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The Health of Nations: Irving Fisher and The Contribution of Improved Longevity to Living Standards

by

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I. Introduction

Among Irving Fisher's many contributions to economics, one that is little noted and barely remembered is his emphasis on the economic importance of health. For the most part, his concern was in promoting healthy life styles. In addition, he made an early (perhaps the earliest) estimate of the impact of mortality and morbidity on national output.

This essay will consider the question of how measures of economic welfare might change if they include measures of health status as well as of conventional consumption. The surprising finding is that inclusion of improvements in health status would, over the twentieth century in the United States, make a substantial difference to our measures of economic welfare. While Fisher thought and cared deeply about index numbers, measurement of income, utility theory, and health, he never connected these different concepts together. On the other hand, he must have had an intuitive understanding of the importance, for he wrote about the shortcoming in estimates of income (in an era even before systematic national income accounting had begun):

> A large part of our subjective income is due to our conditions of health or disease. .... [A] healthy body is absolutely essential for receiving and enjoying the income from external wealth.... Economists, by fixing attention exclusively on physical phenomena, leave out the most essential element of all, the vigor of human life. The true "wealth of nations" is the

[1] The present research was supported by the National Science Foundation. The author is grateful for research support of Joseph Boyer and for helpful comments from William Brainard and T. N. Srinivasan. Version is [fish100198.wpd].

health of its individuals.[2]

In the sections that follow, I begin with a brief discussion of Fisher's attention to health. I then provide an analysis of how traditional measures of income might be modified to incorporate changes in mortality and life expectancy. Finally, I make rough estimates of the quantitative impact of adjusting national-income measures for mortality.

II. Fisher on Health

Fisher's campaign for healthful living today seems quirky. Its origins came when he contracted tuberculosis in the summer of 1898, shortly after having been promoted to full professor of Political Economy at Yale at the age of 31. As Fisher explained in a speech at Vassar college in 1917, it was this experience which opened his eyes to the importance of health:

> I feel a little ashamed to admit that as an economist and as a student of society I had been blind, as the average man or woman of today is blind, to what heath conservation means. Suddenly I discovered I had tuberculosis and took a long enforced vacation. When after three years I went back to Yale, I was unable for two years to do even half a man's work.... At length by dint of conscientious application of a dozen or more specific points of hygiene, not only did I succeed in winning back my previous working power, but acquired more than I had ever dreamed of acquiring.[3]

As with all Fisher's passions, he set about studying and proselytizing with enormous vigor. Among his most notable contributions were the establishment of the Life Extension Institute and a book, jointly written with Dr. Eugene Fisk, which stressed rules on individual hygiene.[4] In this field, as in so many others, Fisher was decades ahead of his time, emphasizing the importance of individual life styles. He laid out the Fifteen Rules of Health

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[2] *Works of Irving Fisher* [1997], vol. 2, p. 204 (*The Nature of Capital and Income*, p. 176).

[3] *Works of Irving Fisher* [1997], vol. 13, p. 83.

[4] See Fisher and Fisk [1915].

(see Table 1). Fisher was open — some might say, too open — to every new nostrum, and it is easy to chortle over many of them. Among more entertaining rules were "Ventilate your clothes while they are on you," "Eat slowly," and "Eat some hard foods." But he also emphasized the importance of exercise, abstinence from tobacco, alcohol, and drugs, and vigorous exercise. All these sound commonsensical today, but it is striking that the Fisher-Fisk volume was the first important pamphlet emphasizing the importance of life styles in addition to anti-microbial health care.

How well does Fisher's campaign stack up after a century of careful biomedical and epidemiological research? It is interesting to compare Fisher's Fifteen Rules will current studies of sources of mortality and morbidity. Table 2 shows the major risk factors in both high-income countries and in Sub-Saharan Africa according to a major study, *The Global Burden of Disease*.[5] Indeed, Fisher identified most of the risk factors of everyday living, particularly the role of tobacco, alcohol, and lack of exercise. Fisher seems to have overemphasized the role of complete abstinence from alcohol, and some of his recommendations are probably no longer applicable largely because of changes in personal hygiene and improvements in sanitation systems, laundering technology, and public health.

III. Health and Economic Welfare

Economists have over the last half-century made enormous strides in developing measures of economic welfare. Starting with rudimentary measures of national income and output, nations now have a wide range of measures that not only include conventional measures but correct for environmental conditions, resource depletion, nonmarket activity, mismeasurement of prices, and many other issues.[6]

One of the possible directions that might be taken would be to incorporate improvements in health status into economic welfare. This is not such a radical step, for a large and growing part of economic activity is devoted to health care. The fraction of personal

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[5] See Advisory Commission [1996] and Murray and Lopez [1996].

[6] See Eisner [1989].

consumption expenditures devoted to medical care rose from 5.1 percent in 1959 to 15.6 percent in 1997. In principle, health is included in measures of national income and output because medical expenditures are included.

Both common sense and recent evidence suggests, however, that there is little connection between medical spending and the measured economic value of health-status improvements. At a common-sense level, the lack of connection comes because "real" medical-care spending in fact measures spending on inputs rather than health outcomes. Output measures include primarily the number of physician-visits, the number of hospital-days, and such measures rather than changes in health status. One of the most striking findings comes from a study of David Cutler et al., who estimate that a true price index for treatment of heart attacks would rise about 5.5 percent per year more slowly than the corresponding component of the CPI.[7]

Given the likelihood that we are dramatically mismeasuring, and probably underestimating, the contribution of improvements in health care to economic welfare, this raises the question of how to proceed to obtain better estimates. One approach would be to construct better measures of output and prices to reflect the (literal) decline in the cost of living. This approach is adopted by the Boskin Commission and is the thrust of current research on health economics.[8]

Another quite different approach would be to obtain direct measures of health status, weight them with appropriate prices, and then estimate the value of improvements in health status. This approach would treat medical care as an instrumental input and subtract it from consumption expenditures. We would instead adjust real income to reflect the hedonic value of the improvement of health status. This approach is actually much simpler than "fixing" price and output indexes because measures of health status are generally much better than data on the impacts of particular technologies on health status.

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[7] Cutler, McClellan, Newhouse, and Remler [1996].

[8] See Advisory Commission [1996] and Murray and Lopez [1996].

IV. Integrating Health Status into Income Measures

Consumption and income are traditionally measured as flows of goods and services (or utilities) during a given period of time. Changes in an individual's health status (while alive) pose no terribly deep issues of measurement, as we can simply consider the tradeoff between health status and other goods and services.

Treatment of shortening or lengthening life, by contrast, poses severe problems of measurement. There has been very little work attempting to integrate health status with conventional income and consumption measures. I begin this section by considering a simple life-cycle model of consumption in which there are tradeoffs between life and consumption. I then show how this approach might be integrated into an income framework.

A. A Life-Cycle Model with Variable Lifetime

We want to examine the gain in "real income" from improved health and life expectancy. We do this in the context of the life-cycle model of consumption. An individual is assumed to value consumption and health according to a lifetime utility function:[9]

$$(1) \qquad V[c_t\,;\,\theta,\,\rho,\,\mu_t] = \int_{\theta}^{\infty} u(c_t)\, e^{-\rho(t-\theta)} S[\mu_t]\, dt$$

Where $V[c_t\,;\,\theta,\,\rho,\,\mu_t]$ is the value at time t of the consumption stream in the future faced by an individual of age θ; $u(c_t)$ is the stream of utilities of consumption; ρ is the pure rate of individual time preference; $S[\mu_t]$ is the set of survival probabilities; and μ_t is the set of mortality rates. The key assumption here is that utility is a function of the expected value of consumption weighted by the probability of survival. As we will see, the utility function has a natural semi-cardinal interpretation as the value of life.

For analytical purposes (to be generalized later) we begin with the simple case where

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[9] A detailed treatment of the value of life with extensions is contained in Rosen in Tolley et al. [1994].

the survival function is exponential. Equation (1) then becomes:

$$(2) \qquad V[c_t ; \theta, \rho, \mu_t] = \int_{\theta}^{\infty} u(c_t)\, e^{-(\rho+\mu)(t-\theta)} dt$$

We can further simplify for computational purposes (to be relaxed later) by assuming that the cost of capital faced by the individual is equal to $(\rho+\mu)$, so consumption is constant during the individual's lifetime, $c_t = c^*$. This then yields a particularly simple outcome:

$$(3) \qquad V[c_t ; \theta, \rho, \mu] = u(c^*) / (\rho+\mu).$$

Equation (3) shows that the total utility value of consumption is the utility of the flow of consumption discounted by both the force of impatience and the force of mortality.

