MACROECONOMIC FORECASTS UNDER THE PRISM OF ERROR-CORRECTION MODELS

Angelos A. Antzoulatos

Federal Reserve Bank of New York
Research Paper No. 9728

September 1997

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Angelos A. Antzoulatos
International Research Department
Federal Reserve Bank of New York
33 Liberty Street
New York, N.Y. 10012
(212) 720-6813
aa.antzoulatos@ny.frb.org

ABSTRACT

When the error correction term exhibits persistence, its change may convey useful information about short-run economic dynamics, which, if not taken sufficiently into account by a forecasting model, could be associated with predictable forecast errors. Such errors are documented in the DRI forecasts for the U.S. consumption, GNP and imports. The strong results, together with the very general assumptions behind the theoretical framework, suggest that similar predictable errors may be pervasive in the forecasts of other large-scale econometric models.

Key Words: Error Correction Models, Forecasting, Consumption, GNP, Imports.

I thank, without implicating, Marjorie Schnader of Schnader and Chesler Associates, Michael Bradley, Frederic Joutz, and seminar participants at the FRBNY, the George Washington University and the March-1995 Meetings of the Eastern Economic Association in New York for several insightful comments and suggestions. I am also indebted to Kathleen McKieman of the Research Library of the FRBNY and Margaret Kieckhefer of the Library of Congress for invaluable assistance in gathering the data.

The views expressed here are those of the author and do not necessarily reflect the views of the Federal Reserve Bank of New York or the Federal Reserve System.

1 INTRODUCTION

By allowing a richer specification of short-run economic dynamics and more efficient estimation than traditional vector autoregressions, error correction models (ECM) hold the promise of, among other things, better macroeconomic forecasts. This promise was identified long time ago, as the famous DHSY model for the U.K. consumption expenditure (Davidson et al. [1978]) suggests. It was widely recognized though after Engle and Granger (1987), in the seminal paper "Co-Integration and Error Correction: Representation, Estimation, and Testing", provided the analytical justification for the inclusion of error correction terms (ECT) in the vector autoregressions of co-integrated variables, and showed that failing to do so would lead to misspecified models and inefficient forecasts.

This paper, building upon Engle and Granger's analytical framework, shows that when the ECT exhibits persistence its change may also convey useful information about short-run economic dynamics and, thus, should be included in error correction models. It then argues that ECM's promise of better macroeconomic forecasts may not materialize in its full potential, if the information conveyed by the ECT change is not taken sufficiently into account by a forecasting model. Alternatively, the forecast errors of such a model will not be orthogonal to this information.

To illustrate this possibility, as well as the associated potential for forecast improvement, the paper uses the forecasts of the *DRI/McGraw Hill Macro Model for the U.S. Economy* –a benchmark in the forecasting industry. The objective though is not to document that the DRI –or any other– forecasts are inefficient by uncovering a particular pattern in the forecast errors and the (significant) test statistics associated with it. Instead, the objective is to provide an explanation for the observed pattern and, based on it, to identify relevant and timely available information which might help improve the forecasts under scrutiny and, hopefully, the forecasts of other models.

The paper proceeds as follows. Section 2 presents the main theoretical results for the system of consumption and income. In particular, it derives an error correction model for (log) consumption in which the ECT change, $\Delta ECT_{t-1} = ECT_{t-1} - ECT_{t-2}$, is included with a negative sign, along with the ECT itself, $ECT_{t-1} = c_{t-1} - y_{t-1}$. ($c$ and y stand for (log) consumption and income, while Δ is the usual first difference operator.) Focusing[1] on ΔECT_{t-1}, this model implies that an ECT decline between the periods $t-1$ and $t-2$, $\Delta ECT_{t-1} < 0$, may –holding expected income constant– signal an upward adjustment of consumption at t. This adjustment, in turn,

[1] So far, the literature has mostly focused on ECT_{t-1}. Its negative sign implies that high consumption relative to contemporaneous income at $t-1$, i.e., high ECT_{t-1}, signals lower consumption next period; and vice-versa.

may lead to consumption underprediction if it is not taken sufficiently into account in forecasting. Further, since consumption is by far the biggest component of aggregate demand, the above "predictable" forecast errors may propagate to GNP and import forecasts.

In line with these expectations, Section 3 documents that the DRI forecast errors are not orthogonal to ΔECT_{t-1}. Putting all the observations together, Section 3 first finds a strong negative bias (tendency to underpredict) for total consumption, GNP and imports. It then documents that consumption's and GNP's bias is completely accounted for by the periods which follow an ECT decline. Imports' bias, however, is completely accounted for by the periods which follow an ECT increase, $\Delta ECT_{t-1} > 0$, an indication that the associated consumption surge at $t-1$ feeds into imports with an one period lag. Moreover, considering the impact of economic variables other than contemporaneous expected income which may affect consumption, Section 3 argues that the negative bias for consumption, and hence for GNP and imports, should be stronger when the ECT decline is coupled with optimistic income expectations or with an expected ECT rise next period. This expectation is also confirmed.

To evaluate whether the patterns in the forecast errors documented in Section 3 are a mere statistical artifact, Section 4 refers to the way the DRI forecasts are made. Based on the strong results, as well as their consistency with the theoretical framework and across the series examined, Section 4 argues that this is unlikely. Thus, it concludes, the paper's intuition has the potential to improve the forecasts under scrutiny by helping improve, at the very least, their judgmental content.

