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HEALTH EXPENDITURES AND PRECAUTIONARY SAVINGS

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ABSTRACT

The precautionary motive for saving is an important issue that is receiving increasing attention. Part of the motivation for this interest stems from the post war coincidence of two trends, one a decline in the U.S. rate of saving and the other an increase in insurance of various types, including unemployment insurance, annuity insurance, disability insurance, and health insurance. This paper examines precautionary saving for uncertain health care payments using a simple two period and illustrates this model's theoretical insights through simulations of a 55 period life cycle model. While derived from a highly stylized model, the simulations give the impression that precautionary saving for uncertain health expenditures could explain a large amount of aggregate savings. Adding uncertain health expenditures to the model's economy raises long run savings by almost one third, assuming individuals self insure. Arrangements for insuring uncertain health expenditures also have potentially quite sizable effects on savings. Introducing actuarially fair insurance to the economy with uncertain health expenditures reduces the steady state level of wealth of that economy by 12 percent. Switching from the fair insurance arrangement to a Medicaid-type program with an asset test further reduces steady state wealth by 75 percent.

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HEALTH EXPENDITURES AND PRECAUTIONARY SAVINGS

1. Introduction

The precautionary motive for saving is an important issue that is receiving increasing attention. Part of the motivation for this interest stems from the post war coincidence of two trends, one a decline in the U.S. rate of saving and the other an increase in insurance of various types, including unemployment insurance, annuity insurance, disability insurance, and health insurance. The post war decline in the ratio of U.S. net national product less total U.S. consumption to net national product is quite striking. This ratio averaged 8.8 percent in the 1950s, 8.7 percent in the 1960s, 7.7 percent in the 1970s, but only 5.1 percent since 1980, with values of 3.2 percent, 5.8 percent and 4.4 percent in the non recession years of 1983, 1984, and 1985, respectively. Over this period the provision of insurance, particularly by the government increased enormously. The Social Security System, including Medicare, now represents the nation's primary source of insurance for length of life, disability, and old age health expenditures. Given these two trends, a natural question to pose is whether improvements in the provision of insurance reduced the demand for precautionary savings and explain the decline in the U.S. saving rate.

In recent years economists have examined precautionary saving arising from lifespan uncertainty and earnings uncertainty. Less attention has been paid to precautionary saving to meet uncertain, uninsured health expenditures. The lack of research on this topic may reflect the difficulty of precisely quantifying the economic risks of morbidity. Unlike the case of lifespan uncertainty for which there are published mortality tables that can be easily incorporated in the analysis, there are no corresponding tables specifying the probabilities of particular levels of health expenditures by characteristics such as age and sex. In addition, unlike certain causes of death, such as being hit by a car, the causes of morbidity and health expenditures are not likely to be independent from one year to the next. What one would really like to have are probabilities of health expenditures conditional on past health expenditures.

An additional problem involved in realistically studying saving for uninsured health expenditures is grappling with the wide array of insurance policies purchased by the public. Many of these policies are employer-provided and are not subject to choice by the employee. Empirical analysis of household saving in response to health expenditure uncertainty requires knowledge of the specific medical insurance policies held by households. Unfortunately, there do not appear to be available any micro data sets that detail type of health insurance coverage together with information about consumption and saving.

This paper abandons the difficult goal of attempting to model realistically uncertainty with respect to health expenditures, and pursues the simpler task of heuristically considering the question of precautionary saving to meet uncertain health care payments. The heuristic analysis here includes examining theoretical issues in a simple two period model as well as illustrating the theoretical points with simulations of a 55 period life cycle model. Several different insurance settings are examined. These are no insurance, actuarially fair insurance, actuarially unfair insurance, and incomplete insurance provided through a government program somewhat similar to the U.S. Medicaid system. Another option that individuals may elect is simply not to receive medical care. While this latter option eliminates the precautionary motive for saving, it also eliminates consumption of health care services. Hence, an economy choosing not to pay for health care may end up with a level of savings similar to that of an economy with significant health expenditures and a significant precautionary saving motive.

The next section discusses briefly some evidence concerning the size of uninsured health expenditures. Section 3 looks at precautionary saving for health expenditures and the affect of insurance arrangements on such saving in a simple two period model. Section 4 uses a 55 period simulation model to illustrate how health insurance arrangements can affect the economy's long run level of savings. The concluding section points out that uncertainty with respect to health expenditures may interact with uncertainty concerning earnings and length of life in influencing precautionary savings and that this interaction merits additional research.

The simulation analysis of Section 4 is conducted in partial equilibrium since it takes factor prices (wages and interest rates) as given. Partial equilibrium exercises of the kind conducted are likely to overstate the corresponding general equilibrium results (Kotlikoff, 1979). Even so, the simulations give one the impression that precautionary savings for uncertain health expenditures could explain a fairly large amount of aggregate savings. Adding uncertain health expenditures to the base case economy raises long run savings by almost one third, assuming individuals self insure. The insurance arrangements available for dealing with uncertain health expenditures also have potentially quite sizable effects on savings. Introducing actuarially fair insurance to the economy with uncertain health expenditures reduces the steady state level of wealth by 12 percent. Switching from the fair insurance arrangement to a Medicaid-type program with an asset test further reduces steady state wealth by 75 percent.

2. The Size of Uninsured Medical Expenditures

In a recent study of uninsured, non nursing home, health expenditures Rossiter and Wilensky (1982) report quite modest average levels of uninsured health expenditures. Their data come from the 1977-1978 National Medical Care Expenditure Survey of about 14,000 households. Three quarters of the U.S. population had some out-of-pocket expenses for health services in 1977. The per capita level of such expenses was $275. This figure and all subsequent dollar figures in this Section are expressed in 1985 dollars. Amoung persons with positive expenditures expenses averaged $364. Average uninsured health expenditures obviously depend importantly on age. For the 83 percent of those 65 and older with positive expenditures, expenditures averaged $579 per person.

