Review of Income and Wealth
Series 49, Number 2, June 2003

THE EFFECTS OF A CONTINUOUS INCREASE IN LIFETIME ON SAVING

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This paper examines the effects on saving of a continuous increase in lifetime and shows that a greater increase in lifetime leads to greater savings. This is because an increase in lifetime is accompanied by uncertainty and because the working-age cohort whose lifetime is longer saves more than the retired cohort dissaves. This result is tested empirically with cross-country data, and it is confirmed that an increase in life expectancy has a positive effect on various saving rates.

1. INTRODUCTION

Human longevity has increased dramatically over the past centuries. According to Livi-Bacci (1997), a newborn child in the middle of the 18th century in England and France lived to, on average, only 33 or 25 years respectively. According to recent life tables, however, a newborn child in developed countries is now expected to live for around 80 years. In Japan, life expectancy at birth was slightly over 40 years at the end of the 19th century; it has since doubled in just one century. Figure 1 shows increases in life expectancy at birth for selected countries over the last half century. It can be seen that life expectancy has been rising steadily. The figure also shows that the increases differ across countries and are not necessarily smooth.[1]

This ongoing change in lifetime has significant implications for various facets of our society. In particular, it is well-known that a change in lifetime affects the allocation of wealth between consumption and saving.

This paper focuses on the relationship between a steady increase in lifetime and saving. As in White (1978), Mirer (1979), and Menchik and David (1983), a number of empirical studies have pointed out that the elderly do not dissave as fast as the simple life-cycle hypothesis predicts. Theoretically, as has been debated between Kotlikoff (1988) and Modigliani (1988), uncertainty of lifetime, or unknown date of death, and bequest motives are suspected as the prime reasons for this slow dissaving behavior. With regard to the effect of lifetime uncertainty, Yaari (1965) and Levhari and Mirman (1977) found that the shape of the survival curve reflects lifetime uncertainty and thus affects saving. Davies (1981) later showed that lifetime uncertainty reduces dissaving.

Note: I thank Hiroshi Yoshikawa, Fumio Hayashi, Charles Yuji Horioka, Murdoch Macphee, Luisito Bertinelli, and anonymous referees for their helpful comments. Of course, any remaining errors are my own.

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[1]The increase in life expectancy appears smooth for several countries. This is due to data limitations, as most of the countries do not publish life expectancy on an annual basis.

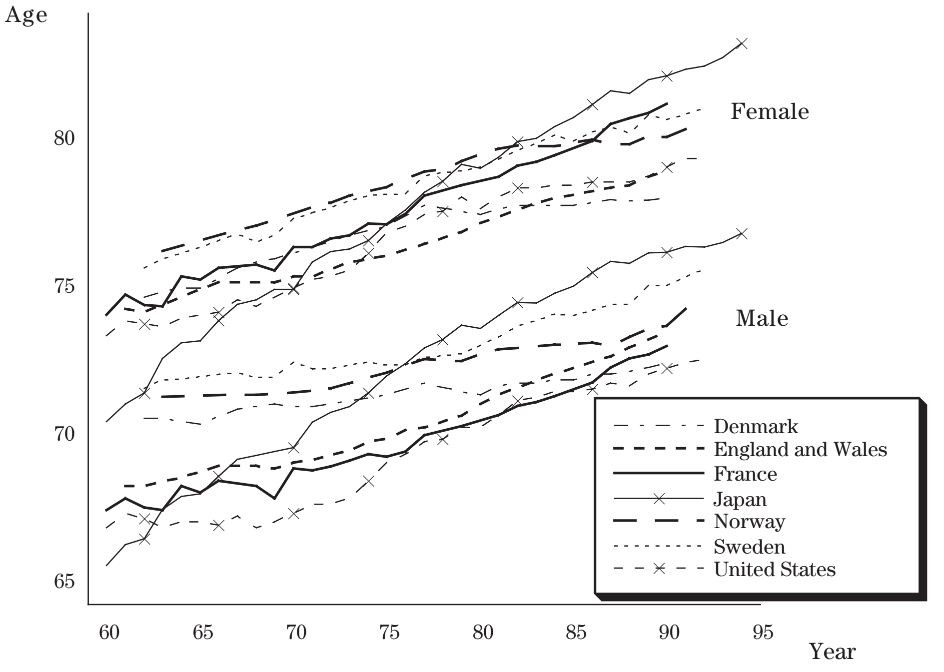

Figure 1. Changes in Life Expectancy
Source: Ministry of Health and Welfare of Japan (1998), *18th Life Tables*.

These studies indicate that an ongoing increase in lifetime which alters the shape of the survival curve should also influence saving. However, a change in lifetime has not been considered in previous studies. This paper examines the effects of increasing lifetime on saving in an attempt to fill this gap.

The main finding of this paper is that a greater increase in lifetime leads to greater savings. Sections 2 and 3 adopt a theoretical perspective and examine the effects on saving of a continuous increase in lifetime under the framework of the life-cycle hypothesis at the individual and aggregate levels. In particular, Section 2 introduces a new lifetime indicator in a bid to overcome the limitations relating to the use of life table data. Using this indicator, the uncertainty associated with an increase in lifetime is found to depress dissaving. Section 3 shows that a greater lifetime increase results in a larger aggregate saving. This is because the working-age cohort whose lifetime is longer saves more than the retired cohort dissaves. These results are examined with aggregate data in Section 4, and it is confirmed that an increase in life expectancy has a positive impact on various saving rates. In particular, an increase in lifetime is found to play a very important role in explaining the high saving rates of Japan relative to other developed countries. The implications of these findings are discussed in Section 5.

2. Dissaving Behavior of the Elderly

2.1. *Basic Model*

The effect of lifetime on the dissaving behavior of the elderly was first explicitly introduced by Yaari (1965). Following his model and letting $P(x, t, j)$ denote the probability of surviving at least x more years for those born in year j and alive in year t (thus, age $t - j$), an individual born in year j and alive in year t faces the following expected intertemporal utility function:

$$E[V(c)] = \int_0^{\overline{X}(t,j)} P(x,t,j)\lambda(x,t,j)U[c(x,t,j)]dx, \quad 0 < x < \overline{X}(t,j), \tag{1}$$

where $\overline{X}(t, j)$ is the maximum remaining lifespan of cohort j in year t, $U[c(\cdot)]$ is the utility function, $c(\cdot)$ is consumption, and $\lambda(\cdot)$ is the subjective discount factor.[2] Then, letting $W(\cdot)$, $y(\cdot)$, and $r(\cdot)$ represent net assets, the individual's earnings (other than interest), and the expected rate of interest, the change in net assets can be written as $\dot{W}(x, t, j) = y(x, t, j) - c(x, t, j) + r(x)W(x, t, j)$. Therefore, letting $U[c(x,t,j)] = \frac{1}{1-\gamma}c(x,t,j)^{1-\gamma}$, $r(x) = r$, and $\lambda(x) = e^{-\rho x}$, maximizing equation (1) under the given constraint, the change in consumption is given by

$$\frac{\dot{c}(x,t,j)}{c(x,t,j)} = \frac{1}{\gamma}\left(r - \rho + \frac{\dot{P}(x,t,j)}{P(x,t,j)}\right), \tag{2}$$

when $W(x, t, j) > 0$. Subsequently, by integrating equation (2), the level of consumption at year t becomes

$$c(x,t,j) = [P(x,t,j)]^{\frac{1}{\gamma}} e^{\frac{1}{\gamma}(r-\rho)x} c(t,j) \tag{3}$$

where $c(t, j)$ is the consumption level at year t.

