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## ASSET HOLDINGS AND THE LIFE-CYCLE\*

*M. A. King and L-D. L. Dicks-Mireaux*

The aim of this paper is to examine the behaviour of wealth-holdings over the life-cycle. We estimate the wealth-age relationship using cross-section data, and investigate its dependence upon provisions for pensions and social security. Previous studies of the life-cycle model have tended to reject the hypothesis of a ‘hump-shaped’ pattern for the wealth-age profile. Lydall (1955) presents data from the 1953 Oxford Institute of Statistics Survey which shows no significant tendency for wealth to decline with age. A similar result was found by Mirer (1979) in the United States in a study of 2,713 married couples over the age of 65 using a simple regression of wealth on age. Studies based on estate tax statistics have also concluded that observed wealth is an increasing function of age (Atkinson (1971), Atkinson and Harrison (1978) and Shorrocks (1975) for the United Kingdom, Brittain (1978) for the United States).<sup>1</sup>

There are, however, serious problems with the interpretation of these results. First, in none of the studies could the wealth-age relationship be controlled for the effect of differences in permanent income. To investigate this requires data on earnings and other characteristics for each observation in the sample.<sup>2</sup> Secondly, no account was taken of wealth held in the form of rights to future pensions (both private and old age security financed by the state).<sup>3</sup> Thirdly, the life-cycle model implies a non-linear relationship between the ratio of wealth to permanent income and age which may be badly approximated by simply adding age and age squared to a linear regression (as suggested by the asymmetric nature of the hump as typically drawn). Finally, the results may have been affected by sample selection bias.<sup>4</sup>

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<sup>1</sup> Shorrocks (*op. cit.*) found some evidence of a decreasing wealth-age relation, but this depended critically upon an adjustment for differential mortality (the rich live longer) which becomes significant only at quite advanced ages.

<sup>2</sup> Two recent US studies using data on older men which did control for the effects of permanent income (Blinder *et al.* (1980) and Diamond and Hausman (1980)) found results which were not encouraging to the life-cycle model of wealth accumulation. These studies are discussed further in Section I.

<sup>3</sup> In particular, doubt is cast on the use of data from estate tax returns which by construction ignore pension wealth.

<sup>4</sup> For example, estate tax data typically refer only to estates above a *de minimis* limit which excludes a large fraction of the population, and Mirer (*op. cit.*) deleted from his sample all couples for which any wealth item was ambiguous, a criterion for selection which may be correlated with the level of wealth.

In this paper we show that, controlling for permanent income and taking account of sample selection biases, it is possible to observe a hump-shaped profile for wealth over the life-cycle. But it appears also that there are two groups of people with low (but positive) and negative levels of net worth, respectively, for whom the simple life-cycle model is inappropriate, either because of low earnings and capital market constraints or because of the size of unexpected shocks or surprises in the value of their net worth.

The data used in this study refer to 12,734 Canadian families in 1977 and come from the Statistics Canada microdata tape *Income (1976), Assets and Debts (1977)* of *Economic Families and Unattached Individuals* which contains data collected as a supplement to the 1977 Survey of Consumer Finances.<sup>1</sup> Unless otherwise stated all tables are derived from this tape and money figures are expressed in Canadian dollars. The survey covers a stratified random sample of the non-institutional population and provides a particularly rich source of information on individual holdings of assets and liabilities. Of the 12,734 households in the sample 2,833 are single-person households and the remainder are family units. The assets data refer to market values in May 1977 and the income data to the calendar year 1976. To protect the identity of certain 'special family units', primarily those with very high incomes, some of their characteristics (including age) are not recorded on the tape.<sup>2</sup> For this reason the 139 special family units were excluded from the econometric analysis. Since our main interest is in estimating equations in which the dependent variable is net worth, neither this omission nor the stratification of the sample lead us to expect sample selection bias. We do, however, adjust for sample selection bias below when estimating equations in which the dependent variable has been truncated.

The plan of the paper is as follows. In Section I we examine the data on net worth and, in particular, the characteristics of those with very little wealth. The basic model to be estimated is set out in Section II. Estimates of permanent income are constructed in Section III, and an econometric model of the wealth/permanent income ratio estimated in Section IV. The role of pensions and social security wealth is examined in Section V.

#### I. THE DATA ON NET WORTH

Before turning to the econometric model it is worth examining the data on net worth. These are available for each of the 12,734 households in the sample. The definition of net worth includes the market value of cash, deposits, bonds, stocks and shares, registered savings plans, other financial assets, vehicles, owner-occupied houses and other real estate, equity in a business or farm, less debts of various kinds.<sup>3</sup> It excludes social security and some pension wealth (of which more in Section V), consumer durables other than cars, life insurance policies, and other 'assets' such as the expected value of future inheritances and support from relatives or children.

<sup>1</sup> All computations on this data base were carried out by the authors and should not be attributed to Statistics Canada. Further details of the data base may be found in Statistics Canada (1979).

<sup>2</sup> Data on incomes and wealth are recorded for this group.

<sup>3</sup> The value of most bonds was recorded at face value.

Table 1 shows the distribution of net worth in our sample. This is given both for the unweighted and weighted samples where the latter employs weights reflecting sampling ratios and estimated non-response (the two distributions differ significantly only for the top decile). Not surprisingly, the distribution is highly skewed with the top 1% of households owning 17.5% of total household net wealth and the top 5% owning 37.6%.<sup>1</sup> It is also striking that a substantial fraction of the sample had very low net worth. Of the 12,734 households, 1,318 (10.4% using sample weights) had non-positive net worth and 2,982 households (23.4% by sample weight) had net worth of less than \$2,500 in 1977. This pattern is similar to that reported by Diamond (1977) and Diamond and Hausman (1980) for the United States. Using data from the National Longitudinal Survey of Mature Men (a sample of 5,020 males aged between 45 and

Table 1  
*Distribution of Net Worth by Deciles 1977 (dollars)*

Decile	Unweighted sample		Weighted sample	
	Mean	Standard deviation	Mean	Standard deviation
1	-2,938.4	9,299.9	-2,889.1	9,556.1
2	459.4	397.3	299.8	288.8
3	3,184.9	1,187.2	2,471.0	1,006.2
4	8,943.9	2,074.0	7,605.3	1,964.4
5	17,519.8	2,857.7	16,024.3	2,897.8
6	28,082.9	3,129.2	27,365.2	3,418.8
7	39,872.4	3,748.3	39,931.2	3,835.1
8	56,050.4	5,803.4	55,898.7	5,598.5
9	84,982.7	13,033.2	81,314.4	10,992.9
10	358,611.9	686,393.0	222,681.8	341,391.3
All sample	59,454	240,282.2	46,273.0	131,490.7
Median	22,632		21,754	
Number of households 12,734				

59) Diamond and Hausman found that in 1966 19.7% of men in this age group reported net worth of less than \$1,000 (a figure comparable with our \$2,500 allowing for inflation and the exchange rate). In themselves these figures do not constitute evidence against the life-cycle hypothesis because net worth excludes the value of pension rights (in both private plans and social security). But they are suggestive of the idea that at least a fraction of the population does not save in accordance with the life-cycle view of 'rational' behaviour.

