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<th>Solving the ‘consumption puzzle’? : a general to specific approach</th>
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"SOLVING THE 'CONSUMPTION PUZZLE'? A GENERAL TO SPECIFIC APPROACH

by

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University College Dublin

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UNIVERSITY COLLEGE DUBLIN

Department of Economics

BELFIELD, DUBLIN 4, IRELAND
Solving the 'Consumption Puzzle'?

A General To Specific Approach.

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University College Dublin
1. Introduction.

Significant and unanticipated short-run changes in aggregate consumer expenditure have posed problems for applied research on Irish consumption and saving behaviour over the last twenty years. For example, in the late 1970's researchers were faced with the problem of explaining a 6.5 percentage point increase in the aggregate savings ratio recorded in 1975. More recently Geary (1992) as pointed to the fact that the consumption function used in the ESRI's medium term model underpredicts consumer expenditure in the late 1980's and raises the possibility "that Ireland may have a serious 'consumption puzzle' to solve". (p.274)

The extent to which a significant underprediction for a single year indicates a fatal defect in a particular model and leads to a consumption puzzle is debatable. However, given that controversy exists on the issue of an appropriate Irish consumption function this paper investigates the relationship between aggregate consumption and disposable income by using a general to specific approach to econometric modelling.¹ The following section outlines the essential elements in general to specific modelling and illustrates how an generalised dynamic model of consumption and income can be reparameterised to a more specific and interpretable error correction form. The results suggest that when this model is augmented by short-run or disequilibrium variables it provides an acceptable explanation of movements in consumption over the last thirty years.

2. An Error Correction Model of Consumption.

This section uses a general to specific approach to modelling Irish consumer expenditure over the period 1960 to 1990. There are five steps in the general to specific approach:
approach:

(a) Specify a long-run relationship between consumption and the variables with which it is assumed to share an equilibrium relationship. Such relationships may be suggested by economic theory and tested using cointegration techniques.

(b) Investigate the possibility of a dynamic relationship between the variables specified in (a). This may be done by estimating a generalised autoregressive distributed lag model specified in terms of the variables of interest.

(c) Reparameterise the model by eliminating insignificant lags and transforming the variables so that the regressors are as orthogonal and interpretable as possible.²

(d) Investigate the significance of variables which may play a role in the adjustment process but not in the equilibrium relationship. For example, unanticipated inflation may influence the short-run dynamics of consumption but does not determine long-run or equilibrium behaviour.

(e) At each stage estimates should be checked for autocorrelation, heteroscedasticity, parameter stability etc. by a range of appropriate diagnostic tests.

**Cointegration:**

Most studies of aggregate Irish consumption start from the hypothesis of a simple linear relationship between real consumer expenditure and real disposable income. For example:

\[ c_t = \alpha + \beta y_t + u_t \]  

(1)

where \( c \) denotes real consumption and \( y \) is real disposable income. The validity of an

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²For example collinear regressors such as \( y_t \) and \( y_{t+1} \) may be transformed to near orthogonal regressors \( \Delta y_t \) and \( y_{t+1} \) by using \( y_t = \Delta y_t + y_{t+1} \).
Table 1. Dickey Fuller and Cointegration Tests.

<table>
<thead>
<tr>
<th>Variable</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_t$</td>
<td>-1.445</td>
<td>-1.448</td>
<td>-1.462</td>
</tr>
<tr>
<td>$y_t$</td>
<td>-1.935</td>
<td>-1.762</td>
<td>-1.760</td>
</tr>
<tr>
<td>$\Delta c_t$</td>
<td>-3.381</td>
<td>-3.763</td>
<td>-3.725</td>
</tr>
<tr>
<td>$\Delta y_t$</td>
<td>-4.223</td>
<td>-3.195</td>
<td>-3.020</td>
</tr>
<tr>
<td>$\hat{u}_t$</td>
<td>-1.959</td>
<td>-1.860</td>
<td>-1.808</td>
</tr>
</tbody>
</table>

Note: Sample 1963-1990. $c_t$ = the logarithm of real per capita consumption, $y_t$ = the logarithm of real per capita disposable income. Rows 1 to 4 are DF and ADF statistics. 95% critical values = -2.971. Row 5 gives DF and ADF statistics for the residuals from an OLS regression of $c_t$ on $y_t$. 95% critical values are -3.57 (DF, lag=0) and -3.59 (ADF, lag=1,2).

