Progress from forecast failure—The Norwegian consumption function.

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Abstract

Forecast breakdowns present us with data that can be used to discriminate forcefully between models. Often a respecification is necessary to account for data ex post, in which case there is a gain in knowledge as a result of the forecast failure. Using the empirical modelling of Norwegian consumption as an example, we show that the financial deregulation in the mid 1980s led to forecast failure both for consumption functions and Euler equations, the former being most adversely affected, even though it is the encompassing model on pre-break data. Forecast breakdown alone then support a Hall/Campbell type model, while respecification led to a third model where wealth plays a central role. That model is updated in this paper and is shown to have constant parameters despite huge changes in the measurement system and nine years of new data.

Keywords: Consumption functions, equilibrium correction models, Euler equations, financial deregulation, forecast failure, progressive research strategies, VAR models

JEL classifications: C51, C52, C53, E21, E27

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1 Introduction

Financial deregulation in the mid-1980s led to a strong rise in aggregate consumption relative to income in several European countries. The existing empirical macroeconomic consumption functions broke down — i.e. they failed in forecasting, and failed to explain the data \textit{ex post}. One view of the forecast failure of consumption functions is that it provided direct evidence in favour of the rivaling rational expectations, permanent income hypothesis: In response to financial deregulation, consumers revised their expected permanent income upward to such an extent that the historical correlation between consumption and current income broke down. The breakdown has also been interpreted as a confirmation of the relevance of the Lucas-critique, in that it was a shock to the non-modelled expectation process that caused the structural break in the modelled causal relationship between income and consumption.

However, econometric studies of aggregate consumption that used data for the breakdown period, provided a less clear cut case for the rational expectations model. Notably, the empirical Euler equations of consumption did not capture the breakdown, cf. Steffensen (1989). Instead, re-specified consumption functions that introduced wealth as a new variable were more successful in accounting for the breakdown \textit{ex post}, while retaining parameter constancy in the years of financial consolidation that followed after the initial plunge in the savings ratio, see Brodin and Nymoen (1989), Brodin and Nymoen (1992) and Brubakk (1994). A key property of these respecified models were that of high variability in the savings rate, compared to the earlier models that were subject to forecast failure.

Nevertheless, 10-15 years on the impression is that the forecast breakdown in the European consumption functions permanently reduced the profession’s belief in the causal mechanism between income and consumption. Correspondingly, there is now widespread scepticism about the possibility of controlling consumption by systematic (i.e. “predictable”) economic policy measures. There may be good reasons for this change in attitude and beliefs in the profession, but the initial forecast failure of the consumption functions does not count among them. As argued by e.g. Clements and Hendry (1998) and (1999a), the single lesson to draw from forecast breakdown, as such, is that something unpredictable happened in the forecast period. In itself, the forecast errors do not invalidate the underlying theory, nor does it validate any rivaling theory. On the other hand, successful re-specification after a breakdown means that we have learned more about the relationships in the economy. A sequence of breakdowns and re-specifications constitutes a process, where models continuously become overtaken by new and better ones.

Viewing empirical modelling as a process, where forecast failures represents a potential for improvement, leads to a progressive research programme that holds some promise for identification of those parts of the empirical model that are relatively invariant to structural changes elsewhere in the economy, i.e. the parameters with a high degree of autonomy, see Haavelmo (1944), Johansen (1977) and Aldrich (1989). Parameters with a high degree of autonomy are of primary interest to decision makers. For example, economic policies will be designed differently depending on whether the autonomous derivative of consumption is with respect to actual or expected income. Autonomous parameters represent structure, in that they remain invariant to changes in economic policies and shocks to the economic system. The
structure is however partial in at least two respects: First, invariance is a relative concept: An econometric model cannot be invariant to every imaginable shock (e.g. a war), but parameters may be invariant to the policy measures typical of democratic industrial societies. Second, all parameters of an econometric model are unlikely to be equally invariant, and it is a widespread view that only parameters with the highest degree of autonomy represent partial structure, see Hendry (1993) and Hendry (1995b). Since partial structure typically will be grafted into equations that also contains parameters with a lower degree of autonomy, forecast breakdown may frequently be caused by shifts in these non-structural parameters. Hence a strategy that puts a lot of emphasis on forecast behaviour, without a careful evaluation of the causes of forecast failure ex post, runs a risk of discarding models that actually contain important elements of structure.

In the following sections we elucidated several of the issues concerning model development after a major forecast breakdown, using the modelling of private consumption as our example. In section 2 the consumption function (CF) and Euler equation (EE) approaches are briefly set out as two contending mechanism that both explain cointegration between consumption and income. However, CF and EE have very different policy implications, and it is argued that the key to testing the rivaling hypotheses is their implications for exogeneity. Section 3 discusses consumption forecasts based on the two models. Interestingly, when the CF-restriction hold within sample, the EE can still have a smaller forecast error bias than the CF-based forecast. This possibility arises in a situation where there is a structural break in the underlying true DGP in the forecast period, and is due to the fact that the non-causal model’s forecasts are less damaged by some types of deterministic shifts than the CF forecasts. The EE is an example of a differenced vector autoregressive system, dVAR, that has been shown to be relatively immune to structural breaks that arise prior to the preparation of the forecast, see Clements and Hendry (1999a, Chapter 5) and Eitrheim et al. (1999).

Thus it transpires that the consumption function and the Euler-equation may have complementary roles in the forecasting of consumption, notwithstanding the clearcut differences in theoretical content and policy implications. Sections 4 and 5 illustrate the theory by reconsidering the breakdown of Norwegian consumption functions in the 1980s, and the respecified consumption function due to Brodin and Nymoen (1992), B&N hereafter. The B&N model is respecified on an extended sample that includes nine years of new quarterly data. Moreover the historical series for income and consumption have been revised as a results of a new SNA for the National Accounts. Despite the extended sample and the change in the measurement system, important features of the B&N model are retrieved almost to perfection, showing the relevance of partial structure as an operational concept in this example.

2 Consumption functions and Euler equations

We assume that the log of consumption (expenditure) is integrated of degree one, I(1), and cointegrated with a vector of other integrated variables. Candidate vari-

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1See Muellbauer and Lattimore (1995) for a comprehensive discussion of other aspects of the two approaches.
ables for cointegration are income, wealth and demographic variables. In this section consumption is assumed to cointegrate with income alone. We assume that the variables are measured in logs. \( c_t \) is consumption in period \( t \) and \( y_t \) is income.

### 2.1 Cointegration

The assumptions have well known implications for the 1st order VAR:

\[
\begin{align*}
    c_t &= \kappa + \phi_{cc}c_{t-1} + \phi_{cy}y_{t-1} + e_{c,t} \\
    y_t &= \varphi + \phi_{yc}c_{t-1} + \phi_{yy}y_{t-1} + e_{y,t}
\end{align*}
\]

where the disturbances \( e_{c,t} \) and \( e_{y,t} \) have a jointly normal distribution. Their variances are \( \sigma_c^2 \) and \( \sigma_y^2 \) respectively, and the correlation coefficient is denoted \( \rho_{c,y} \).