In order to focus on dissaving by the elderly, suppose that every individual retires at year t and receives no earnings other than interest after retirement. Thus, the elderly dissave from their assets accumulated during working years. With this simplification and the terminal condition that $W[\overline{X}(t, j)] = 0$, the optimal consumption level at year t becomes

$$c(t,j) = \frac{W(t,j)}{\int_0^{\overline{X}(t,j)} [P(x,t,j)]^{\frac{1}{\gamma}} e^{\frac{1}{\gamma}(r-\rho)x - rx} dx} \tag{4}$$

where $W(t, j)$ is the level of assets accumulated by year t.[3]

2.2. *Estimation of Survival Curve*

Equation (4) shows that the level of consumption, or dissaving, largely depends on the shape of the survival curve, $P(x, t, j)$ for $0 \le x \le \overline{X}(t, j)$. However,

[2]Though his study includes bequest motives and annuity, these variables are omitted here since incorporating them does not change the result significantly except in extreme cases.

[3]Leung (1994) shows that wealth will be exhausted before the maximum lifetime with $y(\overline{X}, t, j) > 0$ and this utility function.

the true $P(x, t, j)$ is unveiled only in the future. This means that people use an estimated $P(x, t, j)$, not the true $P(x, t, j)$, to determine their level of consumption. Then, it is common to assume that people base their estimates of $P(x, t, j)$ on life table data. However, it is far from clear that the life-table estimator, say $P_{LT}(x, t, j)$, is a good estimator of the true $P(x, t, j)$. Thus, the life-table estimator is worthy of some examination.

Using life tables, the construction of $P_{LT}(x, t, j)$ begins with the assumption that the age-specific mortality rate is constant across time. Under this assumption, $P_{LT}(x, t, j)$ can be calculated simply using the observed age-specific mortality rates of the older generations. These rates become proxies for the future age-specific mortality rates of the younger generations.

Practically, this approach starts by letting the realized age-specific mortality rate of cohort $j + i$ in the previous year be $m(t - 1, j + i)$ and standardizing the number of newborn children in year t to 100,000. Then, the hypothetical number of survivors in cohort j out of 100,000, $N(t, j)$, is calculated as $100{,}000\Pi_{i=0}^{t-j-1}[1 - m(t - 1, j + i)]$. In life tables, this hypothetical number of survivors is called the stationary population of cohort j in year t. The stationary population of cohort $j - x$ in year t, or x-year-older cohort, $N(t, j - x)$, can also be calculated using this method. Then, under the given assumption, the ratio of the stationary population of cohort $j - x$ to the one of cohort j, $\frac{N(t, j-x)}{N(t, j)}$, becomes the survival probability for cohort j applicable to x years later, which is $P_{LT}(x, t, j)$.

The problem with this estimator is that it does not allow for an increase in lifetime. If the direction of a change in lifetime is uncertain, this estimator would still be rational. However, lifetime increases due to a reduction in mortality in the future, and the assumption that the mortality rate remains unchanged excludes the possibility of an increase in lifetime. As a result, the life-table estimator is biased under a situation where lifetime is steadily increasing.

The reason for a secular increase in lifetime is straightforward: it is the same as the reason for economic growth. Income per capita rises due to technological progress. Similarly, lifetime increases because of technological progress in health and medicine and improvements in general living conditions. These factors ensure that the physiological process of aging is slower than actual aging as measured in calendar years. Thus, the physiological process of aging is expected to slow over time, which would correspond to an increase in lifetime.

The magnitude of an increase in lifetime can be found in Figure 2. The dotted lines which are constructed from the 1962 life tables correspond to the life-table survival curves of those aged 60 in 1962. The solid lines represent the realized survival curves of the same cohort. Obviously, the life-table survival curves underestimate the realized survival curves for both sexes. This illustrates the limitations inherent in using life table data to estimate lifetime.

Recognizing the existence of an increase in lifetime, the next question becomes that of how the ongoing increase in lifetime affects the survival curve. To address this question, it is necessary to determine whether the reduction in mortality is concentrated on certain ages or is common to all age groups.

The literature related to mortality reveals two key schools of thought: one is that the reduction in mortality is concentrated on the young due to the biological

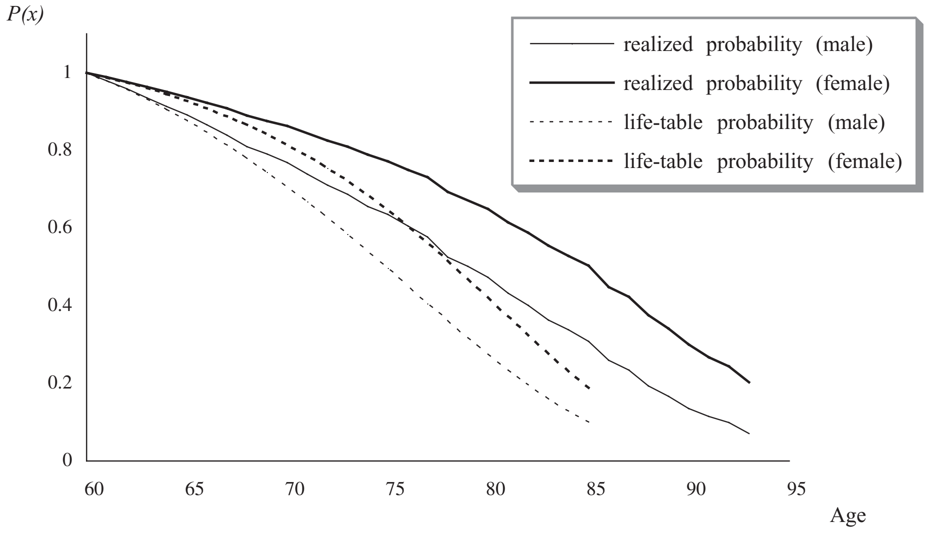

Figure 2. Comparison between Survival Curves

limit of the human species, while the other holds that the very old also experience a reduction in mortality. Vaupel and Lundström (1994) named these two positions the "limited-life-span paradigm" and the "mortality-reduction paradigm." Advocates of the limited-life-span paradigm argue that each species has its own natural, or genetic, limit of lifespan. Thus, the century-long rise in human life expectancy is uniquely transitional and is a result of the reduction in premature death. For example, Fries (1980) concluded that life expectancy at birth would level off at around 85 years after premature death becomes too rare to decline any further. According to this position, an increase in lifetime should stem solely from lower mortality of the young, and the remaining life expectancy of the very old should remain constant. On the other hand, proponents of the mortality-reduction paradigm such as Fogel and Costa (1997) argue that environmental and technological factors are more important than genetic factors in determining maximum lifespan. This implies that better living conditions and technological progress contribute to a reduction in mortality for all ages. Under this viewpoint, the very old as well as the young should experience an increase in remaining life expectancy.

To see which of these viewpoints is consistent with the observed lifetime increase, we use Japanese data to examine changes in the remaining life expectancy of the very old. The reason for choosing Japanese data is that its life expectancy is one of the highest in the world and is thus probably close to our biological limit if such a limit exists.