An econometric model which uses (1) as a maintained long-run hypothesis requires that $c_t$ and $y_t$ be either stationary series or that they are non-stationary but integrated of the same order.\(^3\)

Further, if $c_t$ and $y_t$ are both integrated of order $d$, or $I(d)$, then the validity of (1) also requires that there exists a linear combination:

$$\hat{u}_t = c_t - c - \beta y_t \quad (2)$$

such that $\hat{u}$ is $I(d-b)$ where $d > b$. In such a case $c_t$ and $y_t$ are said to be cointegrated of order $d,b$ or $CI(d,b)$.

Table 1 gives Dickey Fuller (DF) and Augmented Dickey Fuller (ADF) test statistics for the hypotheses that $c_t$, $y_t$, $\Delta c_t$, and $\Delta y_t$ are $I(1)$ against the alternative that they are $I(0)$. In

\(^3\)A integrated variable is one which is transformed to a stationary series after differencing $d$ times. Hence if a variable such as $y_t$ is non-stationary in its level but stationary after first differencing it is said to be integrated of order one or $I(1)$. In such a case $y_t$ is $I(1)$ and $\Delta y_t$ is $I(0)$ where $\Delta$ is the first difference operator.
each case the null hypothesis is accepted for levels but rejected for the first differences. That is, consumption and disposable income are both integrated of order one. However, the last line in Table 1, which reports DF and ADF statistics on residuals from an OLS regression on $c_t$ on $y_t$, suggests that we cannot reject the hypothesis of no cointegration between $c_t$ and $y_t$. Using the terminology of Hendry and Ericsson (1991) this result suggests that we cannot treat (1) as being 'theory consistent' in the sense that it describes a long-run relationship between

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4Consumption, income and tax data were taken from various issues of National Income and Expenditure and deflated by the Consumer Price Index (1985 = 100). Consumption is aggregate consumption inclusive of expenditure on durable goods. Using a narrower definition which excludes durables did not alter the results in a significant way.
Table 2. Autoregressive-Distributive Lag Model
Dependent Variable = c_t.

<table>
<thead>
<tr>
<th>Variable</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>c_t,i</td>
<td>0.927</td>
<td>-0.272</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.87)</td>
<td>(1.02)</td>
<td></td>
</tr>
<tr>
<td>y_t,i</td>
<td>0.619</td>
<td>-0.441</td>
<td>0.102</td>
</tr>
<tr>
<td></td>
<td>(3.356)</td>
<td>(1.79)</td>
<td>(0.457)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.471</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.63)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \bar{R}^2=0.97 \quad LM(2)=0.18[.91] \quad RESET(1)=1.27[.26] \quad F_{crit}(2,22)=.63[.53] \]
\[ DW=1.97 \quad LM(3)=4.51[.21] \quad NM(2)=33.2[0.00] \quad F_{ad}(2,20)=.12[.88] \]
\[ SEE=0.028 \quad ARCH(1)=0.17[.67] \quad PF(5,17)=4.60[.46] \]
\[ ARCH(2)=0.51[.77] \quad CH(6,16)=1.33[.29] \]

Note: See Table 1. Values in parenthesis below coefficients are t-ratios. Values in parenthesis beside test statistics are degrees of freedom. Values in square brackets after test statistics are the significance level at which the null hypothesis is just rejected. LM(i) = Lagrange Multiplier chi-square statistic for serial correlation of order i. ARCH(i) = Lagrange Multiplier chi-square statistic for ARCH process of order i. RESET = Ramsey’s Chi-square RESET test for functional form. NM = Jarque-Bera Chi-square test for normality of residuals. PF = F-test for predictive failure, CH = Chow test for parameter stability. F_{crit} = F-test that additional lags (i = 3) on c and y are zero. F_{ad} = F-test that lags i = 2 on c and y are zero.