Cointegration implies that the matrix of autoregressive coefficients \( \Phi = [\phi_{ij}] \) has one unit root, and one stable root. The equilibrium correction (EqCM) representation is therefore

\[
\begin{align*}
    \Delta c_t &= \kappa - \alpha_c [c_{t-1} - \beta y_{t-1}] + e_{c,t}, \quad 0 \leq \alpha_c < 1, \\
    \Delta y_t &= \varphi + \alpha_y [c_{t-1} - \beta y_{t-1}] + e_{y,t}, \quad 0 \leq \alpha_y < 1
\end{align*}
\]

where \( \beta \) is the cointegration coefficient and \( \alpha_c \) and \( \alpha_y \) are the adjustment coefficients.

It is useful to reparameterize the system with mean-zero equilibrium correction terms. To achieve that, define \( \eta_c = E[\Delta c_t] \), \( \eta_y = E[\Delta y_t] \) and \( \mu = E[c_t - \beta y_t] \). Consequently the constant terms in (3) and (4) can be expressed as \( \kappa = \eta_c + \alpha_c \mu \) and \( \varphi = \eta_y - \alpha_y \mu \) respectively, and thus we can rewrite this system into

\[
\begin{align*}
    \Delta c_t &= \eta_c - \alpha_c [c_{t-1} - \beta y_{t-1} - \mu] + e_{c,t}, \quad 0 \leq \alpha_c < 1, \\
    \Delta y_t &= \eta_y + \alpha_y [c_{t-1} - \beta y_{t-1} - \mu] + e_{y,t}, \quad 0 \leq \alpha_y < 1
\end{align*}
\]

These equations represents the common ground between the consumption function that assume a causal link from income to consumption, and the permanent-income or the life-cycle theory that both imply an Euler-equation for consumption.

### 2.2 Consumption function restrictions on the VAR

Underlying the conditional consumption function is the assumption that consumption is equilibrium correcting, i.e. \( 0 < \alpha_c < 1 \). There is no corresponding implication for the behaviour of income. Instead there are two possibilities. First, if income is determined from the demand side, the “Keynesian” case, income may be found to adjust to past disequilibria, hence \( 0 < \alpha_y < 1 \), and there is mutual Granger-causation between income and consumption. Interpretation is aided by writing the system in model form

\[
\begin{align*}
    \Delta c_t &= \eta_c + \gamma + \pi \Delta y_t - (\alpha_c + \pi \alpha_y) [c_{t-1} - \beta y_{t-1} - \mu] + e_{c,t} \\
    \Delta y_t &= \eta_y + \alpha_y [c_{t-1} - \beta y_{t-1} - \mu] + e_{y,t}
\end{align*}
\]
where (7) is the conditional “consumption function” and (8) is the marginal income equation. From the properties of the normal distribution:

\[
\begin{align*}
\alpha_c &= (1 - \phi_{cc}) \\
\beta &= \frac{\phi_{cy}}{\alpha_c} \\
\pi &= \frac{\rho_{cy}}{\sigma_y} \\
\gamma &= -\eta_y \pi, \\
\varepsilon_{c,t} &= e_{c,t} - \pi e_{y,t}.
\end{align*}
\]

Note that along a growth path characterized by \(E[c_{t-1} - \beta y_{t-1} - \mu] = 0\), the growth rates of \(c_t\) and \(y_t\) are proportional, thus

\[
\eta_c = \beta \eta_y
\]

along a steady state growth path.

The second possibility is that \(\alpha_y = 0\), reflecting that income is “supply-side” determined. In the context of the VAR, the restriction \(\alpha_y = 0\) implies that income is weakly exogenous with respect to the long run elasticity \(\beta\). Moreover, in our case with dynamics restricted to the 1. order case, there is now one-way causation from income to consumption, so income is strongly exogenous. The model form of the system simplifies to

\[
\begin{align*}
\Delta c_t &= \eta_c + \gamma + \pi \Delta y_t - \alpha_c [c_{t-1} - \beta y_{t-1} - \mu] + \varepsilon_{c,t} \\
\Delta y_t &= \eta_y + e_{y,t},
\end{align*}
\]

with \(\eta_y = \varphi\) since there is no equilibrium correction in income.

Equations (7) and (11) are both conditional equilibrium correction equations for \(c_t\), see e.g. Hendry (1995a, Chapter 7), Davidson et al. (1978), Hendry and von Ungern-Sternberg (1981). However, only in the case of (11) can policy analysis and forecasting be done in the single equation context.

### 2.3 Euler equation

Perhaps the most important insight from the life cycle and permanent income hypothesis is that the evolution of consumption is not determined by current or lagged income, but by tastes and life cycle needs. Indeed, in the absence of uncertainty, there is no reason for consumption to track income. More generally, with uncertainty about future income, the proposition is that consumption growth \(\Delta c_t\) is not Granger-caused by lagged income levels, hence \(\alpha_c = 0\) in equation (5). Consumption changes are orthogonal to \(c_{t-1} - \beta y_{t-1} - \mu\), the stationary linear combination of lagged consumption and lagged income. On this interpretation, the disturbance \(e_{c,t}\) is an innovation relative to information available in period \(t - 1\), and reflects unanticipated changes in income, see Hall (1978). Thus, \(\alpha_c = 0\) is referred to as the orthogonality property of consumption.

Given \(\alpha_c = 0\), cointegration implies that \(0 < \alpha_y < 1\). The interpretation for the case of \(\beta = 1\), due to Campbell (1987), is that growth in disposable income
is negatively related to the lagged savings ratio because consumers have superior information about their income prospects. If savings are observed to be increasing “today”, this is because consumers expect income to decline in the future. Hence after first observing a rise in the savings ratio, in the subsequent periods we will observe the fall in income.

The proposition that equilibrium correction should occur in disposable income appears to hold also in less stylized situations: First, if a proportion of the consumers are subject to liquidity or lending constraints, we may find that aggregate income is Granger causing aggregate consumption, as in Campbell (1989). Still, as long as the remaining proportion of consumers adjust their consumption to expected permanent income, observed aggregate disposable income is negatively related to the aggregate savings ratio. Second, the orthogonality condition may not hold empirically if the measure of consumption expenditure includes purchases of durables, see e.g. Deaton (1992, p.99–103). Again, the implication that $\alpha_y > 0$ is unchanged by this, and may in fact be strengthened by imperfections in the credit marked—credit rationed consumers are likely to cut back on purchases of durables when they anticipate a decline in disposable income.

3 Consumption forecasts

The Hall-model has the well known implication that consumption growth is unpredictable. Moreover, the Euler restrictions imply that forecasts from a conditional model like (15) will be poorer than what one is anticipating based on within sample fit. Thus, assuming that the Euler equation restriction holds in the data, users of consumption functions may encounter forecast failure, see section 3.1.

Section 3.2 shows that when the consumption function restriction holds, the forecast of the Euler-equation can nevertheless have a smaller bias than the consumption function based forecast. This possibility arises in a situation where there is a structural break in the DGP, and is due to the insight that the non-causal model’s forecasts are less damaged by some types of deterministic shifts than the consumption function forecasts, see Clements and Hendry (1999a). Thus it transpires that the consumption function and the Euler equation may have complementary roles in the forecasting of consumption, notwithstanding the clear cut differences in theory and policy implications.

