CONSUMPTION AND PERMANENT INCOME: THE AUSTRALIAN CASE

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ABSTRACT

The sharemarket crash of October 1987 has raised the question of the effect of a change in share prices on real consumption expenditure. This paper examines this issue by examining the role of permanent income or wealth in explaining the behaviour of aggregate consumption expenditure in Australia. Two approaches to testing the permanent income hypothesis are used. The first applies extensions to the method proposed by Hall (1978) and the second follows Hayashi (1981). Both approaches, using a variety of tests, give strong support for the permanent income hypothesis. In testing the relative explanatory power of permanent versus current income, we find that between 50 per cent and 70 per cent of consumption expenditure is consistent with the permanent income hypothesis and the remainder is explained by current income.

It is argued in the paper that although consumption expenditure seemed unaffected by the sharemarket crash, this outcome is still consistent with the permanent income hypothesis.

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1. Introduction

The share market crash of October 1987 focussed attention on the effect of changes in wealth or permanent income on aggregate consumption expenditure. Unfortunately, there is very little clear empirical evidence on the role of wealth in determining consumption in the Australian case.[1] There are numerous studies using U.S. data based on the method of Hall (1978) which find varying degrees of relevance for the permanent income hypothesis. However, very few Australian studies have pursued the Hall approach and the subsequent extensions. Exceptions include Johnson (1983) using data on expenditures on non-durables, and Jubb (1986) who examines both durable and non-durable expenditures.

The purpose of this paper is to examine the role of permanent income in explaining aggregate consumption expenditure in Australia using a variety of tests. One test uses a modification of the approach taken by Hall (1978). An advantage of the Hall approach is that with sufficient assumptions, aggregate wealth data is not required to test the role of permanent income. An alternative approach proposed by Hayashi (1981), uses data on non-human wealth. The relationship between the two approaches is developed in this paper, and applied to test for the roles of permanent and current disposable income in explaining aggregate consumption.

We find that tests extending the Hall and Hayashi approaches both give strong and consistent evidence in favour of the permanent income hypothesis, especially when the aggregate consumption data is recalculated with expenditure on durable goods converted into a flow of consumption services from these goods. However, we also find that there remains a residual, though significant, proportion of consumption expenditure that is explained by current and not permanent income.

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1. Summaries of early Australian studies of the consumption-savings decision are provided by Williams (1979) and Freebairn (1976).

Section 2 of the paper derives the testable implications of the life cycle hypothesis following the work of Hall (1978), Flavin (1981), Hayashi (1982) and Mankiw and Campbell (1987). By allowing for some proportion of consumers to base their decisions on permanent income and some part on current income, a more general model can be derived. In Section 3, the data which is used to test the theories are discussed. A modification of Hall's approach is tested using quarterly and annual data for the period 1962(1) to 1987(2) and the Hayashi approach is tested using annual data for the period 1961/62 to 1986/87. A conclusion is summarised in Section 4.

2. Testable Implications of the Life Cycle Model

The life cycle model of consumer behaviour can be tested by examining either consumption or savings behaviour. The most popular approach has concentrated on the consumption side - and this paper will follow that path.[2]

Consider a representative consumer who is faced with a choice of consumption in each period given an initial asset stock and an uncertain income stream. Assume that the only uncertainty is the future stream of income.

The consumer's problem can be written:

$$\text{Maximise } W_t = E_t \sum_{s=0}^{\infty} (1+\delta)^{-s} U(C_{t+s}) \tag{1}$$

$$\text{subject to } A_{t+1} = (1+r_t)(A_t + Y_t - C_t) \tag{2}$$

where δ = rate of time preference

C_t = real consumption in period t

A_t = real non-human wealth at start of period t

Y_t = real after-tax labour income in period t

r_t = real after-tax interest rate in period t

and E_t = denotes expectation at time t

$U(C_t)$ = denotes the utility derived from consumption in period t

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2. However, see Campbell (1988) and Deaton (1986) for an alternative approach based on savings behaviour.

Solving this problem and assuming a bounded solution gives:

$$U'(C_t) = \frac{1+r_t}{1+\delta} E_t U'(C_{t+1}) \tag{3}$$

$$A_{t+1} = (1+r_t)(A_t + Y_t - C_t) \tag{4}$$

Equation (3) gives the familiar result that the consumer equates the marginal utility from consumption across time, adjusted for the rate of time preference and the real return from postponing consumption.

The difference equation (4) can be solved to find:

$$A_t = \sum_{s=0}^{\infty} R_{t+s} (E_t C_{t+s} - E_t Y_{t+s}) \tag{5}$$

where $$R_{t+s} = \prod_{n=0}^{s} (1 + r_{t+s})(1+r_{t+n})^{-1} \tag{6}$$

Equation (5) can be rewritten:

$$\sum_{s=0}^{\infty} R_{t+s} E_t C_{t+s} = A_t + H_t \tag{7}$$

where $$H_t = \sum_{s=0}^{\infty} R_{t+s} E_t(Y_{t+s}) \tag{8}$$

H_t can be interpreted as the expected real value of human wealth at start of period t. It is the present discounted value of the expected future stream of after-tax labour income where the rate used to discount the stream of income is the real return to holding financial wealth.

Equation (7) shows that the present value of consumption expenditure should equal the initial assets plus human wealth. This states that the optimal solution for consumption is to consume all resources during the consumption horizon.

The time path of consumption depends on the form of the utility function. As an illustration, assume that utility is a log function of the level of consumption:

$$U(C_t) = \log C_t \tag{9}$$

We can rewrite (3)

$$E_t \left(\frac{C_t}{C_{t+1}} \; \frac{1+r_t}{1+\delta} \right) = 1$$

Based on Hansen and Singleton (1983), it can be shown that by assuming C and r are jointly log normally distributed, we can make some convenient simplifications. If we let

$$x_{t+1} = \frac{C_t}{C_{t+1}} 1+r_t$$

and assume $X_t = \log x_t$

where $X \sim N(\mu, \sigma^2)$

we have $E(x_{t+1}|I_t) = \exp\ (\mu + \sigma^2/2)$

or $\log E(x_{t+1}|I_t) = \mu + \sigma^2/2$

and $E(X_{t+1}|I_t) = E(\log X_{t+1}|I_t) = \mu$

Therefore, $\log E(x_{t+1}|I_t) = E(\log x_{t+1}|I_t) + \sigma^2/2$

Using this transformation plus the assumption of rational expectations, it can be shown that (10) holds.

$$C_{t+1} = \frac{1+r_t}{1+\delta} kC_t + \mu_{t+1} \tag{10}$$

where $k = e^{\sigma^2/2} \simeq 1$ since $\sigma \simeq .01$

k can be interpreted as a linearization error which we will ignore.