From an econometric viewpoint the implication of non cointegration between a pair of I(1) series is that their inclusion in a model with I(0) variables may lead to spurious results because an I(0) variable cannot explain a variable that is I(1) and vice versa. However two points are worth making. First, the results in Table 1 are based on a relatively short data set (31 annual observations) and it is not clear that such data can adequately detect the presence of unit roots in variables such as consumption and income. Second, it is well documented that Irish consumption and saving data contain significant outliers, especially in the mid 1970’s.\(^5\)

This point is well illustrated by Figure 1 which plots the least squares residuals from (1). In

\(^5\)See, for example, Honohan (1979).
an attempt to control for these outliers (1) was re-estimated with a dummy variable equal to one for the years 1974 to 1977 and zero otherwise. The DF statistic for the residuals is -4.218 with a 95% critical value of -4.036 which rejects the null of no cointegration between $c_i$ and $y_i$.

**Dynamic Modelling:**

Given the reservations implied by cointegration tests we may proceed to investigate the possibility of a dynamic relationship between consumption and income by estimating an autoregressive distributed lag model:

$$c_i = \alpha_0 + \sum\alpha_i c_{i-i} + \sum\beta_j y_{i-j} + \epsilon_i \quad i=1...n, j=0...m.$$  \hspace{1cm} (3)

Table 2 presents OLS estimates of (3) using $n = m = 2$. Except for normality of the residuals (discussed below) the result satisfy all of the diagnostic checks including parameter stability. The estimate also permits acceptance of the hypotheses that the coefficients on $c_{t-2}$ and $y_{t-2}$ are jointly zero ($F_{xse}$) and that the addition of additional lags ($F_{add}$) is insignificant.

**Reparameterisation:**

Given the above estimates it is possible to reparameterise (3) to the error correction form:

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6Lagrange multiplier chi-square statistics for serial correlation in the DF regression $\Delta \hat{u} = \lambda \hat{u}_{t-1}$ are 0.003 (first order) and 0.573 (second order). The marginal significance levels, or the significance level at which the null of no serial correlation is just rejected, are .954 and .751 respectively.

7The data did not permit us to reject the hypothesis that (1) is characterised by AR(1) residuals against the alternative of dynamic misspecification. That is, a likelihood ratio test on the residuals from an OLS regression including $c_{t-1}$ and $y_{t-1}$ could not reject the parameter restriction implied by a first order Cochrane-Orcutt estimator. However, subsequent tests on the residuals from (1) failed to reject higher orders of serial correlation (up to AR(6)).
\[ \Delta c_t = \alpha_0 - \lambda_1 c_{t-1} + \lambda_2 y_{t-1} + \lambda_3 \Delta y_t + \varepsilon_t \] (4)

Note that the error correction model is derived from the general model (3) by:

(a) Setting \( \alpha_2 = \beta_2 = 0 \) (see \( F_{ex} \) in Table 2)

(b) Subtracting \( c_{t-1} \) from both sides, so that \( \lambda_1 = \alpha_1 - 1 \)

(c) Using \( y_t = \Delta y_t + y_{t-1} \) so that \( \lambda_2 = \beta_0 + \beta_1 \) and \( \lambda_3 = \beta_0 \)

Hence (4) can be expressed as:

\[ \Delta c_t = \alpha_0 - (1-\alpha_1)c_{t-1} + (\beta_0 + \beta_1)y_{t-1} + \beta_2 \Delta y_{t-1} + \varepsilon_t \] (5)

In a static equilibrium \( \Delta c_t = \Delta y_t = \varepsilon_t = 0 \) and \( c_t = c_{t-1} \) etc. so that long-run consumption is:

\[ (1 - \alpha_1)c_t^* = \alpha_0 + (\beta_0 + \beta_1)y_t \]

Substituting into (5) gives:

\[ \Delta c_t = \beta_2 \Delta y_t - (1 - \alpha_1)(c_{t-1} - c^*_{t-1}) + \varepsilon_t \] (6)

Hence the error correction model defines the short-run change in \( c_t \) as a function of the change in the equilibrium value, the previous period's disequilibrium or the error correction term, and a random disturbance.

