The Dynamics of Aggregate UK Consumers' Non-durable Expenditure*

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Abstract

From the intertemporal budget constraint, consumption expenditure cointegrates with income and wealth. The resulting equilibrium correction need not be through consumption. Also, when considering non-durable consumption the relative prices of durables and non-durables need to be included. The short-run dynamics and long-run relationship of and between non-durable consumption, non-asset income, wealth and the relative price of durable goods is examined. It is found that much of the adjustment towards the long-run common trend comes from changes in wealth, implying that the consumption cointegrating residual will predict asset returns. We find that at least 30% of fluctuations in non-human wealth are transitory, decoupled from permanent consumption.

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1 Introduction

The modelling of consumer expenditure as an intertemporal optimisation problem yielding an Euler equation was pioneered by Hall (1978). By contrast, since Davidson et al. (1978), many consumption expenditure equations with error correction mechanisms (ECMs) have been estimated. One interpretation of these two approaches is that Euler equations test theories, while ECMs are designed to answer different questions, primarily about the role of different variables in the 'consumption function', and to provide forecasts.

The difference between them can be characterised as the Euler equation embodying the predictions for the consumption path of the particular maximisation problem the investigator specifies. By contrast a 'consumption function' is derived by assuming a stochastic process driving labour income and returns, taking the intertemporal budget constraint and substituting in the Euler equation to yield a solved-out relationship between consumption,[1] any exogenous and lagged endogenous variables (such as wealth). In the UK research has largely centered around the variables which 'explain' consumption, although this has become less popular largely because of its vulnerability to the Lucas critique.[2]

Since Campbell (1987) it is clear that a long-run relationship between consumption, income and wealth can be derived solely from the intertemporal budget constraint. In a series of papers, Sydney Ludvigson and her co-authors (Ludvigson and Steindel, 1999; Lettau and Ludvigson, 2001, 2004) have re-examined the information in the long-run consumption relationship, and ask to what extent consumption is the equilibrium-correcting variable when deviations from the common trend in consumption, income and wealth occur in US data. The answer is, not very much. They conclude that disequilibria tend to be corrected by changes in wealth. This paper examines whether this is evident in the United Kingdom data.

[1]Henceforth we shorten 'consumption expenditure' to consumption for brevity as with other expenditures.

[2]Muellbauer and Lattimore (1995) provide a review of the theoretical and empirical consumption literature.

There is an important complication. Non-durable, rather than total, consumption is commonly used in the empirical literature. This is because of its theoretical appeal: consumers derive utility from the service flows that goods provide, not from expenditure. The correct way to model consumer behaviour is first to calculate the service flow that goods yield, and then to use such measures to test the theory. For non-durable goods and services, expenditure equals the service flow rendered over a chosen time period. But durable expenditure cannot be a good proxy for its service flow. As a result, non-durables and services are typically used to test consumption theories.[3] However, it was observed as early as Blinder and Deaton (1985) and Campbell (1987) that the share of durable goods in total consumption had been increasing, and this can be important in modelling exercises including our own. Figure 1 shows the real share of durables in total consumption for the UK, confirming the trend.[4] In Figure 2 we show the change in the relative price of durables to non-durables, which has been marked. In our model we will need to consider the relative price of durables.

The plan of the paper follows. In Section 2 we set out the basic relationships implied by intertemporal optimisation that motivate our work and outline our treatment of durables. Section 3 presents our results, including decomposing shocks into their transitory and permanent components and assessing the ability of our model to forecast asset returns, as implied by the model. A final section concludes. An Appendix describes the data needed to estimate our model and gives sources.

[3] See Campbell (1987); Flavin (1981) for early tests of the permanent income hypothesis using non-durable data for the US.

[4] Campbell (1987, fn. 15, p. 1260) states 'Blinder and Deaton report that the share of non-durables and services in measured total consumption has displayed a secular decline over the sample period. This casts some doubt on the practice of using non-durables and services consumption as a proxy for the total; nevertheless I follow this tradition and estimate a constant scale factor.'