μ_{t+1} is white noise. It can be seen from (10) that if r is constant and equal to δ, then consumption is a random walk.

Combining (10) and (7) and ignoring k, it can be shown that:

$$C_t = \frac{\delta}{1+\delta} \ (A_t + H_t) + e_t \tag{11}$$

Where e_t is a white noise disturbance. For steady state consumption to be constant we require that δ=r. Substituting this into (11) gives a steady state relation

$$C = r \ (A/(1+r) + Y/r) \tag{12}$$

Equation (12) implies that consumption in each period is the annuity value of human plus non-human wealth. This can also be defined as permanent income (see Flavin (1981)). Note that this result differs slightly from Flavin's because of the discrete approximation for the budget constraint we use in (4) which is the standard approach. If it is assumed that $A_{t+1} = (1+r_t) \ A_t + Y_t - C_t$ then we find the result in Flavin.

Generally, it is convenient to express (11) as:

$$C_t = \alpha \ (A_t + H_t) + e_t \tag{13}$$

where α will not necessarily be independent of r, for example if bequests are important, and depending on the form of the underlying utility function.

To estimate the permanent income model it is possible to follow a variety of approaches, based on the different stages of substitution in the equations above. Before proceeding, it is convenient to introduce a generalisation to the above model. Assume that there are two types of agents in the economy. Agents of type x consume out of permanent income (Y^P) and agents of type v consume out of current (or disposable) income (Y). We assume that agents of type x receive a fixed share Ω of total income and type v agents receive $(1-\Omega)$ of total income.[3] Then:

$$C_t^x = Y_t^{Px} = \alpha(A_t^x + H_t^x) = \alpha(A_t + \Omega H_t)$$

$$C_t^v = Y_t^v = (1-\Omega)Y_t$$

assuming that all assets are held by type X agents.

The model for aggregate consumption becomes:

$$C_t = \alpha(A_t + \Omega H_t) + (1-\Omega)Y_t + e_t \tag{14}$$

In principle, (14) can be estimated given data for C,A,H and Y. Unfortunately, data on human wealth is not available. One alternative is to approximate the value of future income by a distributed lag on past values of income. The problem with this as pointed out by Lucas (1976) is that expectations are inadequately represented.

(a) <u>The Hall Approach</u>

Other alternatives exploit the implications of assuming rational expectations. One such alternative is to estimate the Euler equation (3) directly following Hall (1978). This requires an assumption of the form of the utility function. Again, by assuming log utility, a constant r and rational expectation we have:

$$C_{t+1} = \frac{1+r}{1+\delta} C_t + \mu_{t+1}$$

or

$$C_{t+1} = \gamma C_t + \mu_{t+1} \tag{15}$$

where $E_t\ (\mu_{t+1}) = 0$

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3. In terms of a classical framework, this dichotomy might be interpreted as assuming that one group (call them workers) consume all their current income, do not save (except via government pensions etc.) and thus do not receive property income, while the other class (call them capitalists) consume their permanent income, accumulating savings in the process. The stability conditions of the two class system could be derived, as in Pasinetti (1962), and would probably depend upon the savings rate of the capitalist class being above some crucial value.

Note that if $\gamma=1$ (i.e., $\delta=r$) then consumption follows a random walk. Again, introduce two types of agents.

$$C^x_{t+1} = \gamma C^x_t + \mu_{t+1} \tag{16}$$

$$C^v_{t+1} = Y^v_{t+1} \tag{17}$$

Aggregate consumption becomes:

$$C_{t+1} = \gamma(C_t - C^v_t) + \mu_{t+1} + Y^v_{t+1}$$

$$C_{t+1} = \gamma C_t - \gamma(1-\Omega)Y_t + (1-\Omega)Y_{t+1} + \mu_{t+1} \tag{18}$$

or

$$\Delta C_t = (\gamma-1)C_{t-1} + (1-\Omega)\Delta Y_t - (\gamma-1)(1-\Omega)Y_{t-1} + \mu_t \tag{19}$$

Note that if $r=\delta$, then $\gamma=1$ and C^x_t is a random walk. The change in aggregate consumption is then only a function of the change in income.

Equation (19) can be used to test the joint hypothesis of permanent income, rational expectations and that a share of consumption is determined by current income, though there are some econometric problems to overcome. The first problem we need to consider is the time series properties of C and Y. If C and Y are non-stationary, then as shown by Mankiw and Shapiro (1985), we may encounter bias in testing for the significance of γ, especially if we have a stationary series as a dependent variable and non-stationary series as independent variables. Stock and West (1987) show that the bias from this problem is avoided if the equation can be re-written with only trend stationary variables as dependent variables. The standard t-tests will then be asymptotically valid. In our model, if C and Y are cointegrated,[4] we can, in fact, rewrite the model with only trend stationary variables on the right hand side. For example, equation (19) can be rewritten:

$$\Delta C_t = (1-\Omega)\Delta Y_t + (\gamma-1)(C_{t-1} - (1-\Omega)Y_{t-1}) + \mu_t$$

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4. Two series (C,Y) will be cointegrated if they are the same order of integration and if the residuals from the regression $C_t=\alpha+\beta Y_t+\varepsilon_t$, are stationary.

Under the null hypothesis, $\gamma=1$, $\Omega=1$ and therefore C has a unit root. If Y also has a unit root and C and Y are cointegrated with a cointegrating factor of $(1-\Omega)$ then ΔY and $(C - (1-\Omega)Y)$ will both be stationary. A problem emerges if $\gamma>1$ and if C and Y are not cointegrated. However, C and Y can be tested for cointegration before carrying out the analysis and the residuals from this equation can be tested for non-stationarity which could be an alternative test for cointegration if $\gamma \neq 1$.

Further problems occur because ΔY_t will likely be correlated with μ_t and, therefore, needs to be instrumented out. This may be a problem if Y_t is also a random walk, since by definition there are no instruments for ΔY_t. This also causes problems since from (19), if ΔY is white noise then the hypothesis that consumption is driven by current income is indistinguishable from the permanent income hypothesis; current income is the best guess of permanent income.

(b) The Hayashi Approach

An alternative approach follows Hayashi (1982). The essence of Hayashi's approach is to use the equation for the evolution of human wealth implied by equation (8) to substitute out for human wealth. Hayashi also introduces the possibility that the rate used to discount future income streams is different to the return on financial assets, possibly due to capital market imperfections.