An individual will often face a tradeoff between "health and wealth." What would be the tradeoff given by (3)? At age θ, changes in consumption and health yield:

$$(4) \qquad \begin{cases} dV/dc = u'(c^*)/(\rho+\mu) \\ dV/d\mu = - u(c^*)/(\rho+\mu)^2 \end{cases}$$

Hence

$$(5) \qquad dc/d\mu = -u(c^*)/[u'(c^*)(\rho+\mu)]$$

We can simplify by measuring utility in terms of goods at the equilibrium, which implies that $u'(c^*) = 1$. This gives us a very simple metric for the utility function. First, by setting the marginal utility equal to one at the equilibrium, *utility* is defined so that one unit of utility is one unit of the good. Second, we have chosen the units so that zero is the "death-indifference level of existence." That is, when the utility of consumption is $u(c) = 0$, the individual is indifferent between existence and non-existence.

Given these assumption, (5) reduces to:

(6) $dc/d\mu = -u(c^*)/(\rho+\mu)$

or without discounting

(7) $dc/d\mu = -Tu(c^*)$

where T is life expectancy ($T = 1/\mu$). The interpretation here is that a uniform change in mortality rates at all age groups will produce a welfare change equal to the number of years of life times the value of life (recall that the utility of years after death is normalized at $u = 0$).

Most studies of life value examine the tradeoff between current risk and current income, say at age $\theta = 40$. At age θ^+, if current mortality declines by $\Delta\mu(\theta)$ for one period, then the survival rate is higher by $e^{\Delta\mu(\theta)}$ at the end of the period. Discounted utility evaluated at age θ^+ is then approximately:

(8) $V(\theta^+) = e^{\Delta\mu(\theta)}\, u(c^*)/(\rho+\mu)$

So the tradeoff between current risk and consumption is approximately:

(9) $dc/d\mu(\theta) = u(c^*)$.

Now the decline of $\Delta\mu(\theta)$ leads to a change in life expectancy of approximately $\Delta T = \Delta\mu/\mu$. The value of this change is

$$dV/dT = dV/d\mu(\theta) \quad d\mu(\theta)/dT \sim u(c^*)\mu/(\rho+\mu)$$

So the tradeoff between life expectancy and consumption is approximately:

(10) $dc/dT = u(c^*)\mu$

B. Valuation of Life

Implementing these ideas requires finding appropriate "prices" to use to value health status. There is a voluminous literature on the value of fatalities prevented.[10] It is generally accepted that the "willingness to pay" to reduce risk is the appropriate approach for valuing risk reductions. Studies of this fall into three general categories: labor market studies, which examine the risk-wage tradeoff; consumer purchase decisions (such as for smoke detectors), which examine the price-risk tradeoff; and contingent valuation studies, which attempt to determine preferences from systematic examination of stated preferences.

The most weight is generally put on labor market studies because these reflect actual behavior, because labor force decisions are repeated, and because there are dozens of studies from different periods, countries, occupations, and samples. It is important to note that the tradeoff examined is a *current risk-current income* choice between current occupational hazards and current wages. From these tradeoffs (which involve comparing income per year against mortality risk per year) we derive an implicit dollar per unit mortality risk. Because the risks are relatively small (around between 1/100,000 per year to 50/100,000 per year), the interpretation is the marginal valuation of risk reduction or increase.

Not surprisingly, there is great variation in the implicit price of risk (or price of a statistical life). The range of serious estimates from a recent survey is from $0.6 million to $13.5 million per fatality prevented. The U.S. Environmental Protection Agency use the relatively high figure of $4.8 million per fatality prevented in its cost-benefit study of the value of clear air.[11] Tolley et al. recommend a value of $2.0 million per fatality prevented for use in health-care decisions.[12] In this study, I settle on $3.0 million per fatality prevented as a reasonable choice, but the figures are easily modified to reflect different assumptions.

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[10] See Viscusi [1993] for a comprehensive review of the economics literature. The monumental study edited by Murray and Lopez [1996] is a particularly useful analysis of the issue in the context of health care.

[11] This was based on the survey by Unsworth, Neumann, and Browne [1992].

[12] See Tolley et al. [1994].

There is some confusion about how to measure the value of an added life-year (LY). We have calculated the increment to sustainable consumption of an additional LY. There is little serious evidence on the value of a LY, and most studies instead derive it from the studies of the value of reduced mortality described above. In terms of the model used above, almost all estimates concern the value of reductions in current mortality [$dc/d\mu(\theta)$], which we assume as follows:

$$(11) \quad dV/d\mu(\theta) = \$3 \times 10^6 \qquad \text{(in 1990 incomes and prices)}$$

To convert this to the value of a life-year requires further assumptions. Many of the studies underlying the estimate in (11) concern labor market decisions of working men, for which we can use $\mu(40) \sim 0.025\ yr^{-1}$ for those age 40. Using these values, we obtain

$$(12) \quad dc/dT \,\Big|_{d\mu(40)} = \begin{cases} \$1{,}828 \text{ per LY @ } \rho = 0 \\ \$6{,}757 \text{ per LY @ } \rho = 0.03 \end{cases}$$

These are the flow equivalents of the present value of an increase in a LY. That is, they reflect the increase in sustainable consumption necessary to compensate for a current loss of a life-year. Taking the present value yields a capital value [dV/dLY] of $75,000 per LY at a discount rate of 0 and $162,000 per LY at a discount rate of 3 percent per year. Tolley et al. [1994] recommend a central present value of $100,000 per LY from their studies, which is broadly consistent with these numbers and analysis.

In the estimates presented below, we use actual survival functions rather than the theoretical ones analyzed above. Using 1990 life tables, we obtain the following estimates:

$$(12) \quad dc/dT \,\Big|_{d\mu} = \begin{cases} \$2{,}600 \text{ per LY @ } \rho = 0 \\ \$7{,}600 \text{ per LY @ } \rho = 0.03 \end{cases}$$

The capital values associated with these numbers are given in Table 3.

C. Measuring Income with Variable Lifetimes

Next turn to the issue of measuring income or consumption. We take a Fisherian definition of income for the fixed and certain lifetime. Fisher's basic argument was that income is the yield on society's capital: "The income from any instrument is thus the flow of services rendered by that instrument. The income of a community is the total flow of services from all its instruments."[13] In this view, income is the maximum sustainable consumption consistent with a given flow of labor earnings and at an exogenously given interest rate. Under the assumption of no bequests, note that income is also equal to sustainable consumption, where the latter is defined as the maximum constant real consumption annuity.

More precisely, assume that the consumption discount rate is a constant, r. Once we know the entire path of consumption, we can easily calculate Fisherian or sustainable income, denoted by $\mathcal{C}(t)$, as follows:

$$(13) \quad \int_t^{\infty} \mathcal{C}(t)\exp[-r(s-t)]ds = \int_t^{\infty} C(s)\exp[-r(s-t)]ds$$

or equivalently

$$(14) \quad \mathcal{C}(t) = r\,[\int_t^{\infty} C(s)\exp[-r(s-t)]ds\,]$$

Note that $\mathcal{C}(t)$ measures the *constant* consumption annuity available at time t. Equation (14) shows that the measure of sustainable income is inherently a wealth-like measure as was emphasized by Fisher and Paul Samuelson.[14] Indeed, it makes rigorous Irving Fisher's notion that income is the return to generalized social capital.

The Fisherian definition of income is a natural springboard for considering the

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[13] *Works of Irving Fisher* [1997] (*The Nature of Capital and Income*), p. 101.

[14] Irving Fisher's view was cited above. Paul Samuelson's approach is contained in Samuelson [1961].

measurement of income with varying lifetimes. Begin by extending the definition of income and consumption to uncertain, variable, and endogenous lifetimes. One approach would be to retain the definition of income as potential consumption or consumption plus change in net worth. For example, say that in situation A individuals consume 100 units per year each and live for 50 years while in situation B individuals consume 100 units per year and live for 60 years. Under the standard flow definition of consumption, there would be no change in economic welfare or living standards. This is clearly defective to the extent that people would prefer to live longer.