Figure 1: Ratio of total to non-durable consumption

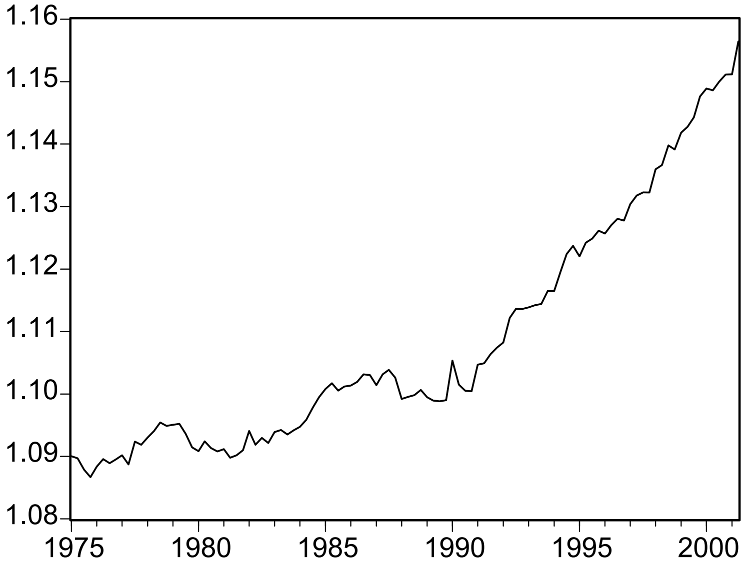
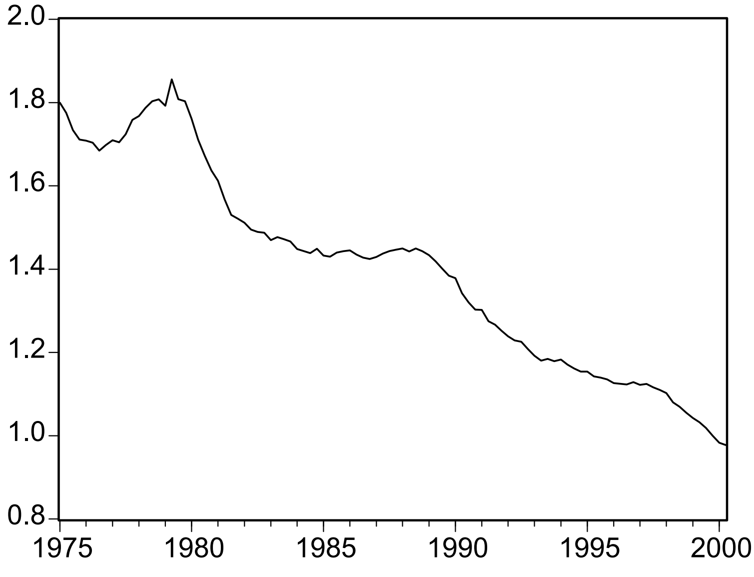


Figure 2: Relative price of durables to non-durables



2 Consumption, relative prices and the budget constraint

In this section we outline the model. The bulk of our analysis depends only on the intertemporal budget constraint, with an explicit allowance for durable goods.

2.1 Implications of the intertemporal budget constraint

We take as our starting point the accumulation equation for aggregate (human and asset) wealth W_t using total consumption C_t

$$W_{t+1} = (1 + r_{t+1})(W_t - C_t) \tag{1}$$

where r_t is the rate of return on (broadly defined) wealth. Total consumption is given by $C_t = C_t^n + P_t^d C_t^d$, where C_t^d is durable consumption, C_t^n is non-durable consumption and P_t^d is the relative price of durable to non-durable goods.

A first-order Taylor expansion after taking logs (Campbell and Mankiw, 1989) yields

$$w_{t+1} - w_t \approx r_{t+1} + k + (1 - 1/\nu)(c_t - w_t) \tag{2}$$

where lower case letters denote the log of the variable, $\nu = \frac{W-C}{W} < 1$ and $k = \ln(\nu) - (1 - 1/\nu)\ln(1 - \nu)$. Solving this equation forward yields

$$c_t - w_t \approx \sum_{i=1}^{\infty} \nu^i (r_{t+i} - \Delta c_{t+i}) + \zeta \tag{3}$$

where ζ is a constant (a function of ν and k), and we require the condition $\lim_{i\to\infty} \nu^i (c_{t+i} - w_{t+i}) = 0$, which is easily satisfied. Notice we can write

$$c_t \approx \tau c_t^n + (1 - \tau)(c_t^d + p_t^d) \tag{4}$$

$$w_t \approx \omega a_t + (1 - \omega) h_t \tag{5}$$

where $\tau = \frac{C^n}{C}$ is the share of non-durable consumption in the total, H is human capital and $\omega = \frac{A}{W}$ is the share of non-labour wealth in total wealth, with A non-labour assets. Substituting (4) and (5) into (3) yields an expression in terms of durables, non-durables and the relative price of durables to non-durables which holds *ex post* in the data and also *ex ante* in expectation. Thus we write it as

$$\begin{aligned} &\tau c_t^n + (1-\tau)\left(c_t^d + p_t^d\right) - \omega a_t - (1-\omega) h_t \\ \approx\ & E_t \sum_{i=1}^{\infty} \nu^i \left[r_{t+i} - \tau \Delta c_{t+i}^n - (1-\tau)\left(\Delta c_{t+i}^d + \pi_{t+i}^d\right)\right] \end{aligned} \tag{6}$$

where the constant is suppressed, π_{t+i}^d is the inflation rate of relative prices and E_t is the expectation operator.

The expression (6) follows solely from the budget constraint. It tells us that there is a long-run relationship between consumption and wealth equal to a discounted sum of future returns and consumption growth. With the use of some minimal theory, this expression can be used to explore consumption dynamics.

2.2 Human wealth and durables

Two issues must be considered before using (6) in our empirical work. First, human wealth is an unobservable quantity and needs to be eliminated. Following Lettau and Ludvigson (2001) we assume labour income,[5] Y, is non-stationary and human capital, H, is described by

$$h_t = \kappa + y_t + z_t \tag{7}$$

where κ is a constant and z a stationary random variable. In particular, as in Campbell (1996), Y is the 'dividend' on human capital H, so

$$r_{t+1}^h = (H_{t+1} + Y_{t+1})/H_t \tag{8}$$

and a log-linear approximation implies that

$$z_t = E_t \sum_{j=0}^{\infty} v_h^j (\Delta y_{t+1+j} - r_{t+1+j}^h). \tag{9}$$

[5]Labour income here is used as short-hand for non-asset income: in the empirical work it includes government transfers, for example.