Assuming rational expectations, equation (8) can be rewritten :

$$H_t = (1+r^h_{t-1})(H_{t-1} - Y_{t-1}) + \varepsilon_t \tag{20}$$

where $\varepsilon_t = \sum_{s=0}^{\infty} R_{t+s} \left(E_t Y_{t+s} - E_{t-1} Y_{t+s}\right)$

and $R^h_{t+s} = \prod_{n=0}^{s} (1+r^h_{t+s})\,(1+r^h_{t+n})^{-1}$

that is, ε_t is the revision to expectations over the path of Y_t, with $E_t Y_{t+s}$ defined as the expectation at time t of Y_{t+s}. r^h is the rate used to discount future income which we now allow to differ from r. For convenience assume r^h is constant.

Using (14), we have

$$H_t = \frac{C_t - \mu_t - \alpha A_t - (1-\Omega)Y_t}{\alpha\Omega}$$

which can be substituted into (20) to find

$$C_t = \alpha A_t + (1+r^h)C_{t-1} + (1-\Omega)Y_t - \alpha(1+r^h)A_{t-1} - \Omega\alpha(1+r^h)Y_{t-1}$$
$$- (1+r^h)(1-\Omega)Y_{t-1} + \rho_t$$

$$\text{where } \rho_t = \mu_t + \alpha\Omega\varepsilon_t - (1+r^h)\mu_{t-1} \qquad (21)$$

Hayashi proceeded to estimate (21) and (14). Recent work has shown that this is problematic if C and Y are non-stationary series. Therefore, the equations are estimated in differenced form here.

$$\Delta C_t = (1-\Omega)\Delta Y_t + \alpha\Delta A_t + r^h(C_{t-1} - (1-\Omega)(1+r^h)Y_{t-1} - \alpha A_{t-1}) - \alpha\Omega Y_{t-1} + \rho_t \qquad (22)$$

$$\Delta A_t = r(A_{t-1} + Y_{t-1} - C_{t-1}) + \psi_t \qquad (23)$$

Note that by assuming $r^h = r = \delta$ we can manipulate equations (22) and (23) to find:

$$\Delta C_t = (1-\Omega)\Delta Y_t + \rho_t + \alpha\psi_t$$

which is our test for the Hall model assuming $\gamma=1$ (i.e., $r=\delta$). This is not surprising since the two approaches are only rearrangements of the same set of first-order condition and budget constraints. The advantage of the Hayashi approach is that it allows us to explore the assumptions about the rates of return used to calculate human wealth and financial wealth.

We make different assumptions about the relationship between r (the real return on financial assets) and r^h (the real rate used to discount future income). Firstly, if we assume both are constant and equal we can estimate (22) and (23) together to find estimates for α, Ω and the constant r^h. These results can be used to test the permanent income hypothesis given data on financial wealth. If the permanent income hypothesis alone explains consumption, then the estimate for Ω will be close to unity. On the other hand, if consumption can be explained purely by current income, then Ω will be close to zero, and the other parameters will be insignificant.

There are some econometric problems with directly estimating equations (22) and (23). The issue of non-stationarity has already been dealt with. Other econometric problems emerge because we have by construction:

$$E(C_{t-1}\mu_{t-1}) \neq 0 \qquad \text{(see equation (10))}$$

and

$$E(A_t\ C_{t-1}) \neq 0 \qquad \text{(see equation (2))}$$

Also note that A_t is not in the information set I_{t-1} on which the expectation of ε_t is conditioned. Therefore $E(\varepsilon_t\ A_t) \neq 0$.
We need a set of instruments that are uncorrelated with μ_t and μ_{t-1}. The NLIV (non-linear instrumental variable) technique suggested by Hayashi is used here.

A third test for the relevance of the permanent income hypothesis was suggested by Flavin (1981). Flavin concentrates on the effect of innovations in income on innovations in consumption. She explicitly models the time series of consumption and income as a bivariate autoregressive process imposing cross equation restrictions from the rational expectation assumption. This has been criticised by Mankiw and Shapiro (1985) amongst others because of the inappropriate test statistics when consumption and income follow random walks. In this case, the test of excess volatility of consumption will be biased. Engle and Granger (1987) further point out that if C and Y are cointegrated then a technique such as Flavin's will be misspecified.[5] We do not pursue the Flavin approach further.

3. Empirical Results

a. Data

Each equation is estimated using real per capita data. All quarterly data (except the financial data used in estimating equation (19)) are seasonally adjusted, except where noted. Data sources are provided in the Appendix B.

For consumption, a series for the flow of services from consumer durables was constructed. The flow of services is defined to be equal to the rental services provided by the stock of durables, where those services are calculated as the rate of depreciation plus the real rate of return. Data for the stock of durables are constructed using data for expenditure on durables, and estimated depreciation rates. Further details of these series are provided in the Appendix.

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5. See Macdonald and Kearney (1987) for estimates of a permanent income model using cointegration techniques.

For aggregate non-human wealth, a series was constructed using the data of Piggott (1986), Horn (1988), Adams (1987), and Helliwell and Boxall (1978). Further details are provided in the Appendix.

Before estimating the different equations, we need to take account of the time series properties of C and Y. In Appendix A we discuss and test the consumption and real household disposable income data for non-stationarity. Using the Augmented Dickey-Fuller test, we find that it is difficult to reject the hypothesis that both series are integrated of order one (i.e. they both have a unit root). We also find that they appear not to be cointegrated although this evidence is not strong and is inconsistent with an alternate test suggested below.

b. <u>The Hall, Campbell, Mankiw Approach</u>

As described in Section II, this approach involves estimating equation (19), repeated here for convenience.

$$\Delta C_t = (\gamma-1)C_{t-1} + (1-\Omega)\Delta Y_t - (\gamma-1)(1-\Omega)Y_{t-1} + \mu_t \tag{19}$$

Since changes in current income will usually lead to changes in perceptions about permanent income, ΔY_t will usually be correlated with the unobserved μ_t. Accordingly, it would be expected that estimates of Ω will be biased downwards if OLS estimation is used. To avoid this problem, instruments must be used for ΔY_t using variables which are uncorrelated with μ_t. Under the assumption of rational expectations, this will usually be satisfied by variables in the information set at time t-1, though as Campbell and Mankiw point out, there may be cases where variables from period t-2 will be more appropriate.

The use of instruments also requires that the instruments be correlated with ΔY_t. If ΔY_t is not well explained by the instruments, then Ω will not be estimated with precision. The results in Appendix A suggest that it will be difficult to find instruments for ΔY_t.