To explore this further, Table 2 shows some of the characteristics of low wealth-holders. Five such groups are distinguished. The first consists of households with negative (strictly speaking, non-positive) total net worth. If we compare this group with the sample as a whole (column 6) we see that it does not contain a substantially larger than average proportion of households with low earnings. Nor is negative net worth associated with positive pension wealth.

<sup>1</sup> The shares were computed using population weights for households.

Over 70% of households with negative net worth had no private pension plan and the same proportion had no life-insurance policies. The significant difference between households with negative net worth and the sample as a whole is that in the former 75% of heads of household were aged less than 40, whereas the figure for the total sample is just over 40%.

The second column refers to households with a low but positive level of total net worth. Age of head of household is much less important for this group, but low earnings now appear to be a significant contributory factor to low levels of wealth. Households in this group are also much less likely to be in a pension plan or have life insurance policies than either the sample mean or, indeed, those with negative net worth. Very similar conclusions apply to low (but

Table 2  
*Characteristics of Low Wealth-holders*

	Net worth ( $W$ )			Net worth excluding equity in home ( $W'$ )		
	$W \leq 0$ (1)	$0 < W$		$W' \leq 0$ (4)	$0 < W'$ < 2,500 (5)	All sample (6)
		$< 2,500$ (2)	$< A < 65$ (3)			
Number of observations ...	1,318	1,664	303	2,150	2,745	12,734
Percentage in column with:						
(1) Age of head of household $< 40$	75·0	58·5	—	67·3	50·6	43·8
(2) Household earnings $< \$6,000$	40·5	53·4	54·1	33·6	47·3	30·8
(3) No pension plan	73·1	78·8	75·2	69·2	73·8	62·9
(4) No life insurance	73·1	72·4	70·6	68·3	68·5	57·2

*Note:* The percentage figures for the age of head of household refer to the total sample excluding the 139 special family units for whom age is not made available.

positive) wealth-holders in the period leading up to retirement when we would expect wealth to be at its peak. Column (3) shows that this group has similar attributes to the second group.

Total net worth includes the value of equity in owner-occupied housing and, because it is sometimes difficult to borrow against this, it may be that a better measure of resources available to finance retirement consumption is net worth excluding equity in housing. Columns (4) and (5) show the characteristics of households with low net worth corresponding to columns (1) and (2) when net worth is defined to exclude equity in owner-occupied housing. The change in definition makes very little difference to the results and demonstrates again the difference between households with negative net worth and those with a small but positive level of wealth.

It is, therefore, tempting to conclude that the population may be divided into three groups. First, there is a group with negative net worth who do not

appear to differ significantly from the rest of the population in terms of economic characteristics, but who are in the early stages of the life-cycle. Observed negative net worth results from a combination of the failure to record all items of wealth (the value of durables such as furniture is not recorded whereas the corresponding consumer debt is included) and the shocks to asset values which result from uncertainty. The second group owns very small (but positive) amounts of wealth. Although it undoubtedly contains some households more characteristic of the first group, the main attributes of households with small amounts of wealth are low earnings, the fact that they are much less likely to have a private pension plan or life insurance policy than on average, and, as we shall see below in Section IV, a lower level of educational attainment. In these respects they are much less successful economically than the group with negative net worth which suggests that membership of the latter group is a short-lived phenomenon whereas ownership of small amounts of wealth is a characteristic which persists (to test this hypothesis would require panel data). This could be for a variety of reasons. Some households may not plan for the future (are 'backward-looking' rather than 'forward-looking'), may simply be unable to manage their own financial affairs, or may receive such low earnings that the optimal life-cycle consumption plan implies that retirement consumption is less than or equal to the expected value of old age social security payments. The third group constitutes the rest of the population (over 75% in our sample), and we wish to test the hypothesis that for this group the life-cycle model describes their savings behaviour.

Two distinct criticisms of the life-cycle model have been made in the literature. On the one hand, it has been argued that the simple life-cycle model cannot account for anything like the level of aggregate savings which is in fact observed leaving a major role for bequests (White, 1978, Kotlikoff and Summers, 1981). On the other hand it has been observed, as here, that there is a large number of households owning amounts of wealth which, on the face of it, appear incompatible with the need to finance that part of retirement consumption not financed by pensions or social security. In this paper we investigate whether, even if these criticisms are valid, nevertheless the behaviour of the majority of households is consistent with the predictions of the life-cycle model.

## II. WEALTH AND THE LIFE-CYCLE

The life-cycle model of consumption (Modigliani and Brumberg, 1954, Modigliani and Ando, 1957) implies a non-linear relationship between the ratio of wealth to permanent income and age. For particular assumptions about the utility functions of households, this relationship is very tightly parameterised, and is the result of deducing the behaviour of wealth from the earnings profile and optimal consumption plan implied by the life-cycle model. Assuming perfect certainty and making specific assumptions about preferences, Blinder *et al.* (1980) estimated the life-cycle model using data for 4,133 older white males from the Longitudinal Retirement History Survey. Because of the tight parameterisation they found the model hard to estimate with imprecisely determined

parameters which implausibly implied negative bequests. One obvious problem is the assumption of perfect certainty. The effect of increased uncertainty about the future upon present consumption is, in general, ambiguous. For example, greater uncertainty over the length of life leads to a conflict between the desire to save more for a possibly longer future life and the desire for certain consumption in the present (Yaari, 1965, Champernowne, 1969, Levhari and Mirman, 1977, and Davies, 1980). Similar considerations apply to uncertainty about future earnings (Hall, 1978, Eden and Pakes, 1981) and interest rates (Sandmo, 1970, Levhari and Mirman, 1977).