Using (7) in (6) and ignoring the constant κ we obtain

$$\begin{aligned} & \tau c_t^n + (1-\tau)(c_t^d + p_t^d) - \omega a_t - (1-\omega) y_t \\ \approx & \; E_t \sum_{i=1}^{\infty} \nu^i \left[r_{t+i} - \tau \Delta c_{t+i}^n - (1-\tau) \left(\Delta c_{t+i}^d + \pi_{t+i}^d \right) \right] + (1-\omega) z_t \end{aligned} \quad (10)$$

where the left hand side is now observable.

Second, the treatment of relative prices. Whereas non-durable consumption has close to random walk behaviour, durable consumption may have much more complicated dynamics. Excluding them simplifies the analysis but we need to take into account that UK durable consumption has increased more than non-durable, and the relative price has fallen (Figures 1 and 2). To do so we need some more theory. Assume consumers face the optimisation problem

$$\max_{U_t,\ K_t} \quad E_t \sum_{i=0}^{\infty} \rho^i U \left(C_{t+i}^n,\ K_{t+i} \right) \quad (11)$$

subject to

$$A_{t+1} = (1 + r_{t+1})(A_t + Y_t - C_t^n - P_t^d C_t^d) \quad (12)$$

and

$$K_t = (1-\delta) K_{t-1} + C_t^d \quad (13)$$

where U denotes the utility function, K is the stock of durables, r is the (real) rate of interest on assets, ρ is the preference discount factor and δ is the (constant) depreciation rate of durables. After taking logs and along the steady growth path (13) implies

$$c^{d*} = \ln(\delta + g) + k^* \quad (14)$$

where g is the steady state growth rate of the durable stock.

Solving the household's problem yields the first-order conditions

$$\rho(1 + r_{t+1}) E_t \left[U_{C^n}(C_{t+1}^n,\ K_{t+1}) \right] = U_{C^n}(C_t^n,\ K_t) \quad (15)$$

and

$$\rho(1 + r_{t+1}) E_t \left[U_K(C_{t+1}^n,\ K_{t+1}) \right] = U_K(C_t^n,\ K_t) \quad (16)$$

where U_x denotes the partial derivative of U with respect to x. The efficiency condition is

$$\begin{aligned} U_{C^n}(C_t^n,\ K_t) &= \frac{(1+r_{t+1})}{(\delta-1)P_{t+1}^d+(1+r_{t+1})P_t^d}U_K(C_t^n,\ K_t) \\ &= \frac{(1+r_{t+1})}{uc_{t+1}P_t^d}U_K(C_t^n,\ K_t) \end{aligned} \tag{17}$$

where $uc_{t+1} = \left[(\delta-1)(1+\pi_{t+1}^d)+(1+r_{t+1})\right]$. This final term is the user cost, as the cost of holding durables is determined not only by the interest rate and their depreciation rate but also the relative-price inflation rate, remembering that this has been consistently negative over recent decades. (17) implies that a relationship exists between the durable stock, non-durable consumption and the relative price, relative price inflation and real interest rates.

Assuming that preferences are of CRRA type (see Mankiw, 1985) such that

$$U\left(C_t^n,\ K_t\right) = \frac{(C_t^n)^{1-\alpha}}{1-\alpha} + \frac{(\theta K_t)^{1-\chi}}{1-\chi} \tag{18}$$

then the efficiency condition is

$$(C_t^n)^{-\alpha} = \frac{(1+r_{t+1})}{uc_{t+1}P_t^d}\left(\theta K_t\right)^{-\chi}. \tag{19}$$

We can take logs of this expression and rearrange to give

$$k_t = \frac{\ln\theta}{\chi} + \frac{\alpha}{\chi}c_t^n - \frac{1}{\chi}p_t^d + \frac{1}{\chi}\ln(1+r_{t+1}) - \frac{1}{\chi}\ln(uc_{t+1}). \tag{20}$$

We now assume that the service flow from durables is a constant proportion of the stock. We use (14) to substitute out for the service flow of durables in (20) and (using $\ln(1+x)\approx x$ for small x) obtain

$$c_t^d \approx \phi_0 + \phi_1 c_t^n - \phi_2 p_t^d + \phi_2 r_{t+1} - \phi_2\ln(uc_{t+1}) \tag{21}$$

where $\phi_0 = \ln\theta/\chi - \ln(\delta+g)$, $\phi_1 = \alpha/\chi$ and $\phi_2 = 1/\chi$. ϕ_1 is the ratio of the reciprocals of the elasticities of substitution between consumption of non-durables and durables. Mankiw (1985) finds that for US data, $\alpha/\chi \approx 3/2$.

