72. R. Dalla-Favera *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **79**, 7824 (1982).
73. T. L. Yang-Feng, U. Francke, A. Ullrich, *Science* **228**, 728 (1985); E. J. McAloon, *N. Engl. J. Med.* **313**, 758 (1985).
74. J. Battey *et al.*, *Cell* **34**, 779 (1983); R. P. Perry, *ibid.* **33**, 647 (1983); O. Bernard, S. Cory, S. Gerondakis, E. Webb, J. M. Adams, *EMBO J.* **2**, 2375 (1983).
75. C. M. Croce *et al.*, *Science* **227**, 1044 (1985).
76. B. de Martinville, J. Giacolone, C. Shih, R. A. Weinberg, U. Francke, *Science* **219**, 498 (1983); B. de Martinville and U. Francke, *Nature (London)* **305**, 641 (1983); S. C. Jhanwar, B. G. Neel, W. S. Hayward, R. S. Chaganti, *Proc. Natl. Acad. Sci. U.S.A.* **80**, 4794 (1983); R. Baer, K.-C. Chen, S. D. Smith, T. H. Rabbitts, *Cell* **43**, 704 (1985).
77. E. J. McAloon, *N. Engl. J. Med.* **313**, 758 (1985); S. D. Smith, R. Morgan, M. P. Link, P. McFall, F. Hecht, *Blood* **67**, 650 (1986).
78. C. Murre *et al.*, *Nature (London)* **316**, 549 (1985).
79. M. K. L. Collins *et al.*, *EMBO J.* **3**, 2347 (1984); C. C. Morton, A. D. Duby, R. L. Eddy, T. B. Shows, J. G. Seidman, *Science* **228**, 582 (1985).
80. M. Isobe, J. Erikson, B. S. Emanuel, P. C. Nowell, C. M. Croce, *Science* **228**, 580 (1985); L. Zech and V. Haglund, *Hereditas* **89**, 69 (1978); Ayme *et al.*, *Hum. Genet.* **31**, 161 (1976); J. H. Ray and J. German, in *Chromosome Mutation and Neoplasia*, J. German, Ed. (Liss, New York, 1983), p. 135; A. Aurias *et al.*, *Hum. Genet.* **29**, 235 (1981); J. M. J. C. Scheres, T. W. J. Hustinx, J. M. Trent, *Cancer Genet. Cytogenet.* **19**, 151 (1986).
81. P. H. Duesberg, *Science* **228**, 669 (1985); H. Rubin, *Cancer Res.* **45**, 2935 (1985).
82. J. L. Bos *et al.*, *Nature (London)* **315**, 726 (1985).
83. A. Koufos *et al.*, *ibid.* **316**, 330 (1985).
84. A. G. Knudson, Jr., *Cancer Res.* **45**, 1437 (1985).
85. J. Campisi, H. E. Gray, A. B. Pardee, M. Dean, G. E. Sonenshein, *Cell* **36**, 241 (1984).
86. K. Kelly, B. H. Cochran, C. D. Stiles, P. Leder, *ibid.* **35**, 603 (1983).
87. A. G. Knudson, Jr., *Adv. Hum. Genet.* **8**, 1 (1977).
88. S. Louie and R. S. Schwartz, *Sem. Hematol.* **15**, 117 (1978); D. Purtilo *et al.*, in *Pathogenesis of Leukemias and Lymphomas: Environmental Influences*, I. T. Magrath, G. T. O'Conor, B. Ramot, Eds. (Raven, New York, 1984), p. 235; W. H. Schubach, G. Miller, E. D. Thomas, *Blood* **65**, 535 (1985); A. H. Filipovich, D. Zerbe, D. B. Spector, J. H. Kersey, in *Pathogenesis of Leukemias and Lymphomas: Environmental Influences*, I. T. Magrath, G. T. O'Conor, B. Ramot, Eds. (Raven, New York, 1984), p. 225; H. Mitsuya *et al.*, *J. Exp. Med.* **158**, 994 (1983).
89. D. Opstelten and D. G. Osmond, *J. Immunol.* **131**, 2635 (1983).
90. U. Bertazzoni and F. J. Bollum, *Terminal Transferase in Immunobiology and Leukemia* (Plenum, New York, 1982); S. V. Desiderio *et al.*, *Nature (London)* **311**, 752 (1984); G. Siu *et al.*, *Nature (London)* **311**, 344 (1984).
91. M. F. Greaves and L. C. Chan, *Br. J. Haematol.* **64**, 1 (1986).
92. K. Lennert, *Malignant Lymphomas* (Springer-Verlag, Berlin, 1978).
93. A. Bernard, L. Boumsell, J. Dauset, C. Milstein, S. F. Schlossman, Eds., *Leukocyte Typing* (Springer-Verlag, Berlin, 1984).
94. E. L. Reinherz, B. F. Haynes, L. M. Nadler, I. D. Bernstein, Eds., *Leukocyte Typing II* (Springer-Verlag, New York, 1986).
95. A. T. Look *et al.*, *Blood* **60**, 959 (1982); J. H. Scarffe *et al.*, *Br. J. Cancer* **41**, 764 (1980); L. W. Dow, L. J. A. Chang, A. A. Tsiatis, S. L. Melvin, W. P. Bowman, *Blood* **59**, 1197 (1982).
96. M. F. Greaves *et al.*, *Int. J. Immunopharmacol.* **3**, 283 (1981).
97. P. M. Chen, S. H. Kwan, T. S. Hwang, B. N. Chiang, C. K. Chou, *Blood* **62**, 251 (1983); C. H. Pui and M. E. Costlow, *Leuk. Res.* **9**, 843 (1985).
98. G. S. K. Yarbro, M. E. Lippman, G. E. Johnson, B. G. Leventhal, *Cancer Res.* **37**, 2688 (1977); M. E. Costlow, C. H. Pui, G. V. Dahl, *Leukemia Research: Advances in Cell Biology and Treatment*, S. B. Murphy and J. R. Gilbert, Eds. (Elsevier, New York, 1983), p. 171; P. A. Bell, M. F. Greaves, J. C. Sloman, E. N. Thompson, J. A. Whittaker, *J. Steroid Biochem.* **19**, 851 (1983).
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# Life Cycle, Individual Thrift, and the Wealth of Nations

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**One theory of the determinants of individual and national thrift has come to be known as the life cycle hypothesis of saving. The state of the art on the eve of the formulation of the hypothesis some 30 years ago is reviewed. Then the theoretical foundations of the model in its original formulation and later amendment are set forth, calling attention to various implications, some distinctive to it and some counterintuitive. A number of crucial empirical tests, both at the individual and the aggregate level, are presented as well as some applications of the life cycle hypothesis of saving to current policy issues.**

*THE ROLE OF THRIFT AND THE KEYNESIAN REVOLUTION.* The study of individual thrift and aggregate saving and wealth has long been central to economics because national saving is the source of the supply of capital, a major factor of production controlling the productivity of labor and its growth over time. It is because of this relation between saving and productive capital that thrift has traditionally been regarded as a virtuous, socially beneficial act.