Based on life table data, Table 1 shows changes in remaining life expectancy and its growth rate at ages 40, 60, 80, and 90. It indicates that the very old experience an increase in remaining life expectancy as well as the young.[4] The rate

[4]The variance of the increase appears to be larger for the very old. This probably results from the smaller population sizes of older cohorts.

TABLE 1

CHANGE IN LIFE EXPECTANCY AT SELECTED AGES

		Age							
		40		60		80		90	
#	Year	Life -Exp.	Increase (%/yr.)	Life -Exp.	Increase (%/yr.)	Life -Exp.	Increase (%/yr.)	Life -Exp.	Increase (%/yr.)
Male									
1	1891–98	25.70		12.80		4.80		2.6	
2	99–1903	26.03	0.214	12.76	–0.052	4.44	–1.250	2.22	–2.436
3	1909–13	26.82	0.303	13.28	0.408	4.70	0.586	2.38	0.721
4	21–25	25.13	–0.525	11.87	–0.885	3.87	–1.472	1.95	–1.506
5	26–30	25.74	0.485	12.23	0.607	4.15	1.447	2.17	2.256
6	35–36	26.22	0.266	12.55	0.374	4.20	0.172	2.14	–0.197
7		not available							
8	47	26.88	0.210	12.83	0.186	4.62	0.833	2.56	1.636
9	50–52	29.65	2.576	14.36	2.981	5.04	2.273	2.7	1.367
10	55	30.85	1.012	14.97	1.062	5.25	1.042	2.87	1.574
11	60	31.02	0.110	14.84	–0.174	4.91	–1.295	2.69	–1.254
12	65	31.73	0.458	15.20	0.485	4.81	–0.407	2.56	–0.967
13	70	32.68	0.599	15.93	0.961	5.26	1.871	2.75	1.484
14	75	34.41	1.059	17.38	1.820	5.70	1.673	3.05	2.182
15	80	35.52	0.645	18.31	1.070	6.08	1.333	3.17	0.787
16	85	36.63	0.625	19.34	1.125	6.51	1.414	3.28	0.694
17	90	37.58	0.519	20.01	0.693	6.88	1.137	3.51	1.402
18	95	37.96	0.202	20.28	0.270	7.13	0.727	3.58	0.399
Ave.(all)			0.547		0.683		0.630		0.509
Ave.(after WWII)			0.780		1.029		0.977		0.767
Female									
1	1891–98	27.80		14.20		5.10		2.70	
2	99–1903	28.19	0.234	14.32	0.141	4.85	–0.817	2.36	–2.099
3	1919–13	29.03	0.298	14.99	0.468	5.26	0.845	2.61	1.059
4	21–25	28.09	–0.270	14.12	–0.484	4.41	–1.347	2.04	–1.820
5	26–30	29.01	0.655	14.68	0.793	4.73	1.451	2.24	1.961
6	35–36	29.65	0.315	15.07	0.380	4.67	–0.181	2.09	–0.957
7		not available							
8	47	30.39	0.208	15.39	0.177	5.09	0.749	2.45	1.435
9	50–52	32.77	1.958	16.81	2.307	5.64	2.701	2.72	2.755
10	55	34.34	1.198	17.72	1.353	6.12	2.128	3.12	3.676
11	60	34.90	0.326	17.83	0.124	5.88	–0.784	2.99	–0.833
12	65	35.91	0.579	18.42	0.662	5.80	–0.272	2.96	–0.201
13	70	37.01	0.613	19.27	0.923	6.27	1.621	3.26	2.027
14	75	38.76	0.946	20.68	1.463	6.76	1.563	3.39	0.798
15	80	40.23	0.759	21.89	1.170	7.33	1.686	3.55	0.944
16	85	41.72	0.741	23.24	1.233	8.07	2.019	3.82	1.521
17	90	43.00	0.614	24.39	0.990	8.72	1.611	4.18	1.885
18	95	43.91	0.423	25.31	0.754	9.47	1.720	4.64	2.201
Ave. (all)			0.600		0.778		0.918		0.897
Ave. (after WWII)			0.816		1.098		1.399		1.477

of the improvement in remaining life expectancy does not slow with age. For example, the average growth rate of remaining life expectancy for a 90-year-old female is much higher than for a 40-year-old female. These rates are about the same as for males. This indicates that the survival curve of the elderly stretches in a similar way to that of the young since remaining life expectancy is equal to the area under the survival curve.

Similar results have been reported in a number of other studies. Vaupel and Lundström (1994) and Vaupel (1998) reached the same conclusion using Nordic and American data. Curtsinger *et al*. (1992) examined genetic and environmental effects on the lifespan of *Drosophila melanogaster* and found that environmental factors influence lifespan more extensively than genetic elements. These findings provide further evidence to support our view that the mortality-reduction paradigm is suitable for explaining the ongoing lifetime increase.

Having concluded that the lifetime increase is not limited to the young, the next step is to examine the effect of this lifetime increase on the survival curve. First, let Y be the random variable expressing the number of years until death when an increase in lifetime is incorporated, and Z (in years) the random variable denoting the delay in aging which occurs in one year.[5] Here, Y has the same support as X (the random variable expressing the number of years until death under life tables), and Z takes a value between a and b ($b < 1$) with the density $f(z)$ and $E[Z] = \bar{z} > 0$. It is worth noting that Z represents the length of the delay in physiological aging, not the length of the increase in remaining life expectancy. Next, assume that Z is independent of both time and age. This implies that an individual in cohort j experiences a zx-year delay in physiological aging over the next x years. Therefore, $X + ZX$ yields the same distribution as Y.

Applying this result to the concept of stationary population, the hypothetical number of those alive x years later in cohort j is now given by $N(t, j - x + zx)$, the stationary population of cohort $j - x + zx$ in year t. In other words, the physiological age of cohort j after x years will be $t - j + x - zx$ whereas actual age will be $t - j + x$. Therefore, the reasonable estimator of $P(x, t, j)$ when a delay in aging is taken into account, say $P_{DA}(y, t, j)$, becomes $\dfrac{N(t, j-x+zx)}{N(t, j)}$.

The relationship between P_{LT} and P_{DA} is presented in Figure 3. The solid and thick lines represent the life-table survival curve and the newly constructed survival curve. The dotted line indicates the new survival curve when $z = \bar{z}$, i.e. when the uncertainty associated with an increase in lifetime is nil. It shows that a continuous increase in lifetime makes the survival curve higher and flatter.

2.3. *Effects on Dissaving*

It should now be clear that it is not appropriate to use the life-table estimator when discussing the effects of lifetime on dissaving. The deficiencies of the life-table estimator stem from two sources. First, it does not allow for the possibility of an increase in lifetime. The relationship, $N(t, j - x + \bar{z}x) \geq N(t, j - x)$ for all x, indicates that the life-table survival probability is biased. The difference of the expected values is given by

$$E[Y] - E[X] = E[X + ZX] - E[X] = \bar{z}E[X]. \tag{5}$$

[5]In fact, there exists another random variable: white noise. This white noise represents the estimation error which exists even if the expected increase in lifetime is nil. However this estimation error is omitted since incorporating it does not change the result in any way.