OLS estimates of (4) are given in Table 3. As with the generalised distributed lag model, the error correction form satisfies all of the diagnostic checks with the exception of
Table 3. Error Correction Model 1.  
Dependent Variable = Δc_t.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lag i =</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>c_{t-1}</td>
<td>-0.260</td>
<td>(1.71)</td>
<td></td>
</tr>
<tr>
<td>y_{t-1}</td>
<td>0.214</td>
<td>(1.65)</td>
<td></td>
</tr>
<tr>
<td>Δy_{t-1}</td>
<td>0.727</td>
<td>(4.72)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.329</td>
<td>(1.15)</td>
<td></td>
</tr>
</tbody>
</table>

\[ \bar{R}^2=0.52 \quad LM(2)=1.31[.51] \quad RESET(1)=2.65[.10] \]
\[ DW=1.76 \quad LM(3)=2.20[.53] \quad NM(2)=30.0[.00] \]
\[ SEE=0.027 \quad ARCH(1)=0.42[.51] \quad PF(5,19)=4.34[.50] \]
\[ \quad ARCH(2)=0.53[.77] \quad CH(4,20)=1.59[.21] \]
\[ \quad \quad WALD(1)=1.51[.22] \]

Note: See Table 2. WALD(1) = Wald Chi-square test that the coefficients on c_{t-1} and y_{t-1} sum to zero.

normality of the residuals. A possible explanation for this failure is found in Figure 2 which plots actual and fitted values for Δc_t. As in the previous case the estimated model fails to pick up significant turning points in the mid 1970’s and late 1980’s suggesting significant outliers in the residuals.

**Short-Run Dynamics:**

The simple error correction model represented by equation (4) attempts to explain short-run changes in consumption in terms of changes in its equilibrium value and as an adjustment to the previous periods disequilibrium - the error correction term. However it is possible that observed changes in consumption may also be explained in terms of variables which are absent from the long-run equilibrium relationship. For example, in an attempt to account for
the 1975 increase in the saving ratio Honohan (1979) estimates an error correction type savings function based on Deaton’s (1977) inflation misperception model. At its simplest Deaton’s hypothesis suggests that during periods of relatively high unanticipated inflation consumers may misinterpret increased prices for certain goods as relative price changes and purchase less of what they, wrongly, perceive as relatively more expensive goods with the consequence that aggregate savings may rise and aggregate consumption fall. Following Honohan and Davidson, Hendry et. al. (1978) we assume that periods of accelerating inflation, such as the mid-1970s, are associated with unanticipated inflation and respecify (3) to include

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8Bulkley (1981) gives an alternative rationale, based on fixed nominal wages, for including inflation in a consumption/savings function.
Table 4. Error Correction Model 2.  
Dependent Variable = Δc<sub>i</sub>.  

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lag i = 0</th>
<th>Lag i = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>c&lt;sub&gt;i&lt;/sub&gt;</td>
<td>-0.481</td>
<td>(3.42)</td>
</tr>
<tr>
<td>y&lt;sub&gt;i&lt;/sub&gt;</td>
<td>0.431</td>
<td>(3.48)</td>
</tr>
<tr>
<td>Δy&lt;sub&gt;i&lt;/sub&gt;</td>
<td>0.668</td>
<td>(5.20)</td>
</tr>
<tr>
<td>Δp&lt;sub&gt;i&lt;/sub&gt;</td>
<td>-0.363</td>
<td>(3.48)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.358</td>
<td>(1.52)</td>
</tr>
</tbody>
</table>

<sup>Total</sup>: 0.68  
<sup>LM(2)=0.88[.64]</sup>  
<sup>RESET(1)=.001[.99]</sup>  
<sup>LM(3)=0.98[.80]</sup>  
<sup>NM(2)=2.50[.28]</sup>  
<sup>ARCH(1)=0.01[.90]</sup>  
<sup>PF(5,18)=0.31[.90]</sup>  
<sup>ARCH(2)=0.18[.91]</sup>  
<sup>CH(5,18)=2.17[.10]</sup>  
<sup>WALD(1)=2.61[.11]</sup>  

Note: See Table 2.

the first difference of the logarithm of the Consumer Price Index denoted Δp<sub>i</sub>. The estimates are given in Table 4. With the inflation term included as a disequilibrium phenomena the model passes all the diagnostic tests, including normality, and the coefficients on c<sub>i-1</sub> and y<sub>i-1</sub> are more precisely estimated. However a plot of actual and fitted values, Figure 3, shows that the model's does not adequately explain consumption behaviour in the mid-1970's and late 1980's. For example the 1975 turning point is predicted for 1974 and the 1977 peak is predicted in 1978.