Yet, there was a brief but influential interval in the course of which, under the impact of the Great Depression and of the interpretation of this episode which Keynes suggested in the *General Theory of Employment, Interest and Money* (*1*), saving came to be seen with suspicion, as potentially disruptive to the economy and harmful to social welfare. The period in question goes from the mid-1930's to the late 1940's or early 1950's. Thrift posed a potential threat, as it reduced one component of demand, consumption, without systematically and automatically giving rise to an offsetting expansion in investment. It might thus cause "inadequate" demand—and, hence, output and employment lower than the capacity of the economy. This failure was attributable to a variety of reasons including wage rigidity, liquidity preference, fixed capital coefficients in production, and investment controlled by animal spirits rather than by the cost of capital.

Not only was oversaving seen as having played a major role in the Great Depression, but, in addition, there was widespread fear that the problem might come back to haunt the postwar era. These fears were fostered by a widely held conviction that, in the future, there would not be too much need for additional accumulation of capital while saving would rise even faster than income. This combination


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could be expected to result, sooner or later, in saving outstripping the "need" for capital. These concerns were at the base of the "stagnationist" school which was prominent in the 1940's and early 1950's.

*Early Keynesian theories of the determinants of saving.* It is interesting and somewhat paradoxical that the present-day interest and extensive research activity about saving behavior owes its beginnings to the central role assigned by Keynesian economics to the consumption function as a determinant of aggregate demand and to the concern with oversaving as a source of both cyclical fluctuations and long-run stagnation. It is for this reason that the early endeavor to model individual and aggregate saving behavior was dominated by the views expressed on this subject by Keynes in the General Theory, and in particular by his well-known "fundamental psychological [rather than 'economic'] law" (*1*, p. 96) to the effect that an increase in income can be counted on to lead to a positive but smaller change in consumption. Even when the analysis followed the more traditional line of demand theory, it relied on a purely static framework in which saving was seen as one of the many "goods" on which the consumer could spend his income. Thus, income was seen as the main systematic determinant of both individual and national saving, and, in line with Keynes' "law," it was regarded as a superior commodity (that is, one on which "expenditure" rises with income) and most likely a luxury, for which expenditure rises faster than income. Also, in contrast to other goods, the "expenditure" on saving could be negative—and, accordingly, dissaving was seen as typical of people or countries below some "break-even" level of income. All these features could be formalized by expressing consumption as a linear function of income with a substantial positive intercept. This formulation was supported by the findings of numerous budget studies, and even by the newly developed National Income Accounts, spanning the period of the Great Depression, at the bottom of which saving turned small or even negative.

As is apparent, in this early phase the dominant approach could best be characterized as crudely empirical; little attention was given to why rational consumers would choose to "allocate" their income to saving. The prevailing source of substantial saving was presumably the desire of the rich to bequeath an estate [Keynes' "pride" motive (*1*, p. 108)]. Accordingly, the main source of the existing capital stock could be traced to inheritance. Similarly, there was little evidence of concern with how, and how long, "poor" people or countries could dissave without having saved first or without exceeding their means.

*Three landmark empirical studies.* In the second half of the 1940's, three important empirical contributions dealt a fatal blow to this extraordinarily simple view of the saving process. First, the work of Kuznets (*2*) and others provided clear evidence that the saving ratio had not changed much since the middle of the 19th century despite the large rise in per capita income. Second, a pathbreaking contribution of Brady and Friedman (*3*) provided a reconciliation of Kuznets' results with budget study evidence of a strong association between the saving rate and family income. They demonstrated that the consumption function implied by family data shifted up in time as mean income increased, in such a way that the saving rate was explained not by absolute family income but rather by its income relative to overall mean income.

Ways of reconciling these findings with the standard linear consumption function were soon provided by Duesenberry (*4*) and Modigliani (*5*), though within the empirical tradition of the earlier period. Duesenberry's "relative income hypothesis" accounted for the Brady-Friedman results in terms of imitation of the upper classes. This is an appealing explanation, though it fails to come to grips with the budget constraint in the case of would-be dissavers below mean income. Similarly, the "Duesenberry-Modigliani" consumption function tried to reconcile the cyclical variations of the saving ratio with its long-run stability by postulating that current consumption was determined not just by current income but also by its highest previous peak, resulting in a ratchet-like upward creep in the short-run consumption function. In my own formulation, primary stress was placed on reasons the savings rate should move procyclically and on the consideration that in an economy with stable long-run growth, the ratio of the current to highest previous income could be taken as a good measure of cyclical conditions. Duesenberry on the other hand, put more stress on consumers explicitly anchoring their consumption on the previous peak. This formulation was brought to its logical conclusion by Brown (*6*) when he proposed that the highest previous income should be replaced by the highest previous consumption.

The third fundamental contribution was the highly imaginative analysis of Reid (*7*) which pointed to a totally different explanation for the association between the saving ratio and relative income, namely that consumption was controlled by normal or "permanent," rather than current, income. This contribution was an important source of inspiration, both for the life cycle and for the roughly contemporaneous permanent income hypothesis (PIH) of Friedman (*8*).

## The Life Cycle Hypothesis

Between 1952 and 1954, Brumberg and I wrote two essays, one on utility analysis and the consumption function [MB-C (*9*)] and a later one on utility analysis and the aggregate consumption function [MB-A (*10*)]. These provide the basis for what has since come to be known as the life cycle hypothesis of saving (LCH). Our purpose was to show that all these well-established empirical regularities could be accounted for in terms of rational, utility-maximizing consumers allocating optimally their resources to consumption during their lives, in the spirit of Fisher (*11*).

*Utility maximization and the role of life resources (permanent income).* The hypothesis of utility maximization (and perfect markets) has, all by itself, one very powerful implication—the resources that a representative consumer allocates to consumption at any age will depend only on life resources (the present value of labor income plus bequests received, if any) and not at all on income accruing currently. When combined with the self-evident proposition that the representative consumer will choose to consume at a reasonably stable rate, close to his anticipated average life consumption, we can reach one conclusion fundamental for an understanding of individual saving behavior, namely, that the size of saving during short periods of time, like a year, will be swayed by the extent to which current income departs from average life resources.

This conclusion is common to LCH and to Friedman's PIH, which differs primarily in that it models rational consumption and saving decisions under the "simplifying" assumption that life is indefinitely long. Accordingly, the notion of life resources is replaced by that of "permanent income," while the discrepancy between current and permanent income is labeled "transitory" income.

The notion that saving largely reflects transitory income has a number of implications that have received ample empirical support, even with some occasional controversy. Among these implications, the best known and well established is that relating to the upward bias arising in estimating the slope of a saving-income relation from budget data, when, as usual, the individual observations are classified by current income classes. Because of the correlation between transitory and current income (relative to mean income), the regression line tends to be steeper than the underlying true relation between the (permanent) saving rate and permanent income. Thus, the estimated saving function departs from the true one by being rotated counterclockwise around the mean, to an extent that is greater the greater the variability of transitory income—for example, more for a sample of farmers than for one of government employees. It is this phenomenon that accounts for the finding of Brady-Friedman (*3*) that the saving ratio, estimated from budget studies at different points of time, appears to depend on the income not in absolute terms but rather relative to overall mean income.

This same consideration provides an explanation for a famous counterintuitive empirical finding first observed in a large survey conducted in the United States in 1936, namely that black families appeared to save more (or dissave less) than white families at any level of income. The reason, of course, is that black families tend to have a much lower average level of permanent income, and, therefore, at any given level of current income the transitory component, and hence saving, tended to be larger (*12*).