With CRRA utility the logs of non-durable consumption, durable consumption and the relative price of durables cointegrate, remembering that the interest rate and user cost terms are stationary.[6] We assume only that there is a long-run linear relationship between them, the real interest rate and relative price inflation

$$c_t^d = \hat{\phi}_0 + \phi_1 c_t^n + \hat{\phi}_2 p_t^d + \hat{\phi}_3 r_{t+1} + \hat{\phi}_4 \pi_{t+1}^d \tag{22}$$

where we further assume that the user cost term can be satisfactorily split into interest and inflation components. If the intertemporal substitution of durable consumption exceeds that of non-durables ($1/\chi > 1/\alpha$), ϕ_1 will exceed unity (as in Mankiw, 1985). Using (22) to substitute out for both the level and differenced terms in durable consumption and ignoring constants and the change in the inflation term for simplicity, we obtain an expression that is the basis for the results presented below

$$\begin{aligned} & c_t^n + \psi_1 y_t + \psi_2 a_t + \psi_3 p_t^d \\ \approx \;& E_t \sum_{i=1}^{\infty} \nu_1^i \left[r_{t+i} - (\tau + \phi_1(1-\tau)) \Delta c_{t+i}^n - (1-\tau)(1-\phi_2) \pi_{t+i}^d \right] \\ & + E_t \sum_{i=1}^{\infty} \nu_2^i \left[\Delta y_{t+1+i} - r_{t+1+i}^h \right] + E_t r_{t+1} \end{aligned} \tag{23}$$

where we have gathered the non-stationary terms on the left hand side, the stationary ones on the right hand side and where ν_1^i and ν_2^i are functions of all the parameters in the model. We have dropped some smaller differenced terms for convenience. $\psi_1 + \psi_2 < 1$ is a testable behavioural restriction if, as is likely, $\phi_1 > 1$.[7]

2.3 Interpretation and implications

The left-hand side of (23) gives the long-run relationship between non-durable consumption, assets, labour income and the relative price, the equivalent to

[6]It is easy to show that if utility is Cobb-Douglas the slope coefficients in (21) will all be unity.

[7]Note that ψ_1 and ψ_2 are now functions of ω, ϕ_1 and τ with $\psi_1 = \omega / (\tau + (1-\tau)\phi_1)$ and $\psi_2 = (1-\omega) / (\tau + (1-\tau)\phi_1)$. If $\phi_1 = 1$ then $\psi_1 + \psi_2 = 1$.

the notion of 'saving' in Campbell (1987) or the consumption to broad wealth ratio in Campbell and Mankiw (1989); Campbell (1993). This is the long-run relationship that we estimate.

We have assumed, uncontroversially, that labour income is non-stationary. By definition, the expression on the left-hand side must (approximately) equal the right-hand side of the expression, driven by expected future returns, expected changes in labour income, planned consumption growth and expected changes in the relative price. Consumption growth will be stationary—given the budget constraint, consumption cannot be an order of integration higher than income. If, again uncontroversially, p_t^d is assumed to be at most $I(1)$ and the rates of return to be stationary, then as Δc_t^n and Δc_t^d are $I(0)$, it follows that the right-hand side is stationary (for $v_i < 1$). Thus the $I(1)$ variables on the left-hand side ($c_t^n,\ p_t^d,\ a_t,\ y_t$) cointegrate. The economic implication is that the cointegrating residual is made up of future returns to assets, future changes in labour income, planned future changes in the growth of non-durable consumption, or future increases in the relative price of durables.

One can take (23) in several directions. If we specify stochastic processes for the driving variables, we can in some cases obtain closed form solutions and use the Euler equation to substitute out for consumption growth and estimate (23) directly. An alternative is the traditional ECM approach where the investigator implicitly substitutes out the forward parts of the expression with a reduced form forecasting equation based on lagged information, typified by Davidson et al. (1978). However, as a VECM exists in ($c_t^n,\ p_t^d,\ a_t,\ y_t$) it automatically follows that the long-run 'disequilibrium' error must equilibrate via at least one of the four variables. The economics make it clear that this equilibration follows from the forward looking nature of the problem.

Campbell (1987) observed that the theory offers additional stronger, overidentifying restrictions on the evolution of consumption and savings. Savings in his model are the discounted (negative) sum of expected future changes in labour income. If labour income is expected to fall in the future, households will have higher savings as in our model. Given that income and consumption (and in our case wealth) cointegrate many applied econometricians have proceeded by estimating a single equation ECM, knowing that one must exist. However, from (23) we know that consumption should not be predictable from past values of anything. The implication, as Campbell (1987) observes, is that equilibration must come through income or wealth. Consumption only deviates from the equilibrium relationship because of some anticipated change in a determinant of future consumption. Suppose households know that labour income is about to permanently fall. Consumption will be low relative to the long-run level. Campbell (1987) considers the possibility that labour income may be expected to change; in Campbell and Mankiw (1989) and Campbell (1993) it is the return to wealth. We allow the relative price of durables to vary.

All this follows from what are uncontroversial assumptions: that agents face an intertemporal budget constraint and that they follow some form of PIH behaviour via intertemporal maximisation. Thus deviations from equilibrium potentially forecast income or wealth, and if so would be significant in any VECM relationship.

3 Econometric results

The data produced by the UK Office of National Statistics (ONS) require adjustments to the consumption and labour income data to obtain series that can be used in our theoretical structure. The data requirements have been discussed at length elsewhere; Blinder and Deaton (1985) and Ludvigson and Steindel (1999) comment on the necessary adjustments for US data. In Appendix A we detail the data that we have used and outline the adjustments. Note that our consumption measure excludes both durables and semi-durables, not simply durables and clothing and footwear as for the US data.