First, we assume γ=1 and use the tests in Campbell and Mankiw (1987). Table 1 shows OLS and instrumental variable estimates for Equation (19) using quarterly data. The variables chosen as instruments for income are variables which are sometimes suggested as being useful in explaining income. They include lagged information on income, consumption, interest rates and monetary aggregates. (Changes in stock prices were also used as instruments but were found to be even worse as explanators of ΔY_t.) Each equation is estimated over the period 1962(1)-1987(2), as well as two sub-periods, 1971(2)-1980(3) and 1980(4)-1987(2). The last period corresponds to the period in which interest rates have largely been deregulated.

The OLS estimates for Ω, even though they should be biased towards rejecting the permanent income hypothesis, suggest that a substantial proportion of consumption is explained by the permanent income hypothesis.

For the instrumental variables estimates, it proved difficult to find variables which explained household income well. As can be seen in columns 2, 5 and 8 in Table 1, of the 18 estimates, only 4 sets of instruments could explain ΔY_t at the 25 per cent significance level. As a result of these problems it is to be expected that Ω will not be estimated with a great degree of precision. On the other hand, it is likely that the instruments for ΔY_t will be uncorrelated with μ_t.

As can be seen in columns 3, 6 and 9 in Table 1, the instrumental variable estimates for Ω were all significantly different from zero at very low significance levels. Estimates for $(1 - \Omega)$ can also be derived from these estimates. As can be seen in columns 4, 7 and 10, the estimates for $(1 - \Omega)$ are all smaller than the estimates for Ω, but in 8 cases were significantly different from zero at the 5 per cent level, and in another 6 cases were significantly different from zero at the 25 per cent level. In only 4 out of 18 cases were the estimates for $(1 - \Omega)$ not significantly different from zero at this wider level of significance.

Similar results were obtained when the dependent variable was derived from data on consumption expenditures. These showed estimates of Ω which were significantly different from zero, and estimates of $(1 - \Omega)$ which were often also significantly different from zero. The estimates for Ω appeared, however, to be slightly higher for the data on pure consumption, implying that the life-cycle hypothesis is more likely to be accepted when consumption is measured on a basis that is more appropriate given the theoretical model.

A further test of the permanent income hypothesis is the strong form of the test suggested by Hall (1978). That is, any other variable in the information set I_t, should be insignificant if included in the regression equation. For this test we regressed the residuals from each of the instrumental variables

TABLE 1: REDUCED FORM ESTIMATES - QUARTERLY RESULTS

Instruments[a]	1962(1)-1987(2) R^2 for ΔY	1962(1)-1987(2) $\hat{\Omega}$	1962(1)-1987(2) $(1-\hat{\Omega})$	1971(3)-1980(3) R^2 for ΔY	1971(3)-1980(3) $\hat{\Omega}$	1971(3)-1980(3) $(1-\hat{\Omega})$	1980(4)-1987(2) R^2 for ΔY	1980(4)-1987(2) $\hat{\Omega}$	1980(4)-1987(2) $(1-\hat{\Omega})$
None (OLS)	-	.8174* (.0307)	.1826*	-	.8321* (.0452)	.1679*	-	.7605* (.0561)	.2395*
ΔY	.0330	.9791* (.1910)	.0209	.0974	.8050* (.1457)	.1950+	.2131+	.8880* (.1334)	.1120
ΔC, ΔY	.0462	.8567* (.1439)	.1433	.1739	.7497* (.1135)	.2503*	.3287	.8012* (.0988)	.1988+
Δ nom M, ΔY	.0978	.7753* (.0991)	.2247*	.2526	.7506* (.0941)	.2494*	.3579	.8861* (.1027)	.1139
Δ real M, ΔY	.0764	.8463* (.116)	.1537+	.1991	.7307* (.1084)	.2693*	.3711	.8429* (.0959)	.1571+
Nom R, ΔY[b]	.2152+	.7879* (.0756)	.2121*	.2140	.8686* (.0987)	.1314+	.4853+	.7727* (.0806)	.2273*
Real R, ΔY[b]	.1263	.8080* (.0984)	.1920+	.1991	.7307* (.1084)	.2693*	.4633+	.8035* (.0833)	.1965*

(a) Four lags of each variable were used as instruments in each case.

(b) Equations using interest rates date from 1971(3)-1987(2) rather than 1962(1)-1987(2)

*,+ denote significantly different to zero using t test for parameter estimates, and F test for goodness of fit, at 5 per cent and 25 per cent levels, respectively.

estimates of Table 1 against a number of the other variables. The results, which are not shown here, indicated that none of the other variables could explain the residuals from equation (15). This can be interpreted as evidence to support the permanent income hypothesis, and the assumption of rational expectations.

Table 2 shows the results when Equation (19) (with the constraint $\gamma=1$) is estimated using annual data for the period 1962/63 to 1986/87. The results using instruments vary relative to the results from the quarterly data (though the OLS estimate for the annual data does appear to be substantially more biased than for the quarterly data). There is still substantial variation among the estimates for Ω, but all are significantly differed to zero. Furthermore, the estimates for $(1-\Omega)$ tend again to be significantly different to zero, lending further credence to the notion that current income is also an important determinant of consumption.

Now consider the results when we drop the assumption that $\gamma=1$ although we still assume a constant r and therefore a constant γ.

An illustrative result using lagged changes in money and income as instruments is presented in Table 3. As can be seen from this result, γ is significantly less than 1 although this does not greatly affect the result for Ω which is marginally higher than the corresponding result in Table 1.

To provide some additional support for our earlier results that C and Y were non-stationary but apparently not cointegrated we can perform some stationarity tests on the residuals from Table 3. We used the Augmented Dicky-Fuller Test discussed in Engle and Granger (1987). The residuals from estimating equation (19) were differenced and regressed on the first lag and four lagged differences. The coefficient on the lagged residual was -0.986 with a t statistic of -3.6. This is significant using the criterion in Engle and Granger (1987) (Table 2), which indicates that the residuals are stationary. Therefore, either both C and Y are stationary or they are co-integrated. This suggests a possible problem with the power of the test of co-integration in the Appendix. It also implies that the co-integrating co-efficient is 0.8 which is close to that found in the more conventional test given in Appendix A.