Most participants in the survey report quite small out-of-pocket health expenditures. Almost 65 percent of surveyed individuals report either no uninsured health expenditures or expenditures totalling less than $177 (100 1977 dollars). There are, however, some respondents for whom these expenditures are more significant. The percentage of individuals with 1977 expenditures above $888 (500 1977 dollars) is 6.6 percent; the percentage above $1775 (1000 1977 dollars) is 2.3 percent. For elderly individuals the percentage with non insured expenditures above $888 is 12.5 percent, while the percentage with non-insured expenditures above $1775 is 4.9 percent. For 70 percent of surveyed individuals out-of-pocket expenditures represent less than 3 percent of income; they represent 20 percent or more of income for 4.2 percent of surveyed individuals.

Unfortunately, no more detailed information concerning expenditures in excess of $1775 is provided in the study. Hence, one can not assess the extent of extremely large uninsured health expenditures. It could well be that a quite small fraction of the population incurs extremely large uninsured expenses. A variety of studies documenting the high cost of particular illnesses and particular health episodes are suggestive of this possibility. For example, Long et. al. (1984) report that terminal cancer patients averaged $21,219 in Blue Cross and Blue Shield reimbursed expenditures in their terminal year. Lubitz and Prihoda (1984) show that for 6 percent of 1978 decedents enrolled in Medicare, Medicare expenses exceeded over $15,000.

Another consideration in viewing the Rossiter and Wilensky findings is that they only describe uninsured expenditures over a short period of time, and do not indicate the cumulative uninsured health expenditures of a prolonged illness, such as cancer. Their data also do not include nursing home expenditures. For private pay patients the cost of a year in a reasonably nice nursing home currently appears to range between $25,000 to $50,000. Obviously, nicer nursing homes can be even more expensive.

An extended stay in a reasonably nice nursing home could easily dissipate the assets of the typical middle class household. Wise and Venti (1985) examine the 1983 Survey of Consumer Finances and report a median level of wealth of those households with household head age 55 to 64 of $55,000; among households with head 65+ the median is $40,100. Most of this wealth is tied up in real estate. For both groups the median level of financial assets is less than $3,600.

The uninsured risks of nursing home care and other health expenditures can not, of course, be assessed without considering the government's role through Medicaid as a residual insurer. Indeed, for most of the 12.6 percent of Americans with no medical insurance the government presumably represents the insurer of first resort. In the case of high quality nursing homes, middle class individuals seeking to insure access to such homes may only need to save enough to cover the first year or so of a stay in a nursing home, since they can, in many cases, become eligible for Medicaid and remain in the same nursing home under Medicaid. Switching to Medicaid coverage of nursing home stays is not, however, without its drawbacks. Medicaid patients in private pay nursing homes typically have smaller rooms or must share their room with another patient. They also loose some of their autonomy. For example, Medicaid severely restricts the number of days one can be away from the nursing home. Finally, once on Medicaid there is the possibility that the nursing home patient will lose his or her bed because of a prolonged stay in a hospital. In this case the patient may be transferred to a much less desirable nursing facility.

In sum it appears that for at least most middle income and upper income households future health expenditures represent a major uninsured risk. While most health problems that do no involve prolonged use of hospitals and nursing home facilities appear to be well insured, catastrophic or near catastrophic health problems may require and induce very substantial levels of precautionary savings by middle and upper income households. For lower income households the availability of Medicaid in conjunction with the very sizeable costs of medical care may make the option of relying on Medicaid preferable to engaging in precautionary savings. Hence, for the better off segment of society the high costs of medical care in conjunction with the lack of catastrophic insurance may induce substantial additional savings, while for the less affluent segment the high cost of medical care in conjunction with the availability of Medicaid may be substantially lowering savings.

3. Modelling Precautionary Saving for Health Expenditures

A. Alternative Regimes

To understand how uncertainty with respect to health expenditures can influence savings consider a simple two period life cycle model in which individuals work when young and consume when young and old. There is no population growth. In their first period when they are young individuals are healthy; in the second period they become ill with probability P. If they fall ill it costs an amount e to become well again. Whether of not individuals who become ill choose to spend e and be cured depends on the utility loss of not making the health expenditures as well as the availability of insurance to help defray the health expenditures.

Consider first the "live with it" case in which individuals choose not to have the cure if they become ill. Letting Cy denote consumption when young and Co consumption when old, expected utility is given by:

(1) $$EU^{\alpha} = U(Cy) + P\alpha\beta U(Co) + (1-P)\beta U(Co)$$

where β is a time preference factor, and α is a parameter whose value lies between zero and one and determines the disutility from being ill. The budget constraint for this problem is simply:

(2) $$Cy + RCo = W$$

where W is first period labor earnings, and R is one divided by one plus the interest rate. The first order condition for utility maximization is:

(3) $$U'(Cy^{\alpha}) = [P\alpha + (1-P)]\beta U'([W-Cy^{\alpha}]/R)/R$$

where Cy^{α} is the optimal choice of Cy in this case.

Next consider the case of self payment in which the individual chooses to have the cure, but must pay for it herself because there is no private insurance nor government assistance. In this case the individual chooses Cy to maximize:

(4) $$EU^{S} = U(Cy) + P\beta U([W-Cy]/R - e) + (1-P)\beta U([W-Cy]/R)$$

and the first order condition is:

(5) $$U'(Cy^{S}) = P\beta U'([W-Cy^{S}]/R - e)/R + (1-P)\beta U'([W-Cy^{S}]/R)/R$$

The third case to examine is that of private insurance. Assume that for a total premium of vF, paid when young, the individual can purchase medical insurance paying F if the individual falls ill. Expected utility with private insurance is:

$$(6) \qquad EU^{i} = U(Cy) + P\beta U([W-vF-Cy]/R + F - e) + (1-P)\beta U([W-vF-Cy]/R)$$

The first order condition for choosing Cy is:

$$(7) \qquad U'(Cy^{i}) = P\beta U'([W-vF-Cy^{i}]/R + F - e)/R + (1-P)\beta U'([W-vF-Cy^{i}]/R)/R$$