Lending support to this conclusion, the paper's main theoretical argument that both the ECT and its change may contain useful information about short-run economic dynamics has been alluded to in earlier empirical research. For example, some empirical specifications of the Phillips curve postulate that not only the "output gap" –the ECT equivalent– but also the rate it closes –its change– matter for inflation. And further highlighting the paper's potential contribution, the very general assumptions behind the theoretical framework suggest that the paper's intuition is likely to apply to many other settings. Therefore, "predictable" forecast errors similar to those documented here may be pervasive in the forecasts of other large-scale econometric models.

2 THEORETICAL FRAMEWORK

2.1 Partial Adjustment and the Error Correction Term

Reflecting the forward-looking nature of the consumers' decision problem, optimal (desired) consumption, c_t^*, in equation (1) is increasing in contemporaneous and future expected income, y_t and $E_t y_{t+k}$ $(k \geq 0)$ (Deaton [1991]). The vector Z_t encompasses other variables which might affect consumption; such as, liquid assets, demographic factors and income uncertainty. (As Foley and Dunkan (1975), Miller (1976), Cantor (1985) and Skinner (1988), among others, have shown, higher income uncertainty leads to lower consumption.) Capital letters denote levels, small letters denote logs (consumption and income appear to be integrated of order one in logs), E is the usual expectations operator, Φ is a function and ϵ_t a stochastic term unrelated to variables known at $t-1$.

$$c_t^* = \mu + \mu_0 y_t + \mu_1 E_t y_{t+1} + \mu_2 E_t y_{t+2} + \ldots + \mu_p E_t y_{t+p} + \Phi(Z_t) + \epsilon_t \quad (\mu_k \geq 0, k \geq 0) \tag{1}$$

Because of some sort of adjustment costs,[2] people cannot set actual consumption, c_t, equal to c_t^*. Instead, c_t adjusts towards c_t^* as described by equation (2) (this partial adjustment mechanism is adapted from Davidson and MacKinnon [1993, p. 680]). The term $(1-\xi)$ measures the speed of adjustment, while e_t is a stochastic term unrelated to variables known at $t-1$.

$$c_t - c_{t-1} = (1-\xi)(c_t^* - c_{t-1}) + e_t \quad (0 < 1-\xi < 1) \tag{2}$$

Substituting equation (1) into (2) gives (3), which can be thought of as a structural error correction model for (log) consumption (for details, see Antzoulatos [1996]). In it, the error correction term, equation (4), has a negative coefficient.

$$\begin{aligned} \Delta c_t = \; & (1-\xi)\mu - (1-\xi)(c_{t-1} - \lambda y_{t-1}) + \psi_0(y_t - y_{t-1}) \\ & + \psi_1(E_t y_{t+1} - y_t) + \ldots + \psi_p(E_t y_{t+p} - E_t y_{t+p-1}) + (1-\xi)\Phi(Z_t) + \eta_t \end{aligned} \tag{3}$$

$$ECT_{t-1} = c_{t-1} - \lambda y_{t-1} \quad (0 < \lambda \leq 1) \tag{4}$$

[2]This is the explanation Engle and Granger (1987) offer for the existence of the error correction term. The ECT may also be justified by small utility costs of deviations from the optimal consumption path (Caballero [1995]) or incomplete information. All the above are consistent with Davidson et al.'s intuitive justification for the inclusion of an ECT in the consumption growth equation, which relies upon the existence of consumer "errors" (Davidson et al. [1978]); i.e., people compensate for overspending (high ECT) with lower-than-otherwise consumption next period, and vice-versa.

Equation (3), whose derivation illustrates the analytical foundations of error correction models with forward-looking expectations, justifies the inclusion of the ECT in the consumption growth equation. Among its implications, a negative ECT_{t-1}, i.e., low consumption relative to contemporaneous income at $t-1$, signals a upward adjustment of consumption next period. Conversely, a positive ECT_{t-1} signals an downward adjustment next period.

Yet, as this paper argues, the above typical error correction model may not capture all the information the ECT may convey about high-frequency consumption dynamics. Specifically, the paper argues that when the ECT exhibits persistence, i.e., relatively long periods of positive or negative values, its change may have additional predictive capacity for consumption growth. This argument can be proven analytically by extending the partial adjustment mechanism of equation (2) as shown below. Under the non-restrictive assumptions $\phi_1 + \phi_2 = 1$, $\phi_1 > 0$ and $\phi_2 > 0$, the new mechanism induces higher ECT persistence.

$$c_t - \phi_1 c_{t-1} - \phi_2 c_{t-2} = (1-\xi)(c_t^* - \phi_1 c_{t-1} - \phi_2 c_{t-2}) + e_t \qquad (0 < 1 - \xi < 1) \tag{5}$$

Substituting (1) into (5) and adding $\phi_2 c_{t-2} + (\phi_1 - 1)c_{t-1}$ in both sides of the resultant equation yield equation (6), which proves the paper's argument. In it, $\lambda = \mu_0 + \mu_1 + .. + \mu_p > 0$, $\psi_{-1} = -(\mu_0 + \mu_1 + .. + \mu_p)\xi\phi_2 < 0$, $\psi_p = (1-\xi)\mu_p > 0$, while the (positive) coefficients ψ_k $(k = 0, 1, ...p-1)$ are given by the recursive formula $\psi_k - \psi_{k+1} = (1-\xi)\mu_k$.