To test the consequence of the assumption that r is constant, we assume

$$\gamma_t = \frac{1+r_t}{1+\delta} \quad \text{and re-estimate equation (19).}$$

Table 2: Reduced Form Model - Annual Results

(standard errors in parentheses)

Instruments[a]	R^2 for ΔY	$\hat{\Omega}$	$(1-\hat{\Omega})$
None (OLS)	-	.2854* (.0582)	.7146
ΔY	.0322	.7940* (.3251)	.2060
ΔC, ΔY	.0620	.5724* (.2660)	.4276+
Δ NomM, ΔY	.2840+	.6391* (.1132)	.3609+
Δ NomR[b], ΔY	.2805+	.4811* (.1467)	.5189+

Table 3. Reduced form Model - γ estimated
Quarterly 1962(1) - 1987(2)

Instruments	R^2 for ΔY	$(\hat{\gamma}-1)$	$\hat{\Omega}$	$(1-\hat{\Omega})$
Δ nom M, ΔY	.0978	-.0125* (.0041)	0.8067* (.1049)	0.1933

Table 4: Introducing a Variable Real Rate of Return
Quarterly 1962(1)-1987(2)

	Instruments	$\hat{\delta}$	$\hat{\Omega}$	$(1-\hat{\Omega})$
Equation (19)(γ=1)	ΔNomM, ΔY	-	.7753* (.0991)	.2247*
Equation (19) $\gamma = \frac{1+r_t}{1+\delta}$	ΔNonM, ΔY	.0225* (.0075)	.7565* (.1047)	.2435*

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a. Two lags of each variable were used as instruments in each case.

b. The bill rate on 90-day bank accepted bills is used after 1969; prior to that a proxy is used.

*+ Denote significant at the 5 and 25 per cent levels using t tests for parameter estimates and F tests for goodness of fit.

Table 4 shows the results when the estimates for equation (19) are modified by assuming a variable real rate of return. In this case, we assume a log utility function and make γ a function of r_t and a constant rate of time preference δ. The expected real rate of return is proxied by the 90-day bank bill rate in the previous quarter less the inflation rate in the year to that quarter (Estimates using only one set of instruments are reported here but other results were quite similar also.) As can be seen the estimate for Ω is little different under the assumption of a variable rate of return.

Furthermore, the estimate for δ, the rate of time preference, appears plausible at around 2.3 per cent per quarter. Estimates for the various sub-periods also gave similar results for Ω (though estimates for δ were less precise), leading us to conclude that the assumption of a constant r does not have a major effect upon estimates for Ω.

Overall, the results obtained from the various quarterly and annual estimates appear to be quite consistent. They suggest the interpretation that aggregate consumption can be explained by the permanent income hypothesis, but that allowance should be made for a small but significant share of consumption which is better explained by current income.

c. The Hayashi Approach

Because movements in income are likely to be correlated with movements in wealth, equation (22) is estimated simultaneously with an equation explaining real wealth. The system of equations is:

$$\Delta C_t = (1-\Omega)\Delta Y_t + \alpha\Delta A_t + r^h(C_{t-1}-(1-\Omega)Y_{t-1} - \alpha A_{t-1}) - \alpha(1-\Omega)Y_{t-1} + \rho_t \qquad (22)$$

$$\Delta A_t = r(A_{t-1} + Y_{t-1} - C_{t-1}) + \psi_t \qquad (23)$$

Equation (23) is now assumed to be stochastic (deviating from the theoretical model) reflecting measurement errors in the data. As mentioned above, we can make various assumptions about the relationship between r^h, and r as well as their variability. Firstly, we assume that $r=r^h$ and both are constant which implies we can make r another parameter to be estimated. The restriction can be tested. We then assume a variable r_t and a constant r^h and finally a variable $r_t^h=r_t$.

The equations are estimated using annual data and the SYSNLIN program in SAS. Instrumental variables are used in both equations. The choice of instruments is somewhat arbitrary. The variables used were a constant, a time trend, and five variables similar to those suggested by Hayashi (described in the Appendix), though in the event the results did not appear to be especially sensitive to the choice of the instruments.[6]

The estimates for the system of equations (22) and (23) with $r=r^h$ are shown in Row 1 of Table 5. The estimation period is too short to test the stability of the equation with any great degree of power, though shortening the sample period at either end had little impact on the parameter estimates. The equations show no signs of autocorrelated residuals. We therefore do not need to follow the procedures suggested by Hansen (1982) for calculating corrected standard errors. All three parameters were of the expected sign and were highly significant. The real rate of return is estimated to be 4.3 per cent per annum, which appears a plausible value. The value for α, 0.021, represents the proportion of total wealth consumed each year. This may be a little less than some might expect (see e.g., Modigliani 1987). Given the evidence that bequests are significant (see again, Modigliani, 1987), it does not seem implausible that this should be reasonably low. Another reason for a lower than expected value would be if (as Simes and Horn, 1986, conjecture), Australian data for aggregate non-human wealth overstate the true level.

The estimate for Ω, of 0.61 is significantly different from zero (using the asymptotic t-test) and can be interpreted as indicating that a large proportion of consumers conform to the behaviour that is postulated by the life-cycle hypothesis. The implied estimate for $(1 - \Omega)$ is 0.39, which using the estimated standard error is also significantly different from zero. This would suggest that a smaller yet significant proportion of total consumption is explained by current disposable income. This could be explained, within the framework of the life-cycle hypothesis, either by liquidity constraints or by a high rate of time preference. The first explanation relies upon agents being either unable to borrow, or facing different lending and borrowing rates which precludes the use of capital markets to optimise their consumption path. The second explanation relies simply upon some consumers having very short planning

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6. It should be noted it did prove possible to find instruments which explained annual consumption well. If the problems with the quarterly series were due to noise in the data, it would be expected that annual data will be less affected.

TABLE 5: Parameter Estimates for Structural Model
(Standard errors shown in parentheses)

Restrictions	$\hat{\alpha}$	$\hat{r}$	$\hat{\Omega}$	Auto-correlation Coefficients Eqn (22)	Eqn (23')	Minimised Objective Fn.
1 None	.0212*	.0427*	.6081*	-.1046	.2248	1.0952
	(.0058)	(.0054)	(.0868)	(-.2151)	(.2155)	
2 Ω=1	.0212*	.0415*	1	.2251	.2232	1.3546
	(.0058)	(.0060)	-	(.2876)	(.2157)	
3 Ω=0	-	.0415*	0	.3342	.2204	1.1787
	-	(.0064)	-	(.2002)	(.2160)	
4 None	.0211*	.0415*	.4946*	-.1989	.2276	1.1163
(original (data)		(.0069)	(.0060)	(.1115)	(-.2160)	(.2147)

Table 6: Structural Model under Various Assumptions
(standard errors shown in parentheses)

Restrictions	$\hat{\alpha}$	$\hat{r}$	$\hat{r}^h$	$\hat{\Omega}$	Minimised Objective Function
1 $r = r^h$	.0212*	.0427*	.0427*	.6081*	1.0952
	(.0058)	(.0054)	(.0054)	(.0868)	
2 r constant, r^h constant	.0025	.0418*	.0237*	.6120*	1.0627
	(.0086)	(.0074)	(.0086)	(.0914)	
3 $r_t=r_t^h$	-.0058	-	-	.0490	0.4012
	(.0208)			(0.1316)	
4 r variable, r^h constant	-.0043*	-	.0183*	.6117*	0.3759
	(.0089)		(.0067)	(.0933)	