In an attempt to improve the model's overall performance two additional variables
were included - the first difference in the unemployment rate, denoted $\Delta ur_t$, and the lagged change in the logarithm of the ratio of taxes on income to gross income denoted $\Delta tx_t$. Including an unemployment measure may be justified on the basis that it is a proxy for liquidity constraints on consumers.\textsuperscript{9} The inclusion of a tax variable may be rationalised as follows. A tax induced decline in disposable income will, \textit{ceteris paribus}, reduce consumption. However if the tax change is perceived as a once-off or temporary event then rational consumers may not revise their forecast of long-run, or equilibrium, disposable

\textsuperscript{9}See, for example, Flavin (1985) and Koskela and Virén (1992). It should also be noted that the unemployment rate increased by 4 percentage points over 1974 to 1976 and fell by 2 percentage points over 1987 to 1989.
Table 5. Error Correction Model 3.
Dependent Variable = Δc_t.

<table>
<thead>
<tr>
<th>Variable</th>
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</tr>
</thead>
<tbody>
<tr>
<td>c_{t-1}</td>
<td>-0.444</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.41)</td>
<td></td>
</tr>
<tr>
<td>y_{t-1}</td>
<td>0.404</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.58)</td>
<td></td>
</tr>
<tr>
<td>Δy_{t-1}</td>
<td>0.455</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.46)</td>
<td></td>
</tr>
<tr>
<td>Δp_t</td>
<td>-0.262</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.62)</td>
<td></td>
</tr>
<tr>
<td>Δur_t</td>
<td>-0.016</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.25)</td>
<td></td>
</tr>
<tr>
<td>Δtx_{t-1}</td>
<td></td>
<td>0.210</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.99)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.274</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.54)</td>
<td></td>
</tr>
</tbody>
</table>

\[ \hat{R}^2=0.81 \quad \text{LM(2)=2.13 [.34]} \quad \text{RESET(1)=1.56 [.11]} \]
\[ \text{DW}=1.62 \quad \text{LM(3)=3.23 [.36]} \quad \text{NM(2)=0.42 [.81]} \]
\[ \text{SEE}=0.016 \quad \text{ARCH(1)=0.36 [.55]} \quad \text{PF(5,16)=0.40 [.84]} \]
\[ \text{ARCH(2)=1.91 [.51]} \quad \text{CH(7,14)=1.34 [.30]} \]
\[ \text{WALD(1)=2.91 [.09]} \]

Note: See Table 2.

income thus modifying the short-run impact of the tax adjustment. Conversely if the tax change is considered permanent and a signal for future changes then disposable income may be considered temporarily high and induce a short-run rise in current consumption.\(^{10}\)

Estimates for the respecified model are given in Table 5. All coefficients are

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\(^{10}\)Also, Koskela and Virén (1992) argue that higher taxes on income - if they are perceived as temporary - "tend to decrease aggregate saving by shifting consumers from savers to 'hand-to-mouth' consumers, and from 'hand-to-mouth' consumers to ... borrowers. As a result, aggregate savings also tends to decrease via these switching effects." (p.146)
statistically significant and the model satisfies all the diagnostic checks including normality and parameter stability. Long-run homogeneity between *per capita* consumption and income is accepted at the 5% significance level but rejected at the 10% level. Also, the plot of actual and fitted values, Figure 4, illustrates that the model tracks most of the major turning points although 1972 and the late 1980's remain problematic.

3. Conclusions.

The results presented in the previous section appear to be reasonably satisfactory in terms of standard criteria. It is particularly encouraging to note that when the final model is estimated to 1980, with ten years left judge predictive performance, it comfortably passes parameter stability tests. Whether or not the model solves the 'consumption puzzle' is a
matter of judgement. However, the cointegration results remain a problem and, if taken at face value, can invalidate the significance of the error correction approach.\textsuperscript{11} Given this reservation it may not be over ambitious to claim that the approach taken provides an explanation of Irish consumption behaviour which appears to have some merit.

\textsuperscript{11}Cuthbertson, Taylor and Hall (1992) put the point as follows: "The danger with dynamic estimation is that the very richness of the dynamic structure may make the residual process appear to be white noise in a small sample when in fact the level terms do not cointegrate and the true process is non-stationary" (p.133) However it is of interest to note that when $c_{t-1}$ and $y_{t-1}$ in Model 3 (Table 5) are replaced with lagged residuals from the 'cointegrating regression' (1) the latter has a coefficient of -0.397 and a t-ratio of 3.62.
References.