3.1 Forecasting when the Euler-equation restrictions hold

Forecasts for the periods $T+1, T+2, ..., T+H$ are made in period $T$. From the Euler-equation, the mean and the variance of the consumption growth forecast errors are

\begin{align}
E[\Delta c_{T+h} - \Delta \hat{c}_{T+h,EE} \mid \mathcal{I}_T] &= 0, \tag{13} \\
\text{Var}[\Delta c_{T+h} - \Delta \hat{c}_{T+h,EE} \mid \mathcal{I}_T] &= \sigma_c^2, \tag{14}
\end{align}

for $h = 1, 2, ..., H$. The subscript $EE$ is used to denote a Euler-equation based forecast, and $\mathcal{I}_T$ denotes the information set that we condition on.
In this situation, the consumption function (CF) forecast is based on the following equation

\[ \Delta c_t = \eta_c + \gamma + \pi \Delta y_t - \pi \alpha_y [c_{t-1} - \beta y_{t-1} - \mu] + \varepsilon_{c,t}, \quad \alpha_y > 0 \tag{15} \]

(where \( \eta_c = \kappa \)). Forecasts of income growth is derived from

\[ \Delta y_t = \eta_y + \epsilon_{y,t} \tag{16} \]

for income. i.e. \( \Delta y_{T+h} = \eta_y, \ h = 1, 2, \ldots, H \). Note that

\[ \epsilon_{y,t} = \alpha_y [c_{t-1} - \beta y_{t-1} - \mu] + \epsilon_{y,t}, \]

implying that the income forecast errors have zero-mean. Thus the growth rate of income is forecasted without systematic errors, even though the implied causality of the system is wrong.

The mean and variance of the 1-step consumption function based forecast (CF) are

\[ \mathbb{E}[\Delta c_{T+1} - \Delta \hat{c}_{T+1,CF} \mid \mathcal{I}_T] = \alpha_y \pi [c_T - \beta y_T - \mu], \]

\[ \text{Var}[\Delta c_{T+1} - \Delta \hat{c}_{T+1,CF} \mid \mathcal{I}_T] = \sigma_c^2. \tag{17} \]

Thus, the erroneous inclusion of an equilibrium correction term makes the 1-step CF forecast biased, unless \( c_T - \beta y_T = \mathbb{E}[c_T - \beta y_T] = \mu \).

For dynamic forecasts we obtain

\[ \mathbb{E}[\Delta c_{T+h} - \Delta \hat{c}_{T+h,CF} \mid \mathcal{I}_T] = b(h) + \alpha_y \pi (1 - \alpha_y \pi)^{h-1} [c_T - \beta y_T - \mu] - \alpha_y \pi (h-1)(\beta \eta_y - \kappa). \tag{19} \]

The term \( b(h) \) is decreasing in \( h \). The contribution of the initial conditions are also dying away, so a for large \( h \) a bias must be due to the last term in the expression. It is useful to rewrite (19)

\[ \mathbb{E}[\Delta c_{T+h} - \Delta \hat{c}_{T+h,CF} \mid \mathcal{I}_T] = \alpha_y \pi (1 - \alpha_y \pi)^{h-1} [(c_T - c^0_T) - \beta (y_T - y^0_T)] - \alpha_y \pi (h-1)(\beta \eta_y - \kappa) \]

for \( h = 1, 2, \ldots, H \). We have dropped the \( b(h) \) term, and

\[ c^0_T = \mu + \beta y^0_T, \]

denotes the steady-state relationship between consumption and income. Along a steady state path \( \beta \eta_y = \kappa \), so we have that

\[ \mathbb{E}[\Delta c_{T+h} - \Delta \hat{c}_{T+h,CF} \mid \mathcal{I}_T] = 0 \]

if consumption and income is growing along a steady-state path.\(^3\)

\(^2\) For \( h = 4 \) we have \( b(4) = (\alpha_y \pi)^2(3 - \alpha_y \pi)(\beta \eta_y - \kappa) \), and for higher \( h \), the exponential is increasing.

\(^3\) \( \beta \eta_y - \kappa = 0 \), implies that \( b(h) = 0 \) for all \( h \).
3.2 Forecasting when the consumption function restrictions hold

Assume (strong) exogeneity of income, so causality is one-way, from income to consumption, the direct opposite of the Euler equation case. Written in equilibrium correction form, the DGP becomes (11) and (12), with parameters (9).

The Euler-equation approach in this case wrongly imposes \( \hat{\varepsilon}_c = 0 \), thus

\[
\begin{align*}
\Delta c_t &= \eta_c + \varepsilon_{c,t}, \\
\Delta y_t &= \eta_y + \alpha_y[c_{t-1} - \beta y_{t-1} - \mu] + \varepsilon_{y,t}, \quad 0 \leq \alpha_y < 1
\end{align*}
\]

(20) \( \Delta c_t = \eta_c + \varepsilon_{c,t} \),

(21) \( \Delta y_t = \eta_y + \alpha_y[c_{t-1} - \beta y_{t-1} - \mu] + \varepsilon_{y,t} \).

where \( \varepsilon_{c,t} = \varepsilon_{c,t} - \alpha_c[c_{t-1} - \beta y_{t-1} - \mu] \).

Since the consumption function model coincides with the DGP, its 1-step forecast

\[
\Delta \hat{c}_{T+1, CF} = E[\Delta c_{T+1, CF} | {\mathcal I}_T] = \eta_c - \alpha_c[c_{T+1} - \beta y_{T+1} - \mu]
\]

(22) \( \Delta \hat{c}_{T+1, CF} = E[\Delta c_{T+1, CF} | {\mathcal I}_T] = \eta_c - \alpha_c[c_{T+1} - \beta y_{T+1} - \mu] \)

is optimal in the sense that no other predictor conditional on information available at time \( T \) has smaller mean-square forecast error (MSFE), see Clements and Hendry (1998, p. 272).

One of the assumptions underlying the theorem is that parameters are constant in the forecast period. Real economies are dynamic and evolving, so parameter constancy is unlikely to hold in practical forecasting situations. Thus it is important to investigate how the CF and EE consumption forecasts are affected by parameter changes. The Euler equation for the evolution of consumption is an example of a model that uses only differenced data, a dVAR. The consumption function in turn is an example of an equilibrium correction model, EqCM. More generally therefore, the issue is the relative forecasting properties of equilibrium correcting systems and dVARs, and has recently been investigated by Clements and Hendry (1996), Clements and Hendry (1998) and Eitrheim et al. (1999).

Clements and Hendry (1999a) argues that changes other than in equilibrium means and growth rates need not induce forecast failure, and are not easily detected in sample. See also Doornik and Hendry (1997) and Hendry (1998) for an analysis of the importance and detectability of shifts.