$$\begin{aligned} \Delta c_t &= (1-\xi)\mu - \xi\phi_2\{(c_{t-1} - \lambda y_{t-1}) - (c_{t-2} - \lambda y_{t-2})\} \\ &\quad -(1-\xi)(c_{t-1} - \lambda y_{t-1}) + \psi_{-1}(y_{t-1} - y_{t-2}) + \psi_0(y_t - y_{t-1}) \\ &\quad +\psi_1(E_t y_{t+1} - y_t) + ... + \psi_p(E_t y_{t+p} - E_t y_{t+p-1}) + (1-\xi)\Phi(Z_t) + \eta_t \\ &= (1-\xi)\mu - \xi\phi_2(ECT_{t-1} - ECT_{t-2}) \\ &\quad -(1-\xi)ECT_{t-1} + \psi_{-1}\Delta y_{t-1} + \psi_0 \Delta y_t \\ &\quad +\psi_1 \Delta E_t y_{t+1} + ... + \psi_p \Delta E_t y_{t+p} + (1-\xi)\Phi(Z_t) + \eta_t \end{aligned} \tag{6}$$

Since both ξ and ϕ_2 are positive, the coefficient of $\Delta ECT_{t-1} = ECT_{t-1} - ECT_{t-2}$ is negative. Thus, an ECT-decline between $t-2$ and $t-1$, $ECT_{t-1} - ECT_{t-2} < 0$, signals an upward adjustment in c_t, and vice-versa. ECT_{t-1}'s coefficient is also negative, as in equation (3).

2.2 U.S. Evidence

Whether ΔECT_{t-1} has significant predictive capacity for U.S. consumption growth (log change) can be tested by estimating equation (6). Besides the restrictions on the sign of the estimated coefficients, the extended model further suggests that ECT's persistence and ΔECT_{t-1}'s predictive capacity should be stronger for total than for non-durables and services consumption. This is so because the adjustment costs are higher for durables than for non-durables and services, making the adjustment mechanism (5) more applicable to the first and, by extension to total, than to the second measure of consumption.

Following Engle and Granger's (1987) two-step approach, ECT_{t-1} is set equal to the lagged residuals of the co-integrating regression of (log) consumption on a constant and (log) income. Consumption corresponds to total, and non-durables and services, while income corresponds to personal disposable income. All are on per capita basis and at 1987 prices. Expected income growth, $E_t\Delta y_{t+k}$ $(k \geq 0)$, is recovered from the projection of Δy_{t+k} $(k \geq 0)$ on Δc_{t-m}, Δy_{t-m}, R_{t-m} and $\Delta LEAD_{t-m}$ $(m = 1, 6)$. R stands for the three-month Treasury bill rate, secondary market, and $LEAD_t$ for the composite index of eleven leading indicators at the third month of the t^{th} quarter. The extensive list of right-hand-side variables for $E_t\Delta y_{t+k}$ $(k \geq 0)$ reflects the difficulty to predict income growth (for details, see Campbell and Mankiw [1990]). This difficulty also restricts the income-growth terms to two. Nevertheless, the results are robust to the set of right-hand-side variables used in the projections. Further, to avoid the distorting impact of the Korean war period and of revisions of initial estimates, the sample begins in 1953:1 and ends in 1992:2 (two years before the latest available estimate). All series were retrieved from CITIBASE.

The co-integrating regressions for total, c_t, and non-durables and services consumption, c_t^n, are shown below. A series of ADF tests, with one, two, three and four lags of $\Delta\nu_t^n$, established that the null hypothesis of no-cointegration between c_t^n and y_t can be rejected at the 5% level. However, the ADF statistics for $\Delta\nu_t$ were in the uncertain range at the 5% level. All the critical values were taken from Charemza and Deadman (1992, TABLE 3).

$$c_t = -0.131 + 0.993y_t + \nu_t; \qquad \text{R}^2 = 0.996;\ \text{D.W.} = 0.311$$

$$c_t^n = -0.491 + 0.940y_t + \nu_t^n; \qquad \text{R}^2 = 0.998;\ \text{D.W.} = 0.419$$

FIGURE 1 plots ν_t and ν_t^n over time, while equations (7) and (8) summarize the estimation results for equation (6). (t-statistics are shown below the estimated coefficients in parentheses, while one, two and three asterisks denote significance at the ten, five and one percent levels, respectively.)

Consistent with expectations, the ECT for total consumption, ν_t, exhibits higher persistence than that for non-durables and services, ν_t^n.

Insert FIGURE 1 here

Also consistent with expectations, ΔECT_{t-1} has higher predictive capacity for total than for non-durables and services consumption growth. Specifically, in the first equation the coefficient of ΔECT_{t-1} ($= \Delta\nu_{t-1}$) is negative and significant. In the second, the coefficient of ΔECT_{t-1} ($= \Delta\nu^n_{t-1}$) is negative but insignificant. Finally, in both equations ECT_{t-1}'s coefficient is negative and significant, while $\Delta\hat{y}_{t+k}$'s coefficient ($k = 0, 1$) is positive and significant, as expected. $\Delta\hat{y}_t$ and $\Delta\hat{y}_{t+1}$ denote the fitted values of the projection of Δy_t and Δy_{t+1} on the variables mentioned above. As for Δy_{t-1}, being insignificant, it was dropped from both equations.

$$\begin{array}{rcllllll} \Delta c_t & = & -0.001 & +0.658\Delta\hat{y}_t & +0.597\Delta\hat{y}_{t+1} & -0.129\nu_{t-1} & -0.177\Delta\nu_{t-1} & +u_t \\ & & (-1.40) & (5.80)^{***} & (5.25)^{***} & (-3.77)^{***} & (-2.93)^{***} & \end{array} \quad (7)$$

$R^2 = 0.339$; D.W. $= 1.94$.

$$\begin{array}{rcllllll} \Delta c^n_t & = & 0.001 & +0.413\Delta\hat{y}_t & +0.296\Delta\hat{y}_{t+1} & -0.076\nu^n_{t-1} & -0.0677\Delta\nu^n_{t-1} & +u_t \\ & & (1.97)^{**} & (5.12)^{***} & (3.43)^{***} & (-2.24)^{**} & (-1.31) & \end{array} \quad (8)$$

$R^2 = 0.245$; D.W. $= 1.77$.

