality.
- We only want the human capital element of health's contribution to wages, not the genetic component.

Problems can be overcome using an instrumental variable

- Suppose instead of health we use predicted health based on the local availability of health services and factors that can used as policies to affect health.
- This removes measurement error
- This removes the reverse causality since the predicted health is independent of an individual's wage.
- The predicted health measure is pure "controlled health" and does not include any individual specific uncontrolled health.

Empirical Results on Wages Determinants

All these variables are instrumented- for example by local food prices or distance to a health facility when young

- Calories important (below 2000 kcal).
- Proteins important
- BMI important
- Height important
- Days ill/working days lost important

Schultz 2001

- Cote d'Ivoire and Ghana
- Four human capital variables
  - Education
  - Migration
  - Height
  - BMI
- All four are instrumented by local food prices, distance to school and health facilities, parents' education and occupation.
- 1cm height leads to 4%-8% wage gain.

Natural Experiments

- Health interventions that can be taken as random.
- Hookworm eradication in the American South.
- Malaria reduction by use of DDT in Sri Lanka and South America.

Estimating Intervention Effects

- Intervention effects tend to be at a point in time.
- May reflect other changes taking place at the same time.
- Use regional variation in pre-intervention prevalence to construct region specific effects
- Measure outcomes in terms of mortality, health, education and income.

Real Experiments

- Iron supplementation and deworming in Indonesia.
- Treatment and control families.
- Reduces iron deficiency anemia.
- Increases energy levels.
- Significant effect on earnings of piece rate workers.

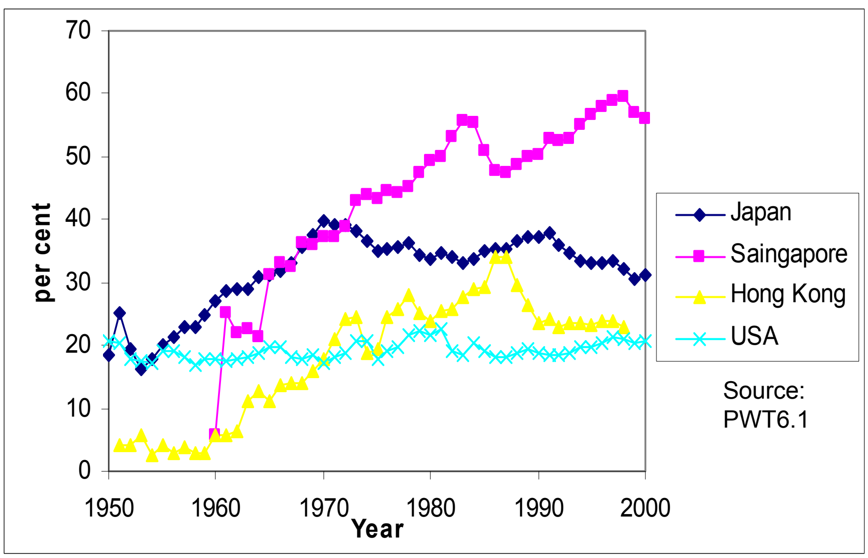
Micro and Macro Health

- Macro health (life expectancy) effects larger than suggested by micro estimates.
- Macro effect includes effect of longer life spans on life cycle behavior
- Macro effect may be less than productivity effect if population crowding effects are negative (Acemoglu)

Lifespan, Retirement, and Saving

- Mis-match between time path of labor income and consumption.
  - Cash and in kind transfers within the household and between generations through bequests.
  - Transfers through the social security system.
  - Private Saving/borrowing.

Savings Rates



Large Literature on Age Structure Effects on Saving

A few examples:

- Higgins and Williamson (1997)
- Higgins (1998)
- Masson, Bayoumi, and Samiei (1998)
- Bloom and Canning (2001)

Micro to Macro

- Macro focus on age structure effects.
- In micro data savings rates vary by age with a peak at around 55 but these age effects on household savings are modest.
- Most of the savings boom in East Asia was due to higher savings at every age with only a modest contribution from age structure effects.
- Accounting effects of demographic change can only explain a small fraction of variation in savings.
- We need to explain changes in saving behavior at each age.

Savings Booms

- Increase in individual savings due to improvements in health and longevity?
- Major alternative theory is habit formation in consumption.
- Effect of new financial institutions is also possible

Small Literature on Longevity Effects on Saving

- Lee, Mason, and Miller (1998)

Longer life means more saving for retirement.

Simulation explains savings boom in Taiwan.