And the first order condition for the choice of F is:

$$(8) \qquad (1-v/R)PU'([W-vF-Cy^{i}]/R + F - e) = v/R(1-P)U'([W-vF-Cy^{i}]/R)$$

If the premium per dollar of coverage, v, is actuarially fair,

$$(9) \qquad v = PR,$$

and from (8) F = e; i.e., when insurance is fairly priced, the individual fully insures. Equation (7) in this case becomes:

$$(7') \qquad U'(Cy^{i}) = \beta U'([W-PRe-Cy^{i}]/R)/R$$

The last case to consider involves a government policy described here as medicaid. If the individual becomes ill the government pays for the cure, but also confiscates all of the individual's assets. Medicaid provides the individual with a level of old age consumption equal to $\bar{C}$. Under medicaid expected utility is determined by:

$$(10) \qquad EU^{m} = U(Cy) + P\beta U(\bar{C}) + (1-P)\beta U([W-Cy]/R)$$

and the first order condition governing the choice of Cy is:

$$(11) \qquad U'(Cy^{m}) = (1-P)\beta U'([W-Cy^{m}]/R)/R$$

Medicaid health care payments and consumption payments for medicaid recipients are financed from medicaid's confiscation of assets of its recipients, i.e.,

$$e + \bar{C} = (W-Cy)/R \tag{12}$$

In this two period model the expected utility from self payment always exceeds that under medicaid since the individual is effectively required to pay for her own health care plus old age consumption, but the choice of old age consumption when ill is predetermined by medicaid.

While medicaid provides no risk pooling in this two period example, it does provide risk pooling in the 55 period simulation model of the next section. In the 55 period model individuals may become ill in any of their last 35 periods. The size of their assets that they surrender to medicaid will depend on when they become ill. If they become ill early in life, their assets will be small, and the value of medicaid payments for health care and subsequent consumption will exceed the value of the assets that medicaid confiscates. If they become ill when quite old, assets will again be small, and medicaid will again receive less than it pays out. For those becoming ill in middle age the assets the assumed compulsory medicaid program takes will exceed the benefits medicaid provides. Hence, modeling medicaid as being financed purely from confiscation of the assets of its recipients implies that medicaid does not pool risk across the healthy and the unhealthy, rather it pools risk, to some extent, among the unhealthy.

B. Savings Comparisons

Figure 1 is convenient for comparing savings in the four regimes. The figure plots the function H(Cy) against Cy, where:

(13) $H(Cy) = RU'(Cy) - (1-P)\beta U'([W-Cy]/R)$

which is clearly decreasing in Cy since $U''<0$. From equations (3), (5), (7'), and (11) we have:

(3') $H(Cy^{\alpha}) = P\alpha\beta U'([W-Cy^{\alpha}]/R)$

(5') $H(Cy^{s}) = P\beta U'([W-Cy^{s}]/R - e)$

(7'') $H(Cy^{i}) = -(1-P)\beta U'([W-Cy^{i}]/R) + \beta U'([W-Cy^{i}]/R - Pe)$

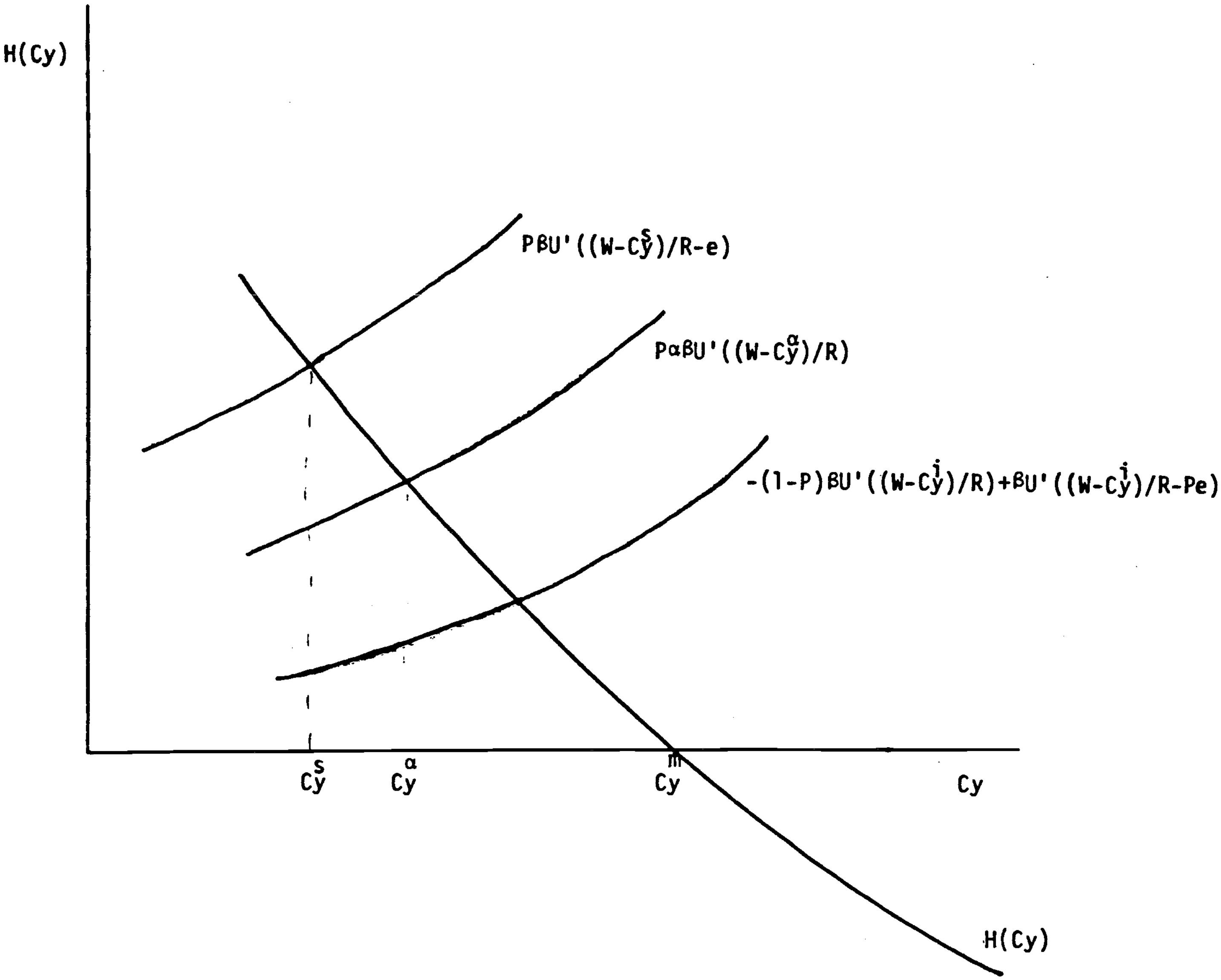
(11') $H(Cy^{m}) = 0$

The right hand sides of (3'), (5'), and (7'') are positive. The right hand sides of (3') and (5') are increasing in Cy. If $U''' > 0$ the right hand side of (7'') is also increasing in Cy. The right hand sides of these three expressions are also plotted in Figure 1 adopting the assumption $U''' > 0$. Note that if $U''' > 0$:

(14)
$$\begin{aligned} H(Cy^{i}) &= -(1-P)\beta U'([W-Cy^{i}]/R) + \beta U'([W-Cy^{i}]/R - Pe) \\ &< -(1-P)\beta U'([W-Cy^{i}]/R) + P\beta U'([W-Cy^{i}]/R - e) \\ &\quad + (1-P)\beta U'([W-Cy^{i}]/R) \\ &= P\beta U'([W-Cy^{i}]/R - e) \end{aligned}$$

From the diagram it is clear that consumption under medicaid exceeds that under the other three regimes. Two other relationships are also immediate. First, $Cy^{\alpha} > Cy^{s}$, i.e., consumption when young in the case the individual

Figure 1. Consumption When Young Under Different Regimes



chooses to "live with it" exceeds consumption when young in the self insurance (self payment) regime, and second, $Cy^i > Cy^s$, i.e., consumption when young with actuarially fair insurance exceeds that under self payment. Whether Cy^i is larger or smaller than Cy^α depends on the size of α, the term PRe, and the degree of risk aversion. The diagram depicts the case in which $Cy^\alpha > Cy^i$, but the curve representing the right hand side of (7'') could lie below that representing the right hand side of (3').

Aggregate wealth held by individuals in this two period model equals only the savings of the older generation, because the young have not yet accumulated wealth. Since the savings of the elderly equals the saving they did when young, wealth per young person, A, in the four regimes equals:

$$A^\alpha = W - Cy^\alpha \tag{15}$$

$$A^s = W - Cy^s$$

$$A^i = W - Cy^i - vF + vF = W - Cy^i$$

$$A^m = W - Cy^m$$

In the case of fair insurance the assets of the economy, A^i, equal the wealth of the elderly, $W - Cy^i - vF$, plus the reserves of the insurance company, vF.

It is clear from (15) that the larger is Cy the smaller is the economy's savings. Hence, if $U''' > 0$ savings is largest in the case of self payment and smallest under medicaid, and the relative size of savings in the cases of fair insurance and "live with it" depends on the specification of α, PRe, and the degree of risk aversion. If $U''' < 0$ savings is largest in the case of fair insurance, followed by savings under self payment, savings under "live with it," and savings under medicaid.

It may seem surprising that consumption when young with self payment could exceed consumption when young with fair insurance, but there are two offsetting factors involved in determining the extent of precautionary saving. On the one hand the individual with no insurance is motivated to consume less because of the possibility that he or she will become ill and need to pay for the cure; on the other hand, there is the chance that the individual will not become ill and, hence, will have the money that would otherwise have been spent on the cure to spend on consumption. In this case the individual will feel ex-post that she has oversaved. By consuming more now the individual can reduce the extent of ex-post oversaving in the case of good health in old age, albeit at the risk of greater ex-post undersaving in the case of bad health in old age. If $U''' > 0$ the concern about saving too little outweighs the concern about saving too much, and consumption in the absence of insurance is less than consumption with fair insurance.

Another case not yet considered is less than actuarially fair insurance. One can show that starting at the actuarially fair value of v and rebating in a lumpsum fashion insurance company profits that the choice of F will be reduced as v increases. The derivative of Cy^i, however, evaluated at the actuarially fair choice of F and Cy^i equals zero. Hence, very small departures from actuarial fairness, while inducing less insurance purchase, will not alter Cy and, therefore, not alter savings. Larger departures from actuarial fairness will, in contrast, affect Cy^i and savings. However, the direction of this effect cannot be determined even assuming $U''' > 0$. Of course, if v is sufficiently large the optimal choice of F will be zero, transforming the insurance regime into the self payment regime. Hence, if v is increased sufficiently, Cy^i will equal Cy^s which, assuming $U''' > 0$, is smaller than the level of consumption under actuarial fairness. Thus sufficiently large increases in the insurance premium will ultimately raise savings. It also appears possible that more moderate increases in the insurance premium could be associated with savings in excess of that under self payment. The simulations of unfair insurance in Section 5 illustrates this possibility.

C. Choice of Regime

The choice of whether to "live with it," to pay one's self for the cure, to purchase insurance, or to rely on medicaid obviously depends on which regime provides the greatest expected utility. The insurance regime dominates self payment because one can't be worse off with the option of buying health insurance. The self payment regime in this two period setting dominates the medicaid regime, since the individual who falls ill is effectively forced to purchase her own cure, is constrained in her choice of consumption after becoming sick. Thus, as modelled here, medicaid would only exist if it were a compulsory program run by the goverment.

The choice of regimes depends on which offers the largest value of expected utility, which depends, in turn, on the set of parameter values W, e, α, and P.[1] As these parameter values change the optimal regime may switch, producing abrupt and potentially significant changes in savings. To see this

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[1]It is easy to show that the regime that is preferred ex-ante is also preferred ex-post.

take the case in which there are only two possible regimes, no cure and self payment. Suppose that initially $EU^s > EU^\alpha$ and consider how savings is affected by an increase in e. Provided EU^s remains above EU^α, Cy^s will fall and savings will rise as e increases. At some point, however, the inequality will switch, and the no cure regime will be preferred to the self payment regime. At that point savings will drop, potentially quite sharply, since $Cy^\alpha > Cy^s$. A similar discontinuity could arise with increases in α that might arise, for example, because of improvements in pain killers. While EU^s may initially exceed EU^α, as α rises EU^α will eventually exceed EU^s. When the switch occurs saving will drop abruptly. Savings may also abruptly increase either do to a fall in e or α or to a rise in W starting in a situation in which EU^α exceeds EU^s. Note that as W increases EU^s converges to the case of no health expenditure risk. The level of utility in the case of no health expenditure risk obviously exceeds EU^α.