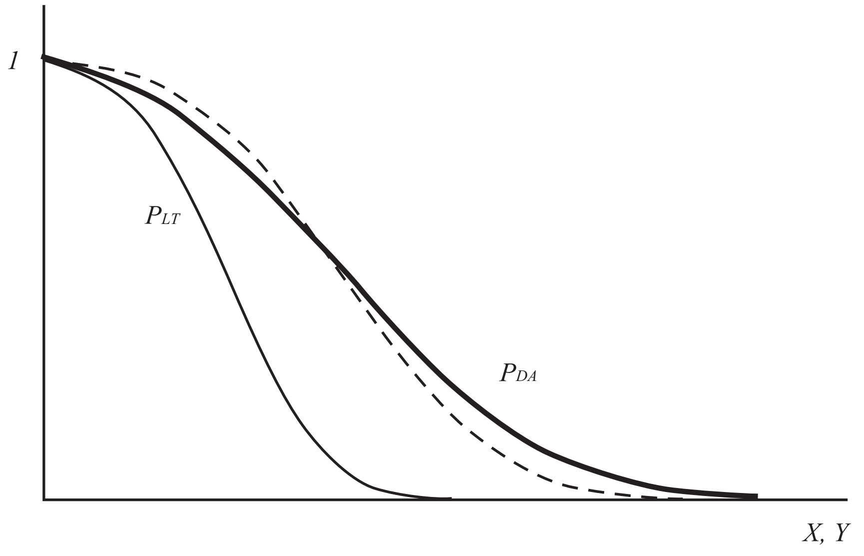

Figure 3. Effect of a Continuous Increase in Lifetime on Survival Curve

Second, the uncertainty attached to a lifetime increase is not incorporated in the life-table estimator. Let $P_{NU}(x, t, j)$ be $\frac{N(t, j-x+\bar{z}x)}{N(t, j)}$, the survival probability in year x with a delay in aging included but without uncertainty. This estimator is the life-table estimator incorporating only a secular increase in lifetime. Although the distributions given by $P_{DA}(x, t, j)$ and $P_{NU}(x, t, j)$ share the same expected value, the difference in the level of uncertainty between these distributions results in the relationship:

$$\int_0^{\bar{X}(t,j)} [P_{DA}(x,t,j)]^{\frac{1}{\gamma}} e^{\frac{1}{\gamma}(r-\rho)x-rx} dx \geq \int_0^{\bar{X}(t,j)} [P_{NU}(x,t,j)]^{\frac{1}{\gamma}} e^{\frac{1}{\gamma}(r-\rho)x-rx} dx, \quad (6)$$

with appropriate estimates of γ, r, and ρ.[6] For example, γ needs to be larger than unity when r and ρ are negligible in order to satisfy equation (6). This is due to lifetime uncertainty as in Levhari and Mirman (1977) and Davies (1981). Intuitively, lifetime uncertainty makes people more cautious.

This uncertainty effect as well as the first factor makes the denominator of equation (4) larger. Therefore, the expected level of dissaving obtained by applying the life-table estimator will be biased upwards. An increase in lifetime and the associated uncertainty need to be incorporated in order to study dissaving behavior.[7]

[6]Equality holds at $x = \bar{X}(t, j)$.
[7]Details of this analysis are available upon request.

3. AGGREGATE EFFECT

So far, the analysis has been limited to individual behavior. The next step is to study aggregate effects. This necessitates taking those who save as well as those who dissave into consideration. For this purpose, the discrete two-period overlapping generation model is used in the following analysis.

To begin, assume that each individual lives with certainty up to the end of the first period (working-age period) but her chance of surviving the second period (retirement period) is less than certain.[8] In particular, the probability of surviving the second period for an individual born in period j is given by $P(j+1, j)$. Next, suppose that saving is entirely invested into life insurance. Then, an individual in cohort j faces the following maximization problem:

$$\begin{aligned} &\max_{c(j,\,j),c(j+1,\,j)} \quad \frac{1}{1-\gamma}c(j,\,j)^{1-\gamma} + \frac{P(j+1,\,j)}{1+\rho}\frac{1}{1-\gamma}c(j+1,\,j)^{1-\gamma} \\ &\text{subject to} \quad W(j,\,j) = c(j,\,j) + s(j,\,j), \\ &\qquad\qquad\quad P(j+1,\,j)c(j+1,\,j) = (1+r)s(j,\,j) \end{aligned} \tag{7}$$

where $W(j, j)$, net assets, is now interpreted as individual earnings for the working-age period, and $s(j, j)$ is individual saving.[9] Then, the levels of consumption for the first and second periods and the amount of individual saving become[10]

$$c(j,\,j) = \frac{W(j,\,j)}{1+\dfrac{P(j+1,\,j)}{1+r}\left(\dfrac{1+r}{1+\rho}\right)^{\frac{1}{\gamma}}}, \tag{8}$$

$$c(j+1,\,j) = \left(\frac{1+r}{1+\rho}\right)^{\frac{1}{\gamma}} c(j,\,j), \tag{9}$$

$$s(j,\,j) = \frac{P(j+1,\,j)}{1+r}\left(\frac{1+r}{1+\rho}\right)^{\frac{1}{\gamma}} c(j,\,j). \tag{10}$$

Assume further that each woman has one daughter such that fertility is constant. This means that aggregate saving is the difference between what the current working-age adults save and what the current old dissave, $S(j) = s(j, j) - P(j, j-1)c(j, j-1)$. Assuming that the growth rates of income and life-

[8]Historically, the retirement age does not rise with an increase in life expectancy as in Lumsdaine and Wise (1994). Besides, Chang (1991) shows that a rise in life expectancy does not necessarily lead to an increase in the retirement age.

[9]I continue to use r, ρ, and γ to avoid the unnecessary introduction of new symbols.

[10]This shows that the amount of assets carried over to the retirement period, $(1+r)s(j, j)$, increases with $P(j+1, j)$ since $\dfrac{\partial s(j,\,j)}{\partial P(j+1,\,j)} > 0$. Therefore, the amount of assets when the retirement period starts, which is conceptually equivalent to the numerator of equation (4), depends positively on lifetime. This indicates that a continuous increase in lifetime makes both the numerator and the denominator of equation (4) larger. Although this may suggest that the effect of the increase on equation (4) is ambiguous, the effect is unambiguously negative. Given that lifetime income is constant, a longer lifetime, which leads to a longer retirement, necessitates a higher level of individual saving. This can be checked easily using a multiple-period, certain-longevity framework.

time are constants, respectively g and $\hat{z}$, and standardizing $W(j-1, j-1)$ and $P(j, j-1)$ to W and P, aggregate saving can be written as

$$S(j) = \frac{(1+\hat{z})P}{1+r}\left(\frac{1+r}{1+\rho}\right)^{\frac{1}{\gamma}} \frac{(1+g)W}{1+\frac{(1+\hat{z})P}{1+r}\left(\frac{1+r}{1+\rho}\right)^{\frac{1}{\gamma}}}$$

$$-P\left(\frac{1+r}{1+\rho}\right)^{\frac{1}{\gamma}} \frac{W}{1+\frac{P}{1+r}\left(\frac{1+r}{1+\rho}\right)^{\frac{1}{\gamma}}}. \tag{11}$$

Equation (11) shows that aggregate saving is equal to zero when $g = r$ and $\hat{z} = 0$. This implies that the length of lifetime does not necessarily affect aggregate saving. However, the important point is not the level of lifetime, but the size of the increase in lifetime, $\hat{z}$. Differentiating equation (11) with respect to $\hat{z}$ reveals that a greater increase in lifetime is expected to raise aggregate saving to a greater extent. Intuitively, this is because the younger cohort saves more than the older cohort dissaves in order to prepare for a longer retirement. This indicates that the rate at which lifetime is increasing is positively correlated with aggregate saving.[11]

4. Empirical Analysis

4.1. *Test with Household Saving Rate*

Given the result in the previous sections, a greater increase in lifetime should lead to a higher saving rate. This section aims to test this result.