An alternative and preferable approach is to convert the combination of consumption and life expectancy (or, technically, the survival function) into the equivalent utility with a benchmark life expectancy and consumption. To take the example of the last paragraph, we would ask what consumption annuity using the life expectancy of situation A would give individuals the same utility as the consumption and life expectancy of situation B. For example, an individual might be indifferent between a constant consumption annuity of 110 units per year with the life expectancy of situation A and a constant consumption annuity of 100 units per year with the life expectancy of situation B. We would then say that (using situation A as the benchmark) the income in situation B was 110 compared to that of 100 in situation A.

Using the notation of the last section, let $V[c_t^A ; \theta, \rho, \mu_t^A]$ be the utility of consumption stream c_t^A and age-specific mortality rate μ_t^A while $V[c_t^B ; \theta, \rho, \mu_t^B]$ is the utility of consumption stream c_t^B and age-specific mortality rate μ_t^B. We define income $c^*(B, \mu^A)$ as the constant consumption stream that would go with mortality rates in A which yields the equivalent utility as the consumption stream and mortality rates in situation B. That is, $V[c^*(B, \mu^A); \theta, \rho, \mu_t^A] = V[c_t^B ; \theta, \rho, \mu_t^B]$. We then compare incomes in different situations by estimating the constant equivalent consumption annuity with a benchmark mortality function. Say we use mortality rates from situation A as the benchmark. We can then compare situations A and B by comparing $c^*(A, \mu^A)$ and $c^*(B, \mu^A)$, such that $V[c^*(A, \mu^A); \theta, \rho, \mu_t^A] = V[c_t^A ; \theta, \rho, \mu_t^A]$ and $c^*(B, \mu^A)$ such that $V[c^*(B, \mu^A); \theta, \rho, \mu_t^A] = V[c_t^B ; \theta, \rho, \mu_t^B]$. There will be the usual index-number problems involved in these comparisons because the definitions will differ whether we use the mortality rates of situation A or B. It is to my knowledge an open question whether the usual index-number theorems apply here, but I see no reason why they should not. Assuming they apply, we would of course use Fisher's ideal index to construct the index of incomes.

V. The Impact of Improved Life Expectancy on Economic Welfare in the U.S., 1900- 1995

A. Previous Studies

The literature on estimating the economic value of improved health is surprisingly sparse. Dan Usher considered the issue as part of a more general study of the adequacy of conventional national output measures, but his approach was highly stylized and was written before the surge of detailed estimates of the value of life.[15] A number of indexes incorporate life expectancy, particularly the United Nations Development Program's Human Development Index (HDI).[16] The technique for incorporating health in the HDI is, however, completely arbitrary. Economic historians have begun to compile systematic indicators on various health-related measures, such as height and the body-mass index, and these tend to move with other measures of health status, but it is difficult to put a price tag on these indexes.[17] An important addition to the literature is a study by David Cutler and Elizabeth Richardson, which is discussed below.[18]

B. Methods

We now implement the ideas in earlier sections for the United States. The calculations here estimate the value of "health income," which is the value of improvements in health

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[15] See Usher [1973] and 1980].

[16] See UNDP [1997] for a discussion and the numbers.

[17] A useful review of the economic-history literature is contained in Costa and Steckel [1995].

[18] See Cutler and Richardson [1997].

status. The fundamental data are shown in Figures 1-4. Figure 1 shows per capita consumption for the U.S. from 1900 to 1995. The data are from the Commerce Department for the period 1929-95 and from various private scholars for 1900-29. The Commerce Department figures are in chained indexes converted to 1990 price levels. Earlier estimates are in constant prices.

Figure 2 shows the survival rates for three years, 1900 1950, and 1995. The most dramatic change came in the early part of this century — the probability of surviving the first year rose from 87 percent in 1900 to 96 percent in 1950. Figure 3 shows life expectancy at different ages. Gains in life expectancy have been substantial throughout the entire century. Figure 4 shows the change in life expectancy at different ages over the last four decades.

One interesting question is whether the famous "productivity slowdown" found in conventional economic measures is mirrored in the health statistics. Figure 5 shows gains in life expectancy at birth along with conventionally measured growth in labor productivity for the decade ending in the year indicated by the point. "Health productivity growth" (measured as the change in life expectancy) rose until 1975 and then declined gradually since then. The trends in health and non-health productivity appear to move quite differently.

To calculate the value of improved health status, we use the approach outlined above. We use two different approaches — the *mortality approach* and the *life-years approach*. Under the mortality approach, the value of improved health status is calculated by taking the change in the population weighted mortality rate times the estimated value of lower mortality. Under the life-years approach, the economic value of improved health is equal to the increase in life expectancy times the value of an additional life-year. In both cases, the estimates are weighted by the share of the population that is experiencing the lower mortality or greater life expectancy.

C. Simple examples

It may be helpful to work through a simple example to illustrate the methodology. For the period 1975 through 1995, the population-weighted average decline in the mortality rate was 2249 per million population. Taking the hedonic estimate of the value of fatalities prevented of $2.66 million (which adjusts the $3 million in 1990 for movements in average consumption), this decline in mortality would have a value of $5980 per person over this period. The average per capita consumption over this period was $14,700. Hence the economic value of improvements of living standards due to reduced mortality is estimated as 40 percent of consumption over this period, or about 2 percent per year. Table 3 shows that this number is 1.8 percent for 1950 population weights.

The estimate using the life-years method is somewhat more complicated. Because improvements in mortality may extend life expectancy well in the future (particularly in the case of reduced infant mortality), we must consider the impact of discounting on valuation. The approach taken here is to calculate the value of a life-year on the assumption that the increase in the life-year takes place through a uniform reduction in mortality. This allows us to use the valuation of mortality discussed above to estimate the value of an additional life year. For example, in 1990, a uniform reduction in mortality of 0.001 per year would lead to an increase in population-weighted life expectancy of 1.16 years. Over the period 1975-1995, the increase in population-weighted life expectancy was 2.1 years. The value of an additional undiscounted life-year is, according to the calculations presented above, equal to $2,600. Therefore the gain in health income over these two decades was $2,600 × 2.1 life-years = $5,400. This is the equivalent of 1.6 percent per year in conventional consumption units. This is the close to the estimate shown by the actual calculations in Table 3.

D. Actual calculations

The actual calculations are shown in Table 3 and in Figure 6. The major result that comes through using all techniques is that the value of life expectancy improvements is about as large as the value of all other consumption goods and services put together. For example, over the two decades from 1975 to 1995, conventionally measured per capita consumption grew at an average rate of 2.0 percent per year. Over this period, the annual average improvements in life expectancy had an economic value between 1.6 and 2.0 percent of consumption.[19] Over the entire period from 1900 to 1995, the value of improved health or health income grew at between 2.2 and 3.0 percent of consumption whereas consumption grew at a rate of about 2.1 percent of consumption. Health income grew somewhat more slowly than other consumption during the second half of this century while it exceeded the value of the growth in consumption during the first half of the 20th century.

The two techniques give approximately the same results. This is not surprising, for they are calibrated to yield the same value of life lengthening for uniform mortality rate changes. The mortality approach gives slightly larger numbers because of the distribution of mortality changes.

How do expenditures on health improvements compare with improvements in health income? This is a difficult question because spending to improve health status pervades our market and non-market activities. Table 4 provides rough estimates of the magnitudes. To begin with, the bottom three rows of Table 4 show the increase in non-health consumption and in health income over the 1980-90 period. This shows again that the size of the gains from health and non-health consumption are approximately the same.

Market expenditures on conventional health care are reasonably well tabulated. They were in 1990 about one-quarter of non-health personal consumption expenditures. Many important items are excluded from these figures. Two exclusions, shown in Table 4, are pollution abatement and expenditures on sewage and sanitation. In addition, there may be substantial non-market costs, primarily in time use. Our time-use studies are particularly inadequate, but existing estimates indicate that the value non-market time devoted to health is but a small fraction of market costs.

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[19] Because there is no natural denominator for measuring improvements in health care, we use the same denominator for calculating growth as we do for consumption. That is, the growth in the value of health is calculated as $\Delta Y_t / c_{t-1}$ whereas the growth in consumption is calculated as $\Delta c_t / c_{t-1}$, where ΔY_t is the change in the per capita value of health income and c_t is the flow of consumption of goods and services during the previous period. This allows us to compare the relative importance of consumption and improvements in health status, whereas there is no obvious way to measure the value of the level of health status (Y_t).