* denotes that parameter estimates are significantly different to zero using asymptotic t test at 5 per cent level.

horizons. As Hayashi (1985) points out, however, it is difficult to devise a test to ascertain the particular cause of this type of behaviour.[7]

More formal tests of the hypothesis of two types of consumption are provided in Rows 2 and 3 of Table 5. Here we test the restrictions that $\Omega=1$ and $\Omega=0$. Row 2 shows the results when the equations are estimated constraining Ω to unity. Analagous to a likelihood ratio test, we can take the difference in the sum of squared residuals from the constrained and unconstrained regression and compute a chi-squared test on the restriction. The test indicates that the restriction can easily be rejected. Row 3 shows the results when the equations are estimated constraining Ω to zero, i.e., assuming that consumption is purely explained by current income. This hypothesis can be also rejected. These two results indicate that the hypotheses of two distinct groups of consumers cannot be rejected.

Row 4 of Table 5 presents the results using consumption expenditures data rather than the pure consumption measure. The estimate for Ω, of 0.49, is significantly different from zero, indicating that the permanent income cannot be rejected. However, the estimate for $(1 - \Omega)$, of 0.51, is also significant, suggesting that permanent income hypothesis is less important for data on expenditures than for the pure consumption series. This finding is similar to Hayashi's (1981) finding for the U.S. case, and our own finding in the tests of the previous section.

The preceding estimates and discussion have focussed upon the results for the structural equations under the assumption that the discount rate that is used in calculating human wealth (r^h) and the real interest rate (r) are constant and equal. Table 6 shows some estimates where these assumptions are relaxed. Row 1 shows the results described above where r and r^h were assumed constant and equal. Row 2 shows the results when the assumption that r and r^h are equal is relaxed. As can be seen, the estimates for r and r^h are quite similar, through r^h is estimated to be less than r, which seems a little counter-intuitive. However, r^h is estimated with less precision than r, which is not surprising giving the low number of degrees of freedom, and the hypothesis that r^h and r are equal cannot be rejected using the chi-squared test.

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7. As an experiment, we attempted to model the parameter Ω as a function of nominal interest rates. If liquidity constraints are important we would expect that this variable would be negatively related to interest rates, approaching unity at times when borrowing was cheap, and falling at times when borrowing was costly. We found some evidence to support this conjecture, but the estimates did not appear to be particularly stable.

Rows 3 and 4 show the results when r is allowed to be variable. Here the actual values of r_t were used in the estimation, where r_t was the (ex post) real interest rate. Row 3 shows the results when the discount rate is constrained to equal the real interest rate. In this case Ω, the proportion of the population that consumes their permanent income is insignificantly different from zero. Row 4 shows the results when the discount rate is held constant. Here the estimate for Ω, 0.61 is very similar to the estimates of rows 1 and 2.

It should be noted that these experiments varying the rate of interest assume that α, the proportion of wealth consumed remains constant which is only true for a small class of utility function. Overall, these results suggest that the assumption of a constant discount rate used to calculate human wealth is reasonable given the maintained hypothesis of the model and does not seem to affect the share of consumption that is driven by permanent income.

4. Conclusion

The analysis of the previous sections has presented evidence which provides reasonable support for the permanent income hypothesis, providing that allowance is made for a proportion of consumption which appears to be better explained by current income. This finding is in line with the U.S. studies by Hayashi, and Campbell and Mankiw, as well as a wide range of other studies which find that the permanent income hypothesis is not easily rejected.

Given the finding that the permanent income hypothesis appears to have explanatory power, it is worth considering the implications for some aspects of macroeconomic policy. In this concluding section, we look at the importance of stock market fluctuations for private consumption and the effect on consumption of changes in interest rates.

The effect on activity of a fall in share prices operates via a fall in the value of wealth. There are two possible explanations as to why consumption in both Australia and overseas did not appear to fall in response to the share market crash. The first explanation is that consumption did not rise with the booming share market preceeding the crash because the capital gains were not realised gains and therefore were not treated as part of wealth given agents understood the share market boom was a bubble with finite probability of bursting. The subsequent crash was discounted in the same way. This is not consistent with the theory since even if capital gains are not realised, as argued in Edey (1988), they should still be built into consumption decisions.

A second explanation is consistent with the theory. Assuming that only unconstrained consumers hold equities, the impact on consumption of a fall in share prices would be the proportion of wealth held as equities adjusted by the rate of time preference and the share of these consumers in aggregate consumption. Assume (as was the approximate effect in Australia in October 1987) a fall in share prices reduces the market value of private wealth by $100 billion. Using the parameter estimates in row 1, Table 6, this implies that, ceteris paribus, consumption should fall by approximately $1.5 billion (i.e. 0.6 *.025 *100), or 1 per cent of consumption in 1987.

That this fall in consumption apparently did not occur after October 1987 does not refute the model. Another implication of the life-cycle model is that movements in interest rates can have strong effects through the discounting of future income streams. A temporary fall in interest rates will have only a small effect, but a fall in short rates which is sustained and expected to be sustained so that it shows up in long rates will have a large effect. As an example, if long interest rates fall by half a percentage point from 13 to 12.5 per cent, that is a fall of 3.8 per cent in interest rates, human wealth would rise by 3.8 per cent. If human wealth is 80 per cent of total wealth, the life cycle model would imply an increase in consumption of about 3 per cent. In the case where only 50 per cent of consumption expenditures are based on the permanent income model, we would expect consumption to rise by 1 1/2 per cent. However, longer term interest rates fell by more than half of a percentage point in the six months after October 1987. Thus, the effect of the stockmarket crash on wealth could easily have been more than offset by the general trend of falling long interest rates.

The results of this paper suggest that the permanent income hypothesis explains a significant proportion of aggregate consumption expenditure in Australia. Perhaps the surprising aspect of the results is the robustness of this conclusion under the alternative tests we performed.

REFERENCES

Adams, P.D. (1987). "Australian Household Sector Wealth Statistics for the Estimation of the Extended Linear Expenditure System with Assets". Impact Project Working Paper, No. IP-34, Melbourne.

Campbell, J.Y. (1987). "Does Saving Anticipate Declining Labour Income? An Alternative Test of the Permanent Income Hypothesis". Econometrica, Vol. 55, No. 6, pp. 1249-1273.

Campbell J.Y. and N.G. Mankiw (1987). "Permanent Income Current Income and Consumption", National Bureau of Economic Research Working Paper, No. 2436.