In recent studies, household data, especially longitudinal data, have been broadly used to examine dissaving behavior or the life-cycle hypothesis. This is because longitudinal data directly show the history of dissaving in each household. Nevertheless, aggregate data are the only practical option for testing the effects of increasing lifetime since data relating to personal expectations of the survival curve are rarely available. The only study which explicitly investigates personal expectations of lifetime is Hamermesh (1985). Hamermesh conducted a questionnaire survey in the U.S. and obtained the result that the life-table survival curve second-order stochastically dominates the personal expected survival curve. This result accords with the theoretical analysis in Section 2. However, his survey data are not related to saving. For this reason, we have no option but to use aggregate data for this analysis.

The relationship between the household saving rate and an increase in lifetime is plotted in Figure 4 for 20 developed countries for which data on the house-

[11]In addition, this model implies that population growth stemming from an increase in life expectancy raises aggregate saving. Since population growth is given by $\frac{\hat{z}P}{1+P}$, a greater increase in lifetime leads to higher population growth as well as a higher level of saving. This demonstrates one aspect of the relationship between population growth and saving. However, we have to bear in mind that population growth stems not only from an increase in lifetime but also from a rise in fertility, which has its own effect on saving.

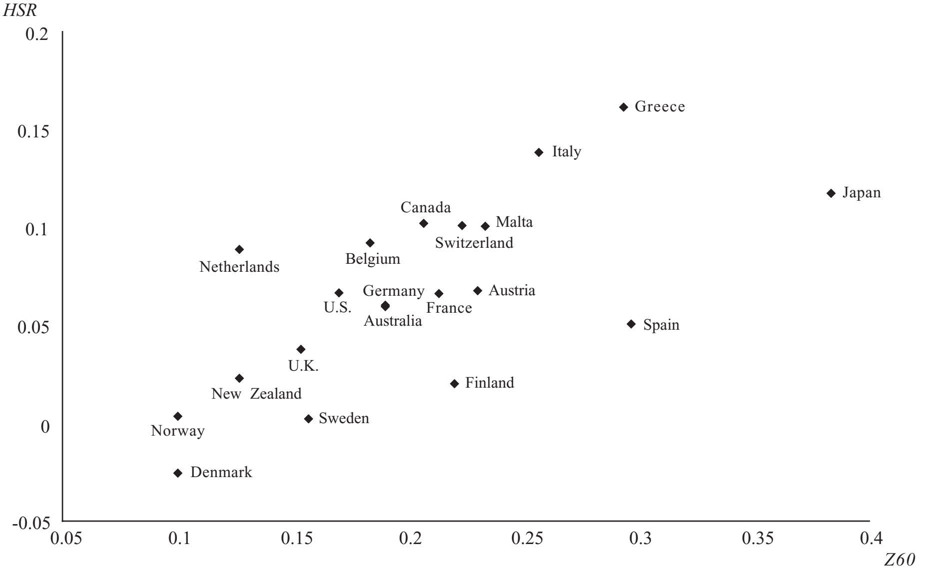

Figure 4. Relationship between HSR and Z60

hold saving rate are available. It shows that the household saving rate and an increase in life expectancy are correlated positively, as predicted by the theoretical analysis. Here, *HSR* is the 1980–89 average of the household saving rate and *Z*60 is the 1960–89 average of the annual increase in life-table life expectancy at birth, the proxy for an increase in lifetime.

The 1960–89 average for the annual increase in life expectancy may seem to be based on a very long period of time compared with the 1980–89 average for the household saving rate. This is based on the assumption that forming expectations with regard to lifetime takes a long period of time. Thinking of death is not a usual thing to do in one's everyday life, and most people only think of death after a relative or friend dies, which fortunately does not occur so often. Expectations about death will be updated at such moments. I therefore assume that forming expectations about lifetime takes a long period of time. Another assumption behind *Z*60 is the linearity of an increase in life expectancy. This assumption relies on the finding, such as Harman (1991) and Lohman, Sankaranarayanan, and Ashby (1992), that life expectancy rises linearly in the long run. More importantly, using *Z*60 as the proxy indicates that we can not isolate the uncertainty effect associated with an increase in lifetime. This is due to data limitations. Although we would like to use the data with regard to the survival curve on an annual basis, they are available for only a handful of countries. If such data were available, we could calculate the variance and use it to isolate the uncertainty effect. However, if the uncertainty effect becomes more significant as life expectancy grows faster, *Z*60 will also reflect the uncertainty effect.[12]

To test the effects further, the household saving rate is regressed on a rise in life expectancy together with the economic and demographic variables which are

[12]For instance, if *Z* is uniformly distributed, its variance will become greater as *Z*60 gets larger.

expected to have influences on the household saving rate and which have been commonly employed in previous studies. These variables are averaged over the years between 1980 and 1989 unless mentioned otherwise. Details such as definitions, sources, and sample countries, are reported in the data appendix.

With respect to the proxy for an increase in lifetime, I continue to use *Z*60. However, *Z*70 or *Z*80, the 1970–89 average or the 1980–89 average of the annual increase in life-table life expectancy at birth, is used instead of *Z*60 in some equations. This is done in order to check the effect of the length of the period over which expectations are formed. Also, *ZEX*, the product of *Z* and *EX* (the level of life expectancy in life tables) is used in some equations in order to provide a comparison between the effects of *ZEX* and *EX*. If people are fully conscious of an increase in lifetime, the effect of *ZEX* should be greater than that of *EX* due to the existence of the uncertainty effect. As shown in equation (5), the sum of *ZEX* and *EX* should be the true life expectancy. Should the uncertainty attached to a lifetime increase be not important, the effects of *ZEX* and *EX* would be equal.

Turning to the other demographic variables, we include two sorts of dependency ratios, *YNG* and *OLD*, respectively the ratio of children to active population and the ratio of the elderly to active population.[13] As for the economic variables, the regression model includes: *GYPC*, the growth rate of real GDP per capita (*YPC*), *RDR*, the real interest rate, *IR*, the inflation rate, and *INVY*, the inverse of *YPC*.[14] The reason for using *INVY* instead of *YPC* is to compare the result here with previous studies that examined saving rates among developed countries.

The effects of these variables are expected as follows. *YNG* and *OLD* are expected to have negative effects as suggested by the life-cycle hypothesis.[15] The effects of *RDR* and *IR* are ambiguous. As for *GYPC*, the effect is also ambiguous as noted by Bosworth (1993). Although it is sometimes argued that the life-cycle hypothesis clearly implies that the rate of economic growth has a positive impact on the aggregate saving rate, this need not be the case. The expectation of higher income in the future can possibly lead to an increase in current consumption at the household level. Thus, if this effect outweighs the aggregate effect, the growth rate would affect the household saving rate negatively. Empirically, however, it is common to capture a positive effect. Next, *EX* is expected to have a positive effect, as in Doshi (1994), since a longer lifetime will normally lead to a longer retirement. Finally, the expected effect of *INVY* is nil under the life-cycle hypothesis.