The last column of Table 4 compares the increases in expenditures with the increases in health income and non-health consumption for the period 1980-90. These show that the increase in health income (from mortality alone) is approximately the same size as the increase in non-health consumption. The increase in expenditure on health care was approximately one-half the increase in mortality-based health income. It seems likely, however, that a substantial part of the expenditures (such as that on dental, psychiatric, vision-related, and nursing home) was life-quality-enhancing rather than life-year-extending. Suppose that half of the per capita of increased expenditures, or $600, was life-extending; this would be a good investment for the increase in health income of between $2,300 and $3,100 per capita over the 1980-90 period.

E. Qualifications

How robust are the estimates provided here? The underlying mortality data are among the most reliable of our social statistics. The most fragile part of the estimates concerns life and mortality valuation, as discussed above. One assumption on which there is little evidence is that the premium on reduced mortality is a constant fraction of per capita consumption over the entire period. More precisely, we assume that the value of a reduction in the mortality rate of 0.001 per year is $3 thousand in 1990 prices and is scaled over time to the ratio of the given year's per capita consumption to 1990 per capita consumption. There is no serious evidence on the mortality premium over time, although movements in the wage of risky occupations (such as coal mining) are consistent with this assumption. I suspect, however, that the premium has risen over time. This would be consistent with the rising share of health care expenditures in total consumption. If the premium were indeed increasing over time, then the contribution of health to economic welfare would be overstated in earlier period.

A few other assumptions are of some significance but will not affect the major results. One important issue is whether people should be weighted the same at every age. Many health-care professionals and some survey evidence suggest that the value of a life-year is higher in the middle of the life span (between 20 and 40 years) than at either end.[20] Most

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[20] A particularly interesting discussion is contained in Murray and Lopez [1996].

surveys indicate, for example, that infant mortality would receive a lower weight than adult mortality. Estimates using an alternative valuation proposed by Murray (the weights proposed by Murray are shown in Figure 7) show virtually identical growth in the 1900-50 period, but slower growth in income in the 1950-95 period. In the latter period, the growth in health income is between 10 and 20 percent slower with differential age weights, primarily because the Murray weights put a lower value on the increases in life expectancy of older people.

Another major omission from this study is the value of reduced morbidity. The data on morbidity is both more difficult to obtain and more difficult to value. Recent studies indicate that including morbidity might add another 5 percent or so to the value of health improvements estimates here.[21]

V. Discussion and Conclusion

The central conclusion of this study is that health status is a major contributor to economic welfare. This conclusion validates the view of Irving Fisher in 1906:

> [T]he devices of modern hygiene, sanitation, and preventive medicine ... are of greater economic import than many of the luxurious and enervating devices commonly connoted by "wealth."[22]

This study corroborates Fisher's view and finds that, to a first approximation, the economic value of increases in longevity over the twentieth century is about as large as the value of measured growth in non-health goods and services. A closer look shows that "health income" probably contributed somewhat more than non-health goods and services in the first half of the 20th century and marginally less than non-health goods and services since 1950.

The first question one should ask is whether this finding is plausible. One way of considering the question is to consider the health equivalent of the Sears-catalogue question:

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[21] See Cutler and Richardson [1997], discussed below.

[22] *Works of Fisher* [1997], vol. 2, p. 204 (*The Nature of Capital and Income*, p. 176).

> Consider the improvements to both health and non-health technologies over the last half century (say from 1948 to 1998). Health technologies include a variety of changes from the Salk polio vaccine, pharmaceuticals, improved sanitation, improved automobile safety, smoke-free workplaces, etc. Over this period, life expectancy at birth increased from a little above 68 year to a little less than 76 years. Non-health technologies were also wide-ranging and include the jet plane, television, superhighways, VCRs, and computers (although the economic benefits of these are probably understated in measured consumption growth).
>
> Now consider the following choice. You must forgo either the health improvements over the last half-century or the non-health improvements. That is, you must choose either (a) 1948 health conditions and 1998 non-health living standards or (b) 1998 health conditions and 1948 non-health living standards. Which would you choose?

If you would either choose (b) or find it a difficult choice, then you would basically agree with the results of this paper. An informal poll finds most people who either choose (b) or have great difficulty choosing, with older people almost always opting for (b).

A recent study by Cutler and Richardson, which examines the improvements in "health capital" in the U.S., has results that are broadly consistent with the present study.[23] Health capital is the present value of the utility of health status. Cutler and Richardson use both a years of life (YOL) approach and a quality adjusted years of life (QALY) approach. Their estimates are only for the years 1970, 1980, and 1990 and they present results only for persons of age 0 and 65. We can make a crude conversion of the Cutler-Richardson estimates to conform to our income estimates by annuitizing their health capital over the expected lifetimes and then taking the changes in the income from health capital as the increase in health income.[24] Table 5 shows the comparison. Two points should be drawn from this table. First, the overall estimates are reasonably comparable. The estimates from Cutler and Richardson bracket the estimates from the present study. One of the most surprising results of Cutler-Richardson, not explained in the paper, is that moving from life-years to QALYs does not change the results significantly. One possible reason for this result is that improvements in the quality of life from lower morbidity are offset by a higher average age (and therefore higher average morbidity) of the population.

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[23] See Cutler and Richardson [1997].

[24] I here use the standard (decidedly non-Fisherian!) definition that income equals consumption plus the change in the value of capital.

The results of this paper as well as much of the emerging research in health economics should shape the way we think about health policy. In the early 1990s, the general hysteria about rising health costs led many to believe that the health-care system was wasteful, out of control, and should be reined in. This view was particularly prevalent in the business community, which saw rising health costs as a threat to national competitiveness. The general atmosphere was colored by the substantial rise in (measured) relative medical-care prices. Over the period from 1975 to 1995, the CPI for medical care rose 64 percent faster than CPI for all goods and services. In the face of rising prices and growing budgets, a natural response was to try to control spending and limit services.

If the results of this study are accurate, the antagonism to expansion of the health-care system should be rethought. Over the last half century, economic welfare from health care expenditures appears to have contributed as much to economic welfare as the rest of consumption expenditures. It is an intriguing thought to contemplate that the social productivity of health-care spending might be many times that of other spending. If this is anywhere near the case, it would suggest that the image of a stupendously wasteful health-care system is far off the mark.

Of course, as Irving Fisher himself emphasized, and as Table 4 suggests, health is more than doctors and hospitals. It encompasses other parts of national output, such as pollution control and highway safety spending, and reflects individual lifestyles, such as decisions about smoking, drinking, driving, drugs, and exercise. Because we cannot tally the totality of costs on health care, we cannot say for sure whether we are getting 2 or 4 or 10 times the return on health dollars that we are on non-health dollars. Nor does this result excuse the bloat in many parts of the system. But notwithstanding the complexity and bureaucracy, health care in the U.S. has produced prodigious increases in economic welfare. It is sobering to reflect that, were the author of this paper to have experienced the 1900 life table, the odds were long that this paper would have to have been written from the grave.

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Table 1. Fisher's Fifteen Rules of Health[25]

The book summarizes in fifteen rules the ways in which the individual has it within his own power to add to his efficiency. These rules are under four heads: Air, Food, Poisons, Activity.

Under Air there are five rules:

1. Ventilate every room you occupy.
2. Ventilate your own clothes while they are on you. In other words, select light, and loose, and porous materials for your clothing. The skin needs the air contact.
3. Live out of doors as much as you can. Seek outdoor avocations and recreations....
4. Sleep out of doors, if it is possible. We do not yet understand what that great sense of well-being is which comes after sleeping out-of-doors, but it is very real.
5. Breathe deeply. Take some long breaths every day systematically. One doctor advises his patients to take 100 long breaths every day. In India, rhythmic deep breathing is a part of the religious system.

Under Food the Four Rules Are:

6. Avoid overeating and overweight. This rule becomes especially important soon after you graduate from college, and therefore it is important before you graduate. It is the rich, overfed sedentary man or woman who later becomes the prey of the wear-and-tear diseases.
7. Avoid overeating of nitrogenous or protein foods. Consequently this rule practically means to avoid overeating of meat and eggs. Such indulgence is really the great dietetic sin of Americans. and one of the chief reasons, I believe, for the fact that in America certain degenerative diseases are more common than in other countries. We eat so excessively of meat, partly because we can afford it, party because of an abnormal appetite coming from the hurry habit. Therefore we who hurry so are heavier meat eaters than the people of Europe and other countries and we pay for that indulgence in high blood pressure and diseases of the kidney.
8. Eat some hard foods, some raw foods and some bulky foods every day. Hard foods exercise the teeth.
9. Eat slowly. The hurry habit is responsible for many evils.