- Bloom, Canning and Graham (2000)

Macro estimates of effect of life expectancy on aggregate saving.

- Tsai, Chu, and Chung (2000)

Micro Data, later cohorts save more. This effect is ascribed to their longer life expectancy.

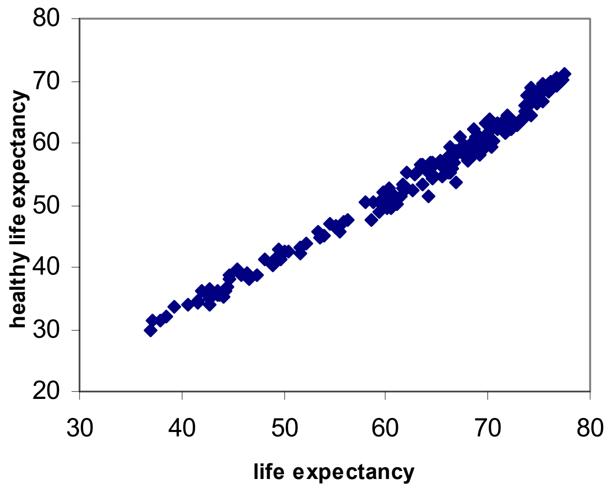
Why Longevity Could Raise Savings Rates

- Possible Arguments
  - Unhealthy life span increase.
  - Effect of longer lifespan on compounding when interest rates and income growth are positive.
  - Effect on returns to saving. Without annuities, a high mortality rate reduces effective returns.
- Our Argument
  - Social security system incentives restrict labor supply of the elderly and effectively limit the retirement age.

Critique
Compression of Morbidity

- If longer life spans are associated with healthy aging (compression of morbidity), optimal response is to extend the working life with little impact on savings rates.
- We can regard a longer life as “stretching” time, which stretches the retirement age but does not affect savings rates.
- The empirical effect of longevity on savings lacks a theoretical foundation.

National Life Expectancy and Health, 2000

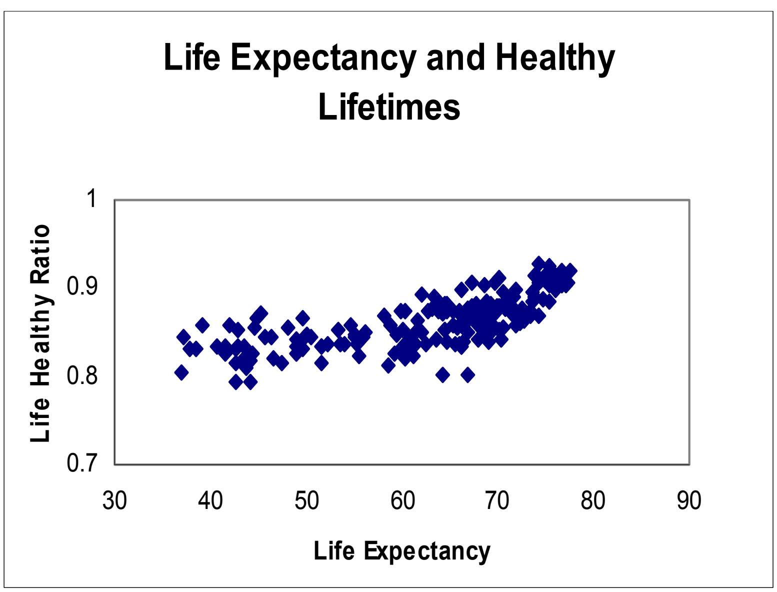


H = Healthy life expectancy
L=Life expectancy

H = -7.062 + 0.979 L
(0.615) (0.010)

R^2 = 0.982

Data from World Health Report 2001



Data for 2000, from World Health Report 2001

Hypothesis

- Under complete markets the effect of longer life spans on savings rates is zero or even negative
- A positive effect of longevity on savings rates depends on the presence of institutions that prevent or discourage longer working lives.