The method of estimation is weighted least squares using the population of each country as the weighting variable. This method has been extensively used in previous studies, starting with Houthakker (1965).[16]

The results are presented in Table 2. In general, the equations including the *Z*-related variables give good $\bar{R}^2$ ranging from 0.617 to 0.800. As for the *Z*-related variables, the expected results are obtained. First, the coefficients always become

[13]Another possible demographic variable is an index of the change in retirement ages. However, no such index is in fact available or readily constructed.

[14]Using real GDP per equivalent adult or per worker instead of *YPC* does not change the result significantly.

[15]The effect of *YNG* can also be examined using a slight extension of the previous theoretical model. Under a three-period model which incorporates changes in fertility, *YNG* is expected to have a negative impact on household saving rate.

[16]The unweighted regression does not alter the results significantly.

TABLE 2

REGRESSION RESULTS (DEPENDENT VARIABLE: *HSR*)

Eq. #	*Z60*	*Z70*	*ZEX60*	*ZEX70*	*Z80*	*ZEX80*	*EX*	*YNG*	*OLD*	*GYPC*	*RDR*	*IR*	*INVY*	*Adj.* R^2
(2-1)	0.4848						0.0047	–0.877	–0.621	–2.691	0.760	0.675	–0.384	0.720
	2.92						0.62	–3.73	–2.03	–1.90	1.38	2.83	–0.95	
(2-2)	0.5092							–0.861	–0.659	–2.452	0.722	0.665	–0.357	0.734
	3.24							–3.78	–2.26	–1.84	1.35	2.87	–0.91	
(2-3)	0.4320							–0.905	–0.797	–2.363	0.692	0.582		0.738
	3.28							–4.10	–3.22	–1.79	1.31	2.74		
(2-4)	0.3253							–0.919	–0.913	–1.415		0.715		0.725
	3.07							–4.06	–3.85	–1.26		3.74		
(2-5)		0.6874						–0.780	–0.377	–1.931	0.621	0.587		0.780
		3.90						–3.75	–1.30	–1.86	1.35	3.07		
(2-6)			0.0054				0.0029	–0.924	–0.770	–2.620	0.735	0.591		0.723
			2.84				0.38	–4.04	–2.98	–1.85	1.34	2.72		
(2-7)				0.0088			0.0071	–0.813	–0.290	–2.882	0.821	0.569		0.800
				3.98			1.19	–4.08	–1.03	–2.50	1.80	3.13		
(2-8)					0.3105			–0.758	–1.091	–0.170	–0.426	0.665		0.623
					1.87			–2.61	–4.13	–0.15	–0.85	2.58		
(2-9)						0.0036	0.0068	–0.808	–1.010	–0.796	–0.236	0.665		0.617
						1.57	0.79	–2.71	–3.61	–0.59	–0.43	2.56		
(2-10)							0.0098	–1.032	–1.125	0.069	–0.060	0.773	0.200	0.545
							1.06	–3.54	–3.49	0.05	–0.10	2.57	0.45	
(2-11)								–1.014	–1.265	0.909	–0.236	0.761	0.325	0.541
								–3.47	–4.30	0.83	–0.40	2.52	0.75	
(2-12)								–1.022	–1.269	0.808		0.709	0.384	0.568
								–3.61	–4.45	0.78		2.66	0.97	

Notes: All equations include a constant term.
The top figure is the estimated coefficient, and the bottom figure is the *t*-statistic.

significantly positive at the 2 percent level or better when the 1960–89 average or the 1970–89 average is used. Second, replacing *Z*60 with *Z*70 does not change the results significantly. Third, the level of significance becomes lower with *Z*80, indicating that forming expectations about lifetime takes more than one decade. Finally, the coefficients of *ZEX*60 and *ZEX*70 are always larger than the coefficients of *EX*.[17] These points accord with the results in the theoretical analysis.

The most striking result with respect to the other variables is that the coefficients of *GYPC* become negative and generally significant when the *Z*-related variables are included. This result does not accord with previous studies such as Feldstein (1977), Modigliani and Sterling (1983), and Horioka (1989). However, in equations (2-10)–(2-12) where none of the *Z*-related variables is included, the coefficients become positive. Therefore, a positive effect of *GYPC* in these previous studies may stem from the omission of an increase in life expectancy.[18]

Comparing the results in this regression model with previous studies further yields two other points of note. First, *YNG* has a larger effect than *OLD*. Although the coefficients of *OLD* are larger than the coefficients of *YNG* in previous studies, as noted by Bosworth (1993), the coefficients of *YNG* are larger than those of *OLD* in this regression model. Second, the coefficients of *INVY* are negative, but are not significantly different from 0 in this regression model. Although this result accords with the life-cycle hypothesis, Feldstein (1977) and Horioka (1989) found significant and positive coefficients of *INVY*. As noted by Horioka (1989), their result cannot be explained by either the life-cycle hypothesis or the Keynesian model.

These differences also stem from the inclusion of an increase in life expectancy. Without an adequate *Z*-related variable, the results become similar to the previous studies. The coefficients of *OLD* become larger than those of *YNG* in equations (2-8)–(2-12), and the coefficients of *INVY* become positive albeit insignificant in equations (2-10)–(2-12). For these reasons, regression models without an increase in lifetime may possibly contain a specification error.

Turning to the other variables, the coefficients of *RDR* are positive and significant at the 10 percent level in equations (2-1)–(2-7). This may indicate that the real interest elasticity of the household saving rate is positive. Also, the coefficients of *IR* are significantly positive. Several reasons can be suggested for this result, such as the households' desire to maintain the real value of their financial assets, uncertainty associated with inflation as in Horioka (1989), and measurement error due to an increase in measured investment income.

4.2. *Test with Gross Domestic Saving Rate*

To test this result further, I construct a variable, *GSR* (1 − consumption share of GDP − government share of GDP), from the Summers and Heston data set.

[17]Although the null hypothesis that the coefficient of *ZEX* is equal to or smaller than the coefficient of *EX* cannot be rejected in equations (2-6) and (2-7), even at the 20 percent level of significance, this is probably due to the large standard error of *EX* and the small sample size.

[18]In the previous studies cited above, the private saving rate, not the household saving rate, is used as the dependent variable. Besides, the sample periods, sample countries, and explanatory variables are not perfectly equal. Thus, precisely speaking, the result here is not directly comparable with previous results. Nevertheless, these two saving rates are highly correlated, as noted by Horioka (1989), and the expected effects of the independent variables do not differ.

This variable is theoretically comparable to the gross domestic saving rate.[19] Replacing *HSR* by *GSR*, the number of countries covered by the model increases to 126 countries. Although *GSR* should be less sensitive to household decisions, since it is influenced by other sectors of the economy such as government and the corporate sector, results are still expected to be similar to the *HSR* estimation.