The extent of bias in the cross-sectional saving function should tend to decline if the households are classified by some criterion less positively correlated with transitory income, and this prediction too has been extensively verified (*13*).

However, we do not intend to pursue here any further the implications of the relation between saving and transitory income since, as already noted, these implications are basically the same for LCH as for PIH. We concentrate, instead, on those aspects that are specific to LCH.

*LCH: The "stripped down" version.* By explicitly recognizing the finite life of households, the LCH could deal with variations in saving other than those resulting from the transitory deviations of income from life resources of PIH. In particular, it could focus on those systematic variations in income and in "needs" which occur over the life cycle, as a result of maturing and retiring, and of changes in family size—hence the name of life cycle hypothesis. In addition, the LCH was in a position to take into account bequests and the bequest motive, which were not amenable to analysis within the approximation of infinite life.

In MB-C (*9*) and in the first two parts of the MB-A (*10*), we made a number of simplifying, stylized assumptions concerning the life cycle path of household opportunities and tastes in order to draw out the essential implications of the LCH approach. These were (i) opportunities—income constant until retirement, zero thereafter; zero interest rate; and (ii) preferred allocation—constant consumption over life; no bequests.

For this "basic" or "stripped down" model, the life cycle path of saving and wealth is described in the graph of Fig. 1. Because the retirement span follows the earning span, consumption smoothing leads to a humped-shaped age path of wealth holding, a shape that had been suggested earlier by Harrod (*14*) under the label of hump saving (though "hump wealth" would seem like a more descriptive label).

In MB-A, it was shown that this basic model led to a number of implications which were at that time quite novel and surprising—almost counterintuitive. They included the following six propositions.

1) The saving rate of a country is entirely independent of its per capita income.

2) The national saving rate is not simply the result of differential thrift of its citizens in the sense that different national saving rates are consistent with an identical individual (life cycle) behavior.

3) Between countries with identical individual behavior the aggregate saving rate will be higher the higher the long-run growth rate of the economy. It will be zero for zero growth.

4) The wealth-income ratio is a decreasing function of the growth rate, thus being largest at zero growth.

5) An economy can accumulate a very substantial stock of wealth relative to income even if no wealth is passed on by bequests.

6) The main parameter that controls the wealth-income ratio and the saving rate for given growth is the prevailing length of retirement.

To establish these propositions, we begin by considering the case of a stationary economy and then that of steady growth.

*The case of a stationary economy.* Suppose that there is neither productivity nor population growth, and assume, conveniently, that mortality rate is 1 at some age $L$ and 0 before. Then, clearly, Fig. 1 will represent the age distribution of wealth, saving, consumption, and income, up to a factor representing the (constant) number of people in each age bracket. Hence, the aggregate wealth-income ration, $W/Y$, is given by the ratio of the sum of wealth held at each age—the area under the wealth path—to the area under the income path. This has a number of significant implications.

First, it is apparent from the graph that $W/Y$ depends on a single parameter, the length of retirement, $M$, which establishes proposition 6 above. The relation between $M$ and $W/Y$ turns out to be extremely simple, to wit (*10*, note 38)

$$W/Y = M/2 \qquad (1)$$

Second, assuming the average length of retirement to be 10 years (*9*), implying a wealth-income ratio of 5, produced an exciting result in that this value was close to the income ratio suggested by preliminary estimates of Goldsmith's monumental study of U.S. savings (*15*). It implied that one could come close to accounting for the entire wealth holding of the United States without any appeal to the bequest process (proposition 5), a quite radical departure from conventional wisdom.

Third, with income and population stationary, aggregate wealth must remain constant in time and, therefore, the change in wealth or rate of saving must be zero, despite the large stock of wealth (proposition 3). The explanation is that, in stationary state, the dissaving of the retired, from wealth accumulated earlier, just offsets the accumulation of the active population in view of retirement. Saving could occur only transiently if a shock pushed $W$ away from $(M/2)\overline{Y}$, where $\overline{Y}$ is the stationary level of income $Y$; then, as long as $Y$ remained at $\overline{Y}$, wealth would gradually return to the equilibrium level $(M/2)\overline{Y}$.

*The case of a steadily growing economy.* In this case, the behavior of the saving rates can be inferred from that of aggregate private wealth, $W$, through the relation $S = \Delta W$, implying

$$s \equiv \frac{S}{Y} = \frac{\Delta W}{W}\frac{W}{Y} = \rho w \qquad \frac{ds}{d\rho} = w + \rho\frac{dw}{d\rho} \qquad (2)$$

where $w$ is the wealth-income ratio and $\rho$ is the rate of growth of the economy which in steady state equals the rate of growth of wealth, $\Delta W/W$. Since $w$ is positive and is based on a level life cycle consumption and income, which ensures that it is independent of the level of income, we have established propositions 1 and 2. If, in addition, the age profile of the wealth-income ratio could be taken as independent of growth, then the saving rate would be proportional to growth with a proportionality factor equal to $M/2$, substantiating proposition 3. Actually, the model implies that $w$ is a declining function of $\rho$ (proposition 4), though with a small slope, so that the slope of the relation between $s$ and $\rho$ tends to flatten out as $\rho$ grows.

When the source of growth is population, the mechanism behind positive saving may be labeled the Neisser effect (*16*): younger households in their accumulation phase account for a larger share of population, and retired dissavers for a smaller share, than in the stationary society. However, $w$ also falls with $\rho$ because the younger people also are characterized by relatively lower levels of wealth holding. Thanks to the simplifying assumptions of the basic model, it was possible to calculate explicitly values for $w$ and $s$: for $\rho = 2\%$, $w = 4$, and $s = 8\%$; for $\rho = 4\%$, $w = 3.25$, and $s = 13\%$.

When the growth is due to productivity, the mechanism at work may be called the Bentzel effect (*17*). Productivity growth implies that younger cohorts have larger lifetime resources than older ones, and, therefore, their savings are larger than the dissaving of the poorer retired cohorts.

If agents plan their consumption as though they did not anticipate the future growth of income, then $w(\rho)$ and $s(\rho)$ for productivity growth are just about the same as for population growth, for values of $\rho$ in the relevant range (*10*). It should be noted that this conclusion is diametrically opposite to that reached by Friedman (*8*, p. 234), namely that productivity growth should tend to depress the saving ratio on the ground that a rise in income "expected to continue tends to raise permanent income relative to measured income and so to raise consumption relative to measured income." This difference in the implications of the two models—one of the few of any significance—can be traced to the fact that, if life is infinite, there cannot be a Bentzel effect. To be sure, to the extent that agents anticipate fully future income, they will tend to shift consumption from the future to the present, and this will tend to reduce the path of wealth and perhaps even generate negative net worth in early life (*18*). But this effect must be overshadowed by the Bentzel effect, at least for small values of $\rho$ which, realistically, are what matter. (This follows from the continuity of $ds/d\rho$ in Eq. 2.)