The timing of the parameter change plays a role. We assume that the long-run mean \( \mu \) changes from its initial level to a new level, i.e. \( \mu \to \mu^* \), before the forecast is made in period \( T \), but that the change is undetected by the forecaster. This set up has a trait of realism since the income and consumption data for period \( T \) may be preliminary (or unavailable) at the time the forecast for \( T+1 \) is carried out.. In equilibrium correction form, the DGP in the forecast period is therefore

\[
\begin{align*}
\Delta c_{T+h} &= \eta_c + \pi \Delta y_{T+h} - \alpha_c[c_{T+h-1} - \beta y_{T+h-1} - \mu^*] + \varepsilon_{c,T+h} \\
\Delta y_{T+h} &= \phi + \varepsilon_{y,T+h}
\end{align*}
\]

(23) \( \Delta c_{T+h} = \eta_c + \pi \Delta y_{T+h} - \alpha_c[c_{T+h-1} - \beta y_{T+h-1} - \mu^*] + \varepsilon_{c,T+h} \),

(24) \( \Delta y_{T+h} = \phi + \varepsilon_{y,T+h} \),

for \( h = 0, 1, \ldots, H \). The consumption function forecasts are derived from (11) and (12), i.e.

\[
\begin{align*}
\Delta \hat{c}_{T+h} &= \eta_c + \gamma + \pi \Delta y_{t} - \alpha_c[c_{T+h-1} - \beta y_{T+h-1} - \mu] \\
\Delta \hat{y}_{T+h} &= \phi
\end{align*}
\]

(25) \( \Delta \hat{c}_{T+h} = \eta_c + \gamma + \pi \Delta y_{t} - \alpha_c[c_{T+h-1} - \beta y_{T+h-1} - \mu] \)

(26) \( \Delta \hat{y}_{T+h} = \phi \).
The $EE$ forecasts are again generated from

$$\Delta c_{T+h} = \eta_c.$$  

(27)

The 1-step forecast biases are.

$$E[\Delta c_{T+1} - \Delta \hat{c}_{T+1,CF} \mid \mathcal{I}_T] = -\alpha_c[\mu - \mu^*]$$  

(28)

$$E[\hat{c}_{T+1} - \hat{c}_{T+1,EE} \mid \mathcal{I}_T] = -\alpha_y\pi[\nu_T - \beta y_T - \mu^*]$$  

(29)

Manifestly, the CF forecasts are damaged by the change that have occurred prior to the preparation of the forecast. In fact the bias expression in (28) is identical to the bias for the case where the parameter change occurs after the forecast is made, see Eitrheim et al. (1999). The forecast does “equilibrium correct”, but to the old equilibrium.

The Euler-equation forecast will be immune with respect to the parameter change. In this important sense, there is an element of “intercept correction” built into the EE forecasts. The implication for practice is that unless “consumption function” forecasters detect the parameter change and take appropriate action by (manual) intercept correction, they may find themselves losing to Euler-equation forecasters in forecast comparisons.

The expression for the $h$-period forecast biases, conditional on $\mathcal{I}_T$, takes the form

$$E[\Delta c_{T+h} - \Delta \hat{c}_{T+h,CF} \mid \mathcal{I}_T] = -\alpha_c(1 - \alpha_c)^{h-1}[(\mu - \mu^*)],$$  

(30)

$$E[\Delta c_{T+h} - \Delta \hat{c}_{T+h,EE} \mid \mathcal{I}_T] = -b(h) + \alpha_c(h - 1)(\beta \eta_y - \kappa)$$

$$-\alpha_c(1 - \alpha_c)^{h-1}[(\hat{c}_T - c_T - \beta(y_T - y_{T+1})]$$  

(31)

for $h = 1, 2, ..., H$.

This shows that the CF-forecast remains biased also for the longer forecast horizons, although the bias dies away eventually. For the EE forecast there may be a trend in the bias, but with $\beta \eta_y - \kappa$ as implied along a steady state growth path, the EE forecast is unbiased for all $h$.

4 Modelling and forecasting Norwegian private consumption expenditure from 1968 to 1985.

In this section we show that a consumption function of the DHSY-type encompasses an Euler equation model on a sample that ends in 1984(4). Financial deregulation was already en route, following liberalization of the housing and credit markets early in the 1980s. We then show how the consumption function loses to the non causal EE in a forecast competition over the years 1985-1987. Finally, we report the respecified consumption function, based on a dataset that ends in 1989(4), see Brodin and Nymoen (1992). The results illustrate both the relevance of the theory of forecast failure above, and that respecification represents a progressive step in the modelling of consumption.
Table 1: Pre-break FIML consumption function estimates.

The consumption function

\[ \Delta c_t = -0.302 \Delta c_{t-1} + 0.227 \Delta c_{t-4} + 0.471 \Delta y_t \]
\[ -0.128 (c - y)_{t-1} - 0.352 \text{STOP}_t + 0.075 \text{VAT}_t \]
\[ -0.13946 \text{CS}1_t - 0.088 \text{CS}2_t - 0.095 \text{CS}3_t \]
\[ \hat{\sigma} = 1.53\% \]

The income equation

\[ \Delta y_t = 0.009 - 0.477 \Delta y_{t-1} + 0.311 \Delta y_{t-4} \]
\[ -0.043 \text{CS}1_t - 0.040 \text{CS}2_t + 0.026 \text{CS}3_t \]
\[ -0.043 \text{VAT} \]
\[ \hat{\sigma} = 1.60\% \]

Diagnostics

<table>
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<tr>
<th>Overidentification</th>
<th>( \chi^2(14) )</th>
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<td>Heteroscedasticity</td>
<td>( F(75,93) )</td>
<td>0.67[0.96]</td>
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FIML estimation. The sample is 1968(2) to 1984(4), 67 observations.

4.1 The breakdown in the mid 1980s

Table 1 shows an empirical “consumption function” model for (log of) total consumption expenditure \((c_t)\) and disposable income \((y_t)\). The first equation models the quarterly rate of change of consumption as a function of lagged rates of change \((\Delta c_{t-1} \text{ and } \Delta c_{t-4})\), the current rate of growth in income \((\Delta y_t)\) and the lagged consumption to income ratio \(((c - y)_t\)). The remaining explanatory variables are three centered seasonal \((\text{CS}j, j = 1, 2, 3)\), a VAT dummy for 1960.1 and 1970.1, and finally a dummy which is non-zero during a wage-price freeze that occurred in 1978, and is zero elsewhere, see Brodin and Nymoen (1992).

The second equation gives the rate of growth in income as an autoregression, augmented by deterministic terms. The omission of \((c - y)_{t-1}\) from the income equation is statistically admissible—the Likelihood-ratio test statistic is \(\chi^2(1) = 1.004[0.3164]\). Thus based on this evidence, causation runs from income to consumption, and not the other way round as implied by Campbell’s hypothesis, see section 2.2 and 2.3. The implication is that the first equation in Table 1 is the empirical counterparts to the consumption function (11), not equation (15) as claimed by the Lucas-critique.

The exogeneity restriction of income is an overidentifying restriction on the underlying VAR. In all there are 15 restrictions involved here, and \(\chi^2(14)\) at the end of Table 1 shows that they are jointly acceptable. The other test statistics include tests of 5. order residual autocorrelation, residual non-normality and heteroscedasticity due to squares of the regressors. The statistics are explained in Doornik and
Consumption function based forecasts

Euler-equation based forecasts

Figure 1: Dynamic forecasts of $\Delta_4 c_t$ for 1984(1)-1987(4), 1986(1)-1987(4) and 1987(1)-1987(4). The thick line is actual values. The thinner lines are predictions.