Only in special cases will it be possible to obtain an explicit solution for the time path of wealth. This suggests that it is difficult to place many *a priori* constraints on the non-linear function describing the age pattern of the ratio of wealth to permanent income. But if we assume that households expect to experience a period of retirement during which they will receive no labour earnings, then for most plausible earnings profiles we would expect the ratio of assets (defined as wealth excluding the present value of future earnings) to permanent income to first increase with age and then to decline after retirement. By 'permanent income' we mean normal annual earnings which is defined in Section III. It is the existence of evidence for this hump-shaped pattern which previous studies have denied and which is the focus of this paper. The lack of convincing theoretical restrictions suggests examining a fairly general functional form for the wealth-age profile which we may write as

$$\ln(W/Y) = f(A, \mathbf{X}) + u, \quad (1)$$

where  $W/Y$  is the ratio of assets or net worth to permanent income,  $A$  is the age of the head of household,  $\mathbf{X}$  is a vector of observable variables which influence the wealth-age relationship, and will include permanent income if preferences are non-homothetic, and where  $u$  is an error term representing unobservable variables and deviations of household preferences from the mean. It allows also for the fact that the age-earnings profile of an individual may differ from the average experience. With cross-section data for a single year we cannot estimate an earnings profile for each individual, and differences from the mean are subsumed within the error term.<sup>1</sup>

The dependent variable is measured in logarithms both to avoid problems of heteroscedasticity in estimation and because permanent income,  $Y$ , is unobservable. In Section III we describe the construction of an instrument for  $Y$  and to obtain consistent estimates of the parameters of (1) it will turn out to be convenient to adopt the logarithmic specification for the dependent variable.<sup>2</sup>

The hypothesis which we wish to test is that the *partial* derivative of  $f$  with respect to  $A$  is positive for values of  $A$  up to the age of retirement and negative thereafter. The function  $f$  is highly non-linear and even in a world of perfect certainty cannot be approximated satisfactorily by, for example, a quadratic function of age. Hence we shall take  $f$  to be a piecewise function of age such

<sup>1</sup> Blinder *et al.* (*op. cit.*) used longitudinal data with four observations on earnings, at two-yearly intervals, to construct an estimated earnings profile for each individual in their sample.

<sup>2</sup> The sample selection bias induced by restricting the model to positive levels of net worth is discussed, and corrected for, in Section IV.

that the functional forms for each piece allow sufficient flexibility to enable us to test the hypothesis of a hump-shaped pattern for the behaviour of wealth. The function will be assumed to consist of six pieces corresponding to pre-determined age ranges where we define the following dummy variables for the head of household  $i$ :

$$\left. \begin{array}{ll} d_{1i} = 1 & \text{if } A_i < 30, \text{ zero otherwise,} \\ d_{2i} = 1 & \text{if } 30 \leq A_i < 40, \text{ zero otherwise,} \\ d_{3i} = 1 & \text{if } 40 \leq A_i < 50, \text{ zero otherwise,} \\ d_{4i} = 1 & \text{if } 50 \leq A_i < 60, \text{ zero otherwise,} \\ d_{5i} = 1 & \text{if } 60 \leq A_i \leq 75, \text{ zero otherwise,} \\ d_{6i} = 1 & \text{if } 75 < A_i, \text{ zero otherwise.} \end{array} \right\} \quad (2)$$

Given that the dependent variable in (1) is measured in logarithms, we will assume that the function  $f$  is piecewise linear over most of its range (corresponding to a constant rate of accumulation of wealth within an age bracket), but is non-linear over the crucial period within which retirement occurs. Thus between the ages of 60 and 75 we assume a quadratic form which allows us to test whether a maximum occurs and, if so, to estimate the age at which this happens.<sup>1</sup> We define the following variables for each household

$$\left. \begin{array}{l} V_{1i} = d_{1i}(A_i - 15) + 15 \sum_{j=2}^6 d_{ji}, \\ V_{2i} = d_{2i}(A_i - 30) + 10 \sum_{j=3}^6 d_{ji}, \\ V_{3i} = d_{3i}(A_i - 40) + 10 \sum_{j=4}^6 d_{ji}, \\ V_{4i} = d_{4i}(A_i - 50) + 10 \sum_{j=5}^6 d_{ji}, \\ V_{5i} = d_{5i}(A_i - 60) + 15d_{6i}, \\ V_{6i} = d_{5i}(A_i - 60)^2 + 225d_{6i}, \\ V_{7i} = d_{6i}. \end{array} \right\} \quad (3)$$

The final variable is simply a dummy variable because in our sample the age of head of household is not recorded if 76 or above.

With these definitions it is possible to estimate the non-linear piecewise function by the following linear regression

$$\ln(W_i/Y_i) = a_0 + \sum_{j=1}^7 a_j V_{ji} + u_i. \quad (4)$$

The value of  $a_0$  is the log of the ratio of wealth to permanent income at age 15; which is approximately the youngest age at which working life could begin. The values of  $a_1$  to  $a_4$  measure the annual growth rates of wealth in the first four age ranges, and  $a_5$  and  $a_6$  measure the non-linearity in the growth rate during the retirement period. If there is a hump-shaped profile then  $a_6$  must be negative, and the maximum is reached at age  $A_i = 60 - a_5/2a_6$ .

<sup>1</sup> Retirement before the age of 60 was negligible in our sample.

## III. ESTIMATING PERMANENT INCOME

In order to estimate the model of asset holdings over the life-cycle given by (4) we need estimates of permanent income for each individual in the sample. We shall denote by  $Y_i$  the permanent income of individual  $i$ , by  $E_i$  his or her current earnings in the sample year, and by  $A_i$  his or her age in the sample year. The model for permanent income (defined as normal age-adjusted annual earnings) is<sup>1</sup>

$$\ln Y_i = \mathbf{Z}_i \gamma + s_i - c(A_i), \quad (5)$$

where  $\mathbf{Z}_i$  is a vector of observable variables for individual  $i$  (such as education and occupation),  $\gamma$  is the associated parameter vector, and  $s_i$  is an unobservable variable measuring characteristics such as skill, drive, or good fortune which is constructed such that its mean value in the population is zero and has variance  $\sigma_s^2$ . The final term,  $c(A)$ , is a cohort effect which reflects the fact that, for given  $\mathbf{Z}$ , younger generations are better off than their elders because of technical progress and capital accumulation.