The model also implies that the short-run behavior of aggregate consumption could be described by a simple aggregate consumption function, linear in aggregate (labor) income ($YL$), and wealth ($W$).

$$C = \alpha YL + \delta W \tag{3}$$

An equation of this type had been proposed by Ackley (*19*), although both the functional form and the presumed stability of the coefficients rested on purely heuristic considerations. By contrast, we showed that, if income followed closely the steady growth path, then the parameters $\alpha$ and $\delta$ could be taken as constant in time and determined by the length of life ($L$), of retirement ($M$), and the rate of growth (*10*, p. 135). For the standard assumption $L = 50$, $M = 10$, and $\rho = 0.03$, $\delta$ comes to 0.07 (*10*, p. 180). Furthermore, the parameters could be well approximated by the same constant even if income moved around the trend line, as long as the departures were not very long lasting and deep, except that $YL$ should be interpreted as long-run expected rather than current income. The short-run Eq. 3 is, of course, consistent with the long-run properties, propositions 1 to 6, as one can readily verify.

*Empirical verifications.* None of these long- and short-run implications of the basic model could be explicitly tested at the time they were established. There were no data on private net worth to test Eq. 3, except for some indirect estimates pieced together by Hamburger (*20*) and some preliminary Goldsmith (*15*) figures for a few selected years. Similarly, information on private national saving was available only for a couple of countries. We could only take encouragement from the fact that the model seemed to fit the single observation available, namely the United States. Both the wealth income ratio, 4 to 5, and the saving rate, $S$, "between one-seventh and one-eighth" (*15*) were broadly consistent with the prediction of the model, for a 3% growth rate, namely 4.33 for $w$ and 13% for $s$.

Availability of data improved dramatically in the next decade. An annual time-series of U.S. private wealth was put together in the early 1960's (*21*), and Eq. 3 was tested (*22*). It was found to fit the data quite well and with parameter estimates close to those predicted by the model. By now the consumption function has become pretty much standard, having been estimated for many countries and periods. The coefficient of wealth is frequently lower than 0.07, but

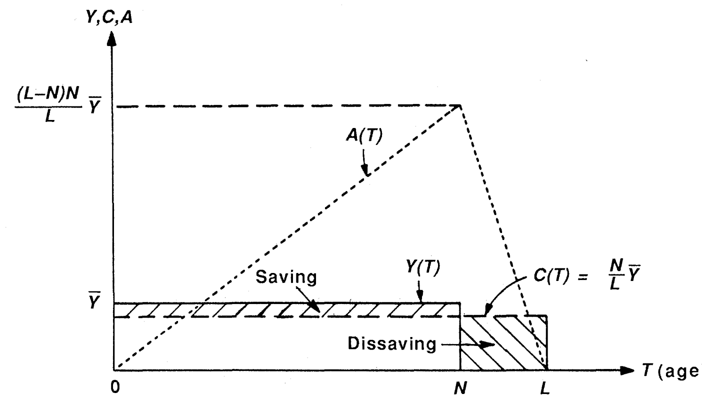


Fig. 1. Income, consumption, saving, and wealth as a function of age. $A(T)$ is net worth at age $T$, $C$ is consumption, $A$ is net worth, $Y(T)$ is income at age $T$, $N$ is retirement age, $L$ is length of life, and $\bar{Y}$ is the level of income throughout the working span.

this can be accounted for, at least in part, by the fact that $Y$ is typically defined as total rather than just labor income.

Also by the early 1960's, the United Nations had put together national account statistics for a substantial number of countries, characterized by wide differences in the growth rate, and it became possible to test the relation between the national saving ratio and the growth rate. The early tests were again quite successful (*23–26*). The newly available data revealed that the saving ratio for the United States, by far the richest country in the world, was rather low compared with other industrial countries (Fig. 2). The LCH could account for this through a relatively modest growth rate. By now it is generally accepted that growth is a major source of cross-country differences in the saving rate.

*The effect of dropping the simplifying assumptions.* Most of the simplifying assumptions can be replaced by more "realistic" ones without changing the basic nature of the results, and, in particular, the validity of propositions 1 to 5 above (*10*).

First, we must consider a nonzero interest rate. Allowing for a nonzero interest rate, $r$, has two effects. One effect is on income as we must distinguish between labor income, say $YL$, property income, $YP$, whose "permanent component" may be approximated by $rA$, and total income, $Y = YL + YP = YL + rA$. If we continue to assume a constant labor income until retirement, then the graph of income in Fig. 1 is unchanged. However, the graph of consump-

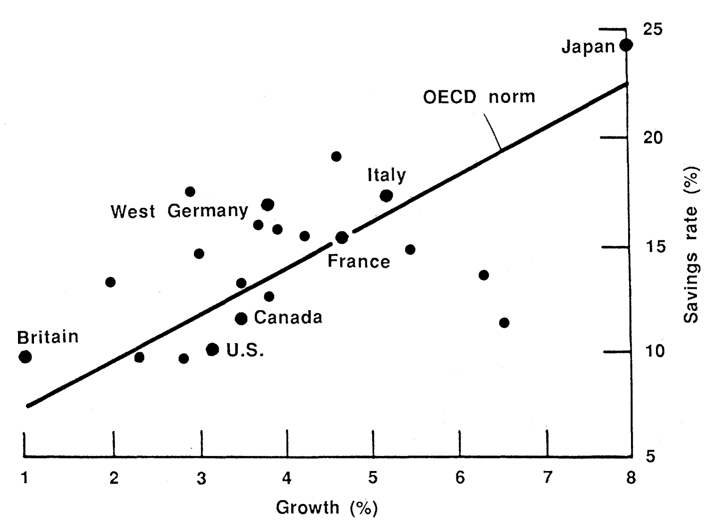


Fig. 2. Personal savings (as a percentage of disposable income) as a function of compound annual growth in per capita disposable income.

tion changes through an income and substitution effect: the addition of $rW$ increases income, but at the same time $r$ also affects the opportunity cost of current in terms of future consumption. It is possible that the consumer would still choose a constant rate of consumption through life (if the elasticity of substitution were zero). In this case, in Fig. 1, consumption will still be a horizontal straight line, but at a higher level because of the favorable "income effect" from $rA$. As for saving, it will be the difference between $C$ and $Y$. The latter differs from the (piecewise) horizontal $YL$ in the figure by $rW$, which is proportional to $A$. As a result, the path of $A$ will depart somewhat from the "triangle" of Fig. 1, and, in particular, the overall area under the path can be shown to decline with $r$. This means that $W$ and, a fortiori, $w = W/Y$, will fall with $r$.

This result has interesting implications for the much debated issue of the effect of interest rates on saving. Turning back to Eq. 2, we see that (i) in the absence of growth, a change in $r$ has no effect on saving (which remains zero), and (ii) for any positive rate of growth, a higher interest rate means a lower saving rate. However, this conclusion depends on the special assumption of zero substitution. With positive substitution, consumption will start lower and will rise exponentially: this "postponement" of consumption, in turn, lifts saving and peak assets. If the substitution effect is strong enough, $w$ will rise and so will $s$, as long as $\rho$ is positive.

This same conclusion can be derived from Eq. 3 and the definition of $Y$. These can be shown to imply

$$\frac{A}{Y} = \frac{1 - \alpha}{\rho + \delta - \alpha r} \qquad (4)$$

Numerical calculations (*10*) suggest that $\alpha$ is not much affected by $r$, but $\delta$ is. In 1975 I hypothesized (*27*) that the effect of $r$ on $\delta$ might be expressed as $\delta = \delta^* + \mu r$ when $\mu$ is unity for 0 substitution, and declines with substitution (possibly to a negative value). Substituting for $\delta$ in Eq. 4, one can see that, when the interest rate rises, saving may fall or rise depending on whether $\mu$ is larger or smaller than $\alpha$.