4. Simulating the Savings Response to Uncertain Health Expenditures

A. The Simulation Model

Simulations of a 55 period life cycle model can provide a sense of the savings differences that might arise under the different regimes. The model assumes that individuals work full time from age 1 (corresponding to a real world age of 20) through age 45 (a real age of 65) earning a constant amount W. Between ages 45 and 55 (a real age of 75), the age of death, the individual is retired. During the first 20 years of life there is no possibility of becoming ill. Beyond age 20 there is a P percent chance of becoming ill in a particular year given that one has not already been ill. The illness, once cured, can not strike again. Illness occurs at the beginning of the period. Once the illness occurs the sick have the option either to purchase the cure or to remain ill. If they remain ill their utility from consumption is multiplied, as above, by α, a parameter whose value lies between zero and one.

The specific form of utility from consumption in a particular year is:

$$U(C) = \frac{C^{1-\gamma}}{1-\gamma} \tag{16}$$

and, as above, there is a time preference factor β that discounts future values of utility from consumption. The four regimes considered are "live with it," self payment, insurance, and medicaid. In the case of insurance, unfair as well as fair insurance arrangements are examined, with the premium per dollar of coverage in the unfair insurance case set equal to 1.5 times that in the fair insurance case.

The consumption choice problems in the four regimes can be solved with dynamic programming. Consider first the case of self payment. At any age above age 20 there are two types of individuals, those who have become ill (either in the past or in the immediate period) and those who have not yet become ill. Those who already have become ill can not become ill again and, therefore, face no additional health expenditure risk. Those who have already become ill maximize (17) subject to (18):

$$\hat{U}_k = \sum_{j=0}^{55-k} \beta^j \frac{C_{k+j}^{1-\gamma}}{1-\gamma} \tag{17}$$

$$M_k = \sum_{j=0}^{55-k} R^j C_{k+j} \tag{18}$$

where M_k stands for the present value of resources at age k and equals the sum of current assets plus the present value of future labor earnings. Let $\hat{V}(M_k)$ stand for the indirect utility function for this problem. The indirect expected utility function for an individual age k who has not yet become ill is defined by:

$$V_k^s(M_k) \equiv \max_{C_k} \frac{C_k^{1-\gamma}}{1-\gamma} + \beta P\hat{V}_{k+1}([M_k-C_k-e]/R) + \beta(1-P)V_{k+1}([M_k-C_k]/R) \tag{19}$$

The indirect utility functions $V_k(M_k)$ can be calculated recursively using (19), $V_k(M_k)$, and noting that:

$$V_{55}(M_{55}) = \frac{M_{55}^{1-\gamma}}{1-\gamma} \tag{20}$$

The case of no cure is quite similar. The indirect utility function for those who have already become ill is:

$$\hat{V}_k^{\alpha}(M_k) = \alpha\hat{V}_k(M_k) \tag{21}$$

And for those not yet ill the indirect utility function can be derived from the recursion (22) plus (23).

$$V_k^{\alpha}(M_k) \equiv \max_{C_k} \frac{C_k^{1-\gamma}}{1-\gamma} + \beta P\hat{V}_{k+1}^{\alpha}([M_k-C_k]/R) + \beta(1-P)V_{k+1}^{\alpha}([M_k-C_k]/R) \tag{22}$$

$$V_{55}^{\alpha}(M_{55}) = \frac{M_{55}^{1-\gamma}}{1-\gamma} \tag{23}$$

The case of insurance is slightly more complicated. Given the choice of F, the amount of coverage, the appropriate recursion for indirect utility of those not yet ill is:

$$(24)\qquad V_k^{iF}(M_k) = \max_{C_k} \frac{C_k^{1-\gamma}}{1-\gamma} + \beta P\hat{V}_{k+1}([M_k-C_k+F-e]/R) + \beta(1-P)V_{k+1}^{iF}([M_k-C_k]/R)$$

$$(25)\qquad V_{55}^{iF}(M_{55}) = \frac{M_{55}^{1-\gamma}}{1-\gamma}$$

The superscript F refers to the fact that the indirect utility functions of those not yet sick is conditional on the level of F. Denoting by v the premium payment made for lifetime coverage of F regardless of when one becomes ill, the optimal choice of F, F*, satisfies:

$$(26)\qquad F^* \equiv \max_{F} V_0^{iF}(M_0-vF)$$

Thus to find the optimal choice of insurance coverage, F, one solves the dynamic programming problem for all possible choices of F and chooses that value of F yielding the highest initial (k=0) value of expected utility. In the case of actuarially fair insurance the solution does not reguire dyamic programming, since F is set equal to e in this case and the consumption path is derived by maximizing U_0 subject to the constraint that the present value of consumption equals M_0-v_fF, where v_f is the actuarially fair premium. Note that v_f equals the present expected value of the payment of one dollar at the time one becomes ill.

This analysis assumes that any profits made by the insurance company if it charges an actuarially unfair premium are retained by the insurance company and not rebated to the insured. This assumption is inappropriate to the macro model since there are no seperate agents in the model who are owners of the insurance company. A more appropriate assumption made below is that the profits of the insurance company are rebated back to the insured as lump sum payments. Since individuals view these rebates as lump sum, they will still preceive that at the margin the price of insurance is actuarially unfair. The rebate is calculated as the difference between the actuarially fair and unfair premia on the coverage purchased. The optimal value of F is no longer determined by (26), but by:

$$F^* = \max_F V_0^{iF}(M_0 - vF + r) \tag{26'}$$

where r stands for the rebate and equals $(v - v_f)F^*$. Equation (26') suggests a procedure for finding F^*. For each possible value of F^* one can form r and check using the V_0^{iF} functions whether the candidate value satisfies (26'). If it does, it is the true value of F^*.