The paper now turns to examine whether ΔECT_{t-1} has any predictive capacity for the forecast errors of the DRI model for the U.S.A..

3 FORECAST EVALUATION

3.1 Data

All series are collected from the DRI/Mc Graw Hill Review of the U.S. Economy (henceforth, the Review). The Review has been published at monthly intervals since the mid 1970s. Each issue contains forecasts for a large number of aggregate variables for several quarters ahead, as well as estimates which usually go back one to four quarters. The quarterly forecasts used here come from the issue pertaining to the *third* month of the corresponding quarter. For example, the forecasts for the first quarter of 1994 come from the March 1994 issue of the Review. Since there is a lag between the end of a quarter and the time a satisfactory picture for it is put together, the March forecasts are genuine ones for the first quarter. In the few instances the appropriate issue could not be located, the issue closest to it was used instead. The only exception is the third quarter of 1983 for which no data could be found in the Library of Congress or in the research libraries of the Federal Reserve System. It should also be pointed out that the forecasts made in the third month of a quarter are partly derived by adding up existing monthly data. As a result, they do not reflect accurately the dynamic properties of the DRI model. How could this affect the interpretation of the paper's results is explored in the concluding section.

The percent forecast error, equation (9), is calculated using the estimates reported in the Review of the third month of the following quarter; in the above example, the estimates reported in the June 1994 issue.

$$XERROR_t = \text{Log}(E_{t+1}X_t) - \text{Log}(E_tX_t) \tag{9}$$

X stands for consumption, GNP and imports, while $E_{t+1}X_t$ denotes the estimate for X_t reported at the third month of the $t+1$ quarter. This preliminary estimate is likely to be revised later but, nevertheless, it is the one the DRI forecasters have in mind when they prepare the forecasts for the $t+1$ quarter and beyond. In addition, other forecast evaluation studies, such as, Ash et al.'s (1990) and Zarnowitz's (1991), use similar estimates.

The consumption, GNP, total imports and personal disposable income series are in real terms. There is no loss of observations, however, caused by the two base-year changes which took place during the sample period, 1976:1 to 1994:4. This is so because, following a period of a base-year change, the Review reports figures for both the old and the new series.

3.2 Test Description

Since it is hard to identify how much of the information conveyed by ΔECT_{t-1} a large scale econometric model, like the DRI model, captures, the paper follows a simple approach. Using the intuition about predictable adjustments signaled by ΔECT_{t-1}, it tries to identify periods at which the forecast error will tend to be positive if these adjustments are not taken sufficiently into account. Thus, the sample is split into two groups, denoted by the values 1 and 0 of the dummy variable DUM_t. The $DUM_t = 1$-group comprises of the observations likely to correspond to a positive forecast error (underprediction). Next, the ratio of positive to negative errors and the mean forecast error (m.f.e.) for each group are compared with the corresponding figure for the whole sample. Let ρ and μ denote the ratio and the m.f.e. for the whole sample, and $\rho|_{DUM_t=i}$ and $\mu|_{DUM_t=i}$ $(i = 1, 0)$ those for the two groups.

A ranking of

$$\rho|_{DUM_t=0} < \rho < \rho|_{DUM_t=1} \tag{10}$$

and

$$\mu|_{DUM_t=0} < \mu < \mu|_{DUM_t=1} \tag{11}$$

would provide evidence of a tendency to underpredict (relative to the whole sample) the series under scrutiny for the $DUM_t = 1$-periods, and overpredict for the remaining. This tendency and, thus, the potential for improving the forecasts will be increasing in the difference between ρ (μ) and $\rho|_{DUM_t=i}$ ($\mu|_{DUM_t=i}$), $i = 1, 0$.

Further, if the forecasts capture all the relevant information except that (presumably) conveyed by ΔECT_{t-1}, ρ will be close to one and μ close to zero, while a t-test for zero mean forecast error may fail to reveal any bias. This reflects the fact that the errors associated with ΔECT_{t-1} will tend to average out over sufficiently long horizons, say, over the span of a few business cycles, in the same way as ΔECT_{t-1} does.[3] If, however, the forecasts miss more information than that conveyed by ΔECT_{t-1}, ρ will tend to be greater than one and μ significantly positive for negatively biased forecasts. By the same token, ρ will tend to be less than one and μ significantly negative for positively biased forecasts. Still, however, the rankings (10) and (11) should hold.

In order to use information strictly available at the time the forecasts were made, the ECT is set equal to (log) consumption minus (log) income, as in the DHSY model by Davidson et al. (1978). Considering, however, that λ is approximately equal to one for total consumption ($\lambda = 0.993$), setting $ECT_{t-1} = c_{t-1} - y_{t-1}$ is not likely to affect the results significantly.

In the base case, DUM_t is set equal to one when $ECT_{t-1} - ECT_{t-2} < 0$. In mathematical terms,

$$DUM_t = 1 \text{ if } (E_t c_{t-1} - E_t y_{t-1}) < (E_t c_{t-2} - E_t y_{t-2}); \text{ else } DUM_t = 0 \tag{12}$$

$E_t c_{t-k}$ and $E_t y_{t-k}$ ($k = 1, 2$) denote the estimates of c_{t-k} and y_{t-k} ($k = 1, 2$) reported at t. Since savings is equal to $S_t = Y_t - C_t$, this condition implies that an underprediction is likely when the savings ratio rises between $t-2$ and $t-1$; or, equivalently, when consumption grows more slowly than income.