Table 1: ADF statistics; no trend, SIC, 10% critical value of −2.57

Variable	t-stat	(Lag)
Δy^l	$\mathbf{-11.75}$	(0)
y^l	0.27	(0)
Δa	$\mathbf{-8.00}$	(0)
a	0.14	(1)
Δc^n	$\mathbf{-12.50}$	(0)
c^n	−1.24	(0)
π^d	$\mathbf{-3.94}$	(1)
p^d	0.90	(2)

3.1 Order of integration and cointegrating rank

In this section we report the results of estimating a VECM based on (23) over the period 1975 Q1 to 2001 Q2. We must test for the order of integration of each variable, and for the number of cointegrating relationships amongst the four variables. Table 1 reports the results of ADF tests[8] for the order of integration of all (log) series. We cannot reject the hypotheses that all the series are $I(1)$. Given this, we test for common trends. To do so, we first use the Johansen (1995) method. The choice for the correct number of lags is important and can affect the results of the cointegration test, so we follow standard procedure by running an unrestricted VAR in the levels of the $I(1)$ variables, and impose restrictions that coefficients of successively higher order lags are zero. We employ the Schwarz criterion to test for the significance of these lags. It is also important to ensure the residuals are Gaussian (normal and white noise) as the method is maximum likelihood. According to the Schwarz criterion, one lag is sufficient. This is sufficient to yield a VECM with no autocorrelation and normal residuals. Once the optimal lag length is chosen we test for cointegration using the Johansen (1995) procedure. We allow for trends in the data but no trend in the cointegrating space. We include the dummies described in Appendix A.

[8]Throughout the paper test statistics whose significance exceeds 10% are in bold.

Table 2: Cointegration tests

Series: c^n, y^l, a, p^d		
Johansen tests		
Linear trend, no trend in cointegrating space, 1 lag		
Eigenvalue	Trace statistic	Hypothesized no. of CV(s)
0.228	**46.58**	None
0.109	20.42	At most 1
0.080	8.74	At most 2
Eigenvalue	Max-Eigen statistic	Hypothesized no. of CV(s)
0.228	**26.17**	None
0.109	11.68	At most 1
0.080	8.39	At most 2
CCR test		
Test statistic	5 percent critical value	p-value
0.14	3.84	0.71

The results are shown in Table 2.[9] The Johansen tests indicate that for our consumption measure there is evidence at the 10% significance level that a single cointegrating vector exists. Applying the small-sample correction of Reimers (1992) leaves our conclusions unchanged. Johansen (1995) advocates a conservative choice of cointegrating rank, as the consequences of falsely rejecting cointegration are more severe than maintaining it when it is false, so we should be conservative in our choice of critical values. In addition, there are significant loading terms reported below which is further evidence of cointegration. Ogaki and Park (1997) point out that tests of the null of no cointegration are known to have very low power against some alternatives, and often fail to reject the null with high probability even though the variables are actually cointegrated. They argue that when the economic model implies cointegration, as it does here, it is more appropriate to test

[9]To assess sensitivity, we repeated the tests with with two and three lags. We find that in each case at least one cointegrating vector exists (results not reported).

the null of cointegration. As additional evidence we therefore report results from Park's fully modified canonical cointegrating regression (CCR). This method has an additional potential advantage. Our fundamental relationship, (23), shows that the long-run relationship is equated to what amounts to a complex error structure involving long overlapping leads. It may be that the Johansen method, which assumes the dynamic process can be modelled by a well-behaved VAR, is ill equipped to deal with this type of error process. But the CCR, as a fully modified estimator, may be more robust. The result is reported in Table 2, indicating that we cannot reject the null of cointegration. On the basis of all the evidence we conclude that the four variables satisfactorily cointegrate.

3.2 Evidence from the VECM

Given the evidence for a unique cointegrating vector, we proceed to estimate our VECM.[10] We begin with the Johansen results reported in Table 3, which gives the relationship between non-durable consumption, labour income, wealth and the relative price, including the long-run coefficients. The long-run parameters are appropriately signed. Non-durable consumption increases with wealth, labour income and the relative price of durables. The elasticity with respect to the relative price is small, although significantly different from zero. For total consumption we would expect the coefficients on income and assets to sum to unity but as we explained above this need not hold for our data. A test that the coefficients for assets and income summing to unity is rejected ($\chi^2_1 = 13.14$). Given that the sum of these two coefficients is 0.85 this is consistent with $\phi_1 > 1$ which Mankiw (1985) found for the US implying that the intertemporal elasticity of substitution for durables exceeds that for non-durables. The marginal propensity to consume (MPC) out of either labour income or wealth depends upon the ratios of consumption to labour income or wealth. For income, the MPC is 0.58 (evaluated

[10] In this paper we only report results where we include the relative price. In Fernandez-Corugedo et al. (2003) we report results both with and without it and find evidence that our main results continue to hold even if we exclude this variable.