Which of these inequalities actually holds is an empirical matter. Despite a hot debate, no convincing general evidence either way has been produced, which leads me to the provisional view that $s$ is largely independent of the interest rate. It should be noted in this connection that, insofar as saving is done through pension schemes aimed at providing a retirement income, the effect of $r$ on $s$ is likely to be 0 (or even positive) in the short run but negative in the long run.

Second, we must allow for the life cycle of earning and family size. Far from being constant, average labor income typically exhibits a marked hump pattern which peaks somewhat past age 50, falls thereafter, partly because of the incidence of retirement, and does not go to zero at any age, though it falls sharply after 65. However, consumption also varies with age, largely reflecting variations in family size, as one might expect if the consumer smooths consumption per equivalent adult (*28*). Now the life cycle of family size, at least in the United States, has a very humped shape rather similar to that of income, though with a somewhat earlier peak. As a result, one might expect and generally finds a fairly constant rate of saving in the central age group, but lower saving or even dissaving in the very young or old. Thus, as in Fig. 1, the wealth of a given cohort tends to rise to a peak around age 60 to 65 (*29–33*).

It is also worth noting that available evidence supports the LCH prediction that the amount of net worth accumulated up to any given age in relation to life resources is a decreasing function of the number of children and that saving tends to fall with the number of children present in the household and to rise with the number of children no longer present (*32*, *34*).

Third, we must consider the length of working and retired life. One can readily drop the assumption that the length of retired life is a given constant. As is apparent from Fig. 1, a longer retirement shifts forward and raises the peak of wealth, increasing $w$ and the saving rate. This does not affect the validity of propositions 2 to 6, but it could invalidate proposition 1. It is possible, in fact, that, in an economy endowed with greater productivity (and, hence, greater per capita income), households might take advantage of this by choosing to work for fewer years. This, in turn, would result in a higher national saving rate. Note, however, that this scenario need not follow. The increase in productivity raises the opportunity cost of an extra year of retirement in terms of consumables, providing an incentive to shorter retirement. Thus the saving rate could, in principle, be affected by per capita income, but through an unconventional, life-cycle mechanism and, furthermore, in a direction unpredictable a priori. Empirical evidence suggests that the income effect tends to predominate but is not strong enough to produce a measurable effect on the saving rate (*35*).

Aside from income, any other variable that affects the length of retirement could, through this channel, affect saving. One such variable that has received attention lately is social security. Several studies have found that the availability of social security, and terms thereof, can encourage earlier retirement (*33*, *35–39*). To this extent, social security tends to encourage saving, though this effect may be offset, and even more than fully, by the fact that it also reduces the need for private accumulation to finance a given retirement.

A fourth consideration is liquidity constraint. Imperfections in the credit markets as well as the uncertainty of future income prospects may, to some extent, prevent households from borrowing as much as would be required to carry out the unconstrained optimum consumption plan. Such a constraint will have the general effect of postponing consumption and increase $w$ as well as $s$. But, clearly, these are not essential modifications, at least with respect to the aggregate implications; on the contrary, they contribute to ensure that productivity growth will increase the saving rate. However, significant liquidity constraints could affect quantitatively certain specific conclusions, such as those concerning temporary tax changes.

Finally, the LCH presupposes a substantial degree of rationality and self-control to make preparations for retired consumption needs. It has been suggested—most recently by Shefrin and Thaler (*40*)—that households, even if concerned in principle with consumption smoothing, may be too myopic to make adequate reserves. To the extent that this criticism is valid it should affect the wealth income ratio in the direction opposite to the liquidity constraint, though the effect of transitory changes in income from any source would go in the same direction. However, such myopia is not supported empirically. The assets held at the peak of the life cycle are found to represent a substantial multiple of average income (on the order of five, at least for the United States) and an even larger multiple of permanent income which, in a growing economy, is less than current income. Such a multiple appears broadly consistent with the maintenance of consumption after retirement. This inference is confirmed by recent studies which have found very little evidence of myopic saving behavior. In particular, both Kotlikoff, Spivak and Summers (*41*) and Blinder and Gordon (*34*, figure 4.1), working with data on households close to retirement, find that for most families the resources available to provide for retired consumption appear to be quite adequate to support retired consumption at a rate consistent with life resources.

*The role of bequests and the bequest motive.* Obviously bequests exist in market economies (and not only in market economies). How does their presence affect the relevance and usefulness of the model, and, in particular, the validity of propositions 1 to 5? In attacking this problem, one must distinguish the issue of principle from the empirical one of how important a role bequests may play in the accumulation of wealth.

*How important are bequests in the accumulation of wealth?* This is an interesting question. The traditional approach took it for granted that bequests are a major source of the existing wealth while the LCH suggested that they might not contribute appreciably.

I recently (*42*) reviewed a substantial body of information on inherited wealth from direct surveys of households and various sources of estimates on the flow of bequests. This review yields a fairly consistent picture suggesting that the proportion of existing wealth that has been inherited is around 20%, with a margin of something like 5 percentage points.

This conclusion is at odds with that presented by Kotlikoff and Summers (*43*). They endeavor to estimate the share of bequests by two alternative methods: (i) from an estimated flow of bequests, as above, and (ii) by subtracting from an independent estimate of private wealth in a given year their own estimate of the amount of life cycle wealth, accumulated by every cohort present in that year. Using the first method, they reach an estimate of inherited wealth of over one-half; the second, which they regard as more reliable, gives an even higher estimate, above four-fifths. I have shown (*42*) that the difference between my estimate and their much higher ones can be traced (i) to some explicit errors of theirs, for example, their treatment of the purchase of durable goods, and (ii) to unconventional definitions, both of inherited wealth and of life cycle saving. I have shown that when one corrects the error and uses the accepted definitions, one of their measures, that based on bequest flows, coincides closely with all other estimates. Their alternative measure remains somewhat higher, but I show that it is subject to an appreciable upward bias which could easily account for the difference.

Kotlikoff and Summers have suggested an alternative operational criterion of "importance" which should be independent of definitional differences—namely, by what percentage would aggregate wealth decline if the flow of bequests declined by 1%? The suggestion is sound but very hard to implement from available observations. Nonetheless, it would appear this effect, measured in terms of its impact through inherited wealth, can be taken as approximately equal to the observed share of bequeathed wealth when wealth is measured according to the conventional definition. Thus, with either measure, bequeathed wealth can be put at less than 25%.

The only other country for which the relevant information is available seems to be the United Kingdom [see (*44*)]. The estimated share of inherited wealth is, again, close to 20%.