The condition for $DUM_t = 1$ can also be strengthened to account for the possibility that $ECT_{t-1} < ECT_{t-2}$ may reflect other economic forces at work than the lagged adjustment implied by equation (5). For example, consumption may be relatively low to contemporaneous income at $t-1$, thus leading to $ECT_{t-1} < ECT_{t-2}$, because of increased income uncertainty. (Income uncertainty and other variables which may affect consumption are subsumed into the vector

[3]But as the paper argues, this does not preclude the possibility that the forecast errors may tend to be positive or negative for some identifiable periods which, in turn, would indicate that the forecasts under scrutiny could be improved.

Z_t.) This case is unlikely though when the ECT decline, and the associated savings increase, is coupled with optimistic income expectations for periods $t+k$ $(k \geq 0)$. Similarly, $ECT_{t-1} < ECT_{t-2}$ is more likely to reflect the lagged adjustment implied by equation (5) –and thus signal higher c_t– and less likely to capture the effect of the Z_t-variables when it is coupled with an expected ECT increase for next period; i.e., with $E_{t-1}c_t - E_{t-1}y_t > c_{t-1} - y_{t-1}$. The last condition is equivalent to an expected savings decline for period t.

The conditions for optimistic income expectations and predicted rise in the ECT, which are used to strengthen the condition for likely underprediction, are given respectively by:

$$(E_t \Delta y_{t-1} < E_t \Delta y_t) \text{ .OR. } (E_t \Delta y_{t-1} < E_t \Delta y_{t+1}) \tag{13}$$

and

$$(E_t c_{t-1} - E_t y_{t-1}) < (E_t c_t - E_t y_t) \tag{14}$$

In (13), the logical operator ".OR." is used instead of the stronger ".AND." operator because the latter in conjunction with (12) leaves too few observations for the $DUM_t = 1$-group for any meaningful analysis. Also, personal disposable income in (13) is in per capita terms (in [12] and [14] the conditions apply to both total and per capita figures). If the paper's intuition is correct, the strengthening of the condition for underprediction with either (13) or (14) should produce stronger test rankings than the base case (condition [12]).

An intuitive discussion of conditions (13) and (14) follows. Combining (12) and (13), consumption underprediction is more likely when the slower consumption growth relative to income at $t-1$ (condition [12]) is coupled with faster expected income growth at t or $t+1$ relative to $t-1$ (condition [13]). Next, combining (12) and (14) and re-arranging terms in (14), an underprediction is more likely when the slower consumption growth relative to income at $t-1$ is coupled with a predicted faster growth at t (condition [14]); that is, with $E_t c_t - E_t c_{t-1} > E_t y_t - E_t y_{t-1}$.

At this point, it should be reiterated that the conditions for the identification of likely periods of a positive forecast error ($DUM_t = 1$) are calculated from figures reported in the issue of the Review pertaining to the t^{th} quarter. Thus, these figures were available to the people producing the forecasts and, as a consequence, the results reported below are not a statistical artifact arising from mixing data from different sources. To further appreciate these results, the appendix discusses briefly some of the equations of the DRI model.

3.3 Results

Consumption Forecasts.

TABLE 1 summarizes the evidence for consumption forecasts. It has six columns, three for total and three for non-durables and services consumption. The columns show the test statistics for all, $DUM_t = 1$ and $DUM_t = 0$-observations. Each shell reports the ratio of positive to negative forecast errors, the mean forecast error (m.f.e.) in percent and the corresponding t-statistic for zero m.f.e.. One, two and three asterisks indicate significance at the 10%, 5% and 1% level, respectively.

Insert TABLE 1 here

The ratios of positive to negative forecast errors for total, and non-durables and services consumption, $\rho = \frac{43}{30} \approx 1.5$ and $\rho = \frac{50}{23} > 2$, indicate a negative bias (tendency to underpredict) which is bigger for non-durables and services. However, the corresponding m.f.e.s, $\mu = 0.25\%$ and $\mu = 0.14\%$, and the associated t-statistics, 3.09 and 1.87, indicate that the bias is actually bigger for total consumption. This finding is consistent with the paper's intuition that ΔECT_{t-1} should have a higher predictive capacity – and thus be associated with stronger negative bias– for total than non-durables and services consumption.

In the base case (condition [12]), the negative bias for total consumption is completely accounted for by the $DUM_t = 1$-periods, while the non-durables and services forecasts exhibit a strong negative bias for these periods as well despite their marginally significant μ. In greater detail, for total consumption the ratio of positive to negative errors rises to $\rho|_{DUM_t=1} = \frac{24}{10} \approx 2.5$ from $\rho \approx 1.5$ for the whole sample; the m.f.e. rises to $\mu|_{DUM_t=1} = 0.37\%$ from $\mu = 0.25\%$ and becomes more significant (the t-statistic rises to 3.86). For the $DUM_t = 0$-periods, the tendency to underpredict total consumption is significantly weaker relative to the whole sample; the positive and negative errors are almost equally split, $\rho|_{DUM_t=0} = \frac{19}{20}$, while the m.f.e. declines to $\mu|_{DUM_t=0} = 0.16\%$ and is insignificant at all conventional levels (t-statistic 1.21). For non-durables and services consumption, the corresponding statistics are
$\rho|_{DUM_t=0} = \frac{24}{15} < \rho = \frac{50}{23} < \rho|_{DUM_t=1} = \frac{26}{8}$ and $\mu|_{DUM_t=0} = 0.10 < \mu = 0.14 < \mu|_{DUM_t=1} = 0.20$.
The m.f.e. $\mu|_{DUM_t=1} = 0.20$ is significant at the 5% level (t-statistic 2.39). In summary, not only the negative bias for both consumption measures is accounted for by the $DUM_t = 1$-observations, but, in addition, the test rankings (10) and (11) hold.