Table 3: VECM results

$c^n_t = \mathbf{-0.76} + \underset{(6.93)}{\mathbf{0.603}} y^l_t + \underset{(8.57)}{\mathbf{0.25}} a_t + \underset{(2.01)}{\mathbf{0.09}} p^d$				
	Equation			
Dependent Variable	Δc^n_t	Δy^l_t	Δa_t	π^d_t
Δc^n_{t-1}	−0.119 (−1.23)	−0.123 (−0.84)	−0.381 (−1.09)	−0.111 (−1.22)
Δy^l_{t-1}	**0.167** (2.26)	−0.150 (−1.34)	0.088 (0.33)	**0.157** (2.26)
Δa_{t-1}	**0.051** (1.78)	**0.079** (1.83)	0.161 (1.55)	−0.002 (0.07)
π^d_{t-1}	**0.279** (2.56)	0.163 (0.99)	0.611 (1.55)	**0.425** (4.15)
r_{t-1}	0.00002 (0.12)	0.0003 (1.01)	**0.0018** (2.35)	0.0003 (1.49)
$DUM79$	**0.042** (7.27)	0.0006 (0.06)	0.023 (0.99)	0.04 (6.91)
$DUM804$	**−0.021** (−2.52)	−0.010 (−0.80)	0.008 (0.27)	−0.005 (−0.68)
$DUM981$	0.0002 (0.02)	**−0.035** (−2.82)	**0.059** (1.95)	0.0004 (0.04)
Constant	**0.007** (4.29)	**0.006** (2.62)	**0.011** (2.10)	**−0.004** (−3.0)
Loadings (γ)	−0.079 (−1.17)	0.011 (0.11)	**0.681** (2.78)	**0.185** (2.90)
$\overline{R}^2$	0.47	0.08	0.12	0.44
Jarque-Bera	$\chi^2_8 = 5.20$			
Autocorrelation	$\chi^2_{48} = 60.56$			

at the sample mean); for wealth, it is 0.050. Lettau and Ludvigson (2001) report an almost identical figure, 0.046, for the US.

In the dynamics of this system, adjustment takes place in both the wealth and relative price equations, and not through consumption or post-tax labour income. The (normalised) loadings ('speed of adjustment' coefficients) for the wealth equation, γ_a, and for the relative price equation, γ_p, are 0.170 and 0.017 respectively and are both significant.[11] By contrast, the loadings for consumption and labour income, γ_c and γ_y, are individually and jointly ($\chi^2_2 = 1.22$) insignificant. Thus the major shocks driving consumption are

[11] Each loading reported in the text is normalised by the coefficient on the relevant level in the long-run relation, rather than on the coefficient on consumption.

changes in wealth and the relative price. One implication is that expected income growth need not exhibit much short-run variation although *ex post* it could. It also follows that the simple PIH model is a good approximation. Finally, from a statistical error correction perspective, all the loadings are correctly signed.

Turning to the other dynamics, we find that for consumption, lagged changes in labour income, assets and the relative price are important. This differs from Lettau and Ludvigson (2001), who find only lagged consumption growth significant.[12] This may follow from habit persistence, be evidence in favour of near-rational rules of thumb, or imply that consumers are liquidity constrained. In income, apart from assets, the 1998 dummy and the constant, nothing is significant. In the wealth equation, none of the lagged endogenous variables are significant and only the lagged real interest rate term is significant.

3.3 Permanent and transitory effects

We can explicitly evaluate the contributions of shocks to the evolution of the variables in the system. To do this, we need a meaningful identification scheme for the shocks. In our VECM framework there is an obvious decomposition of shocks that have permanent and transitory effects, and this sits perfectly with our economic framework. This can be achieved using the method suggested by Gonzalo and Ng (2001). Briefly, if the model is written as

$$\Delta X_t = \Gamma(L)\Delta X_{t-1} + \gamma\beta' X_{t-1} + \varepsilon_t \tag{24}$$

where $\varepsilon_t \sim N(0,\ \Omega)$, it also has a multivariate Wold representation given by

$$\Delta X_t = C(L)\varepsilon_t \tag{25}$$

where $C(L)$ is a lag polynomial of potentially infinite order.

[12] Note that short-run predictability of consumption growth (the lags of income, assets and relative price inflation) is distinct from significant long-horizon predictability which stems from error correction behaviour. This last type of predictability is absent in consumption growth. See Section 3.4 below for additonal discussion.

Table 4: Variance decomposition

	$\Delta c_{t+h} - \Delta c^e_{t+h}$		$\Delta y_{t+h} - \Delta y^e_{t+h}$		$\Delta a_{t+h} - \Delta a^e_{t+h}$		$\pi^d_{t+h} - \pi^{de}_{t+h}$	
Horizon	P	T	P	T	P	T	P	T
Unrestricted loadings $\gamma = [\ -0.0792 \quad 0.0111 \quad 0.6811 \quad 0.1846\ ]'$								
1	0.949	0.051	1.000	0.000	0.712	0.288	0.686	0.314
2	0.866	0.134	0.973	0.027	0.718	0.282	0.736	0.264
3	0.861	0.139	0.972	0.028	0.719	0.281	0.750	0.250
4	0.861	0.139	0.970	0.030	0.715	0.285	0.749	0.251
∞	0.859	0.141	0.969	0.031	0.710	0.290	0.740	0.260
Restricted loadings $\gamma = [\ 0.0000 \quad 0.0000 \quad 0.6811 \quad 0.1846\ ]'$								
1	1.000	0.000	1.000	0.000	0.618	0.382	0.584	0.416
2	0.932	0.068	0.968	0.032	0.623	0.377	0.646	0.354
3	0.929	0.071	0.968	0.032	0.636	0.364	0.670	0.330
4	0.929	0.071	0.968	0.032	0.641	0.359	0.679	0.321
∞	0.923	0.077	0.966	0.034	0.647	0.353	0.684	0.316

Gonzalo and Ng (2001) show that if we define

$$G = \begin{bmatrix} \gamma'_\perp \\ \beta' \end{bmatrix} \tag{26}$$

where $\perp$ denotes orthogonal complement[13] then

$$\Delta X_t = C(L)G^{-1}G\varepsilon_t = D(L)\epsilon_t = \begin{bmatrix} D_{11}(L) & D_{12}(L) \\ D_{21}(L) & D_{22}(L) \end{bmatrix} \begin{bmatrix} \epsilon^P_t \\ \epsilon^T_t \end{bmatrix} \tag{27}$$

decomposes the shocks into those with permanent effects (ϵ^P_t) and those that are only transitory (ϵ^T_t). Shocks are continually hitting the system, but not all are passed through on to the long-run as any shocks are filtered through γ and β in the VECM. Clearly, the transitory shocks are defined to be shocks that have no impact on the long-run. The matrix G contains the submatrix $\gamma_\perp$ that ensures that only the $n-r$ shocks are passed through. Note the permanent and transitory shocks are not necessarily separately identified, so further identification is needed for impulse response analysis.