Under Poisons the Four Rules Are:

10. Evacuate thoroughly, regularly and frequently, to avoid "auto intoxication."
11. Stand, sit and walk erect for the same purpose; for bad posture is largely responsible for constipation.
12. Do not allow poisons and infections to enter the body. Among other things this rule means total abstinence from alcoholic beverages and from the use of tobacco.
13. Keep the teeth, gums and tongue clean. Primitive people have perfect sets of teeth without the use of the toothbrush.

Under Activity, There Are Two Rules:

14. Work, play, rest and sleep in moderation and in due relation to each other.
15. Keep a healthful mental attitude, for it is worry rather than work which kills.

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[25] From *Works of Irving Fisher* [1997], vol 13. They have been renumbered for this table.

Table 2. Major Health Risk Factors in Different Regions, 1990

Risk Factor	Global Totals		Established Market Economies		Sub-sahran	
	Years of Life Lost (000)	percent of Total (percent)	Years of Life Lost (000)	percent of Total (percent)	Years of Life Lost (000)	p o (p
Malnutriton	199,486	22.0	0	0.0	89,305	
Poor water supply, santiation, and personal and domestic hygiene	85,520	9.4	8	0.0	28,781	
Unsafe sex	27,602	3.0	1,271	2.6	12,226	
Tobacco	26,217	2.9	7,967	16.0	927	
Alcohol	19,287	2.1	2,537	5.1	3,319	
Occupation	22,493	2.5	2,826	5.7	1,973	
Hypertension	17,665	1.9	3,471	7.0	1,674	
Physical inactivity	11,353	1.3	3,860	7.8	796	
Illicit drugs	2,634	0.3	717	1.4	449	
Air pollution	5,625	0.6	310	0.6	377	
TOTAL	**417,882**	**46.0**	**22,967**	**46.2**	**139,827**	

Source: Murray and Lopez [1996], vol 1, pp. 311-315.

Table 3

Growth in Living Standards from Health Improvements and Consumption

[Increase as percent of per capita consumption; in annualized percentage growth rates]

	1900-1925	*1925-1950*	*1950-1975*	*1975-*
Consumption	2.0	1.8	2.4	2.0
Health Value: Life-years approach				
Discount rate				
0 percent p. a.	2.3	3.3	1.9	1.7
3 percent p. a.	2.3	3.2	1.8	1.6
Health Value: Mortality Approach				
Current pop. weights	3.2	4.0	2.6	2.0
1950 weights	2.9	4.2	2.3	1.8

Notes on valuation:

Value of Life: (1990)	3000.0 thousand 1990 dollars
Value of Life year (1990)	
rho = 0.00	14.5 thousand 1990 dollars
rho = 0.03	95.3 thousand 1990 dollars
Consumption (1990)	16.5 thousand 1990 dollars

Table 4

National Health Expenditures and Income, 1980-90

[Per capita in 1990 prices and incomes]

	Time, 1985 [minutes per day]	Value per capita [1990 prices] 1980	1990	Increase, 1980-90
Total Expenditures		**2,477**	**3,690**	**1,213**
Market [a]				
Conventional Health Care		1,856	3,004	1,148
Other				
Pollution abatement		378	404	26
Sanitation and sewage		99	123	24
Nonmarket				
Time spent on medical care [b,c]				
Child care: medical	1.0	32	32	0
Obtaining Goods and services: medical appointments	2.0	64	80	16
Personal needs: medical care	1.5	48	48	0
Income and Consumption				
Health income, life-year method				
Life-year method [d]		*na*	*na*	***2,292***
Mortality method [e]		*na*	*na*	***3,120***
Non-health personal consumption		*12,261*	*15,198*	***2,937***

[a] Current dollar figures are converted into 1990 prices using the price index for personal consumption.
[b] Time is converted into current prices using average hourly earnings in 1990 less a tax rate of 30 %.
[c] From Robinson and Godbey [1997], Appendix A.
[d] Uses the life-year method with a discount rate of 3 percent.
[e] Current population weights

Table 5

Comparison of This Study with Cutler-Richardson

[Increase in health income per person, 1970-1990, 1990 prices and incomes]

	Discount rate	
	0 percent per year	*3 percent p*
This study		
Health Value: Life-years approach	*6,166*	*5,769*
Health Value: Mortality Approach	*7,701*	*7,701*
Cutler-Richardson		
Years of Life		
Age 0	*5,514*	*2,526*
Age 65	*15,000*	*12,289*
Quality Adjusted Life Years		
Age 0	*5,230*	*3,117*
Age 65	*15,438*	*13,062*

Note: "Health income" is defined as the annuitized value of the increase in health capital fc Cutler-Richardson study and as the increase in the value of population-weighted mortality or life expectancy in this study.

Source: This study from Table 1. Cutler and Richardson [1997] is from their Table 11. The estimates have been annuitized over the life expectancy at the given age and at the given discount rate.

Figure 1

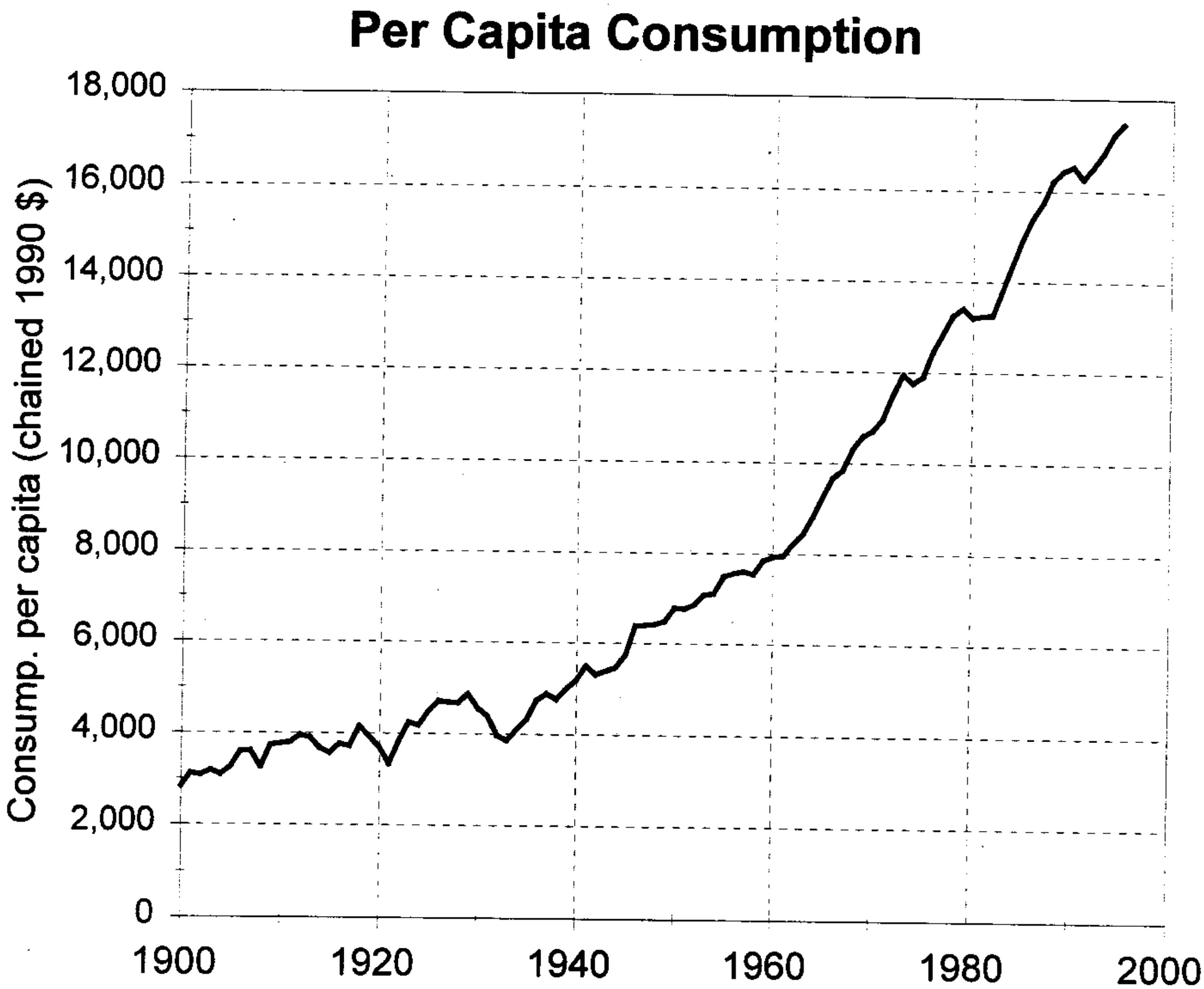

Per Capita Consumption
Consump. per capita (chained 1990 $)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1900
1920
1940
1960
1980
2000