However, increasing the number of countries introduces other problems due to the inclusion of developing countries. The endogeneity between economic growth and saving is a good example. While a country is still in the transitional period and its ability to import foreign saving is limited, its saving rate may greatly influence economic growth. This effect is likely to be more significant in developing countries. Moreover, it would not be surprising if the effects of the explanatory variables used here were to vary among the countries at different stages of development. For instance, as mentioned by Giovannini (1983), a positive real interest elasticity of saving cannot be detected easily among developing countries. The effects of the dependency ratios are sometimes difficult to identify, as noted by Ram (1982).

Paying attention to an increase in lifetime, its effect may not be identical between developing and developed countries. For one thing, a greater increase in lifetime may not result in more saving in developing countries since their life expectancy is normally not very high. If people expect to die before retirement even after considering an increase in lifetime, the amount of savings needed for retirement is not affected by an increase in lifetime. Additionally, an increase in lifetime is not necessarily accompanied by more uncertainty in developing countries. This is because the reduction in mortality is relatively concentrated on young ages during the demographic transition which developing countries are generally undergoing. This means that an increase in lifetime shifts the survival curve upwards and to the right during the transitional period, not only to the right as in developed countries. In this case, an increase in lifetime could possibly lead to more certainty rather than more uncertainty.

Due to these problems, I modify the analysis in two ways. First, a dummy variable *DL*5 is included in some equations. *DL*5 is equal to 1 if *YPC* is at least $5,000 and 0 otherwise. Second, weighted two-stage least squares is used for some equations as well as simple weighted least squares. When 2SLS is employed, the instrumental variables include a constant term, the lag of *GYPC* (the 1970–79 average), a measure of openness, the rate of population growth, and the variables shown in the first row of Table 3 (except *GYPC*). Also, *INVY* is replaced by *YPC* for consistency with previous studies.

The results are presented in Table 3. Generally, $\bar{R}^2$ is around 0.50 and using 2SLS does not change the results significantly. Equation (3-1) includes *RDR* and *IR* as the independent variables for 67 countries, equations (3-2)–(3-10) exclude *RDR* and *IR* in order to increase the sample to 126 or 121 countries, and equations (3-11)–(3-18) limit the sample to the countries with *YPC* of at least $5,000. Since *RDR* and *IR* are generally insignificant, I have chosen to omit these variables and increase the number of countries.

[19]A similar variable is also used in Carroll and Weil (1993).

TABLE 3

REGRESSION RESULTS (DEPENDENT VARIABLE: *GSR*)

Eq. #	*Z60*	*Z70*	*ZEX60*	*ZEX70*	*EX*	*YNG*	*OLD*	*GYPC*	*YPC*	*DL5*	*RDR*	*IR*	*Adj.* R^2	# of Sample	Method
(3-1)	0.2906					–0.568	–0.365	–1.463			–0.188	–0.053	0.654	67	WLS
	2.40					–7.67	–1.22	–2.39			–0.81	–0.55			
(3-2)	0.1009				0.0036	–0.264	–0.571	–0.379	0.0023				0.572	126	WLS
	2.12				2.75	–4.06	–2.20	–1.41	1.02						
(3-3)	0.0974				0.0034	–0.278	–0.674	–0.336		0.035			0.597	126	WLS
	2.26				2.69	–4.25	–2.47	–1.25		1.51					
(3-4)	0.0763				0.0043	–0.262	–0.526	–0.393					0.572	126	WLS
	1.86				3.76	–4.03	–2.05	–1.46							
(3-5)		0.1030			0.0045	–0.331	–0.775	–0.431					0.576	126	WLS
		2.17			4.27	–4.68	–4.21	–1.61							
(3-6)			0.0012		0.0038	–0.257	–0.500	–0.370					0.573	126	WLS
			1.90		3.04	–3.96	–1.90	–1.41							
(3-7)				0.0019	0.0037	–0.337	–0.722	–0.442					0.580	126	WLS
				2.40	3.13	–4.79	–3.84	–1.68							
(3-8)					0.0051	–0.268	–0.865	–0.166					0.564	126	WLS
					4.89	–4.10	–4.75	–0.69							
(3-9)	0.2506				0.0012	–0.503	–0.472	–2.447					0.464	121	2SLS(W)
	2.38				0.57	–3.11	–1.55	–2.02							
(3-10)		0.1259			0.0044	–0.372	–0.866	–0.657					0.579	121	2SLS(W)
		1.97			3.65	–3.03	–3.47	–1.08							
(3-11)	0.3059					–0.524	–0.825	0.376	–0.0040				0.577	42	WLS
	3.71					–5.90	–3.06	0.91	–1.89						
(3-12)	0.3103					–0.560	–0.821		–0.0041				0.579	42	WLS
	3.77					–7.06	–3.05		–1.92						
(3-13)		0.2212				–0.559	–1.082	0.489	–0.0070				0.501	42	WLS
		2.49				–5.59	–3.99	1.09	–3.07						
(3-14)			0.0045		–0.0029	–0.527	–0.786	0.417	–0.0034				0.567	42	WLS
			3.52		–0.54	–5.10	–2.82	0.79	–1.47						
(3-15)				0.0032	–0.0005	–0.548	–1.052	0.427	–0.0068				0.487	42	WLS
				2.24	–0.09	–4.59	–3.75	0.73	–2.93						
(3-16)					0.0053	–0.439	–1.264	0.122	–0.0065				0.430	42	WLS
					0.95	–3.82	–4.54	0.20	–2.66						
(3-17)	0.2927					–0.444	–0.708	0.934	–0.0033				0.584	38	2SLS(W)
	3.39					–4.79	–2.64	1.63	–1.49						
(3-18)		0.2243				–0.481	–0.920	1.051	–0.0062				0.515	38	2SLS(W)
		2.48				–4.62	–3.40	1.76	–2.75						

Notes: Refer to Table 2.

Looking at the effect of the Z-related variables, the expected results are obtained once again.[20] The coefficients of the Z-related variables are significantly positive at up to the 1 percent level. However, the coefficients of ZEX are now smaller than the coefficients of EX in the full-sample estimation. In equations (3-6) and (3-7), the coefficients of EX become larger than those of ZEX with good t-values. This probably results from the inclusion of developing countries, as mentioned earlier. When the sample of countries is limited to those with YPC of at least $5,000, the coefficients of the Z-related variables become larger while the coefficients of EX become insignificant and negative.[21] This possibly indicates that the variation in lifetime is more influential in developed countries.

Turning to the other demographic variables, YNG and OLD are found to be important, as in the HSR estimation. Although the coefficients of OLD are larger than those of YNG in almost all equations, the tendency towards a rise in the relative importance of YNG with the inclusion of the Z-related variables does not change. On the other hand, the effects of the economic variables, both $GYPC$ and YPC, now become ambiguous. The coefficients of $GYPC$ become negative under the full-sample estimation and positive under the limited-sample estimation. Also, the level of significance depends on the regression method, yielding a higher level of significance with 2SLS. The coefficients of YPC also change in sign: they are insignificant and positive in the full-sample estimation, but negative and sometimes significant in the limited-sample estimation.

4.3. *Case Study*

The above results strongly suggest that an increase in life expectancy has a positive impact on saving rates, and accord with the results in the theoretical analysis.

A further question relates to the explanatory power of an increase in lifetime on the saving rates. For this purpose, we apply the estimated coefficients of the regression models to Japanese data.