Current earnings differ from permanent income for two reasons. One is the existence of an age-earnings profile over the life-cycle, and the other is the transitory component of earnings. Hence we have that earnings in year  $t$  are given by

$$\ln E_{it} = \ln Y_i + h(A_{it} - \bar{A}) + u_{it}. \quad (6)$$

The function  $h$  measures the age-earnings profile (assumed constant across the population), and  $\bar{A}$  is some 'standard' age with respect to which permanent income is defined. The transitory component of earnings, denoted by  $u_{it}$ , is assumed to have zero mean, variance  $\sigma_u^2$ , and to be uncorrelated with  $s_i$ . Combining (5) and (6) gives the following earnings equation

$$\ln E_{it} = \mathbf{Z}_i \gamma + g(A_{it}) + s_i + u_{it}, \quad (7)$$

where

$$g(A_{it}) = h(A_{it} - \bar{A}) - c(A_{it}).$$

The error term in (7),  $s_i + u_{it}$ , has zero mean and variance  $\sigma_s^2 + \sigma_u^2$ . The  $u_{it}$  may be correlated across households in which case OLS estimates of (7) are unbiased though inefficient.

Estimation of the earnings equation (7) provides consistent estimates of  $\gamma$  and the function  $g$ . It is clear that the age-earnings profile and the cohort effect cannot be separately identified from estimation of  $g$ , and so we shall use data from outside the sample to impose a cohort effect. The details of this will be discussed below and we shall proceed on the assumption that we have estimates of both the  $h$  and  $c$  functions. With the estimates  $\hat{\gamma}$  and the  $\hat{c}$  function we may construct an estimate of the permanent income of each individual in the sample, provided that we can impute a value for the unobservable individual-specific effect  $s_i$ . The information available to do this is the estimate of  $(s_i + u_{it})$  given by the residuals from the estimated earnings equation. It is easy to show that the minimum-variance estimator of  $s_i$  given  $(s_i + u_{it})$  is

$$\hat{s}_i = \alpha(s_i + u_{it}), \quad (8)$$

where

$$\alpha = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_u^2}. \quad (9)$$

<sup>1</sup> This definition excludes the annuity value of receipts of gifts and inheritances, on which no data are available in our sample, and also 'super-normal' profits (and losses).

Hence our estimate of permanent income is

$$\ln Y_i^e = \mathbf{Z}_i \hat{\gamma} - \hat{\epsilon}(A_{it}) + \hat{s}_i, \quad (10)$$

and  $\hat{s}_i$  is the product of  $\alpha$  and the residual from the earnings equation. Given values for  $\sigma_s^2$  and  $\sigma_u^2$  permanent income may be constructed for each individual in the sample.

It is worth noting that the error in the estimate of permanent income is uncorrelated with the information used to construct the estimate, and hence with the estimate itself. To see this denote the error in the estimate by

$$\eta_{it} = \ln Y_i^e - \ln Y_i = \alpha u_{it} - (1 - \alpha) s_i, \quad (11)$$

$$E(\eta_{it} \ln Y_i^e) = E[\eta_{it}(s_i + u_{it})]. \quad (12)$$

From (11) this expression is equal to zero when  $\alpha$  is given by (9). This means that since  $\ln Y$  appears linearly in the equation for asset holdings we still obtain consistent estimates of the parameters of the wealth equation (4) even though we are using only an estimate of permanent income.

With longitudinal data on earnings it would be possible to estimate a fixed effects model, and hence obtain estimates of  $\sigma_s^2$  and  $\sigma_u^2$  as well as  $\gamma$  from (7).<sup>1</sup> Unfortunately, this procedure is not open to us because we have observations on household earnings for only one year. We shall, therefore, assume a value for  $\alpha$  based on the results of the few studies which have used longitudinal data to estimate the relative magnitudes of  $\sigma_s^2$  and  $\sigma_u^2$ . The value of  $\sigma_s^2$  clearly depends on the variables contained in the  $\mathbf{Z}$  vector; the more relevant observable variables there are, the smaller will be the residual variance. Lillard and Willis (1978) examined data for 1,144 male heads of households for seven years from the University of Michigan Panel Study of Income Dynamics, and found that for a simple set of explanatory variables in the earnings equation (race, years of schooling and work experience) the implied value of  $\alpha$  was 0.606. With a more comprehensive set of explanatory variables including education, occupation, region, labour force status and local labour market conditions, the implied value was 0.471. Similar results were found by Lillard (1977) for a sample of World War II veterans and by Lillard and Weiss (1979) for a sample of American scientists. In the earnings regressions which we report below, we employ a fairly comprehensive set of explanatory variables, comparable with that used by Lillard and Willis, except that we have no data on local labour market conditions. When constructing estimates of permanent income, therefore, we shall assume a value for  $\alpha$  of 0.5.

The earnings equation (7) was estimated separately for male heads of households and for wives. Households headed by a woman were deleted from the sample because a substantial fraction of these were headed by elderly women, probably widows. Permanent income of these households is determined primarily by the lifetime earnings of the deceased husband, on which their widows were not asked to provide information. Deleting households headed by a woman and also special family units (for whom data on age and characteristics such

<sup>1</sup> See Hausman (1978), Mundlak (1978), Hausman and Taylor (1981) for a discussion of the estimation of fixed effects models, and also Nickell (1981) for the biases involved in estimating such models when the dynamic structure is mis-specified.

as occupation were not recorded), reduced the sample from 12,734 to 10,118 households.

Equation (7) implicitly assumes that individuals are in 'full-time' employment. The individual effect,  $s_i$ , may include variations in individual tastes for leisure, but it does not allow for systematic changes in annual hours worked resulting from spells of unemployment during part of the year, temporary layoffs, or part-time work by wives or in retirement.<sup>1</sup> Hence the earnings equation was estimated for all individuals whose annual earnings were greater than \$2,000. Earnings data relate to the calendar year 1976. Significant numbers of both men and women had very low levels of earnings, although the proportion is much higher for wives because of non-participation in the labour force. Only 34.3% of wives had earnings of more than \$2,000. The difference in the mean age of men with earnings above and below \$2,000 (40.4 as against 60.2 years) suggests that for men part-time work in retirement is a contributory factor to low levels of observed earnings.