Figure 2

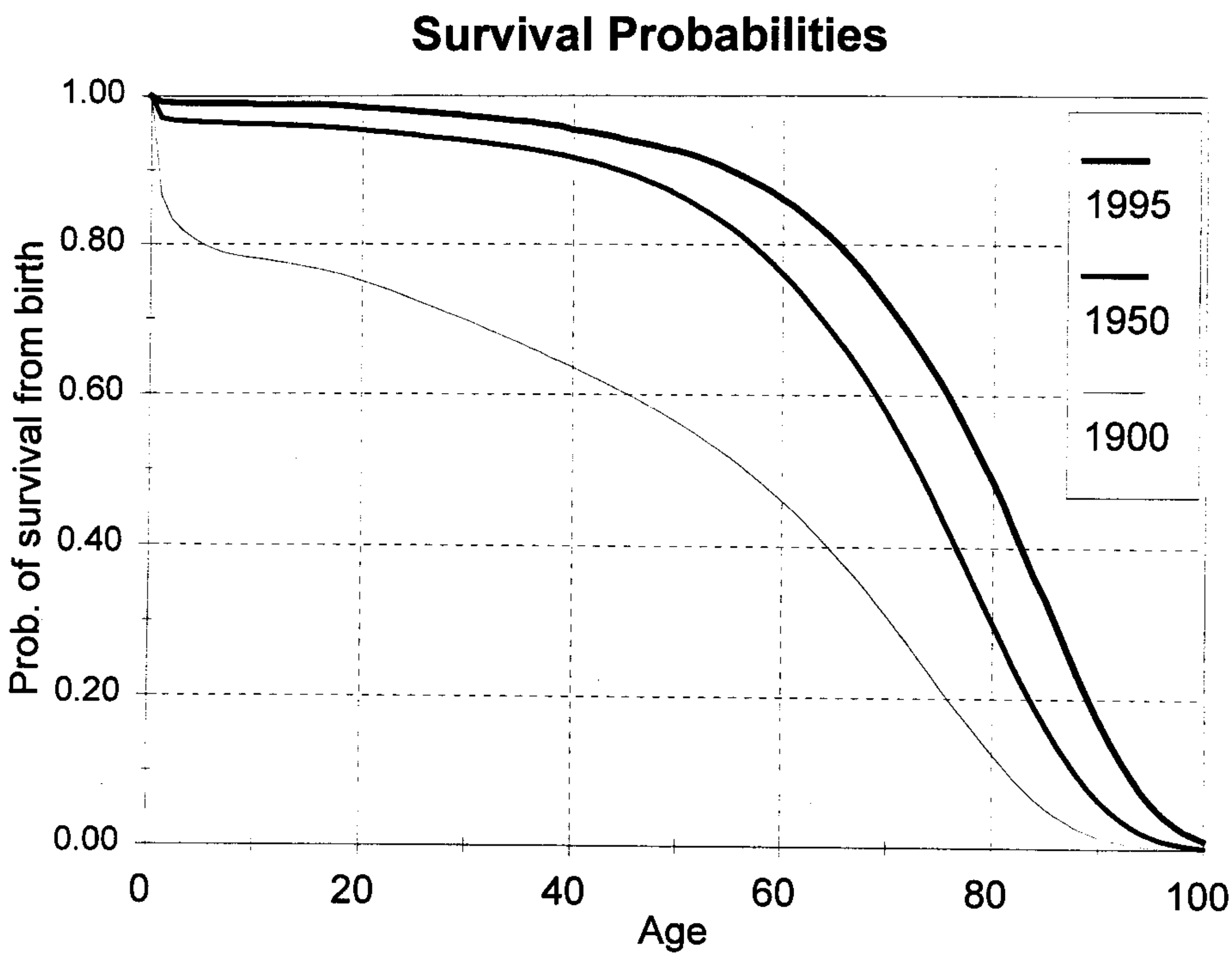

Survival Probabilities
1.00
0.80
0.60
0.40
0.20
0.00
Prob. of survival from birth
0
20
40
60
80
100
Age
1995
1950
1900

Figure 3

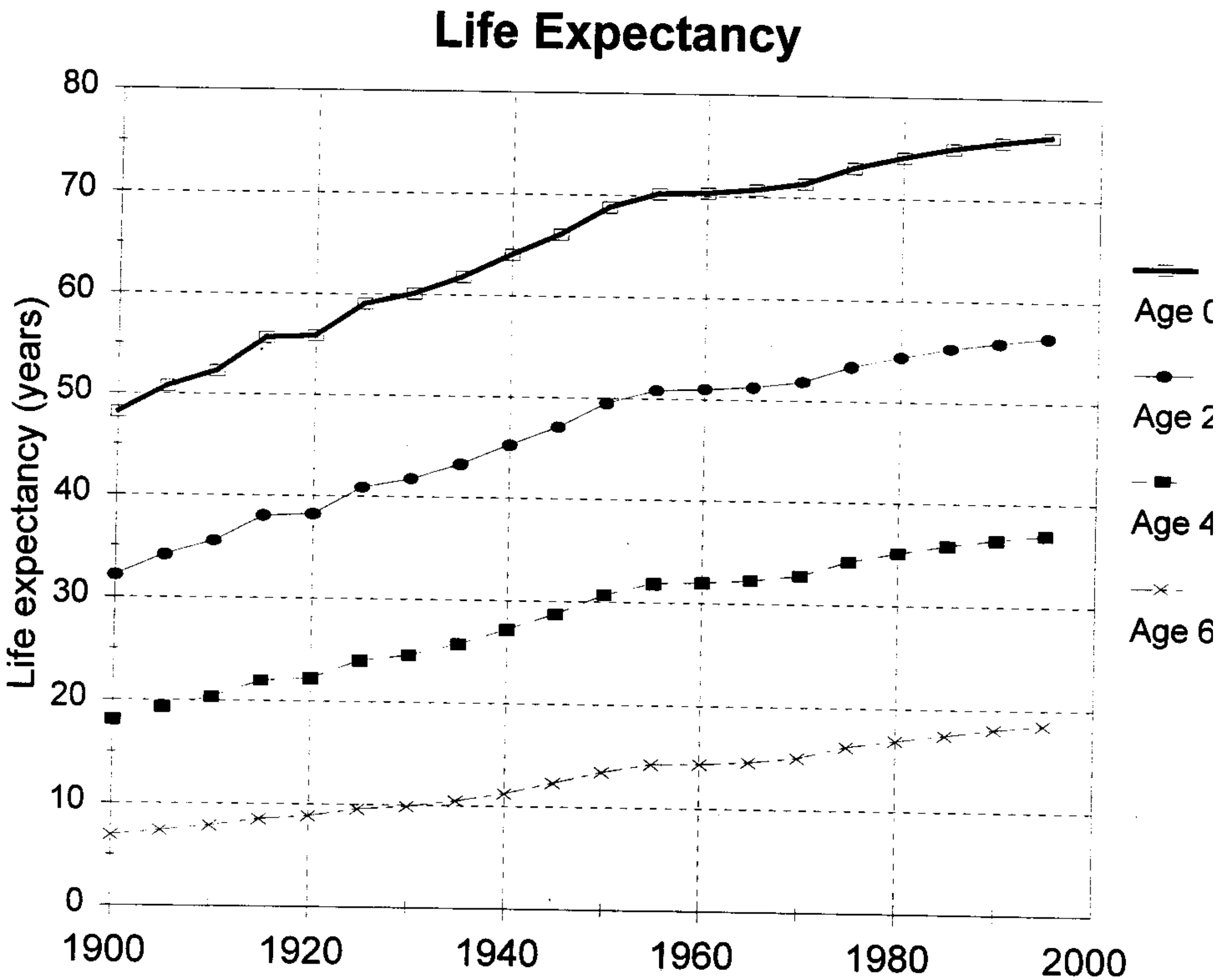

Life Expectancy
80
70
60
50
40
30
20
10
0
Life expectancy (years)
1900
1920
1940
1960
1980
2000
Age (
Age 2
Age 4
Age 6