The last case to consider is medicaid. Once one has become ill, one goes onto medicaid and is forced to consume $\bar{C}$. Utility under medicaid is given by:

$$V_k^m = \sum_{j=0}^{55} \beta^j \frac{\bar{C}^{1-\gamma}}{1-\gamma} \tag{27}$$

The recursion for indirect utility for those not yet ill is:

$$V_k^m(M_k) = \max_{C_k} \frac{C_k^{1-\gamma}}{1-\gamma} + \beta P V_{k+1}^m + \beta(1-P)V_{k+1}^m([M_k - C_k]/R) \tag{28}$$

and

$$V_{55}^m(m_{55}) = \frac{M_{55}^{1-\gamma}}{1-\gamma} \tag{29}$$

B. Calculating Aggregate Savings

In both the cases of no cure and self payment aggregate wealth just equals the sum of the private savings of all individuals in the economy. Since the population growth rate is assumed to be zero, at any point in time there is a fixed distribution of individuals of different ages with different medical histories. For an individual who is age k, private wealth equals the difference between labor earnings and consumption plus medical expenditures at each age in the past accumulated with interest up through age k. Since individuals at a given age will differ with respect to their medical histories, and, therefore, their past expenditures, one needs to keep track of all possible medical histories as well as the number of individuals in each cohort with each medical history.

Aggregate wealth in the case of medical insurance equals the sum of private wealth holdings plus the reserves of the stylized insurance company. In this case private wealth is calculated by accumulating earnings plus insurance payments plus the one time rebate (paid at age 1) less consumption and medical expenditures less the initial payment of the lifetime insurance premium. The reserves of the insurance company equal the sum of reserves on the policies of each individual. While the sum of reserves is positive, the reserves on any one policy can be positive or negative. The reserves on an individual's policy equals the accumulated value of the initial premium, less the initial rebate, less any insurance payments.

Adding up for this case, private wealth and the reserves of the insurance company may seem a rather cumbersome calculation. There is, indeed, a much simpler method of arriving at aggregate wealth. One can ignore the transfers to and from the insurance company and simply add together over all individuals in the economy the accumulated difference between earnings and consumption plus medical expenditures at each age. This same method can be used in calculating aggregate wealth in the medicaid economy. Alternatively one could calculate the wealth in private hands and add this to the medicaid trust fund, which in the fully funded system considered here would have assets that equal the sum of accumulated confiscated assets less accumulated medicaid payments on $\bar{C}$ and medical expenditures. The assumption that the medicaid trust fund is fully funded provides an equation to determine the value of $\bar{C}$. In a fully funded medicaid system the present expected value of payments to each individual over his or her lifetime, including payment of the consumption stream $\bar{C}$ and the health expenditure e, equals the present expected value of medicaid's confiscation of assets from medicaid participants.

C. Solution Method and Parameterization of the Model

It should be clear that there are not, in general, closed form solutions to the dynamic programming problems outlined above. As a consequence, the solutions to these problems were computed numerically. The technique here is simply to calculate the values of the $V_k(\ )$ functions for specific grid values of M_k. Since the calculation of $V_k(\ )$ depends on the entire function $V_{k+1}(\ )$ and not simply on particular grid values, one needs to interpolate values of $V_{k+1}(\ )$ from the calculated grid values.

Given the interpolated function $V_{k+1}(\ )$, the value of V_k for a particular grid value of M_k is determined by finding, numerically, the value of C_k that maximizes the relavant expression for $V_k(\ )$. Hence, as a by product of calculating the $V_k(\ )$ functions, one obtains optimal values of C_k for the grid values of M_k. Interpolating across these values gives $C_k(M_k)$ functions, indicating approximately the optimal level of consumption. Clearly, the finer the grid of values of M_k, the better is the approximation. For purposes of this paper the fineness of the M_k grid was chosen such that increased fineness would have only a trivial affect on the calulation of total wealth.

The $C_k(\ )$ consumption functions are then used in calculating the economy's total savings. This calculation involves starting with a cohort age 1, deriving each possible lifetime consumption and health expenditure path, determining the number of members of the cohort who will experience each path, and then computing accumulated savings as just described.

In the base case economy γ, the reciprocal of the coefficient of relative risk aversion, equals 4, a value suggested by the empirical literature (Auerbach and Kotlikoff,1987). The base case economy also features a 4 percent interest rate and a 4 percent rate of time preference. Hence, both R and β equal 1/1.04. The value of M_0 is set equal to 100, and W, the yearly wage, is determined by the condition that the present value of earnings equals M_0. The resulting value of W is 4.64.

The value of e, the cost of the cure, is five times W, or 23.2. The probability of becoming ill in any year given that one is healthy, P, equals .05. With these assumptions the actuarially fair value of a dollar of health expenditure coverage, v_f, is 24.8 cents. Hence, in the case of fair insurance total initial premium payments equal 5.75, almost 6 percent of the present expected value of total lifetime consumption plus health expenditures. The premium under unfair insurance is set equal to 1.5 times the fair insurance premium. For the case of "live with it," the value of α is 1/2. For the case of Medicaid, the value of $\bar{C}$ that Medicaid can finance from its asset confiscation is 2.25. The calculation of total wealth is based on a population of 1000 in each cohort.

5. Simulation Results

Table 1 presents the values of total wealth for the base case economy under the different health expenditure regimes. The table also indicates the seperate effects on savings in each of the regimes of reducing e by half and lowering P to .01. As suggested by the fact that $U''' > 0$ (in (16)) and by Figure 1, base case savings for the case of self payment exceeds that under fair insurance, while base case savings is smallest for the case of medicaid. Savings under fair insurance also turns out to exceed that under the "live with it" regime. Savings under unfair insurance slightly exceeds savings under self payment. The amount of insurance coverage chosen in this case is 7.00, less than one third of the cost of the cure.

The savings differences across these regimes are very substantial. The introduction of actuarially fair insurance reduces savings by 12 percent if the economy is initially in the self payment regime. If medicaid, rather than fair insurance is introduced, savings is reduced by 80 percent! Alternatively, if individuals opted to "live with it," savings would fall by 48 percent relative to the self payment regime. These numbers would likely be reduced quite a bit if general equilibrium considerations were included in the analysis, but even so they would remain quite large.