The truncation of the dependent variable induces sample selection bias, and this was corrected for using the two-stage procedure proposed by Heckman (1976; 1979).<sup>2</sup> In the first stage the parameters of the probability that an individual will be in the truncated sample are estimated from a probit analysis of the full sample. From these estimates the values of the inverse of Mills' ratio are computed for each observation in the truncated sample. The second stage is to estimate (7) by OLS with the inverse of Mills' ratio as an additional explanatory variable. This procedure gives consistent estimates of the parameters  $\gamma$  and of the  $g$  function (provided the latter is linear in parameters).<sup>3</sup>

Details of the maximum-likelihood estimates of the probit model for earnings of \$2,000 or less are available from the authors. The coefficients are all highly significant. Very young or old workers are more likely to have low or no earnings, as are those with little education, single men, women with young children, and those in households able to rely on investment income as the main source of income. In addition, low current earnings may reflect spells of unemployment and part-time work rather than potential earnings.

The second-stage OLS estimates of the earnings equation (7) adjusted for sample selection bias are also available on request.<sup>4</sup> The  $g$  function was approximated by a cubic function of age. The age coefficients are significant and imply that earnings (unadjusted for the cohort effect) reach a maximum at age 43.21

<sup>1</sup> The transitory component of earnings,  $u$ , will pick up some of these effects, but it does not allow the density function of earnings to have a positive mass at particular earnings levels such as zero (for unemployment throughout the year) or a low but positive level corresponding to a conventional number of hours for part-time workers.

<sup>2</sup> Essentially the same procedure was suggested by Lee and Trost (1978); see also the different approach recommended by Amemiya (1973). The set of independent variables in the probit equations is not identical with that in the subsequent regression because earnings (and, later, wealth) below the truncation level are generated by a different model, e.g. part-time work.

<sup>3</sup> Although the parameter estimates are consistent, the estimated standard errors are biased (but not necessarily downwards, see Greene (1981)). This is of little concern in the earnings equations which are used simply to construct an instrument for permanent income.

<sup>4</sup> The computation of the inverse of Mills' ratio for each observation allows for the fact that the probit model is for the probability of not being in the truncated sample. In this case the inverse is  $f(-X\beta)/F(-X\beta)$ , where  $f$  and  $F$  are the density and distribution functions respectively of the standard normal variate.

for men and 37·5 for women. Allowing for the imposed cohort effect described below implies a pure age effect on earnings (the  $h$  function in (6)) with a maximum at age 52·2 for men and no maximum for wives before retirement age.

To estimate permanent income the 'standard' age was taken to be 45, and the cohort effect was estimated as follows. It was assumed that one-half of the growth rate of real earnings was accounted for by improvements in education, changes in occupational structure, and other factors used as explanatory variables in the earnings equation, and that the other half was accounted for by technical progress and capital accumulation. The latter is the cohort effect. Data on growth rates in earnings and consumer prices in Canada were obtained from Podoluk (1968) and Statistics Canada (1978a). These give annual growth rates of real earnings attributable to the cohort effect of 0·75% before 1936, 1·25% in 1936–46, 1·5% in 1946–56, and 1·75% in 1956–76.<sup>1</sup>

As explained above, our estimate of permanent income for each individual is given by (10) with a value for  $\alpha$  of 0·5. In other words, permanent income is equal to the age-adjusted structural component of earnings given by observable variables, plus one-half of the residual in the earnings equation. This gives an estimate of permanent income for each individual in the sample included in the earnings regressions. But 1,873 of the 10,118 male heads of households were omitted from the regression because their current earnings were \$2,000 or less. For these individuals, permanent income was predicted by the structural component alone given by setting  $\hat{s}_i = 0$ . For wives the same procedure was adopted but here we made an explicit adjustment for non-participation in the labour force at various stages of the life-cycle. Permanent income of wives was estimated as

$$Y_i^w = Y_i^e \text{prob} (E_i > 2,000) + \bar{E}_w \text{prob} (E_i \leq 2,000), \quad (13)$$

where  $Y_i^e$  = permanent income estimate given by (10),  $\bar{E}_w$  = mean earnings of those with  $E \leq 2,000$  (= \$160·8), and the probabilities of earnings being above and below \$2,000 were computed for each wife in the sample from the probit estimates.<sup>2</sup> Household permanent income is the sum of the estimates for husbands and wives.<sup>3</sup> Mean estimated permanent income of men is \$15,928 and of wives is \$7,451.

<sup>1</sup> The cohort effect is described by a piecewise linear function for  $c(A_i)$  such that at the 'standard' age (45) it has a zero value. With the figures for the growth rates of real earnings given in the text, the function is

Age	$C(A)$
$A_i \leq 35$	$-[0·15 + 0·0175(35 - A_i)]$
$35 < A_i \leq 45$	$-0·015(45 - A_i)$
$45 < A_i \leq 55$	$0·0125(A_i - 45)$
$55 < A_i$	$0·125 + 0·0075(A_i - 55)$

<sup>2</sup> The variables used to compute the probabilities were the constant terms and the education and children dummies. In the wives' earnings regressions the sign of the coefficient of the occupational dummies reflects the fact that reported earnings of wives are high in farming (the default occupation) which is probably the result of tax planning.

<sup>3</sup> Taking the arithmetic rather than the geometric sum of permanent income for husbands and wives will lead to some bias in the estimates of (4), but this is likely to be small because not all households contain wives and the mean permanent income for wives is much lower than for men because of non-participation.

## IV. THE WEALTH-AGE PROFILE

With the estimates of permanent income for each household constructed in Section III, we may now examine the wealth-age profile. Table 3 shows the ratio of net worth to permanent income by age range for both the 'full sample' of 10,118 households headed by a male and the 8,279 households headed by a male and with total net worth greater than or equal to \$2,500. The ratios are given for two net worth series, total net worth and net worth excluding the value of owner-occupied housing. The striking feature of Table 3 is that for both the full and the truncated samples, and for both definitions of net worth, there is clear evidence of a hump-shaped pattern in the ratio of wealth to permanent income. Wealth accumulation is rapid in the age range

Table 3  
*Ratio of Net Worth to Permanent Income by Age 1977*

Age	Full sample			Net worth $\geq \$2,500$		
	No. of observations	$W/Y$	$W'/Y$	No. of observations	$W/Y$	$W'/Y$
15-24	836	0.280	0.181	357	0.678	0.455
25-29	1,350	0.656	0.338	928	0.981	0.523
30-34	1,322	1.374	0.731	1,066	1.745	0.941
35-39	1,052	2.047	1.121	914	2.370	1.304
40-44	959	2.883	1.699	857	3.237	1.911
45-49	948	3.800	2.323	852	4.230	2.589
50-54	820	4.380	2.800	740	4.858	3.105
55-59	799	4.262	2.660	732	4.656	2.909
60-64	669	4.583	2.943	617	4.976	3.202
65-69	518	4.210	2.511	473	4.607	2.747
70-75	463	3.733	2.071	416	4.153	2.303
> 75	382	3.377	1.782	327	3.935	2.072

Note:  $W$  is total net worth;  $W'$  is total net worth excluding equity in own home;  $Y$  is estimated household permanent income.