Figure 4

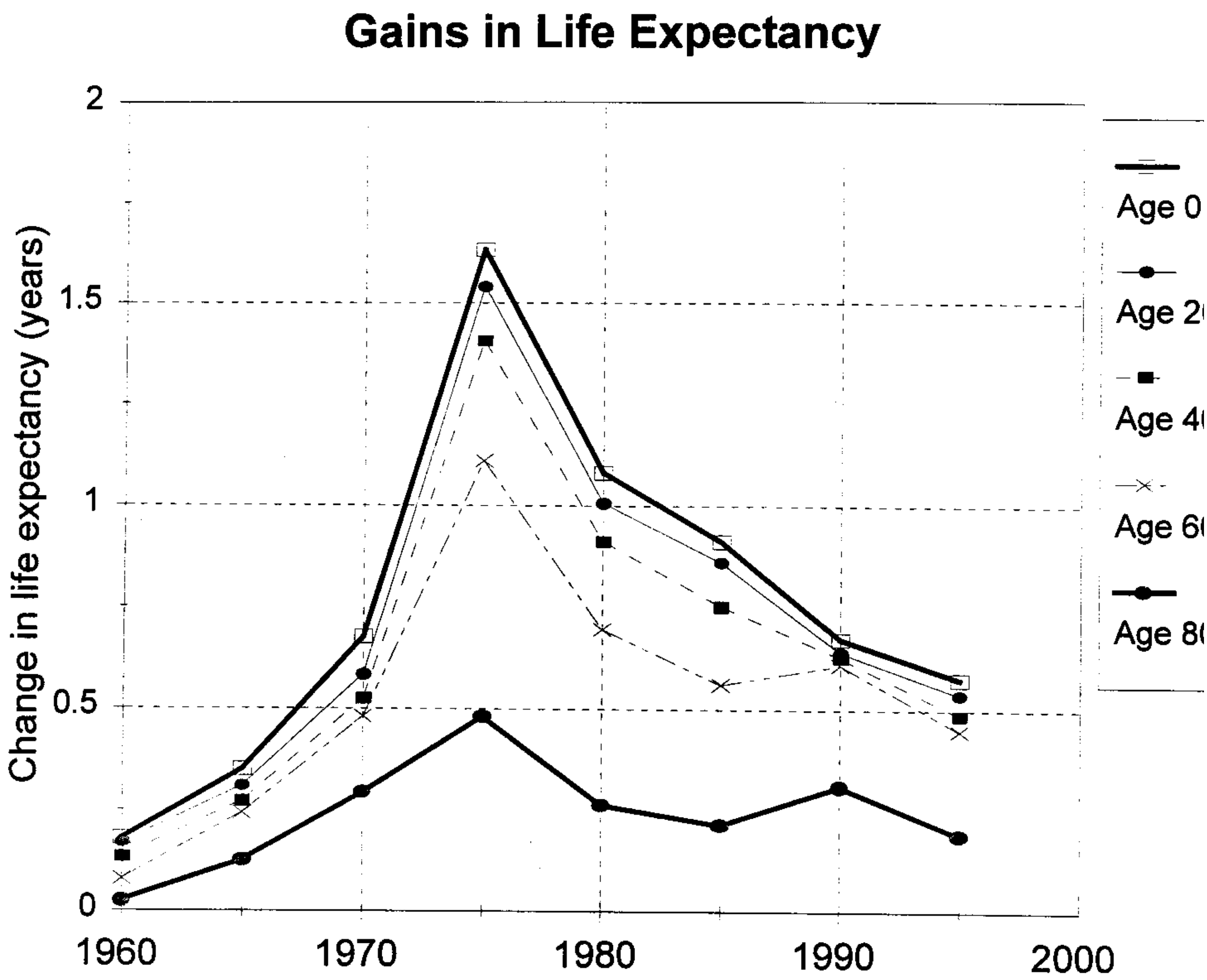
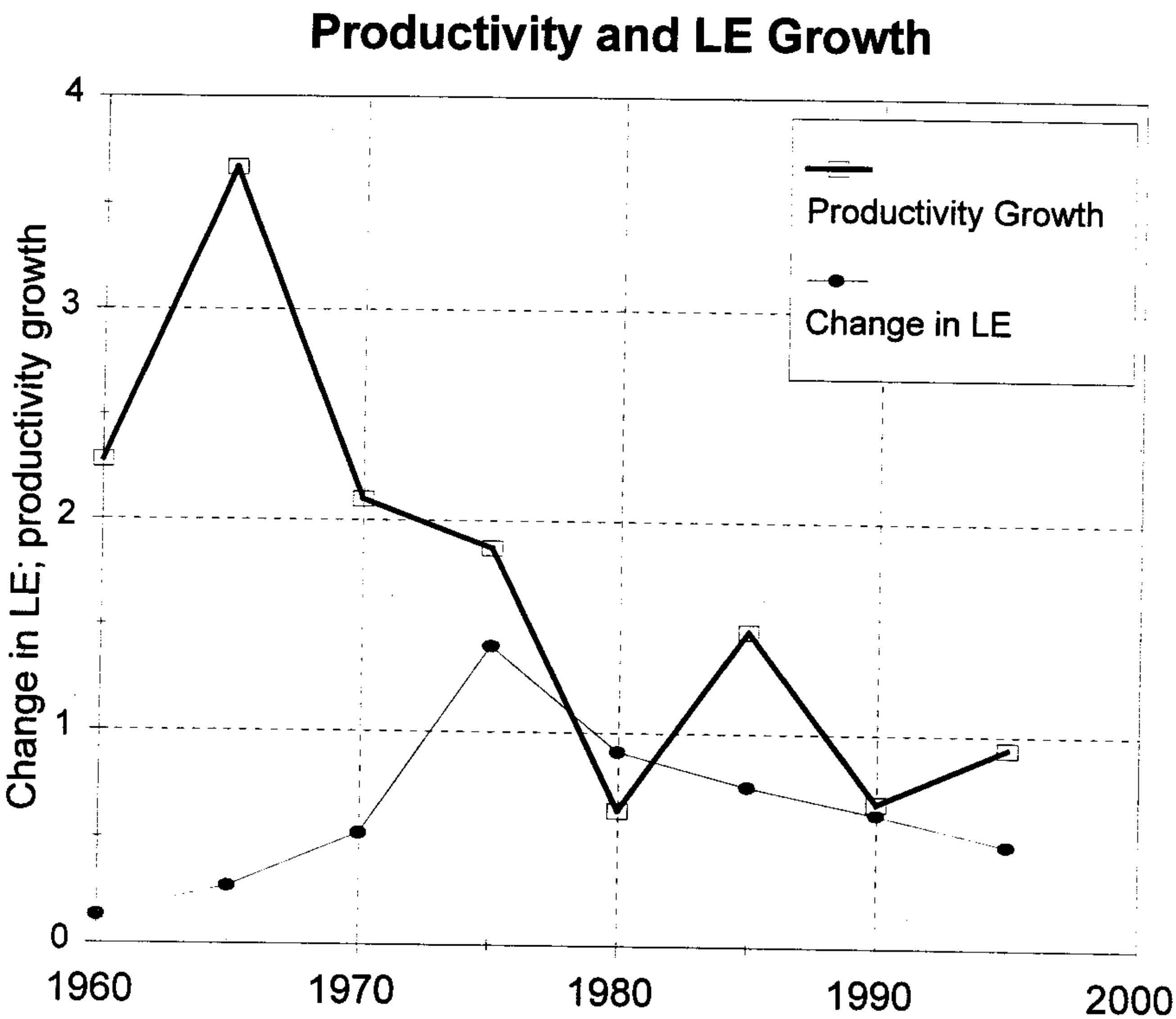
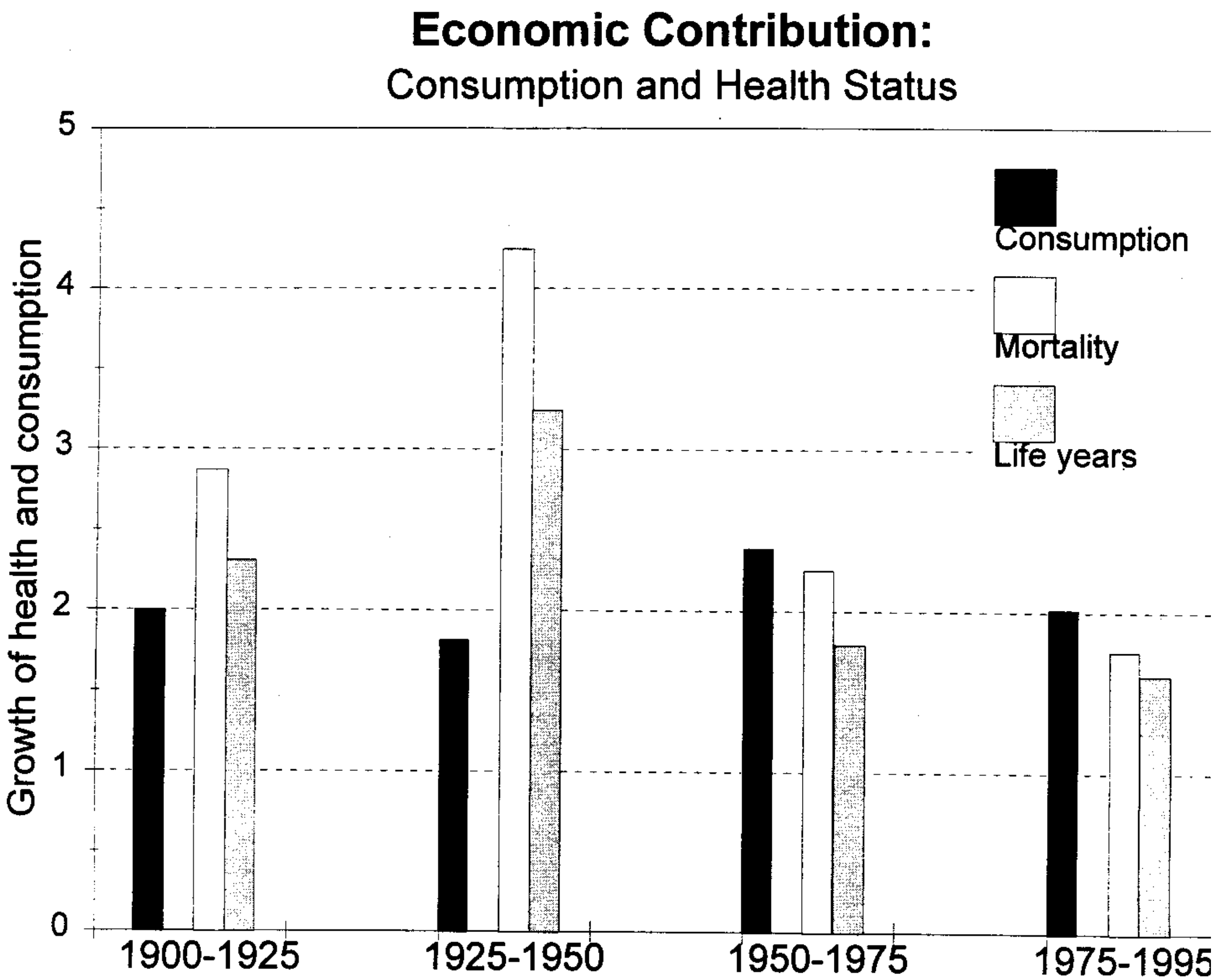