Strengthening the condition for likely underprediction with optimistic income expectations (conditions [12] and [13]) produces stronger statistics than the base case (condition [12]). The $\mu|_{DUM_t=1}$ rises further for both consumption measures, $\rho|_{DUM_t=1}$ rises as well for non-durables and services, and the test rankings (10) and (11) hold. The statistical significance of $\mu|_{DUM_t=0}$ for total consumption reflects the fact that, as the number of observations in the $DUM_t = 1$-group decreases, the remaining observations reflect more of the overall bias of the forecast series. Also, strengthening the condition for $DUM_t = 1$ with a predicted ECT rise (conditions [12] and [14]) produces stronger statistics than the base case. Notably, the m.f.e. for the $DUM_t = 1$-periods now becomes significant at the 1% level even for non-durables and services ($\mu_{DUM_t=1} = 0.23$, t-statistic 2.73).

These results support the paper's thesis that the changing ECT conveys information about short-run consumption dynamics that may help improve macroeconomic forecasts. More important, the stronger test rankings produced when the condition for underprediction is strengthened relative to the base case indicate that the documented patterns in the forecast errors are consistent with the paper's intuition.

Further support for the paper's thesis is provided by TABLE 2. The first case examines whether the results hold when relatively small ECT changes are omitted. So, the sample is ranked in ascending order according to the difference $(E_t c_{t-1} - E_t y_{t-1}) - (E_t c_{t-2} - E_t y_{t-2})$ and split into three groups of approximately equal size. DUM_t is set equal to one for the first group, for which $(E_t c_{t-1} - E_t y_{t-1}) - (E_t c_{t-2} - E_t y_{t-2}) < -0.0035$, and equal to zero for the third, for which $(E_t c_{t-1} - E_t y_{t-1}) - (E_t c_{t-2} - E_t y_{t-2}) > 0.0035$. The middle group is dropped. Again, there is strong evidence –stronger than in the base case– of underprediction relative to the whole sample for the $DUM_t = 1$-group and of overprediction for the $DUM_t = 0$-group.

Insert TABLE 2 here

The second case in TABLE 2 tests whether the results change when relatively small forecast errors are excluded from the analysis. Now, the sample is ranked according to the forecast error, split into three groups of approximately equal size, and the middle group, which consists of the errors around zero, is dropped. As the test statistics indicate, the evidence of underprediction for the $ECT_{t-1} < ECT_{t-2}$-periods is considerably stronger than in the base case.

In another test, the forecast error was projected on ECT_{t-1} but the resulting coefficient was insignificant for both consumption measures. This implies that the forecasts under scrutiny capture the information conveyed by ECT_{t-1}. Evidently though they do not capture that conveyed by ΔECT_{t-1}.

GNP Forecasts.

TABLE 3 summarizes the results for GNP forecasts. Its three columns correspond to all observations and to $DUM_t = 1, 0$-ones. Each shell contains the same statistics as the shells in

TABLE 1. Two observations, 1980:4 and 1985:4, have been deleted from the sample because of strong evidence of revisions in the reported series unrelated to the forecast errors. These large revisions cause errors in excess of 10% for the two periods. For example, the estimate of GNP for the period 1985:3 reported in the 1985:4 (December 1995) issue of the Review is $1689 billion in 1972 dollars. The estimate reported in the following issue, March 1986, is $1764 billion. It is unlikely that this difference of $75 billion in the two estimates of 1985:3 GNP reflects the usual revision of initial estimates. Further, all the reported figures in the March 1986 issue, which cover the period from 1985:1 to 1987:4, show similar upward adjustments for both nominal and real GNP[4]. Similar patterns emerge from the comparison of the GNP figures reported in the 1980:4 and 1981:1 issues of the Review.

Insert TABLE 3 here

In any event, the positive and negative errors are almost equally split in the whole sample, $\rho = \frac{38}{33}$. But the m.f.e. $\mu = 0.18\%$, which is significant at the 1% level (t-statistic 2.61), indicates a strong negative bias for GNP forecasts as in the case of total consumption.

The parallels with the consumption forecast errors do not end here though. The negative bias is totally accounted for by the periods of declining ECT (base case: $DUM_t = 1$ if $E_t c_{t-1} - E_t y_{t-1} < E_t c_{t-2} - E_t y_{t-2}$) for which the test statistics rise to $\rho|_{DUM_t=1} = \frac{21}{13}$ and $\mu|_{DUM_t=1} = 0.30\%$ ($\mu|_{DUM_t=1}$ is significant at the 1% level –t-statistic 3.16). Strengthening the condition for $DUM_t = 1$ with optimistic income expectations produces even stronger statistics. But strengthening the condition for $DUM_t = 1$ with predicted rise in the ECT does not produce significantly different statistics from the base case. In all three cases, $\rho|_{DUM_t=0}$ is approximately equal to one, $\mu|_{DUM_t=0}$ is insignificant, and the test rankings hold.