*The behavior of saving and the wealth of the aged.* A quite different ground for questioning whether the accumulation of wealth can be better accounted for by a life cycle parable than by a bequest motive is to be found in the behavior of saving and assets of elderly households, especially after retirement. The basic LCH implies that, with retirement, saving should become negative, and thus assets decline at a fairly constant rate, reaching zero at death. The empirical evidence seems to reveal a very different picture: dissaving in old age appears to be at best modest (*32, 45–47*). According to Mirer (*47*), the wealth-income ratio actually continues to rise in retirement. (Note, however, that his estimate is biased as a result of including education in his regression. Given the steady historical rise in educational levels, there will be a strong association between age, educational attainment, and socioeconomic status relative to one's cohort if one holds constant the absolute level of education. Thus, his results could merely reflect the association between bequests, wealth, and relative income. Most other recent analysts have found that the wealth of a given cohort tends to decline after reaching its peak in the 60 to 65 age range (*30, 31, 33, 48, 49*), though there are exceptions, for example, Menchik and David (*50*). To be sure, the results depend on the concept of saving and wealth used. If one makes proper allowance for participation in pension funds, then the dissaving (or the decline in wealth) of the old tends to be more apparent, and it becomes quite pronounced if one includes an estimate of social security benefits. But, when the saving and wealth measures include only cash saving and marketable wealth, the dissaving and the decline appear weaker or even absent. Also, those studies which provide median as well as mean values (*49*) suggest that the picture of a steady decline in wealth is clearer for the median than for the mean, which has a more erratic behavior, reflecting the extreme variability of the data.

There are several considerations that can account, at least in part, for the above finding within an LCH framework. In particular, the survey data may give an upward biased picture of the true behavior of wealth during old age for two reasons. First, as Shorrocks has argued (*48*), one serious bias arises from the well-known positive association between longevity and (relative) income. This means that the average wealth of successively older age classes is the wealth of households with higher and higher life resources—hence the age profile of wealth is upward biased. Second, in a similar vein, Ando and Kennickell (*32*) found evidence that aged households which are poor tend to double up with younger households and disappear from the sampled population so that the wealth of those remaining independent is again an upward biased estimate of average wealth.

*Bequests and uncertainty of the length of life.* While it is difficult to assess the extent of these biases, the decumulation, at least of the marketable assets, would seem to be too slow to be explained by the basic LCH. A possible partial reconciliation is provided by giving explicit recognition to the existence of uncertainty about the length of life. Indeed, in view of the practical impossibility of having negative net worth, people tend to die with some wealth, unless they can manage to put all their retirement reserves into life annuities. However, it is a well-known fact that annuity contracts, other than in the form of group insurance through pension systems, are extremely rare. Why this should be so is a subject of considerable current interest. It is still ill-understood. "Adverse selection," causing an unfavorable payout, and the fact that some utility may be derived from bequests (*51*) are, presumably, an important part of the answer.

In the absence of annuities, the wealth left behind will reflect risk aversion and the cost of running out of wealth. This point has been elaborated in particular by Davies (*52*) who has shown that, for plausible parameters of the utility function including a low intertemporal elasticity of substitution, the extent to which uncertainty of life depresses the propensity to consume increases with age. As a result, uncertain lifetime could provide the major element in a complete explanation of the slow decumulation of the retired (relative to what would be implied by a standard LCH model). This conclusion is reinforced by allowing for the uncertainty of major medical expenses. Note also that the wealth bequeathed as a result of a precautionary motive, related to uncertainty of death, must tend, on the average, to be proportional to life resources. Hence, it can be readily incorporated into the basic model and the result labeled LCH with precautionary bequests.

These considerations may go part of the way toward explaining the slow decumulation. Still, this phenomenon may also reflect, in part, the working of an explicit bequest motive and life planning for it. We may, therefore, ask whether there is any intrinsic inconsistency between a significant amount of bequests induced by a bequest motive and the LCH view of the world, in particular, propositions 1 to 5.

*Bequest motive in the LCH.* First, it is obvious that no inconsistency arises if planned bequests are, on average, proportional to life resources. However, this possibility is uninteresting. The most casual observation suggests that the planning and leaving of bequests is concentrated in the upper strata of the distribution of life resources, by which we now mean the sum of (discounted) lifetime labor income and bequests received. This observation suggests the following hypothesis (*10*).

1) The share of its resources that a household earmarks, on the average, for bequests is a (nondecreasing) stable function of the size of its life resources *relative* to the average level of resources of its age cohort.

We might expect the share to be close to zero until we reach the top percentiles of the distribution of resources, and then to rise rapidly with income.

One can readily demonstrate (*27*) that this assumption ensures that propositions 1 to 5 will continue to hold at least as long as

2) The frequency distribution of the ratio of life resources to mean life resources for each age group is also stable in time.

Indeed, under these conditions, if income is constant, wealth will also tend to be constant and, therefore, saving to be zero, even in the presence of bequests. To see this, note first that 1 above ensures that bequests left ($BL$), are a fraction, say $\gamma$, of life resources, $\hat{Y}$, $BL = \gamma(\hat{Y} + BR)$, where $BR$ is bequests received. Number 2 above ensures that $\gamma$ is constant in time (presumably $<1$). Next, note that life savings, LS, is given by:

$$LS = BL - BR = \gamma\hat{Y} - (1-\gamma)BR \qquad (5)$$

Thus, $LS$ increases with $Y$ and decreases with $BR$, and is zero if $BR = [\gamma/(1-\gamma)]\hat{Y}$. But this last condition must hold in long-run equilibrium since, if $BR$ is smaller, then there will be positive saving which will increase $BR$ and reduce $LS$ toward zero; and vice versa if $BR$ is larger.

This generalization of the basic model has a number of implications, a few of which may be noted here.

1) The age patterns of Fig. 1 for a stationary society are modified, as bequests raise the average wealth path by a constant, equal to $BR$, beginning at the age at which bequests are received. The new path remains parallel to the old so that at death it has height $BL = BR$.

2) If labor income is growing at some constant rate, then average $BR$ will tend to grow at this same rate and so will $BL$, but $BL$ will exceed $BR$ by a factor $e^{\rho T}$, where $T$ is the average age gap between donor and recipient. Thus, with positive growth, and then only, the existence of bequests involves life saving, on top of hump saving. In other words, bequests result in a higher wealth-income ratio, depending on $\gamma$, and a higher saving ratio, to an extent that is proportional to $\rho$.

3) The share of life resources left as bequests could be an increasing function of the household's resources relative to the resources of the cohort. This, in turn, implies that at any age, the saving-income and wealth-income ratios for individual families could be an increasing function of relative (not absolute) income.

This last suggestion, which is clearly inconsistent with PIH, is supported by a good deal of empirical evidence, beginning with Brady and Friedman (*3*). Menchik and David (*50*) have assembled, from probate records, a large body of data on individual bequests which they have matched with income data from tax returns. Their sample covers persons born since 1880 (including a few before) and deceased between 1947 and 1978. They find striking evidence that (i) bequests depend on the position of the household's life resources in the distribution of life resources of its cohort, (ii) that they are small for people whose estimated life resources fall below the 80th percentile in that distribution, but that, (iii) beyond the 80th percentile, they rise rapidly with (permanent) income.

*The individual bequests and the share of bequeathed wealth—a reconciliation.* There remains one serious puzzle. If something like two-thirds of peak wealth is passed on at death, be this "unintentional" transmission through precautionary saving or the conscious result of a desire to bequeath, how can the share of wealth received by bequests amount to less than 25% of the total?