Deaton, A.S. (1986). "Life Cycle Models of Consumption: Is the Evidence Consistent with the Theory?", National Bureau of Economic Research Working Paper, No. 1910.

Dickey, D.A. and Fuller, W.A. (1979). "Distribution of the Estimators for an Autoregressive Time Series with a Unit Root", Journal of the American Statistical Association, 74, 366, 427-431.

Edey, M. (1988). "Some Macroeconomic Implications of the October 1987 Sharemarket Crash", paper presented to the Pacific Basin Central Bank Conference on Economic Modelling, Kuala Lumpur, Malaysia.

Flavin, M.A. (1981). "The Adjustment of Consumption to Changing Expectations about Future Income", Journal of Political Economy, Vol. 89, No. 5, pp. 974-1009.

Freebairn, J.W. (1976). "Determination of Consumption", in W.E. Norton and D.W. Stammer (Eds), Conference in Applied Economic Research: Papers and Proceedings, Reserve Bank of Australia, Sydney.

Fuller, W.A. (1976). Introduction to Statistical Time Series, (New York: John Wiley).

Hall, R.E. (1982). "Stochastic Implications of the Life Cycle-Permanent Income Hypothesis". Journal of Political Economy, Vol. 86, No. 5, pp. 971-987.

Hansen, L.P (1982). "Large Sample Properties of Generalised Method of Moments Estimates". Econometrica, Vol. 50, No. 4, pp. 1029-54.

Hansen, L.P. and S.J. Singleton (1983). "Stochastic Consumption, Risk Aversion, and the Temporal Behaviour of Asset Returns". Journal of Political Economy, Vol. 91, No. 2, pp. 249-265.

Hayashi, F. (1981). "The Permanent Income Hypothesis: Estimation and Testing by Instrumental Variables". Journal of Political Economy, Vol. 90, No. 5, pp. 895-916.

Hayashi, F. (1985). "Tests for Liquidity Constraints: A Critical Survey". National Bureau of Economic Research Working Paper, No. 1720.

Helliwell J. and P. Boxall, (1978). "Private Sector Wealth: Quarterly Estimates for use in an Aggregate Model. Economic Record, Vol. 54, No. 145, April 1978, pp. 45-64.

Horn, P. (1987). "Private Non-Human Wealth of Australian Residents in the NIF88 Model", Background Paper for the Conference on the NIF88 Model, Canberra.

Johnson, P. (1983). "Life-Cycle Consumption Under Rational Expectations: Some Australian Evidence", Economic Record, Vol. 59, No. 167, pp. 345-350.

Jubb, C.D. (1986) "Hall's Hypothesis and the Consumption of Durable Goods: Theory and Empirical Evaluation for Australia". Paper presented to the 15th Australian Conference of Economists, Monash University, Melbourne.

Lucas R.E. (1976). "Econometric Policy Evaluation: A Critique", Journal of Monetary Economics, No. 2, Supplement Carnegie-Rochester Series, Vol. 1.

Mankiw N.G. and M.D. Shapiro, (1985). "Trends, Random Walks and Tests of the Permanent Income Hypothesis". Journal of Monetary Economics, Vol. 16, No. 2, pp. 165-174.

Modigliani, F. (1987). "Life Cycle, Individual Thrift and the Wealth of Nations", in Rudiger Dornbusch, et. al. (Eds), Macroeconomics and Finance. MIT Press, 1987.

Pasinetti, L.L. (1962). "Rate of Profit and Income Distribution in Relation to the Rate of Economic Growth". Review of Economic Studies, Vol. 29, pp. 267-279.

Piggott, J. (1986). "The Nation's Wealth - Some New Calculations for Australia". Reserve Bank of Australia Research Discussion Paper, No. 8606.

Simes R.M. and P.M. Horn, (1986). "Wealth, Inflation and the Consumption Functions. Paper presented to the 15th Australian Conference of Economists, Monash University, Melbourne.

Williams, R.A. (1979). "Household Saving and Consumption", in W.E. Norton and I.W. Little (Eds), Conference in Applied Economic Research, Reserve Bank of Australia, Sydney.

APPENDIX A: TIME SERIES PROPERTIES OF THE DATA

To test if the consumption and disposable income series are stationary we used the method of Dickey and Fuller (1979) and regressed:

$$\Delta X_t = a_1 + a_2 X_{t-1} + a_3 \Delta X_{t-1} + \ldots + a_6 \Delta X_{t-4} \tag{A1}$$

where X is consumption in Table A1 and disposable income in Table A2.

The distribution of the t-statistics on α_2 are non-standard. We, therefore, use the critical values tabulated by Fuller (1976). The critical value for the significance of the coefficients is 2.6 at the 1 per cent level of significance and 1.95 at the 5 per cent level. There is some ambiguity about the results for consumption which implies that consumption is I(1) at the 1 per cent level, but not at the 5 per cent level. The results for income are a little clearer.

These results indicate that consumption and income are apparently non-stationary, although there are problems with the power of these tests. Rather than undertake a further battery of tests for non-stationarity of the individual series, we will use the properties of the residuals from the alternative models in the paper to check for possible problems.

We next test to see if consumption and income are cointegrated. The results are:

$$C_t = \underset{(0.0214)}{-0.0107} + \underset{(0.0170)}{0.8988}\, Y_t$$

The residuals from this cointegrating equation were tested for non-stationarity using the Augmented Dickey-Fuller test as in equation (A1). These results are:

$$\Delta\varepsilon_t = \underset{(.0018)}{.0010} - \underset{(.0593)}{0.0767}\varepsilon_{t-1} - \underset{(.1147)}{0.1839}\Delta\varepsilon_{t-1} - \underset{(.1138)}{0.0330}\Delta\varepsilon_{t-2} - \underset{(.1128)}{0.08997}\Delta\varepsilon_{t-3}$$

$$+ \underset{(.1088)}{0.1120}\Delta\varepsilon_{t-4}$$

Again, we have non-standard t-statistics. In this case, we use the critial values in Table II in Engle and Granger (1987). These are 3.17 at the 95 per cent level of significance. These results show no significant co-efficient. It, therefore, appears that consumption and income are not co-integrated.