Wealth is so small in the Medicaid case because of the significant saving

Table 1: Aggregate Savings Under Alternative Health Expenditure Regimes

Regime	Parameterization		
	Base Case	Base Case, e=2.5W	Base Case, P=.01
Self Payment	1,008,670	869,710	1,136,140
Fair Insurance	891,521	828,212	822,061
Unfair Insurance	1,016,510	915,333	1,173,450
Live With It	527,017	527,017	682,301
Medicaid	222,062	325,871	626,383

disincentive associated with Medicaid's asset confiscation. Quite simply, this asset confiscation and Medicaid's provision of $\bar{C}$ make assets worthless once an individual becomes ill; hence, the individual's need for assets in the future is greatly reduced by Medicaid. This major saving disincentive from asset confiscation would remain even if part of Medicaid's expenditures were financed from general revenues, such as a wage tax.

In the "live with it" regime individuals consume more when young relative to the case of self payment because they know that if they become ill their marginal utility of consumption will be greatly reduced. Since 83 percent of individuals ultimately become ill in the base case, there is a substantial incentive to consume early in the "live with it" regime. One way of assessing the sensitivity of savings in this regime to its perceived future value is to determine the change in savings associated with lowering α from 1/2 to 1/4. Savings in this case falls by 16 percent.

Since earnings is the same in each of the different regimes, any differences in total wealth are due to differences in consumption levels and, in comparing "live with it" with the other regimes, to differences in health expenditures. Table 2 presents consumption levels at different ages for individuals who have not yet become ill and for individuals who become ill at specified ages. In the case of fair insurance, consumption always equals 4.10 regardless of age or the occurrence of the illness. This is because the individual is fully insured and because the interest rate equals the time preference rate. The consumption profiles for the other three regimes of Table 2 are also flat up through age 20 reflecting the $R = \beta$ assumption; for each of these cases the future after age 20 is uncertain, but this uncertainty

Table 2: Consumption

Age	Not Yet Ill				Age of Onset of Illness	Already Ill			
	Self Payment	Fair Insurance	Live With It	Medicaid		Self Payment	Fair Insurance	Live With It	Medicaid
1	4.05	4.10	4.53	4.62	1	NA	NA	NA	NA
5	4.05	4.10	4.53	4.62	5	NA	NA	NA	NA
10	4.05	4.10	4.53	4.62	10	NA	NA	NA	NA
20	4.05	4.10	4.53	4.62	20	NA	NA	NA	NA
21	4.06	4.10	4.52	4.61	21	3.64	4.10	4.07	2.25
30	4.34	4.10	4.20	4.12	30	3.89	4.10	3.97	2.25
40	4.74	4.10	3.87	3.61	40	4.18	4.10	3.87	2.25
50	5.29	4.10	3.52	3.17	50	4.50	4.10	3.45	2.25
54	5.87	4.10	3.46	2.95	54	4.80	4.10	3.40	2.25
55	29.00	4.10	3.34	2.85	55	4.83	4.10	3.34	2.25

NA = Not applicable.

does not affect the marginal decision between consumption at different ages prior to age 21.

Under the self payment regime consumption grows after age 20 for those remaining healthy, reflecting the fact that the extra precautionary savings accumulated in case an individual had become ill in the previous year rather than the future did not have to be tapped. In the last year of life, at age 55, the individual who remains healthy is able to consume an additional 23.2, which corresponds to the amount that would otherwise have been spent on the cure if the individual had become ill in his or her last year. If, on the other hand, the individual becomes ill at a particular age after age 20, his or her consumption immediately falls and stays constant at this lower level through age 55 (again reflecting the $R = \beta$ assumption). For example, the individual who is healthy at age 40 in the self payment case consumes 4.74, while if she had become ill at age 40, her consumption would have been only 3.87.

The consumption profile for those remaining healthy in the "live with it" regime falls after age 20, reflecting the trade off between the marginal utility of consuming today and the possibly lower marginal utility of consuming tomorrow in the event one is ill. Once an individual becomes ill, however, the consumption profile is flat because $\beta = R$, and there is no further uncertainty.

The Medicaid age consumption profile also declines after age 20, again because of the lower expected marginal utility of saving another dollar relative, for example, to the fair insurance case. Consumption prior to age 21 is highest under Medicaid, reflecting the lower marginal utility of saving for consumption after age 20 relative to the marginal utility of consuming prior to age 20.

After the Medicaid regime consumption prior to age 21 is greatest in the "live with it" regime. This reflects the fact that individuals will never be making health expenditures and, hence, need not save for them. Note that the present expected value of health expenditures, if they were made, is 5.75.

The level of savings is fairly sensitive to the size of medical costs and to the probability of becoming ill. Reducing by half the cost of medical treatment leads to a 14 percent drop in wealth in the self payment regime and a 9 percent drop in the fair insurance regime. In these regimes the reduced incentive to save is offset somewhat by the reduction in health expenditures in the determination of the net impact on savings. In the medicaid regime the reduction in the cost of treatment, rather than reducing savings, raises savings by almost one third. At the individual level the incentive to save under medicaid is not affected by the reduced treatment cost; since medicaid will pay these costs and since $\bar{C}$ is also under medicaid's control, the tradeoff remains between current consumption when healthy and future consumption when healthy.

While private wealth is not altered under medicaid by the reduction in e, the size of medicaid's trust fund increases because the health expenditure payments it must make are reduced. On the other hand, with a lower e, medicaid can afford to pay a higher $\bar{C}$. For the case of e=2.5W the value of $\bar{C}$-paid by medicaid is 3.00, 25 percent larger than its base case value. The reduction in e and the increase in $\bar{C}$, while leaving unchanged medicaid's receipts from asset confiscations, pushes the timing of its expenditures off into the future. A smaller e and a larger $\bar{C}$ means less medicaid payments at the time the individual becomes ill and more payments later in the individual's life. The consequence of this change in the timing of medicaid expenditures means that medicaid will have a larger trust fund.

Returning to Table 1 there are also some dramatic changes in savings that arise from a reduction in P from .05 to .01. Wealth under medicaid almost triples as individuals respond to the reduced probability of experiencing medicaid's effective asset tax. The private incentive to save is also strengthened in the "live with it" case; in this case the reduction in the likelihood of becoming ill and having greatly diminished marginal utility from consumption prompts a 30 percent increase in aggregate savings. In the self payment regime the reduction in P reduces the need for precautionary savings. Despite this fact there is a modest increase in wealth. This reflects the reduced health expenditures. Relative to the higher P self payment case, total cohort consumption plus health expenditures in the P = .01 self payment case is greater prior to age 21, smaller thorugh age 49, and greater thereafter. Hence, the latter case has more lifecycle saving among the middle age (counting their health expenditures), although less among the young. The increased saving occurring in middle age reflects the reduced health expenditures.