Overall, and despite that the GNP forecast errors reflect errors in all GNP components, it seems that the consumption errors –by the sheer force of magnitude– dominate. Consistent with this observation, the m.f.e. for the $DUM_t = 1$-periods for total consumption and GNP move to the same direction as the condition for underprediction is strengthened. That is, $\mu_{DUM_t=1}$ is greater in the case of optimistic expectations than in the case of predicted rise in the ECT for

[4]For the 1986:1 forecast round, the large revisions in GNP may reflect the fact that the "industrial production forecast was produced with a new version of the DRI Model's production block that uses the revised and rebenchmarked data that became available in July", as written in page A.10 of the March 1986 issue of the Review. On the other hand, the 1985:4 data reflect the old indices. As written in page A.7 of the November 1985 Review, "The Federal Reserve Board (FRB) completed a general revision of its industrial production data in July. The forecast and @USMODEL still contain the pre-revised indexes and will continue to do so until DRI completes a reestimation of the industrial block of the model."

both consumption and GNP. Perhaps surprisingly, however, there is no evidence for over- or under-prediction for personal disposable income for the $DUM_t = 1, 0$-periods in any of the three cases.

Import Forecasts.

TABLE 4, which has the same format as TABLE 3, indicates that ΔECT_{t-1} is associated with predictable forecast errors for imports as well. In greater detail, the statistics $\rho = \frac{56}{17} > 3$ and $\mu = 1.69\%$ (significant at the 1% level) indicate a strong negative bias for import forecasts. Further, $E_t c_{t-1} - E_t y_{t-1} > E_t c_{t-2} - E_t y_{t-2}$ ($ECT_{t-1} > ECT_{t-2}$) is associated with an underprediction for period t, suggesting that the bulk of the corresponding consumption surge at $t-1$ feeds into imports with an one period lag. More important, the strong negative bias for import forecasts is completely accounted for by the $DUM_t = 1$-periods (here, $DUM_t = 1$ if $E_t c_{t-1} - E_t y_{t-1} > E_t c_{t-2} - E_t y_{t-2}$). The corresponding statistics rise to $\rho|_{DUM_t=1} = \frac{34}{5} \approx 7$ and $\mu|_{DUM_t=1} = 2.31\%$ ($\mu|_{DUM_t=1}$ is significant at the 1% level –t-statistic 3.80). For the remaining observations, the negative bias is very weak as indicated by $\rho|_{DUM_t=0} = \frac{22}{12}$ and $\mu|_{DUM_t=0} = 0.89\%$ which is insignificant at all conventional levels (t-statistic 1.36).

Insert TABLE 4 here

Strengthening the condition for a probable underprediction with optimistic income expectations (equation [13]), produces similar strong results. The rationale behind this strengthening is that part of the consumption and GNP surge at t, which is induced by optimistic income expectations, will be satisfied by contemporaneously rising imports. Thus, the effect of the consumption surge at $t-1$ will not be diluted by weak demand at t (induced by pessimistic expectations). The strongest results –m.f.e.-wise– are produced when consumption relative to contemporaneous income is predicted to rise for two consecutive periods, i.e., when $E_t c_{t-2} - E_t y_{t-2} < E_t c_{t-1} - E_t y_{t-1} < E_t c_t - E_t y_t$. As in the previous case, two factors are behind the underprediction at t; the part of the consumption surge at $t-1$ which feeds into imports with some delay, and the part of the surge at t which is satisfied by contemporaneously rising imports. In the last two cases, imports have been underpredicted in almost every single period.

4 FURTHER THOUGHTS

The patterns in the forecast errors for consumption, GNP and imports identified above suggest that changes in the error correction term may convey information about short-run dynamics which could help improve macroeconomic forecasts. It is conceivable though that these patterns are an artifact of the selection process. More specifically, the forecasts used correspond to the "baseline" scenario reported in the Review. But the Review reports alternative scenarios in a section currently called "Risks to Forecasts". For example, the September 1994 issue reports the descriptively named "boom-bust" (20% probability), "optimistic" (15% probability) and "fizzle" (10% probability) alternative scenarios. This raises the possibility that the above patterns may simply be the product of the uncertainty reflected on the alternative scenarios.

It is unlikely though that the "expected outcomes" forecasts, i.e., the weighted averages of all scenarios, will not exhibit similar patterns. Consider the projections and the assumptions of the four scenarios in the September 1994 issue of the Review: They differ across such variables as the stance of monetary policy, inflation, productivity growth, the stock market, consumer confidence, the savings rate, oil prices, the dollar exchange rates, foreign growth and foreign interest rates. It seems unlikely that the patterns in the forecast errors could be entirely attributed to some combination of these disparate variables. But even in this case, the paper's contribution is not diminished; by identifying information which may help improve the "baseline" forecasts, the paper can help improve the statistical performance of the "expected outcomes" forecasts as well.

In addition, the stronger statistics produced when the condition for likely underprediction is strengthened, along with the consistency of the error patterns across the forecast series, further indicate that the paper's results are not likely to be an artifact of the selection process. Therefore, the forecasts under scrutiny could be improved by taking into account the information conveyed by the ECT change. Of course, this assertion rests upon the belief that the paper provides the right explanation for the observed patterns, so that one can be fairly confident that they will occur again under similar circumstances. Increasing this confidence, as one seminar participant observed, the patterns are consistent with another explanation. This explanation relates to the tendency to underpredict consumption during recoveries and overpredict it during recessions. The argument is as follows. The decline in the ECT from $t-2$ to $t-1$ is equivalent to an increase in savings, $S_{t-1} > S_{t-2}$. Given the procyclical behavior of savings, $S_{t-1} > S_{t-2}$ may indicate recoveries. Moreover, this is more likely so when $S_{t-1} > S_{t-2}$ is coupled with optimistic income expectations.