Table A1: Augmented Dicky-Fuller Test for Consumption

$$\Delta C_6 = \alpha_1+\alpha_2 C_{t-1}+\alpha_3\Delta C_{t-1}+\alpha_4\Delta C_{t-2}+\alpha_5\Delta C_{t-3}+\alpha_6\Delta C_{t-4}$$

Parameter	Value	t-statistic
α_1	0.0602	2.665
α_2	-0.0054	-2.403
α_3	-0.0761	-0.795
α_4	-0.0886	-0.919
α_5	0.0712	0.737
α_6	0.2029	2.109

Table A2: Augmented Dicky-Fuller Test for Disposable Income

$$\Delta Y_t = \beta_1 + \beta_2 Y_{t-1} + \beta_3\Delta Y_{t-1} + \beta_4\Delta Y_{t-2} + \beta_5\Delta Y_{t-3} + \beta_6\Delta Y_{t-4}$$

Parameter	Value	t-statistic
β_1	0.1132	1.985
β_2	-0.0105	-1.800
β_3	-0.1871	-1.931
β_4	-0.0394	-0.390
β_5	-0.0440	-0.435
β_6	0.0026	0.025

APPENDIX B: DATA SOURCES AND CONSTRUCTION

1. Sources of Data

- National Accounts data - RBA Forecasting Section database (from ABS Quarterly Estimates of National Expenditure)
- Interest Rate on 90-Day Bank Accepted Bills, All Ordinaries share price index, and M3 - RBA Bulletin database
- Australian population (end of quarter) - Demography Australia (CBCS, Bulletin No.86) and Population Estimates, Australia (ABS, 3219.0)
- PAYE income tax paid - Commonwealth Budget Statements (various years)

2. Definition of Variables

- Consumption - log of real per capita pure consumption of non-durables plus the imputed flow of services from consumption of durables.
- Consumption expenditure - log of real per capita private consumption expenditure
- Income - log of real household disposable income
- Interest rate - log of 90-day bank bill rate, end month of quarter
- Real interest rate - logged interest rate less the logged inflation rate (defined as 12 m.e. change in the consumption deflator)
- Share prices - log of real share prices
- Labour income - the sum of wages, salaries and supplements, plus cash benefits, less PAYE income tax, in real, per capita terms
- Wealth - real, per capita wealth defined below
- Population - estimated population, average of end quarter levels

Instrumental Variables (following Hayashi)

- Real per capita M3 (average of end quarter data, adjusted for new banks)
- Relative price of imports (deflator for imports of goods divided by consumption deflator)
- Real per capita government expenditure on goods and services
- Real exports of goods
- Real cash benefits to residents

Quarterly consumption and income data are seasonally adjusted, financial data are unadjusted. Except for the real interest rate, all data described as real are deflated by the consumption deflator. Disposable income was used instead of the labour income variable because quarterly data on PAYE income tax could not be obtained.

3. Stock of Consumer Durables

The relevant measure of consumption for the life-cycle hypothesis is a measure which includes the flow of services from the accumulated stock of consumer durables. This is in contrast to the usual National Accounts measure which measures consumer expenditures.

The sixteen expenditure groups in the National Accounts measure of private consumption expenditures can be aggregated into five groups: expenditure on motor vehicles, household durables, food, rent, and other non-durables. The last three categories are generally known as non-durables, and consumption flows are generally equated with expenditures. The first two (motor vehicles and household durables) are known as durables, and yield a flow of services over a considerably longer period than the quarter in which the expenditure is made.

To generate a series for the flow of services from consumer durables, it is first necessary to obtain a series on the stock of consumer durables. There is no officially collected series for either the stock of household durables or the stock of motor vehicles. Accordingly, a series must be constructed using the following identity.

$$KD_t = (1-a_0)\ KD_{t-1} + (1-a_0/2)\ CD_t$$

where KD_t = stock of durables at end of period t
CD_t = expenditure on durables during period t
a_0 = depreciation rate

and it is assumed that expenditures occur smoothly through each period.

Using estimates for the starting value of the stock of durables and for the depreciation rates, the NIF model database contains estimates of the stock of motor vehicles and household durables from 1959(3). Our own data takes the NIF model depreciation rates (quarterly rates of 6.5 and 5.75 per cent for motor vehicles and household durables, respectively) but assumes different (higher) starting values, especially so for household durables.

Our departure was based on the observation that, taken with the expenditure data, the NIF data implies a rate of increase in the stock of durables at the beginning of the period, especially for household durables, which is significantly higher than for the rest of the period. Accordingly, higher initial starting values were chosen, yielding series for the stock of durable which seem more plausible. These data are available from the authors upon request.

4. Consumption of Durables

Quarterly data for the flow of services from durables are derived from the assumption that this flow is directly proportional to the existing stock of durables in that quarter. The factor relating the flow of services to the stock of durables is determined as follows. In equilibrium, the utility gained from buying and consuming durable goods must be equal to the return available on alternative assets. Given that alternative assets yield a positive rate of return, while durables actually depreciate, the flow of services from durables must equal the sum of the real rate of return and the depreciation rate for durables. Assuming an average real rate of return of 1.25 per cent per quarter, and quarterly depreciation rates of 6.5 per cent for motor vehicles and 5.75 per cent for durables, this yields quarterly service flows of approximately 7.75 per cent and 7.0 per cent of the real value of the stock of motor vehicles and household durables, respectively.[1]

Data for pure consumption are constructed by adding the constructed series for the flow of services from durables to the data for expenditure on other classes of goods.

5. Household Wealth

Estimation of the life-cycle model presented in this paper requires a series for household wealth. Unfortunately, there is no single series for household sector wealth in Australia for the period of this study (i.e. 1959 to the present). Accordingly, a series was constructed using standard splicing techniques from the series of Piggott (1986), Horn (1987), Adams (1987) and Helliwell and Boxall (1978). There are a number of differences in definition between various series, for example the coverage (household or private), and the method of valuation (market value or replacement cost). For the interested reader, further discussions are provided by Piggott and Horn.

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1. The assumed annual rate of return of 5.0 per cent corresponds quite closely to the estimated discount rate of 4.4 per cent per annum. As an experiment, the estimated discount rate was substituted back into the calculations for the flow of services from durables, and the equations including the discount rate re-estimated. This process quickly iterated to yield parameter estimates which were insignificantly different to those shown in the paper.

   Similarly, another cross check on the discount rate (and the series for the stock of durables) is to compare values of the series for the service flow measure of consumption with the expenditure measures. In equilibrium these will be similar, and the mean value of the ratio of the two series will be unity. As expected, the ratio based on our series at times showed significant deviations from unity but the long-run average was very close to unity, suggesting that the constructed series were relatively robust.

Our own series, which is available on request, is based on the following series.

- Piggott (1986), total personal wealth, Table 5, p.15, plus updates.
- Horn (1987), net private domestic wealth at market value, last column, Table 2.
- Adams (1987), market value of total net wealth, Table 4.1, pp.76-7.
- Helliwell and Boxall (1978), private sector wealth (excluding land) plus value of private land, Table 3, pp.59-60.

It is clear that these series are not totally consistent. However, the different series tend to move quite similarly, so our spliced series should be relatively consistent.