Hendry (1996). They give no indication of residual misspecification of the model in Table 1. [Since $c - y$ is approximately minus the rate of savings, the overall interpretation of the model is that consumption is equilibrium correcting to maintain an equilibrium savings ratio. Using the sample average for the rate of growth of income, the estimated equilibrium savings ratio is 3% (purchase of durables included).]

The consumption function in Table 1 represents the “typical” empirical model of consumption that had been implemented in the Norwegian policy and forecasting models by the mid 1980’s, following the papers on UK consumption expenditure a few years earlier, see Davidson et al. (1978) and Davidson and Hendry (1981). Its relevance here will be to highlight the forecast failure of a congruent model in a situation where the economy changes (credit market deregulation) in the forecast period.

Table 2 shows the empirical model that is consistent with the Euler-restrictions on the income-consumption system. The first equation is the Euler equation for consumption. There is no equilibrium correcting term, but we retain a lagged growth rate of consumption growth. This modification seems inconsequential, as the substance of the theoretical argument is that lagged changes in income are orthogonal to current consumption growth. The significance of $\Delta c_{t-4}$ may be due to habit forma-
Table 2: Pre-break FIML Euler-equation estimates.

<table>
<thead>
<tr>
<th>The Euler equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta c_t = 0.0059 + 0.236 \Delta c_{t-4} )</td>
</tr>
<tr>
<td>( (0.003) )</td>
</tr>
<tr>
<td>(- 0.396 \ STOP_t + 0.097 \ VAT_t )</td>
</tr>
<tr>
<td>( (0.102) )</td>
</tr>
<tr>
<td>(- 0.184 \ CS1_t - 0.034 \ CS2_t - 0.070 \ CS3_t )</td>
</tr>
<tr>
<td>( (0.025) )</td>
</tr>
<tr>
<td>( (0.009) )</td>
</tr>
<tr>
<td>( (0.011) )</td>
</tr>
<tr>
<td>( \hat{\sigma} = 2.10% )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The savings equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta y_t = 0.0144 - 0.308 \Delta y_{t-1} + 0.231 \Delta y_{t-4} )</td>
</tr>
<tr>
<td>( (0.003) )</td>
</tr>
<tr>
<td>( (0.098) )</td>
</tr>
<tr>
<td>( (0.01) )</td>
</tr>
<tr>
<td>(+ 0.158 \ (c-y)_{t-1} + 0.041 \ VAT )</td>
</tr>
<tr>
<td>( (0.068) )</td>
</tr>
<tr>
<td>( (0.013) )</td>
</tr>
<tr>
<td>(- 0.049 \ CS1_t - 0.023 \ CS2_t + 0.037 \ CS3_t )</td>
</tr>
<tr>
<td>( (0.013) )</td>
</tr>
<tr>
<td>( (0.011) )</td>
</tr>
<tr>
<td>( (0.014) )</td>
</tr>
<tr>
<td>( \hat{\sigma} = 1.62% )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diagnostics</th>
</tr>
</thead>
</table>
| Overidentifi-
| cation \( \chi^2(15) \) = 48.40[0.00] |
| AR 1 \(- 5 \ F(20,98) \) = 1.55[0.08] |
| Normality \( \chi^2(4) \) = 7.43[0.11] |
| Heteroscedasticity \( F(75,96) \) = 1.15[0.26] |

The sample is 1968(1) to 1984(4), 68 observations.
The finding that both sets of 12-period forecasts are manifestly biased, starting in 1985(1), is consistent with what the algebra suggests would happen if there was a reduction in the long-run saving ratio 1985(1). Based on that interpretation, the forecasts for 1986(1)-1987(4) can be seen to illustrate a situation where we are conditioning the forecast on a structural break that has occurred prior to the forecast period. We would then expect that the consumption function forecast remains biased, but that there is an element of intercept-correction in the Euler-equation forecast, see e.g. (28) – (31). Indeed, the figure shows that the forecasts errors for 1986(1) and 1986(2) are much smaller for the Euler-equation than for the consumption function.

Interestingly, the box-line shows that 1986(3) and 1986(4) are much better forecasted by the consumption function than the algebra in section 3.2 suggests: This is brought out even clearer by the 4-period forecasts from 1987(1)-1987(4) where the consumption function has recovered completely. A possible explanation for this is that the savings rate might have changed back, toward its initial level so that the change in early 1985 was temporary. In turn this suggests that other factors than income might be acting on consumption (and the savings ratio), and that there may be ways of modelling those effects. We consider this possibility in the next section.

The analysis of the mid-1980 forecast failure illustrates that in forecasting, the consumption function and Hall's model (the Euler equation) are complementary. Based on the evidence in Table 1 and 2 a modeller may feel confident that the CF-model is closer to the underlying data generating process. Yet, the Hall-model, by virtue of being a (scalar) dVAR for consumption, may forecast better (as in 1986) and gives automatic information on how to intercept correct the consumption function forecasts.

4.2 The reconstructed Norwegian consumption function.

Forecast failure invites modelling, but in itself does not provide any information about the re-specification of the model, see Clements and Hendry (1999b) for a discussion. Thus, the response to the forecast failure investigated different routes, including measurement error (emphasizing income), see Moom (1991), Euler equations, Steffensen (1989) and finally model misspecification, see Brodin and Nymoen (1992). Among these, only B&N provided a model with constant parameters over the full sample, i.e. both over the pre-break sample and over a sample that contained the post-break period from 1985q1 to 1989q4.

B&N provides a model in which the equilibrium relationship is that the log of consumption ($c_t$) is determined by the log of disposable income ($y_t$) and the log of a real household wealth ($w_t$), made up of the net financial wealth and the value of residential housing. Hence, the implication of B&Ns model is that the forecast failure was due to model misspecification, revealed by the omitted variable's (i.e. wealth) behaviour.

In more detail, B&Ns results can be summarized in three points

1. **Cointegration.** Cointegration analysis of the three variables $c$ (log consumption), $y$ (log disposable income), and $w$ (log net household wealth) establish
that the linear relationship

\[ c_t = \text{constant} + 0.56y_t + 0.27w_t, \]

is a cointegrating relationship. Hence, while the individual variables in (32) are assumed to be non-stationary integrated, the variable is stationary with a constant mean, showing the discrepancy between the current level of consumption and the long-run equilibrium level \(0.56y_t + 0.27w_t\).

2. Weak Exogeneity. Income and wealth are weakly exogenous for the cointegration parameters. Hence, the respecified equilibrium correction model for \(\Delta c_t\) is a consumption function according to the definition in section 2.2, only augmented by wealth as a second conditioning variable.

3. Invariance. Estimation of the marginal models for income and wealth show evidence of structural breaks. The joint occurrence of a stable conditional model (the consumption function) and unstable marginal models for the conditional variables is evidence of within sample invariance of the coefficients of the conditional model and hence super-exogenous conditional variables (income and wealth). The result of invariance is corroborated by Jansen and Teräsvirta (1996) using an alternative method based on smooth transition models.