Kennickell (*53*) and Ando and Kennickell (*32*) have pointed the way to a satisfactory resolution, by demonstrating that, in the presence of significant growth, the share of wealth inherited is not a satisfactory indication of the importance of bequests. To understand their argument, suppose, conveniently, that all wealth ever accumulated is passed on at death, there being therefore no life cycle (hump) saving. If the economy is stationary, and thus saving is zero, it will be true that all wealth is due to the bequest motive. It will also be true that all existing wealth is inherited so that, in this case, the share of bequeathed wealth will provide a valid measure of the importance of bequests. But suppose there is growth. Then there is also saving and, therefore, a portion of the existing wealth will be held by those who are accumulating it on its way to be bequeathed. And that portion rises rapidly with growth: for example, at 3% growth, bequests left are, on the average, some 2.5 times as large as those received, and, correspondingly, the share of wealth received by bequests falls to just below 40% (*53*), even though all wealth would again disappear in the absence of the bequest motive.

The empirical relevance of this conclusion has been confirmed by an interesting calculation carried out by Ando and Kennickell (*32*). Starting from estimates of national saving and allocating them by age, using the saving-age relation derived from the Bureau of Labor Statistics' consumer expenditure survey of 1972–73, they are able to estimate the aggregate amount of wealth accumulated through life saving by each cohort living in a given year. They then compare this with aggregate wealth to obtain an estimate of the shares of wealth that are, respectively, self-accumulated and inherited.

Even though the age pattern of saving they use involves relatively little dissaving in old age, their estimate of the share of inherited wealth turns out to be rather small. For the years after 1974, it is around 25%, which agrees well with my findings (*42*). For the years 1960 to 1973, the share they compute is somewhat larger, fluctuating between 30 and 40%. But this higher figure may at least partly reflect an upward bias in their estimate of inherited wealth. The bias arises from the fact that the change in overall real wealth includes capital gains, while the change in the self-accumulated portion largely excludes them. In the period before 1974, capital gains were unquestionably significantly positive, and hence self-accumulation is underestimated and the share of bequests overestimated. In the years from 1973 to 1980, depressed conditions in the stock market reduce the significance of this effect, though this is partially offset by the boom in real estate values.

## A Summing Up

We have found that the basic version of the LCH has proved quite helpful in understanding and predicting many aspects of individual and aggregate saving and wealth-holding behavior. However, two of the assumptions embodied in the stripped down version—a deterministic length of life and the absence of a bequest motive appear, in the light of presently available information, to be conspicuously counterfactual. There is substantial evidence that wealth declines slowly in old age, even after correcting for various sources of bias, implying that households, on the average, leave substantial bequests relative to peak wealth.

This evidence can be readily accommodated within the generalized LCH framework. That portion of bequests that arises from the precautionary motive can be handled by a straightforward relaxation of the assumptions to allow for a stochastic length of life and risk averse behavior. The holding of wealth arising from this mechanism can be rightfully regarded as life cycle wealth since it reflects the optimum allocation of resources to consumption through life. Furthermore, the expected size of bequests relative to life resources should be largely independent of resources. The remaining bequests arising from a genuine bequest motive can also be accommodated within the generalized LCH, provided that motive satisfies the first assumption above, and the limited evidence available appears to support this assumption.

The generalized LCH still implies the basic propositions 1 to 5. On the other hand, proposition 6 must be released: the generalization of the basic model points to a number of variables that could affect wealth and saving. These include demographic characteristics like the dependency ratio, the rate of return on wealth, household access to credit, and the strength of the bequest motive. Another potentially important variable is social security, though its systematic effect on saving has so far proved elusive, a failure not convincingly accounted for by its having two offsetting effects on private saving.

Allowing for a significant bequest motive raises the issue of its importance. How large a portion of wealth can be traced to this motive, as against true life cycle saving? It seems impossible at present to give a well-founded answer to the question. We know that the share of wealth received through inheritance can be placed at one-fifth to one-fourth for the United States (and presumably the United Kingdom), but this information is of little help. On the one hand, we know that in a growing economy, if all the inheritance resulted from the bequest motives, the share would tend to underestimate its "importance." On the other hand, the observed share is biased upward to the extent that it reflects not just the bequest motive but also that portion of bequests which arise from the precautionary motive. We do not know how total bequests are split between the two. There is evidence suggesting that the bequest motive is not very important. Thus, in a 1962 survey (*54*), only 3% of the respondents gave as a reason for saving, "to provide an estate for the family." However, the proportion rises with wealth, reaching one-third for the top class (half a million 1963 dollars and over). Similar, though somewhat less extreme, results have also been reported. Thus, the bequest motive seems to be limited to the higher economic classes. This hypothesis is supported by the finding of Menchik and David (*50*) that for (and only for) the top 20% bequests rise proportionately faster than total resources, something which presumably cannot be explained by the precautionary motive. Furthermore, it is consistent with the observation that the decline in wealth with age tends to be more pronounced and systematic in terms of the median than of the mean. But, then the top fifth of the income distribution can be expected to account for substantially more than one-fifth of all bequests. Thus, there is, at present, no basis for estimating, or even placing bounds on, the importance of the bequest motive. My hunch, based on preliminary analysis, is that hump plus precautionary wealth is likely to account for well over half, but this is only conjecture.

## Policy Implications

It is not possible here to present a systematic analysis of policy issues for which the LCH has implications that are significantly different from those derivable by the standard Keynesian consumption function or refinements thereof. I will, however, list some of the major areas of applications with a brief statement of the LCH implications.

*Short-run stabilization policy.* The fact that wealth enters importantly in the short-run consumption function means that monetary policy can affect aggregate demand not only through the traditional channel of investment but also through the market value of assets and consumption (*26*). Attempts at restraining (or stimulating) demand through transitory income taxes (or rebates) can be expected to have small effects on consumption and to lower (or raise) saving because consumption depends on life resources which are little affected by a transitory tax change (*35, 55*).

*Long-run propositions.* A progressive tax on consumption is more equitable than one on current income because it more nearly taxes permanent income (quite apart from its incentive effects on saving).

Expenditures financed by deficit tend to be paid by future generations; those financed by taxes are paid by the current generation. The conclusion rests on the proposition that private saving, being controlled by life-cycle considerations, should be (nearly) independent of the government budget stance (*35*), and therefore private wealth should be independent of the national debt (*56*). It follows that the national debt tends to crowd out an equal amount of private capital at a social cost equal to the return on the lost capital (which is also approximately equal to the government interest bill).

This conclusion stands in sharp contrast to that advocated by the so-called Ricardian equivalence proposition (*57*), which holds that whenever the government runs a deficit, the private sector will save more in order to offset the unfavorable effect of the deficit on future generations. Of course, to the extent that the government deficit is used to finance productive investments, then future generations also receive the benefit of the expenditure, and letting them pay for it through deficit financing may be consistent with intergenerational equity.

In an open economy, the investment crowding-out effect may be attenuated through the inflow of foreign capital, attracted by the higher interest that results from the smaller availability of investable funds. However, the burden on future generations is roughly unchanged because of the interest to be paid on the foreign debt.

Finally, if there is slack in the economy, debt-financed government expenditures may not crowd out investment, at least if accompanied by an accommodating monetary policy, but may, instead, raise income and saving. In this case, the deficit is beneficial, as was held by the early Keynesians; however, the debt will have a crowding-out effect once the economy returns to full employment. The life cycle hypothesis suggests that to avoid this outcome, a good case can be made for a so-called cyclically balanced budget.