[13] $\gamma_\perp$ is defined by the condition $\gamma\prime\gamma_\perp = 0$.

However, it is unnecessary to identify the shocks explicitly in order to decompose the effect on the overall variances of the various series. In Table 4 we report the variance decomposition with the freely estimated coefficients. In the second panel we set the first two insignificant loading coefficients to zero as recommended by Gonzalo and Ng (2001). Although the restrictions have some impact on the variance decomposition, the overall picture is unchanged.[14] As with Lettau and Ludvigson (2004), we find that the forecast error in consumption and income is almost entirely attributable to the impact of shocks to the stochastic trends. In contrast to their results, the forecast error in both wealth and the relative price is also dominated by the permanent component, although slightly less than 30% of the variance in each case is explained by the single shock with only transitory effects. They found over 85% of the variance of assets was explained by transitory shocks, but a transitory component of nearly a third should not be considered small. One explanation of this might be the importance of housing in UK wealth, which by 2003 had risen to about 50% of total wealth. In the US it was less, although not a great deal, at around 40%, up from around 30% in 2000 (Federal Reserve's Flow of Funds data). If shocks to housing are disproportionately permanent compared to other wealth this could help to explain some of the contrasting results.[15] However, the conclusion regarding the importance of permanent shocks to consumption and income is unchanged.

[14]We also explored the implications of increasing the lag length on the dynamics. As the lag length in the VAR increases, the proportion of permanent shocks in consumption and income fall: in the case of income, the decrease is only marginal. The permanent proportions of assets and relative prices both rise. While the details change, the broad conclusions are unchanged.

[15]The treatment of relative prices also matters. Excluding them means that consumption and income continue to be dominated by permanent shocks, but the shocks to assets are now overwhelmingly transitory. See Fernandez-Corugedo et al. (2003) for details. These results are numerically much closer to those reported in Lettau and Ludvigson (2004).

3.4 Forecasting stock returns

We have argued that the significant loading of the long-run consumption relationship in the wealth ECM reflects agents' expectations of future changes in wealth. The implication, as stressed by Lettau and Ludvigson (2001), is that the disequilibrium term should forecast asset returns. This is a strong prediction, as it involves forecasting data not used in the generating regressions, and is therefore a good test of the model. We follow their methodology, and look at total equity returns, in our case from the UK FT-Actuaries All-Share Total Return Index.

Table 5: Forecasting quarterly stock market returns

Dependent variable $r_t - r_{f,t}$		
Variable	Coefficient	t-statistic
constant	**0.04**	3.55
$r_{t-1} - r_{f,t-1}$	0.03	0.38
$r_{t-2} - r_{f,t-2}$	**−0.30**	−3.68
$r_{t-3} - r_{f,t-3}$	0.01	0.10
$r_{t-4} - r_{f,t-4}$	**−0.19**	−1.92
ecm_{t-1}	**1.20**	2.14
R^2	0.18	

Table 5 reports a regression of the quarterly excess return over the three-month T-bill rate on lagged excess returns and the lagged disequilibrium term from the estimates reported in Table 3. To account for overlapping returns a Newey-West correction is employed. The disequilibrium is both significant, and of a similar size to those reported in Lettau and Ludvigson. Thus deviations from the long-run consumption relation reflect anticipated future asset returns.

We also examine the horizon over which the disequilibrium term can forecast. We can think of the VECM as informing us about both short- and long-run dynamics but, as in the finance literature on price-earnings ratios and returns, we expect the disequilibrium term to forecast best at medium

Table 6: Regression of i-period excess returns on consumption disequilibrium

Dependent variable: $R_i = \prod_0^i (1 + r_{t+i} - r_{f,t+i}) - 1$									
Horizon	1	2	4	5	6	8	12	16	24
Coefficient	**1.30**	**2.89**	**4.93**	**5.67**	**5.64**	**4.97**	**7.65**	**8.05**	**7.94**
t-statistic	1.76	2.18	3.11	3.23	3.41	3.95	2.84	2.69	2.21
R^2	0.06	0.15	0.27	0.31	0.30	0.27	0.27	0.23	0.15
Dependent variable: $C_i = \prod_0^i (1 + \Delta c_{t+i}^n) - 1$									
Horizon	1	2	4	5	6	8	12	16	24
Coefficient	−0.15	−0.13	−0.16	−0.09	−0.11	0.01	0.03	0.07	0.18
t-statistic	−0.79	−1.02	−0.65	−0.33	−0.34	0.02	0.06	0.16	0.30
R^2	0.06	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00

to long horizons. An indication of this is given in Table 6, where the results of cumulative i-period returns regressed on the disequilibrium term are reported. The peak forecasting power (measured by R^2) is at 5 periods. The timing of this peak is identical to the one obtained by Lettau and Ludvigson (2001) and the estimates are numerically similar.[16] Finally, we also take the opportunity to re-examine the power of the disequilibrium term to forecast consumption. The table clearly indicates that it has no power at any horizon considered.