B&N noted the implication that the re-specification explained why the Lucas-critique lacked power in this case: First, while the observed breakdown of conditional consumption functions in 1984-1985 is consistent with the Lucas-critique, that interpretation is refuted by the finding that a conditional constant-parameter model is shown to exist. Second, the invariance result shows that an Euler equation type model (derived from e.g., the stochastic permanent income model) cannot be an encompassing model. Even if the Euler approach can yield parameter constancy it cannot explain why a conditional model is also stable. Third, finding that invariance holds, at least as a empirical approximation, yields an important basis for the use of the dynamic consumption function in forecasting and policy analysis, the main practical usages of empirical consumption function.

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\(^6\)In fact, the existing Euler equation for Norwegian consumption are themselves unstable.
5 Stability of the Brodin-Nymoen model over an extended sample: 1990(1)-1998(4)

5.1 Data issues
The old and new data for consumption, income and wealth are compared in figure 2. Details on the data are also briefly discussed in the appendix. While the old data were reported in fixed 1988-prices, the new data are reported in 1996-prices. This is the main explanation of the level shift in the data in subfigure 2(a) and subfigure 2(b). The level of household sector real income has been revised upwards *inter alia* since household wage income from domestic services production was revised upwards due to the implementation of new SNA. The household sector savings ratio in the early 1990s declined somewhat as a consequence of the SNA-revision. The historical real income series prior to 1991 have been adjusted for this shift in the saving ratio, cf. figure 2(c).

For a closer comparison of the two data sets we have matched the means and ranges of the consumption and income series in the overlapping period 1966(1)–1989(4). From figure 3(a) we see that the consumption data have only been subject to minor revisions, and although figure 3(b) reveal somewhat larger discrepancies between the two sets of income data, we conclude that the joint pair of income and consumption series match the old data rather closely. This is of course due to our revisions of the income series before 1990 which aimed at matching the old path for the household savings ratio over this period. Finally, figure 3(b) show that the old and new real wealth data match each other over the overlapping sample period.

5.2 Cointegration
Table 3 report Johansen tests for cointegration in a VAR model of the three variables $c_t$, $y_t$ and $w_t$, ($n = 3$), with five lags, ($k = 5$), see Johansen (1988), Johansen (1995). The full sample evidence 1968(3)-1998(4) is reported in the table. As in Brodin and Nymoen (1992), we find that the formal test statistic support at most one cointegrating vector, although taken at face value, the evidence is not very strong cf. the reported $\lambda_{\text{trace}}$ test in table 3 and its small sample corrected counterpart, $\lambda_{\text{trace},T-nk}$ (Reimers (1992)), in which the test is scaled down with a multiplicative factor $(T-nk)/T$. Strictly, the tests indicate that we cannot reject any of the hypotheses in the sequence of tests. Compared to B&N the long run elasticity of income and wealth are completed recovered from the sample ending in 1989(4), but as we can see from table 5 and figure 4 the income elasticity increase somewhat from 0.57 to 0.65 as we expand the sample and the same time the wealth elasticity decrease from 0.26 to 0.23, cf. figure 4 which shows the overall recursive stability of the two coefficients of the cointegrating vector over the longer period from 1978(2)-1998(4). Despite this apparent long run parameter non-constancy, the overall impression is that the long run relationship has been quite stable across this period in which the Norwegian economy experienced some strong cyclical movements in the household savings ratio.

Finally figure 5 shows the recursive stability the corresponding feedback coefficients (loading factors). The reported ±2 standard error bands cover the zero-line.
(a) Old data for real consumption, income and wealth (mean adjusted) from 1966(1) to 1989(4), fixed 1988-prices

(b) New data for real consumption, income and wealth (mean adjusted) from 1966(1) to 1998(4), fixed 1996-prices

(c) Old and new data for the savings ratio 1966(1) to 1998(4)

Figure 2: Old and new data for real consumption, income and wealth, and the savings ratio
(a) Old and new data for real consumption from 1966(1) to 1989(4)

(b) Old and new data for real household disposable income from 1966(1) to 1989(4)

(c) Old and new data for total real household wealth from 1966(1) to 1989(4)

Figure 3: Old and new data for real consumption, income and wealth - matching mean and ranges from 1966(1) to 1989(4)
Table 3: Johansen tests for cointegration using revised data for consumption and income, full sample analysis 1968(3)–1998(4).

<table>
<thead>
<tr>
<th>Eigenvalues</th>
<th>$\lambda_{trace}$</th>
<th>$\lambda_{trace,107}$</th>
<th>$\lambda_{trace}$</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1110</td>
<td>$r = 0$</td>
<td>19.9681</td>
<td>24.1199</td>
<td>29.6800</td>
</tr>
<tr>
<td>0.0652</td>
<td>$r \geq 1$</td>
<td>8.0846</td>
<td>9.7655</td>
<td>15.4100</td>
</tr>
<tr>
<td>0.0125</td>
<td>$r \leq 2$</td>
<td>1.2710</td>
<td>1.5352</td>
<td>3.7620</td>
</tr>
</tbody>
</table>

95% fractiles are from Osterwald-Lenum(1992)

Table 4: Cointegration vectors, $\beta$, estimated on different subsamples, i.e. 1968(3)–1989(4), 1968(3)–1994(4) and 1968(3)–1998(4) - based on updated estimates of other short run parameters

<table>
<thead>
<tr>
<th>Subsample</th>
<th>$c_t = \beta_y y_t + \beta_w w_t + \text{Const}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968(3)–1989(4)</td>
<td>$\hat{c}_t = 0.5658 y_t + 0.2604 w_t + \text{Const}$</td>
</tr>
<tr>
<td>1968(3)–1994(4)</td>
<td>$\hat{c}_t = 0.6514 y_t + 0.2257 w_t + \text{Const}$</td>
</tr>
<tr>
<td>1968(3)–1998(4)</td>
<td>$\hat{c}_t = 0.6494 y_t + 0.2255 w_t + \text{Const}$</td>
</tr>
</tbody>
</table>

Multivariate cointegration analysis using av VAR-model with five lags sample.

Table 5: Estimated loading factors, $\alpha$, estimated on different subsamples, i.e. 1968(3)–1989(4), 1968(3)–1994(4) and 1968(3)–1998(4) - based on updated estimates of other short run parameters

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_c$</td>
<td>- 0.8453</td>
<td>- 0.4136</td>
<td>- 0.3965</td>
</tr>
<tr>
<td></td>
<td>(0.1604)</td>
<td>(0.1148)</td>
<td>(0.1102)</td>
</tr>
<tr>
<td>$\alpha_y$</td>
<td>- 0.6302</td>
<td>- 0.1057</td>
<td>- 0.0992</td>
</tr>
<tr>
<td></td>
<td>(0.2331)</td>
<td>(0.1568)</td>
<td>(0.1490)</td>
</tr>
<tr>
<td>$\alpha_w$</td>
<td>- 0.1244</td>
<td>- 0.0062</td>
<td>- 0.0394</td>
</tr>
<tr>
<td></td>
<td>(0.2088)</td>
<td>(0.1531)</td>
<td>(0.1437)</td>
</tr>
</tbody>
</table>
Figure 4: The long run equilibrium relationship for consumption, recursive estimates (1978(2)-1998(4)) of the cointegration parameters $\hat{\beta}_y$ and $\hat{\beta}_w$. Based on full sample estimates of the short run parameters.