### REFERENCES AND NOTES


1. J. M. Keynes, *General Theory of Employment, Interest and Money* (Harcourt, Brace, New York, 1936).
2. S. Kuznets, *National Income: A Summary of Findings* (National Bureau of Economic Research, New York, 1946).
3. D. S. Brady and R. D. Friedman, *Studies in Income and Wealth* (National Bureau of Economic Research, New York, 1947), vol. 9.
4. J. S. Duesenberry, *Income, Saving and the Theory of Consumer Behavior* (Harvard Univ. Press, Cambridge, 1949).
5. F. Modigliani, *Studies in Income and Wealth* (National Bureau of Economic Research, New York, 1949), vol. 11.
6. T. M. Brown, *Econometrica* **20**, 355 (1952).
7. M. G. Reid, unpublished paper.
8. M. Friedman, *A Theory of the Consumption Function* (Princeton Univ. Press, Princeton, NJ, 1957).
9. F. Modigliani and R. Brumberg, in *Post-Keynesian Economics*, K. Kurihara, Ed., (Rutgers Univ. Press, New Brunswick, 1954), pp. 388–436.
10. ——, *Collected Papers of Franco Modigliani*, A. Abel, Ed. (MIT Press, Cambridge, MA, 1979), vol. 2, pp. 128–197.
11. I. Fisher, *The Theory of Interest* (Macmillan, New York, 1930).
12. F. Fisher and R. Brown, *Rev. Econ. Stat.* **40**, 79 (February 1958).
13. F. Modigliani and A. Ando, in *Consumption and Saving* (Wharton School of Finance and Commerce, University of Pennsylvania, 1960), vol. 2, pp. 74–108, 138–147.
14. R. F. Harrod, *Towards a Dynamic Economics* (Macmillan, London, 1948).
15. R. W. Goldsmith, *A Study of Saving in the United States* (Princeton Univ. Press, Princeton, NJ, 1956).

16. H. P. Neisser, *Soc. Res.* **11**, 470 (1944).
17. R. Bentzel, in *Festskrift Tillagnad Halvar Sundberg* (Uppsala Universitetes Arsskrift 1959:9, Uppsala, 1959).
18. J. Tobin, in *Ten Economic Studies in the Tradition of Irving Fisher*, W. Fellner *et al.*, Eds. (Wiley, New York, 1967).
19. C. Ackley, *J. Polit. Econ.* **59**, 154 (April 1951).
20. W. Hamburger, thesis, University of Chicago, Chicago (1951).
21. A. Ando, E. G. Brown, J. Kareken, R. M. Solow, in *Stabilization Policies* (Prentice Hall, Englewood Cliffs, NJ, 1963).
22. F. Modigliani and A. Ando, *Am. Econ. Rev.* **53**, 55 (1963).
23. H. S. Houthakker, "An international comparison of personal saving," *Bull. Int. Stat. Inst. 38* (1961).
24. ———, in *Problems in Economic Development*, E. A. G. Robinson, Ed. (Macmillan, London, 1965).
25. N. Leff, *Am. Econ. Rev.* **59**, 886 (1969).
26. F. Modigliani, in *Consumer Spending and Monetary Policy: The Linkages* (Federal Reserve Bank of Boston, Boston, 1971), conf. ser. 5; F. Modigliani, "The life cycle hypothesis of saving and inter-country differences in the saving ratio" in *Induction, Growth and Trade*, W. A. Eltis *et al.*, Eds. (Clarendon, London, 1970).
27. ———, in *Contemporary Issues in Economics*, M. Parkin, Ed. (Manchester Univ. Press, Manchester, 1975), pp. 2–36.
28. ——— and A. Ando, "Tests of the life cycle hypothesis of savings: comments and suggestions," *Bull. Oxford Univ. Inst. Stat.* (1957), pp. 99–124.
29. D. Projector, *Survey of Changes in Family Finances* (Board of Governors of the Federal Reserve, Washington, DC, 1968).
30. M. A. King and L-D. L. Dicks-Mireaux, *Econ. J.* **92**, 247 (1982).
31. R. B. Avery *et al.*, *Fed. Reserve Bull. 70* (1984).
32. A. Ando and A. Kennickell, "How much (or little) life cycle is there in micro data? Cases of U.S. and Japan," paper presented at Istituto Bancario San Paolo di Torino Conference to Honor Franco Modigliani, Martha's Vineyard, MA, 19 to 21 September 1985.
33. P. A. Diamond and J. A. Hausman, *J. Public Econ.* **23**, 81 (1985).
34. A. Blinder, R. Gordon, D. Wise, in *The Determinants of National Saving and Wealth*, F. Modigliani and R. Hemming, Eds. (St. Martins Press, New York, 1983), pp. 89–122.
35. F. Modigliani and A. Sterling, in *The Determinants of National Saving and Wealth*, F. Modigliani and R. Hemming, Eds. (St. Martins Press, New York, 1983), pp. 24–55.
36. M. Feldstein, *J. Polit. Econ.* **82**, 905 (1974).
37. ———, in *The Economics of Public Services*, M. Feldstein and R. Inman, Eds. (Macmillan, London, 1977), pp. 174–205.
38. A. Munell, *The Effect of Social Security on Personal Saving* (Ballinger, Cambridge, 1974).
39. M. Boskin and M. Hurd, *J. Public Econ.* **10**, 361 (1978).
40. H. M. Shefrin and R. Thaler, unpublished paper.
41. L. J. Kotlikoff, A. Spivak, L. Summers, *Am. Econ. Rev.* **72**, 1056 (1982).
42. F. Modigliani, "Measuring the contribution of intergenerational transfers to total wealth: conceptual issues and empirical findings," paper presented at the Modeling the Accumulation and Distribution of Personal Wealth seminar, Paris, France, 10–11 September 1985.
43. L. J. Kotlikoff and L. Summers, *J. Polit. Econ.* **89**, 106 (1981).
44. Royal Commission on the Distribution of Income and Wealth, *Report 5, Third Report on the Standing Reference* (Her Majesty's Stationery Office, London, 1977).
45. J. Fisher, thesis, Columbia University, New York (1950).
46. H. Lydall, *Econometrica* **23**, 131 (1955).
47. T. W. Mirer, *Am. Econ. Rev.* **69**, 435 (1979).
48. A. F. Shorrocks, *Rev. Econ. Stat.* **57**, 155 (1975).
49. A. Ando, "The savings of Japanese households: A micro study based on data from the National Survey of Family Income and Expenditure, 1974 and 1979" (Economic Planning Agency, Tokyo, Japan, 1985).
50. P. L. Menchik and M. David, *Am. Econ. Rev.* **73**, 672 (1983).
51. A. Masson, *Econ. J.* **96** (1986).
52. J. B. Davies, *J. Polit. Econ.* **89**, 561 (1981).
53. A. Kennickell, thesis, University of Pennsylvania (1984).
54. D. Projector and G. Weiss, *Survey of Financial Characteristics of Consumers* (Board of Governors of the Federal Reserve, Washington, DC, 1964).
55. F. Modigliani and C. Steindel, *Brookings Pap. Econ. Activity 1* (1977).
56. F. Modigliani, "The economics of public deficits," paper presented at a Conference in memory of Abba Lerner, Tel Aviv University, Israel, 28 to 31 May 1984.
57. R. J. Barro, *J. Polit. Econ.* **82**, 1095 (1974).