30-55, reaches a plateau in the pre-retirement phase, and then decumulation occurs in retirement. In all four columns of Table 3 the maximum value of wealth is found in the age bracket 60-64. There is a puzzling dip in the ratio of wealth to permanent income for the group aged 55-59. One possible explanation is that this group was starting its working life when World War II began, and may thus have been particularly adversely affected by the disruption to their early work experience. Fig. 1 shows the age profile of the ratio of wealth to permanent income for the full sample for both definitions of net worth. The hump-shaped pattern is clearly evident.

The percentage reduction in total net worth between ages 60-64 and the age bracket over 75 is 26.3% for the full sample and 20.9% for the sample of those with net worth greater than or equal to \$2,500. The corresponding figures for net worth excluding equity in owner-occupied housing are 39.4% for the

full sample and 35·3% for the truncated sample. These figures represent quite substantial rates of decumulation, particularly when it is remembered that the net worth figures exclude pension and social security wealth.

The next step is to estimate the wealth equation given by (4). Since the dependent variable is measured in logarithms the model cannot be estimated on the full sample. Moreover, in Section I we argued that the population may be composed of several groups displaying different types of savings behaviour. We therefore report the results of estimating (4) on the truncated sample of households with total net worth greater than or equal to \$2,500.<sup>1</sup> To correct for sample selection bias thus induced we use the two-stage procedure employed for the earnings equations in Section III. Table 4 shows the maximum likelihood estimates of the probit model for low wealth holdings. The estimated

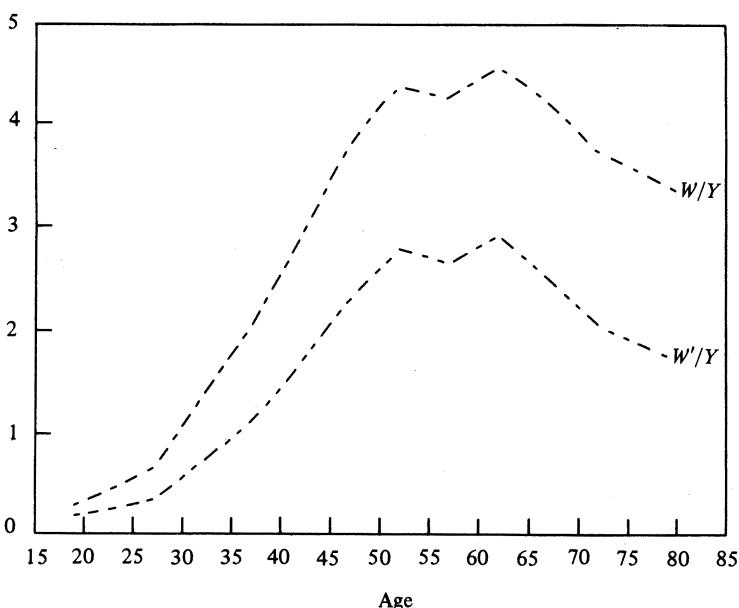


Fig. 1. Ratio of wealth to permanent income/age profile.

coefficients reinforce our earlier remarks regarding the difference between households with negative and those with small but positive amounts of wealth, and low educational attainment as well as low earnings are seen to be correlated with the latter rather than the former. Estimates from the final column were used to construct values of the inverse of Mills' ratio for each household which were used in the estimation of the wealth models shown in Tables 5 and 6.

Table 5 gives estimates of (4) for total net worth and Table 6 gives estimates of the same models for the definition of net worth excluding equity in owner-occupied housing. In both cases the sample was truncated by the dependent

<sup>1</sup> Fig. 1 and Table 3 show, however, that the hump-shaped pattern is characteristic of both the full and truncated samples. Results for the sample of households with positive wealth are available from the authors on request.

Table 4  
*Probit Model for Low Wealth Holdings*  
 (Standard errors in parentheses.)

Variable*	Coefficient		
	$W \leq 0$	$0 < W < \$2,500$	$W < \$2,500$
Constant	2.770 (0.823)	1.987 (0.834)	4.209 (0.752)
$\ln Y$	-0.419 (0.087)	-0.277 (0.089)	-0.475 (0.080)
Household earnings < \$6,000	0.097 (0.057)	0.301 (0.055)	0.353 (0.052)
Number of persons unemployed	0.161 (0.033)	0.127 (0.034)	0.229 (0.030)
Age < 40	0.806 (0.058)	0.393 (0.586)	0.884 (0.052)
Self-employed	-0.198 (0.119)	-0.878 (0.191)	-0.607 (0.117)
Home owner	-1.373 (0.048)	-1.563 (0.052)	1.899 (0.042)
Farm family†	-0.209 (0.199)	-6.610 (16.742)	-0.406 (0.202)
Married	0.223 (0.070)	-0.133 (0.069)	0.018 (0.064)
Education: secondary or above	-0.178 (0.051)	-0.293 (0.053)	-0.361 (0.047)
Numbers below limit	895	944	1,839
Numbers above limit	9,223	9,174	8,279
$\chi^2 (9)$	1,660.6	1,965.8	4,116.2

\* Dummy variables take the value unity when the description applies to the household, zero otherwise. Individual variables refer to the head of a household.

† A family in which any member receives more than 50% of his income from self-employment in farming.

variable.<sup>1</sup> Column 1 of Table 5 shows estimates of the basic life-cycle equation (4) for homothetic preferences. All of the coefficients have the predicted sign (though not all are significantly different from zero at conventional significance levels) and wealth increases with age at a decelerating rate until a maximum is reached at age 71. After this point wealth is a decreasing function of age. Columns (2) and (3) show the effects of introducing additional explanatory variables. Farm families possess greater wealth than is predicted by the simple model which may reflect the importance of land prices to the value of such families' net worth. Unemployment has a depressing effect on wealth, and household size appears to have little significant influence on wealth-holding. Measured wealth does not include the value of life insurance policies, and we know only the number of persons in each household covered by life insurance.

<sup>1</sup> The values of the Mills' ratio used in Table 6 were computed from estimates of a probit model for  $W' < 2,500$ , the results of which are available from the authors on request.