Life Cycle Theory

- Maximize lifetime utility with a budget constraint

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

$$\frac{dW}{dt} = \chi_t w_t + (\lambda + r) W_t - c_t$$

Assumptions

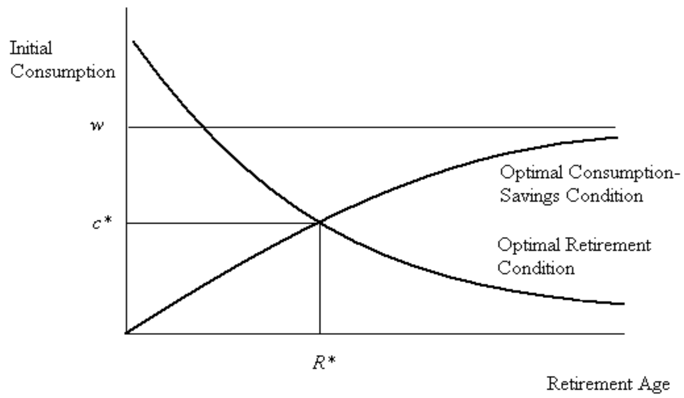
- Full insurance – annuities
- Exogenous health and mortality
- Constant death rate
- Disutility of work rises with age but depends on life expectancy – compression of morbidity

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

Optimal Consumption and Retirement

- Two conditions – optimal consumption over time.
- Optimal retirement – wage times marginal utility of consumption equals the disutility of working.
- General solution defines retirement and consumption by an implicit function.

Figure 1
Retirement and Consumption



Assume Log Utility

- Use implicit function theorem to find optimal retirement and consumption

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

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

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

Wage Level Effects

- In a model with log utility the wage level does not affect the retirement decision – income and substitution effects balance.
- With a general utility function (CRRA > 1), rising wages promote earlier retirement and a lower consumption/wage ratio, i.e., a higher savings rate.

Preliminary Empirical Results Micro

- Use HRS survey. Gives good measures of household wealth and subjective survival probabilities for individuals.
- Question: do people who expect to live longer save more and so hold more wealth?
- Problem: all current variables depend on wealth. Subjective survival probabilities depend on wealth and have large measurement error (lots of 0 or 1 in replies).

Estimation

Model current Wealth as depending on

- Inheritances.
- Planned accumulation to date as proxied by a function of age, schooling, and height.
- Probability of survival to 75, instrumented with parents' current age, or age at death.
- Unplanned accumulation to date, the error term.

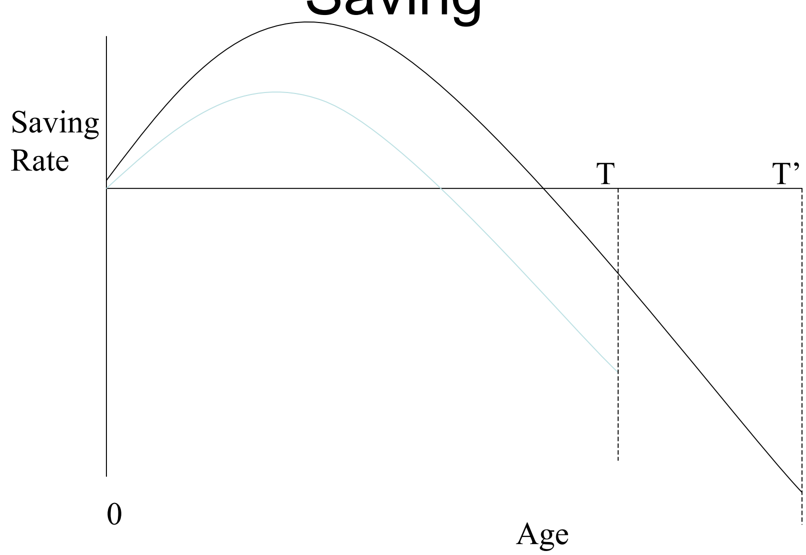
Results

- Wealth increases with inheritances.
- Wealth increases with height and education, probably reflecting higher income.
- Wealth increases with age in the HRS sample (primarily between 40 and 60).
- Instrumented subjective survival probabilities have a positive and significant effect on wealth holdings. (Passes instrument validity test).

Macro Saving

- Aggregation over cohorts is not stright forward – depends on the distribution of income.
- Age specific savings rates may rise while average savings rates fall when life span increases.
- Zero savings over lifespan means zero saving on average in steady state – saving is a disequilibrium phenomenon.

Increasing Longevity and Saving



Aggregate Savings Rates

- In a stable population, with a fixed life expectancy, net life cycle savings are zero.
- A **rise** in life expectancy with a **fixed** age structure increases aggregate savings; the saving of the young and middle aged for retirement is larger than the dis-saving of the older generation.
- This saving boom is temporary; it disappears when the age structure adjusts to a stable structure given the higher lifetimes.

Table 5
Effects on Steady-State Saving Rate

	Effect on Steady-State Saving 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)

Health and Education

- Health and cognitive development
- Incentive effects from longer working life
- Lower depreciation of human capital
- Heath and education complementarities
  - Fewer working days lost