Figure 5: Estimated feedback coefficients $\hat{\alpha}_c$, $\hat{\alpha}_y$, $\hat{\alpha}_w$, recursive tests for weak exogeneity (1978(2)-1998(4)) - based on full sample estimates of other short run parameters.
for most subsamples, which indicate that income and wealth are weakly exogenous with respect to the cointegrating parameters.

5.3 Consumption, income and wealth

Conditional of the cointegration findings we next model the vector

\[ x_t = (\Delta c_t, \Delta y_t, \Delta w_t, \Delta rph_t)' . \]

\( \Delta rph_t \) denotes the growth rate of the real price of residential housing, and is added to the system because of its importance for the valuation of the existing wealth. The system is

\[ x_t = \Gamma(L)\Delta x_{t-1} + \kappa D_t + \alpha EqCM_{t-1} + \varepsilon_t . \]

\( \Gamma(L) \) is a matrix polynomial. The polynomials for \( \Delta c_{t-1}, \Delta y_{t-1} \) and \( \Delta w_{t-1} \), are of 4. order. For \( \Delta rph_t \), a 2. order polynomials was found to be sufficient. \( D_t \) is a vector of deterministic terms, it includes an intercept, three (centered) seasonals and the dummies \( VAT_t \) and \( STOP_t \) introduced earlier. \( \kappa \) is the corresponding matrix of coefficients. Finally, \( \alpha \) is the vector of equilibrium correction coefficients, and the equilibrium correction mechanism is specified as

\[ EqCM_t = c_t - 0.65 * y_{t-4} - 0.23 * w_t - 0.93 , \]

with \( y_{t-4} \) rather than \( y_t \), since the implied parameterization of the income part of \( \Gamma(L) \) was easier to interpret. The number 0.93 is the mean of the long-run relationship over the period 1968q3-1989q4, i.e. the sample used in section 5.2.

Estimation of the system in (33) on a sample from 1968q3 to 1994q4 yielded a residual vector \( \tilde{\varepsilon}_t \) without any detectable autocorrelation, non-normality or heteroscedasticity, and we therefore sought to estimate a model that encompasses that system. The results are reported in Table 6. In the Diagnostics part of the table, \( \chi^2(63) = 77.7415[0.1001] \), shows that the overidentifying restrictions are jointly acceptable, so the VAR in (33) is indeed encompassed by the model.

The consumption function has the same autoregressive structure as on the pre-break data (cf. Table 1), but in addition there is now an effect of the average growth rate in income over five quarters, and the quarterly growth rate in wealth. Averaging real income growth means that the coefficients of \( \Delta y_{t-1},...\Delta y_{t-4} \) have been restricted to 0.20. The test statistic for the joint restrictions yields \( \chi^2(14) = 11.9534[0.6100] \), and the results indicate that households smooth quarterly income growth to extract more permanent income changes.

The income equation is basically autoregressive, and a 1-1 reparameterization allows it to be written with \( \Delta^4 y_t \) on the left-hand side. In addition there are effects of lagged growth in wealth and of the real price of housing. There is no equilibrium correction term which is consistent with the weak exogeneity of income in section 5.2 and in B&N. For wealth, the third equation in the model, the equilibrium correction term turned out to be not significant and was excluded, hence real wealth is basically a dVAR type equation driven by the growth in real house prices along with some effect from lagged consumption growth. The last equation in the table shows that
Table 6: Extended consumption function model (CF).

The consumption function

\[ \Delta c_t = -0.2715 \Delta c_{t-1} + 0.4016 \Delta c_{t-4} + 0.2000 \Delta \delta y_t \]  
\[ - 0.3410 EqCM_{t-1} - 0.0676 CS_{1t} - 0.0709 CS_{2t} \]  
\[ - 0.0367 CS_{3t} + 0.0761 VAT_t + 0.2109 (\Delta STOP_t - \Delta \delta cpi_t) \]

\[ \hat{\sigma} = 1.53\% \]

The income equation

\[ \Delta y_t = 0.0117 - 0.4082 \Delta y_{t-1} - 0.2491 \Delta y_{t-2} + 0.4755 \Delta y_{t-4} \]  
\[ - 0.3431 \Delta w_{t-1} - \Delta rph_{t-1} + 0.0465 VAT_t \]  
\[ - 0.0164 CS_{2t} + 0.0031 CS_{3t} \]

\[ \hat{\sigma} = 2.24\% \]

The wealth equation

\[ \Delta w_t = 0.0088 + 0.1510 \Delta c_{t-1} - 0.2374 \Delta w_{t-3} \]  
\[ + 0.6949 \Delta rph_t + 0.0135 CS_{1t} + 0.0308 CS_{2t} \]  
\[ + 0.0047 \]  
\[ \hat{\sigma} = 1.47\% \]

The house price equation

\[ \Delta rph_t = -0.0070 + 0.3443 \Delta \delta c_t \]  
\[ + 0.0956 (\Delta c_{t-4} + \Delta rph_{t-4}) + 0.2743 \Delta rph_{t-1} \]  
\[ + 0.0429 CS_{1t} + 0.0593 CS_{2t} + 0.0537 CS_{3t} \]

\[ \hat{\sigma} = 2.02\% \]

Diagnostics

\[ Overidentification \chi^2(63) = 77.7415[0.1001] \]
\[ Restrictions \chi^2(14) = 11.9534[0.6100] \]
\[ AR 1 - 5 F(80, 302) = 1.2228[0.1179] \]
\[ Normality \chi^2(8) = 9.7725[0.2814] \]
\[ Heteroscedasticity F(410, 496) = 0.7754[0.9963] \]

FIML estimation. The sample is 1968(3) to 1994(4), 106 observations.
Table 7: Extended Euler equation model (EE).

**The consumption function**

\[
\begin{align*}
\hat{\Delta}c_t &= 0.0064 - 0.4060 \Delta c_{t-1} \\
&\quad - 0.0874 CS_{1t} - 0.0822 CS_{2t} - 0.0284 CS_{3t} \\
&\quad + 0.0675 VAT_t + 0.2685 (\Delta STOP_t - \Delta 4\pi_i_t) \\
&\quad - 0.0874 \Delta c_{t-1} - 0.0167 CS_{1t} - 0.0214 CS_{2t} \\
&\quad - 0.0060 + 0.1579 \Delta w_{t-2} + 0.0932 (\Delta c_{t-1} + \Delta w_{t-2}) \\
&\quad + 0.2265 \Delta w_{t-4} + 0.5222 \Delta rph_t + 0.0241 CS_{2t} \\
&\quad + 0.1490 \Delta w_{t-2} + 0.1897 \Delta w_{t-3} + 0.0236 VAT_t + 0.0420 CS_{3t}
\end{align*}
\]

\[\hat{\sigma} = 1.85\%\]