Table 5  
*Net Worth Regressions: Truncated Sample,  $W \geq 2,500$*   
(Standard errors in parentheses.\*)

	Dependent variable $\log W/Y$			
	(1)	(2)	(3)	(4)
Constant	-0.823 (0.146)	-0.978 (0.140)	2.389 (0.523)	3.893 (0.693)
$V_1$	0.074 (0.011)	0.081 (0.010)	0.076 (0.010)	0.083 (0.010)
$V_2$	0.052 (0.006)	0.052 (0.006)	0.043 (0.006)	0.043 (0.006)
$V_3$	0.037 (0.006)	0.040 (0.006)	0.033 (0.006)	0.034 (0.006)
$V_4$	0.007 (0.007)	-0.001 (0.007)	-0.003 (0.007)	0.0002 (0.0071)
$V_5$	0.018 (0.020)	0.030 (0.019)	0.023 (0.019)	0.029 (0.019)
$V_6$	-0.001 (0.002)	-0.001 (0.001)	-0.001 (0.001)	-0.003 (0.001)
$V_7$	-0.018 (0.124)	0.003 (0.115)	-0.010 (0.117)	-0.048 (0.118)
Farm family dummy	—	1.271 (0.056)	1.207 (0.058)	1.214 (0.059)
Number of persons unemployed	—	-0.009 (0.026)	-0.043 (0.027)	-0.038 (0.027)
Number of adults in household	—	-0.029 (0.016)	-0.012 (0.017)	0.017 (0.017)
Number of persons with life insurance	—	0.029 (0.014)	0.040 (0.014)	0.043 (0.014)
$\ln Y$	—	—	-0.321 (0.048)	-0.454 (0.064)
$\ln \frac{\text{social security wealth}}{Y}$	—	—	—	-0.264 (0.056)
$\ln \frac{\text{private pension wealth}}{Y}$	—	—	—	-0.091 (0.027)
Inverse of Mills' ratio	-1.101 (0.047)	-0.993 (0.045)	-1.054 (0.047)	-1.085 (0.048)
Standard error of equation*	1.105	1.034	1.047	1.054
$R^2$	0.394	0.454	0.461	0.465
Degrees of freedom	8,270	8,266	8,265	8,263

\* These are the corrected asymptotic standard errors appropriate for a two-step estimator (Greene, 1981).

Table 6  
*Net Worth Regressions: Truncated Sample,  $W' \geq 2,500$*   
 (Standard errors in parentheses.\*))

	Dependent variable is $\log W'/Y$			
	(1)	(2)	(3)	(4)
Constant	-0.588 (0.210)	-1.543 (0.156)	5.520 (0.768)	6.396 (0.906)
$V_1$	0.049 (0.015)	0.062 (0.011)	0.054 (0.013)	0.064 (0.013)
$V_2$	0.035 (0.010)	0.054 (0.007)	0.027 (0.009)	0.027 (0.009)
$V_3$	0.026 (0.010)	0.041 (0.007)	0.020 (0.008)	0.023 (0.008)
$V_4$	0.020 (0.011)	0.003 (0.008)	0.003 (0.009)	0.004 (0.009)
$V_5$	0.031 (0.029)	0.035 (0.021)	0.026 (0.024)	0.030 (0.024)
$V_6$	-0.001 (0.002)	-0.002 (0.002)	-0.001 (0.002)	-0.003 (0.002)
$V_7$	0.017 (0.177)	0.042 (0.125)	0.013 (0.146)	-0.032 (0.146)
Farm family dummy	—	1.862 (0.066)	1.507 (0.085)	1.510 (0.086)
Number of persons unemployed	—	-0.021 (0.029)	-0.010 (0.036)	-0.010 (0.036)
Number of adults in household	—	-0.028 (0.018)	-0.008 (0.021)	0.023 (0.022)
Number of persons with life insurance	—	0.022 (0.016)	0.034 (0.018)	0.039 (0.018)
$\ln Y$	—	—	-0.639 (0.068)	-0.714 (0.081)
$\ln \frac{\text{social security wealth}}{Y}$	—	—	—	-0.255 (0.066)
$\ln \frac{\text{private pension wealth}}{Y}$	—	—	—	-0.184 (0.033)
Inverse of Mills' ratio	-1.058 (0.070)	-0.311 (0.060)	-0.737 (0.085)	-0.741 (0.085)
Standard error of equation*	1.444	1.153	1.248	1.244
$R^2$	0.219	0.312	0.326	0.336
Degrees of freedom	6,646	6,642	6,641	6,639

\* These are the corrected asymptotic standard errors appropriate for a two-step estimator (Greene, 1981).

We might expect that, *ceteris paribus*, the more members covered the less would be the level of household wealth invested in other assets. But in fact the coefficient on the life insurance variable is positive, suggesting rather that purchase of life assurance is correlated with a greater than average preference to save (resulting perhaps from a higher than average degree of risk aversion).

In Column (3) we test the hypothesis that the ratio of wealth to permanent income is independent of the level of permanent income. Homotheticity appears to be rejected. The higher is permanent income, the lower is the ratio of wealth to permanent income. This might simply reflect a positive correlation between permanent income and the provision of private or public pensions, and homotheticity is not rejected when pensions and social security wealth are introduced into the model as we shall see in Section V.

The coefficient of the inverse of Mills' ratio, and its small standard error, show that truncation of the sample would, if no correction were made, lead to biased estimates. A test of the null hypothesis of no sample selection bias can be performed by making use of the result that the square of the *t*-statistic of the inverse of Mills' ratio is the Lagrange multiplier statistic (Melino, 1982). This is asymptotically equivalent to the likelihood ratio and Wald tests, and from the  $\chi^2$  distribution the null hypothesis is rejected by all four columns in both Tables 5 and 6 at conventional significance levels.

The annual rate of decumulation of wealth is given by the derivative of (4) with respect to age. For ages between 60 and 75 the rate of decumulation is  $-[\alpha_5 + 2\alpha_6(A - 60)]$ . At age 75 the annual rates of decumulation implied by the first three columns of Table 5 are, respectively, 0.67%, 0.91%, and 1.15%. These are small and are inconsistent with a pure life-cycle model in which date of death is certain. But they are close to the values computed by Davies (1980) in a numerical simulation of a life-cycle model with uncertainty about date of death. Assuming constant relative risk aversion Davies found rates of decumulation between ages 65 and 85 of around 2% per annum. Allowing for the value of social security wealth, (column 4 in Table 5) yields a rate of decumulation at age 75 of 5.1%. Other numerical simulations by Diamond (1977) found that the ratio of wealth to permanent income at age 60 would, under 'plausible' assumptions, lie between 2 and 6 depending on parameter values and social security coverage. The mean value of the ratio for the 60–64 age range in our sample is 4.56. Hence the behaviour of the 'average' household in our sample appears to fit well with the life-cycle model of saving allowing for an uncertain date of death. There is, however, a great deal of variation in household behaviour. Of the 669 households where the head was in the age range 60–64, 249 (37.2%) had wealth to permanent income ratios below 2. The behaviour of this group is less easy to reconcile with the life-cycle model unless these households anticipated very high replacement ratios from pensions and social security (for which there is no evidence in the data).