Gains in Life Expectancy
Change in life expectancy (years)
2
1.5
1
0.5
0
1960
1970
1980
1990
2000
Age 0
Age 2(
Age 4(
Age 6(
Age 8(

Figure 5



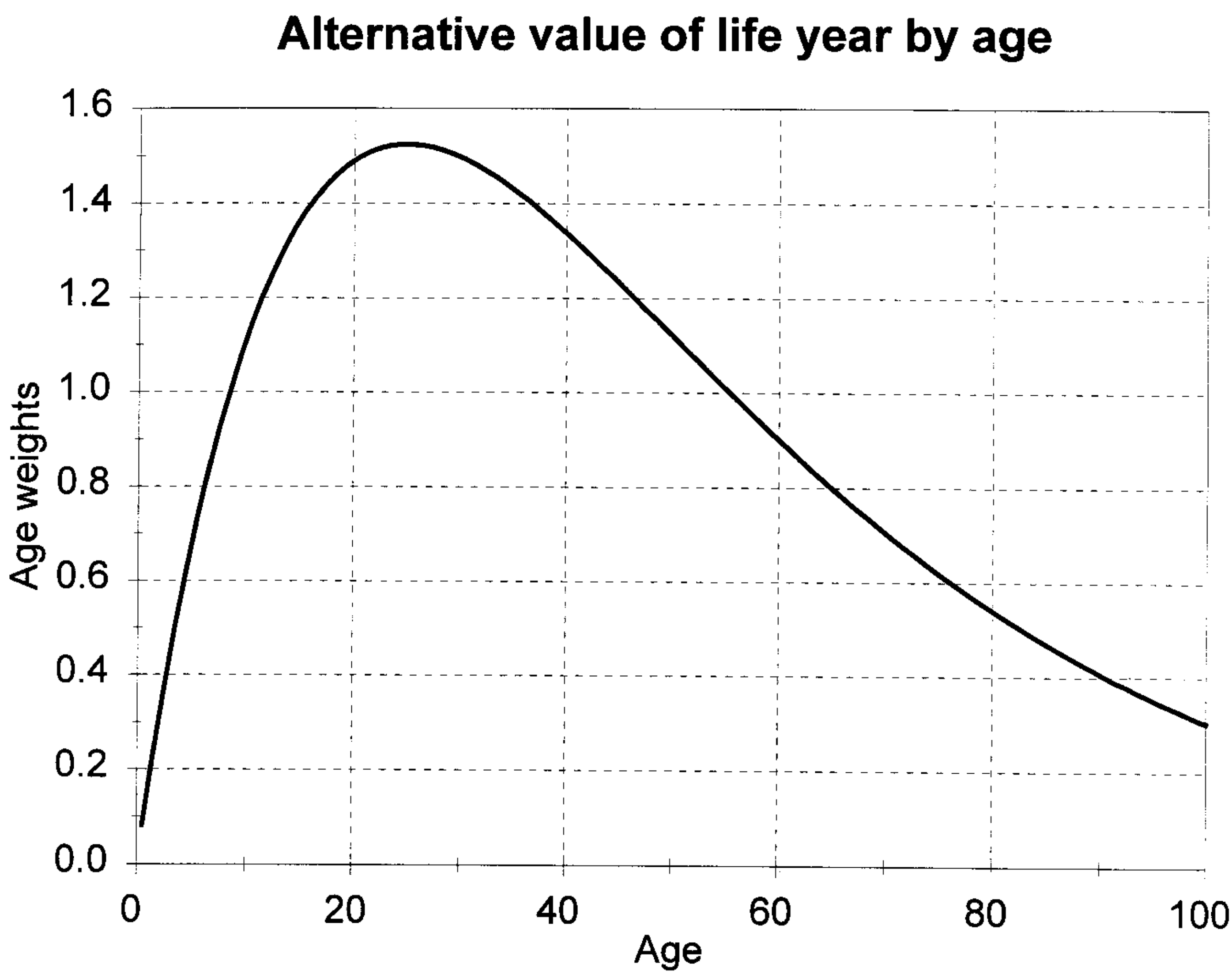
Productivity and LE Growth
Productivity Growth
Change in LE
Change in LE; productivity growth
0
1
2
3
4
1960
1970
1980
1990
2000

Figure 6



Note: Bars show the increase in either conventionally measured per capita consumption and in per capita "health income" for the period. In each case, the denominator used in calculating the growth rate is the level of conventionally measured per capita consumption. The figures are averages of for five-year periods. The two right bars use the mortality approach and the life-years approach to valuing increases in longevity.

Figure 7


Alternative value of life year by age
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Age weights
0
20
40
60
80
100
Age