**The income equation**

\[
\begin{align*}
\hat{\Delta}y_t &= 0.0146 - 0.4050 (\Delta y_{t-1} + \Delta w_{t-1} - \Delta rph_{t-1}) \\
&\quad - 0.2258 \Delta y_{t-2} - 0.2023 \Delta w_{t-2} \\
&\quad + 0.0548 (c_{t-1} - y_{t-1}) - 0.0167 CS_{1t} - 0.0214 CS_{2t} \\
&\quad + 0.0057 + 0.1579 \Delta y_{t-2} + 0.0932 (\Delta c_{t-1} + \Delta w_{t-2}) \\
&\quad + 0.2265 \Delta w_{t-4} + 0.5222 \Delta rph_t + 0.0241 CS_{2t} \\
&\quad + 0.0057 + 0.1579 \Delta y_{t-2} + 0.0932 (\Delta c_{t-1} + \Delta w_{t-2}) \\
&\quad + 0.2265 \Delta w_{t-4} + 0.5222 \Delta rph_t + 0.0241 CS_{2t}
\end{align*}
\]

\[\hat{\sigma} = 2.35\%\]

**The wealth equation**

\[
\begin{align*}
\hat{\Delta}w_t &= 0.0146 - 0.4050 (\Delta y_{t-1} + \Delta w_{t-1} - \Delta rph_{t-1}) \\
&\quad - 0.2258 \Delta y_{t-2} - 0.2023 \Delta w_{t-2} \\
&\quad + 0.0548 (c_{t-1} - y_{t-1}) - 0.0167 CS_{1t} - 0.0214 CS_{2t} \\
&\quad + 0.2265 \Delta w_{t-4} + 0.5222 \Delta rph_t + 0.0241 CS_{2t} \\
&\quad + 0.0057 + 0.1579 \Delta y_{t-2} + 0.0932 (\Delta c_{t-1} + \Delta w_{t-2}) \\
&\quad + 0.2265 \Delta w_{t-4} + 0.5222 \Delta rph_t + 0.0241 CS_{2t}
\end{align*}
\]

\[\hat{\sigma} = 1.55\%\]

**The house price equation**

\[
\begin{align*}
\hat{\Delta}rph_t &= - 0.0060 + 0.2279 \Delta rph_{t-1} + 0.3382 \Delta c_{t-2} + 0.1251 \Delta c_{t-4} \\
&\quad + 0.1490 \Delta w_{t-2} + 0.1897 \Delta w_{t-3} + 0.0236 VAT_t + 0.0420 CS_{3t}
\end{align*}
\]

\[\hat{\sigma} = 1.99\%\]

**Diagnostics**

\[
\begin{align*}
Overidentification \chi^2(58) &= 92.4751[0.0259]^* \\
Restrictions \chi^2(8) &= 1.6296[0.9903] \\
AR 1 - 5 F(80, 302) &= 0.9713[0.5512] \\
Normality \chi^2(8) &= 11.529[0.1735] \\
Heteroscedasticity F(430, 478) &= 0.7838[0.9951]
\end{align*}
\]

* FIML estimation. The sample is 1968(3) to 1994(4), 106 observations.
Figure 6: 16-quarter dynamic forecasts based on the consumption function model (CF) in Table 6.

the growth rate of the house price index depends positively on its past values and on wealth and consumption growth.

Given the absence of labour market variables, government transfers and income taxes, the income equation in Table 6 has a low causal content. The same can be said of the other two marginal equations, for example the “housing price” equation does not include any of the variables that have been shown to be important econometric determinants of housing prices, see Eitrheim (1996). As a result, the estimated prediction intervals from our 4-equation model are certain to be wider than those arising from a system that also incorporates sector models of income determination and the housing market. At least this must be true for the shorter forecast horizons, since the larger model would condition on a wider set of (relevant) variables. Another implication of the confluent nature of the marginal models is that they are sources of parameter non-constancy that will be harmful for the consumption forecasts. The parameter constancy tests based on the 1-step forecasts errors of the estimated model for the period 1995(1)-1998(4), are $F(64, 96) = 1.6329[0.0146]$ (using $\Omega^2$) and $F(64, 96) = 1.4373[0.0532]$ (using $V(e)$).
Figure 7: 16-quarter 1-step forecasts based on the consumption function model (CF) in Table 6.

Figure 8: 16-quarter dynamic forecasts based on the estimated Euler equation model (EE) in Table 7.
Figure 9: 16-quarter 1-step forecasts based on the estimated Euler equation model (EE) in Table 7.
6 Summary and conclusions

Financial deregulation in the mid-1980s led to a strong rise in aggregate consumption expenditure. Existing empirical macroeconometric consumption functions broke down—i.e. they failed in forecasting and failed to explain the data ex post. Predictability was lost, which seemed to provide confirmation of the Lucas-critique of econometric consumption functions and support for Euler-equation specification, i.e. Hall’s original random walk hypothesis, or Campbell’s “saving for a rainy day” version of the permanent income hypothesis. The algebraic sections of this paper showed that even in the case where the consumption function is the correct model, it will regularly lose in forecast contests with a random walk equation for consumption. This is a special case of Clements’s and Hendry’s finding that it is impossible to show that causal models will forecast more accurately than non-causal relationships.

A re-appraisal of the breakdown in Norwegian consumption functions in 1985, showed the relevance of the theory. Over a sample ending in 1984.4, a consumption function encompasses a Campbell-type models. The forecasts of both models are hurt by the occurrences in 1985. However the Euler-equation forecast for 1986, conditional on 1985 is more accurate than the corresponding consumption function forecast. We next showed the results of a update of Brodin and Nymoen’s re-specified consumption function. That model contains a stable cointegrating relationship, despite major changes in the measurement system and nine years of new data, and the causal direction between income and consumption is also unchanged in the new model. Apparently, the B&N re-installs predictability of consumption. However, the gains in forecastability is limited by the fact that the wealth variable also has to be forecasted jointly with consumption and income.

Thus it may be misleading to measure the gain from the re-specification after the 1985 forecast break only in terms of increased forecast success relative to the random walk. Instead the lasting merit of the re-specified model is that it contains partial structure, and that it provides those responsible for financial and monetary policy with a more complete model of the dynamics and causal links between income, consumption and wealth.
References


A Data definitions

The data for total consumption expenditures, $C_t$, and income, $Y_t$, used in section 5 are collected from the annual and quarterly National accounts of Statistics Norway. They are in fixed 1996-prices. Nominal wealth is defined as

$$NW_t = (L_{t-1} + NL_{t-1} - CR_{t-1} + (PH/PC)_t \cdot nhf_t \cdot K_{t-1},$$

where:

$L_t$ = Household sector liquid assets (money stock and deposits).
$PC_t$ = Price deflator for total consumption expenditures.
$CR_t$ = Liabilities, loans and by banks and other financial institutions.
$K_t$ = Real values of residential housing stock, million 1996 NOK.
$NL_t$ = Non-liquid financial assets.
$nhf_t$ = Fraction of residential housing stock owned by households.
$PH_t$ = Housing price index. (1996=1).

In the model we use real-wealth, deflated by the implicit deflator of consumption (1996=1). Note that in the B&N data $NL_t$ was not included in the wealth measure, and (implicitly) $nhf_t$ was constant and equal to one.