#### V. PENSIONS AND SOCIAL SECURITY WEALTH

The most important component of wealth on which we do not have direct observations is the value of the right to future pension and old age social security payments. Social security in Canada provides flat-rate benefits to those aged 65 and over and benefits are linked to the consumer price index.<sup>1</sup> Full

<sup>1</sup> Income-tested guaranteed income supplement available to pensioners is included in the data for social security payments. Further details of pension provisions in Canada may be found in Statistics Canada (1978b) and Wolson (1979).

indexation has been effective since 1972. Other pension schemes include the Canada and Quebec pension plans which cover almost the entire labour force; benefits are related to previous earnings and are indexed. In contrast private pension plans are rarely fully indexed. An alternative vehicle for private pension provision is Registered Retirement Savings Plans (RRSP). These were introduced in 1957 and increased rapidly in the 1970s after the limit on tax-deductible contributions was raised. Sums invested in RRSP are included in our measure of household net worth. The two main forms of pension wealth which are omitted are, therefore, flat-rate social security and earnings-related pension plans (which may be either private or Canada and Quebec pension plans). For the former we have information on receipts for retirees, and for the latter we have information on both receipts and eligibility.

For each individual in the sample we constructed an estimate of the present value of both social security (which includes Canada and Quebec pensions) and private pension wealth using the estimated age-earnings profiles and the relevant survival probabilities. Details of these calculations are presented in Dicks-Mireaux (1981). For private pensions actual receipts were used for retirees and an expected pension was imputed for those in pension plans who were below retirement age.<sup>1</sup> The imputation was based on a regression for pension receipts in terms of permanent income, age and occupation, adjusted for sample selection bias.<sup>2</sup> The mean values of wealth in these various forms for the 8,279 households headed by a male and with net worth no less than \$2,500 were the following: for net worth recorded in the survey \$65,821, social security wealth \$74,363, and, for the 3,832 households with private pension wealth, \$61,349.

Pension wealth is not a perfect substitute for other forms of wealth, and we assume that total wealth ( $TW$ ) may be expressed in terms of net worth, social security ( $SW$ ) and private pension wealth ( $PW$ ) by a loglinear approximation

$$\ln TW = \ln W + \eta \ln SW + \delta D_1 \ln PW, \quad (14)$$

where  $D_1 = 1$  if the household is eligible for a private pension plan, zero otherwise.

If we suppose that the life-cycle model given by (4) applies to total wealth, then we have that observed net worth is

$$\ln (W_i/Y_i) = f(A_i) - \eta \ln (SW_i/Y_i) - \delta D_1 \ln (PW_i/Y_i) + \rho \ln Y_i, \quad (15)$$

where  $f(A_i)$  is a non-linear function of age, and  $\rho = (\eta + \delta D_1)$  if preferences are homothetic.

Approximating the function  $f$  by the original piecewise non-linear function the results of estimating (15) are shown in column 4 of Tables 5 and 6. The coefficients of the age terms are similar to those in columns 1–3, although the implied rate of decumulation after retirement is higher. Both pension wealth variables have the predicted negative sign and are significantly different from

<sup>1</sup> The assumptions made concerning pre- and post-retirement indexation of pensions are discussed in Dicks-Mireaux (1981).

<sup>2</sup> Details available from the authors on request.

zero. The coefficient on permanent income is not insignificantly different from the sum of the coefficients on the pension and social security wealth variables and the hypothesis of homothetic preferences cannot be rejected when we allow for pension wealth.<sup>1</sup> These findings lend some support to the hypothesis that, *ceteris paribus*, social security and pension wealth reduce household saving, and are of interest because they are based on a data set comprising both young and old households in contrast with the several studies using data on heads of households in the immediate pre-retirement phase (Kotlikoff, 1979; Blinder *et al.*, 1980; Diamond and Hausman, 1980).

The effect of social security and private pension wealth on the accumulation of wealth in other forms may be computed from our estimates. The implied offset to saving resulting from an additional dollar of social security or pension wealth evaluated at the mean values for the sample are:

Extra dollar of	$\Delta W$ (\$)	$\Delta W'$ (\$)
Social security wealth	-0.24	-0.25
Private-pension wealth	-0.10	-0.18

The estimated offset is an increasing function of wealth and at the mean values for the top decile group of the distribution of net worth the reduction in saving per additional dollar of pension wealth is estimated to be \$1.00 for social security and \$0.40 for private pensions.

#### VI. CONCLUSIONS

We have found that there is evidence that wealth declines after retirement once we control for differences in permanent income. Moreover this is true of net worth excluding the value of rights to future payments of pensions and social security. But the rate at which wealth declines after retirement is less than would be predicted by a life-cycle model with neither bequests nor uncertainty about date of death. Our evidence is consistent, therefore, with either a significant bequest motive or uncertainty about date of death.

There is a tendency in the literature to identify the behaviour of all households with a single model. Our evidence suggests that different motives are likely to exist side by side. The estimated 'life-cycle' model accounts for only 50% of the variance of the ratio of wealth to permanent income and, although there is clearly a good deal of noise in the measurement of permanent income, it is likely that there is a distribution of motives for saving in the population. The observation that the wealth holdings of a majority of the population appear explicable in terms of a life-cycle model is perfectly consistent with the evidence that a certain fraction of the population does not, for whatever reason, save adequate resources for retirement. Indeed, the evidence in our data set suggests that there is such a group – although we cannot rule out the possibility that

<sup>1</sup> An alternative approximation to total wealth would deflate each variable in (14) by permanent income. In this model the test for homotheticity is based simply on the coefficient of permanent income, and homotheticity is rejected for both definitions of net worth. The two approximations might be regarded as providing upper and lower bounds for the coefficient on permanent income.

households with little wealth plan to finance retirement consumption almost entirely out of indexed social security.

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