A reduced P also means less health expenditures in the fair insurance regime, but in this case the increased consumption of individuals more than offsets this reduction in health expenditures leading to a somewhat lower level of wealth. The lower P means a premium of 1.75 rather than 5.75 and finances a higher level of consumption at every age. Hence the reduced saving of the young outweighs the increased saving of the middle age (including their reduced health expenditures) and total wealth health expenditures) and total wealth falls by 8 percent compared to the P = .05 case.

One may summarize this table by saying first, that the changes in savings down any column indicate that insurance arrangements and government intervention in the form of medicaid can significantly alter the amount of precautionary savings and second, that the changes along any row indicate that holding constant the saving regime, changes in the size and riskiness of health expenditures can greatly influence savings.

Before concluding this section it may be useful to consider the level of savings that would arise in this economy if there were zero probability of the illness occurring. The answer is 758,878. This is almost a quarter below base case savings under self payment and 15 percent below base case savings with fair insurance. Intuitively the introduction of significant health expenditures, whether insured or uninsured, shifts the age consumption (including health expenditures) profile of each cohort towards more consumption at later ages. This change implies more accumulated savings at each age.

Since moving from an economy with zero health expenditures to one depicted in column 2 of Table 1 in which health expenditures equal roughly 6 percent of total lifetime consumption could mean anywhere from a 33 percent increase in savings to a 71 percent decrease in savings depending on the chosen regime, it is clear that health expenditures are a potential critically important determinant of savings.

6. Conclusion

This paper has examined some of the theorectical issues involved in precautionary savings for uncertain health expenditures. The highly stylized simulation model gives the strong impression that uncertain health expenditures represent a strong motive for saving, which may, however, be greatly influenced by the availability of private insurance and the presence of government programs such as medicaid. The model is too stylized to be anything more than suggestive. More realistic modeling will require improved estimates of the riskiness of health expenditures as well as better understanding of the extent to which private insurance mitigates that risk.

A more realistic model should also consider the interaction of health expenditure risk and earnings and lifespan risk. These risks are clearly interdependent. Saving for future health care may become much more important if one's earnings and, indeed, one's very life depends on receiving that care. In this context, disability insurance, which represents earnings insurance in the case of particular health episodes, may be having a very substantial affect on precautionary savings.

Insuring the riskiness of lifespan, like insuring the riskiness of earnings, appears to require special types of insurance related to health or health expenditures. In the absence of uncertainty with respect to health expenditures one could purchase annuities that would hedge the risk of living longer than expected and not having sufficient savings. In the presence of health expenditure uncertainty and less than full health insurance coverage, fully annuitizing, the best option if only life span is uncertain and fair indexed annuities are available, becomes highly risky. If one is fully annuitized and cannot borrow against future annuity payments, one will have no resources to meet immediate uninsured health expenditures. Perhaps this is why the private market in annuities in the U.S. is virtually nonexistent.

Another issue in thinking about health expenditure risk and precautionary savings is the role of the extended family in directly providing health care as well as providing financial assistance for the purchase of health care. In other contexts the family appears to constitute an excellent implicit insurance market (Kotlikoff and Spivak, 1981); presumably the same applies in this context and, perhaps more so.

In sum, exploring the interactions of savings, health expenditures, medical insurance, and other types of risks represents a very fertile and apparently quite important area for future research.

References

Abel, A.B., 1983, "Bequests and Social Security with Uncertain Lifetimes," mimeo, Harvard University, June.

Auerbach, A.J. and L.J. Kotlikoff, 1987, Dynamic Fiscal Policy, Cambridge University Press.

Bayer, R., et al., 1983, "The Care of the Terminally Ill: Morality and Economics," The New England Journal of Medicine 309(4), 1490-1494.

Davies, J., 1981, "Uncertain Lifetime, Consumption and Dissaving in Retirement," Journal of Political Economy 89(3), 561-77.

Eckstein, Z., M. Eichenbaum and D. Peled, 1983, "Uncertain Lifetimes and the Welfare Enhancing Properties of Annuity Markets and Social Security," mimeo, March.

Fuchs, V.R., 1982, "Time Preference and Health: An Exploratory Study," in V. Fuchs, ed., Economic Aspects of Health. Chicago: University of Chicago Press.

Hubbard, G.R., 1983, "Uncertain Lifetimes and the Impact of Social Security on Individual Wealth Accumulation," mimeo, May.

Kotlikoff, L.J., 1979, "Social Security and Equilibrium Capital Intensity," Quarterly Journal of Economics 93(2), 122-42.

Kotlikoff, L.J. and A. Spivak, 1981, "The Family as an Incomplete Annuities Market," Journal of Political Economy 89(2), 372-91.

Kotlikoff, L.J., J. Shoven and A. Spivak, 1986, "The Impact of Annuity Insurance on Savings and Inequality," Journal of Labor Economics.

Long, S.H., et al., 1984, "Medical Expenditures of Terminal Cancer Patients

During the Last Year of Life," Inquiry 21 (Winter), 315-327.

Lubitz, J. and R. Prihoda, 1984, "The Use and Costs of Medicare Services in the Last 2 Years of Life," Health Care Financing Review 5(3), 117-131.

McCall N., 1984, "Utilization and Costs of Medicare Services by Beneficiaries in Their Last Year of Life," Medical Care 22(4), 329-342.

Rossiter, L.F. and Wilensky, G.R., 1982, "Out-of-Pocket Expenditures for Personal Health Services," 1982, National Health Care Expenditures Study, DHHS Publication No. (PHS) 82-3332, U.S. Department of Health and Human Services, October.

Scitovsky, A.A., 1984, "'The High Cost of Dying': What Do the Data Show?" Health and Society 62(4), 591-608.

Sheshinski, E. and Y. Weiss, 1981, "Uncertainty and Optimal Social Security Systems," Quarterly Journal of Economics 96(2), 189-206.

Venti, Steven and David Wise, "IRAs and Saving." Mimeo, 1986.