4 Conclusions

The PIH has profound implications for the dynamic behaviour of (non-durable) consumption. In the simplest models, it should follow a random walk, although in general that may not be true: models incorporating habit persistence, for example, predict the consumption ECM exists. It should also be true that consumption cointegrates with income and wealth. From the Granger Representation Theorem, we know an equilibrating ECM must exist: but the theory suggests it will not lie solely in consumption. Instead,

[16]Brennan and Xia (2002) have argued Lettau and Ludvigson's result is spurious, and the residual '*tay*' formed by regressing time on assets and income does better at forecasting returns. Lettau and Ludvigson (2003) offer a spirited defence. In our case, there is nothing to defend as *tay* has no predictive power for excess returns at any horizon.

this equilibration should also take place via income or wealth reflecting the forward looking aspect of consumer behaviour. Households save in response to expected future changes in income and asset returns. Thus consumption does not economically cause future income and wealth; but because current behaviour is affected by expected future events, deviations of consumption from the long-run equilibrium Granger-cause wealth.

To examine these issues, we constructed a data set excluding semi-durables as well as durables from our preferred consumption measure. Then the short-run dynamics and long-run relationship of and between non-durable consumption, labour income, wealth and the relative price of durable goods were examined. The relative price of durables is important because of our use of non-durable consumption, over a period which saw a large rise in the real share of expenditure on durables, and a large fall in the relative price. A cointegrating relationship between these series was found to exist. A further theoretical implication is that consumption may predict asset returns, and this is confirmed by a regression of stock returns on the lagged disequilibrium consumption term, interpretable as detrended wealth. Our results imply that a full understanding of consumption dynamics requires analysis of the entire system; single equation results will be misleading. Moreover, we are able to decompose the shocks hitting the wealth-consumption system into their transitory and permanent components. Almost all of the variation in the consumption and income process can be ascribed to permanent shocks. We find that at least 30% of fluctuations in non-human wealth are transitory. This means a substantial part of short-term fluctuations in wealth are decoupled from permanent consumption.

In summary, we find that wealth does most of the work of equilibration in the relation between consumption, income and wealth. There is no non-durable consumption ECM; there is, however, a VECM in which it plays a role.

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A Data appendix

The ONS divide consumption expenditure into durables, semi-durables, non-durables and services. Our definition of non-durable consumption is total consumption minus consumption of durables and semi-durables; we deflate by the correspondingly defined deflator. All nominal series other than non-durables are deflated by the total consumers' expenditure deflator. We also constructed an alternative definition of non-durable consumption, defined as total consumption minus durable consumption minus the consumption of clothing and footwear, to aid comparison with the results obtained for the US. A proper measure of non-durables, consistent with our model, is an important part of the analysis. This is supported by the broader definition failing to cointegrate satisfactorily (see Fernandez-Corugedo et al., 2003). Note that our measure of non-durable consumption excludes all semi-durables, not just clothing and footwear. Data are quarterly, seasonally adjusted and real. The consumption data source is the ONS (Consumer Trends). In estimation we include dummies for the rise in VAT in 1979, an unexplained outlier at the end of 1980 and a change in PAYE rules affecting disposable income in 1998.

The ONS does not produce a direct measure of after-tax labour income. It only produces measures of after tax total income: see Tables A38 to A40 in Economic Accounts. Our preferred measure of labour income is given by

$$Y = (Y^T - Y^A - T)/P \qquad (28)$$

where Y is our measure of post-tax labour income, Y^T is total household sector pre-tax income, Y^A is households' non-labour income, T is taxes on labour income and P is the consumers' expenditure deflator. Taxes are defined as the share of labour income in total income times total taxes paid. Thus income includes wages and salaries, self employment income, benefits and social contributions, essentially post-tax non-asset income. Again, the resulting series is real and seasonally adjusted.

Total wealth is gross housing wealth (W^G) plus net financial wealth. Net financial wealth is obtained from Table A64 in Economic Accounts. W^G is constructed using

$$W_t^G = \left(P_t^{GDP} I_t^H\right) + W_{t-1}^G \left(\frac{P_t^H}{P_{t-1}^H}\right) \tag{29}$$

where P^{GDP} denotes the GDP deflator at factor cost, I^H denote private sector dwellings investment and P^H denotes UK house prices. I^H comes from Table A8 in Economic Accounts, and P^H is the Department of Transport, Local Government and the Regions (DTLR) house price index. Population data come from the Monthly Digest of Statistics, Table 2.1. Population figures are mid year estimates, interpolated to obtain quarterly series. We divide non-durable consumption, post-tax labour income and wealth by the total consumers expenditure deflator to obtain real *per capita* series. We obtain deflators for both our non-durable and durable series (the latter defined as total consumption minus the specific measure of non-durable consumption) by dividing the real consumption measures by the corresponding nominal measures. The relative price series is then obtained as the deflator for the durable series divided by the non-durable deflator. Finally, the real interest rate is the base rate less contemporaneous retail price index (RPI) annual inflation.