First, we examine the effect of a rise in life expectancy on GSR. The results are summarized in the third column of Table 4. Here, the coefficients from the limited-sample estimation are used since the effect of an increase in lifetime is expected to differ between developing and developed countries. Applying the coefficients obtained from equation (3-12), which yields the highest $\bar{R}^2$ in the limited-sample estimation, the estimated GSR becomes 32.24 percent while the true GSR is 34.49 percent. Now, suppose that the increase in life expectancy declines to the mean level while the other variables remain unchanged. The estimated GSR would become 29.46 percent, which is 8.6 percent lower than the current estimated level.[22] Furthermore if the decline should reach the lowest level, that of Hungary, the estimated GSR would become 22.93 percent, which is 29 percent lower.

[20]The results with $Z80$ and $ZEX80$ are not reported in Table 3 because the results are similar to the ones in the HSR estimation. The coefficients of $Z80$ and $ZEX80$ become less significant.

[21]The null hypothesis that the coefficient of $ZEX60$ is equal to or smaller than the coefficient of EX can be rejected in equation (3-14) at the 15 percent level of significance.

[22]The figure 8.6 percent comes from $\frac{32.24-29.46}{32.24}$.

TABLE 4
EFFECT OF Z-RELATED VARIABLES ON JAPANESE SAVING RATES

	Z (years)	*GSR* (%) Eq. (3-12)	*HSR* (%) Eq. (2-3)	Eq. (2-7)
Estimated value		32.24	11.43	11.63
Estimated value	*Z60 (GSR)* = 0.29	29.46		
with mean *Z*	*Z60 (HSR)* = 0.20		3.63	
	ZEX70 (HSR) = 16.79			1.83
Estimated value	*Z60* = 0.08 (Hungary)	22.93		
with lowest *Z*	*Z60* = 0.10 (Denmark)		–0.80	
	ZEX70 = 7.48 (Denmark)			–6.36

The effect of a rise in life expectancy is even stronger under the *HSR* estimation as presented in the fourth and fifth columns of Table 4. Using the mean level of *Z*60 and the coefficients from equation (2-3), which gives the best $\overline{R}^2$ with *Z*60, the estimated *HSR* would drop by more than two thirds from the current estimated level of 11.43 percent, to 3.63 percent. If *Z*60 should decrease to the lowest level, that of Denmark, the estimated *HSR* would become negative, falling to –0.80 percent. The results are particularly striking if we use the coefficients from equation (2-7), which yields the highest $\overline{R}^2$ in this regression model. The estimated *HSR*, currently 11.63 percent, would fall to 1.83 percent and –6.36 percent respectively based on the mean and lowest levels of *ZEX*70.

These results indicate the important role played by an increase in lifetime in explaining saving rates. In particular, Japan's high saving rates relative to those of other developed countries may be attributed to its large increase in life expectancy. Japan's household saving rate is 11.75 percent, the third highest after Greece and Italy, while its increase in life expectancy has been the largest among the 20 countries.

5. CONCLUSION

The purpose of this study is to examine the effects on saving of a continuous increase in lifetime. Sections 2 and 3 showed that, under the framework of the life-cycle hypothesis, an increase in lifetime positively affects saving. This result is tested in Section 4 and supported by evidence that a rise in life expectancy is accompanied by higher saving rates.

This conclusion has the following implications. First, the effect of an aging population on saving is ambiguous. This is because the two factors that cause the population to age have opposite effects on saving. On the one hand, an increase in lifetime has a positive effect on saving while on the other, the aging of baby boomers has a negative effect. Therefore, studies focusing on the relative importance of these two factors are indispensable if we are to comprehend the effect of an aging population on saving.

Second, Japan's saving rates could decrease more than expected. As shown in Figure 1, Japan's rise in life expectancy has been remarkable. However, this trend may not continue in the future. Thus, a smaller increase in lifetime could lead to a reduction in saving, even though the level of life expectancy should remain high.

In this case, both a smaller increase in life expectancy and the aging of baby boomers will have a negative impact on saving, resulting in a greater decline in saving than one might first expect.

Data Appendix

Definition of Variables

The 1980–89 averages are taken unless mentioned otherwise.
HSR: the ratio of net household saving to household income.
GSR: 1 – real consumption share of GDP (1985 intl. prices)
– real government share of GDP (1985 intl. prices).
EX: life expectancy at birth in life tables.
*Z*60: average annual increase in *EX* between 1960 and 1989.
*Z*70: average annual increase in *EX* between 1970 and 1989.
*Z*80: average annual increase in *EX* between 1980 and 1989.
*ZEX*60: *Z*60 ∗ *EX*.
*ZEX*70: *Z*70 ∗ *EX*.
*ZEX*80: *Z*80 ∗ *EX*.
YNG: the ratio of those 14 and under to those between 15 and 64.
OLD: the ratio of those 65 and over to those between 15 and 64.
YPC: real GDP per capita in thousands of constant dollars expressed in 1985 international prices (Chain Index).
GYPC: annual growth rate of *YPC*.
INVY: inverse of *YPC*.
IR: the rate of change in consumer price index.
RDR: discount rate – *IR*.
*D*L5: 1 if *YPC* is over 5,000, and 0 otherwise.

Source

HSR: U.N. (1993).
GSR, *YPC*: Summers and Heston (1991).
EX, *Z*, *YNG*, *OLD*: U.N. (1996).
IR, *RDR*: IMF (1998).

Sample Countries

HSR (20)

Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Malta, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, U.K., U.S.

GSR (67)

Australia, Austria, Bangladesh, Barbados, Belgium, Botswana, Burkina Faso, Burundi, Cameroon, Canada, Central African Republic, Colombia, Congo, Costa Rica, Cyprus, Denmark, Ecuador, Egypt, Fiji, Finland, France, Gabon, Gambia, Germany, Greece, Guatemala, Guyana, Hungary, Iceland, India, Ireland, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Lesotho, Malaysia, Malta, Mauritius, Morocco, Netherlands, New Zealand, Niger, Nigeria, Norway, Pakistan, Papua New Guinea, Philippines, Portugal, Senegal, South Africa, Spain, Sri Lanka, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Thailand, Togo, Trinidad and Tobago, Turkey, U.K., U.S., Venezuela, Zimbabwe.

GSR (126 and 42)

Countries included in both 126 and 42 sample

Argentina, Australia, Austria, Barbados, Belgium, Bulgaria, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Oman, Portugal, Puerto Rico, Qatar, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, Trinidad and Tobago, U.K, U.S.A, United Arab Emirates, Venezuela, Yugoslavia.

Countries included only in 126 sample

Algeria, Angola, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Gabon, Gambia, Ghana, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran, Jamaica, Jordan, Kenya, Korea, Lesotho, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Morocco, Mozambique, Myanmar, Namibia, Nicaragua, Niger, Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Reunion, Romania, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Sri Lanka, Sudan, Suriname, Swaziland, Syrian Arab Republic, Thailand, Togo, Tunisia, Turkey, Uganda, Uruguay, Yemen, Zaire, Zambia, Zimbabwe.

GSR (121 and 38)

GSR (126): Belize, Bulgaria, Kuwait, Qatar, United Arab Emirates.
GSR (42): Bulgaria, Kuwait, Qatar, United Arab Emirates.

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