Still, however, a question remains to be answered. Why a large-scale econometric model evidently missed some relevant information, that conveyed by the changing ECT? One would reasonably expect that the detailed equations of the DRI model should approximate sufficiently well any kind of short-run dynamics. A potential explanation, suggested by the paper's conceptual framework, is that the effect of variables driving short-run dynamics may average out over sufficiently long horizons. As a result, typical unbiasedness tests (which put all the available observations together) may fail to reveal evidence of, and thus initiate a search for, unused information.

Another potential explanation was proposed by a seminar participant. That is, the patterns in the forecast errors uncovered by the paper may reflect not only a failure of the model to take into account error-correction dynamics, but also something in the way judgmental forecasts are made. More specifically, it is difficult to determine how much of published forecasts reflect the model and how much is judgement. This difficulty is bigger for forecasts published late in the quarter –as here– because they involve (in declining importance) adding and extrapolating recent data, judgement about special factors impacting on the economy, and simulations of the model. Pertaining to the judgmental component, there may be a systematic tendency to rely too much on recent data or to look for reversible special factors. (Even in the extreme case the patterns uncovered here are entirely due to the tendency to look for reversible factors, like the ECT, the paper could still help improve the DRI forecasts. Essentially, the paper identifies another such factor, the ECT change, which –at the very least– could help improve the forecasts' judgmental content.) Also, forecasters may systematically underpredict fluctuations in an effort to avoid the embarrassment of large forecast errors.

These explanations, along with the paper's general conceptual framework, further suggest that similar patterns may be pervasive in the errors of other professional forecasts and/or large-scale econometric models. They also suggest that the documented patterns do not necessarily imply inefficient forecasts; they may simply reflect some sort of Bayesian learning about the short-run dynamics of components of aggregate demand (see Lewis [1989] for a related discussion in the context of foreign exchange). In this respect, the paper's contribution could be viewed as helping improve our understanding of these dynamics and their implications for econometric modeling and forecasting.

APPENDIX

This appendix describes briefly some selected equations in the *DRI/McGraw Hill Macro Model of the U.S. Economy* (henceforth, the Model). The aim is to illustrate the Model's complexity and the associated intellectual labor put into building and refining it, and, thus, further highlight the paper's potential contribution.

In the Model, total consumer spending is calculated as the sum of its major components, i.e., durables, non-durables and services, all expressed in constant prices. Consumer spending on durables is further divided into the sub-categories of motor vehicles and parts, furniture and household equipment, and other durables. For each sub-category there is an equation. For example, the equation for spending on motor vehicles and parts includes as explanatory variables time dummies; the University of Michigan's index of consumer sentiment; the implicit price deflator for gasoline and oil; the average fuel efficiency of new imported and domestic cars; the implicit price deflator for consumer spending excluding free financial services; the finance rate of consumer installment credit; the prime rate on short-term business loans; the marginal rate on Federal, State and Local personal taxes; the share of non-mortgage interest payments deductible from federal income; the expected rate of inflation; several lags of personal disposable income and of number of households; the ratio of producer price index (passenger cars) over the implicit price deflator (consumer spending); and a term measuring the effects of household size and age mix.

Similarly, consumer spending on non-durables is estimated as the sum of the food, clothing and shoes, gasoline and oil, other non-durables, and fuel oil and gas sub-categories. Spending on services includes housing services, electricity, natural gas, other household operation, transportation services, other services and medical care. As with motor vehicles and parts, for each sub-category there is an equation in the Model.

GNP is equal to GDP plus exports of factor income minus imports of factor income. GDP is broken down to the traditional National Income and Product Accounts components. Because of errors in the other components, one would expect weaker patterns for the GNP forecast errors than for the consumption errors.

Total imports are the sum of merchandise and services imports. Merchandise imports are the sum of food, feeds and beverages; industrial supplies and materials excluding petroleum and products; petroleum and products; capital goods excluding autos; autos; imports of consumer goods; imports of other goods. As with other aggregate variables, for each sub-category there is an equation in the model. The equation for food, feeds and beverages includes, among other explanatory variables, three lags of consumer spending on food. Also, the equation for industrial supplies and materials includes three lags of GDP minus consumer spending on services minus government purchases. These lags may explain why the consumption and GNP underpredictions are associated with import underprediction in the following period.

Overall, the large number of very detailed equations in the Model makes the patterns in the forecast errors identified in the main text look surprising. One would expect that, as the number of explanatory variables increases, a model could capture any kind of short-run dynamics, especially those driven by a specific mechanism –such as, the ECT– regardless of whether the mechanism is a formal part of the model or not.

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TABLE 1.

CONSUMPTION FORECASTS

Total Consumption			Non-Durables & Services		
ALL Obs.	$DUM_t = 1$	$DUM_t = 0$	ALL Obs.	$DUM_t = 1$	$DUM_t = 0$
$DUM_t = 1$ if $(E_t c_{t-1} - E_t y_{t-1}) < (E_t c_{t-2} - E_t y_{t-2})$					
$\frac{43}{30}$ 0.25 3.09***	$\frac{24}{10}$ 0.37 3.86***	$\frac{19}{20}$ 0.16 1.21	$\frac{50}{23}$ 0.14 1.87*	$\frac{26}{8}$ 0.20 2.39**	$\frac{24}{15}$ 0.10 0.80
$DUM_t = 1$ if $(E_t c_{t-1} - E_t y_{t-1}) < (E_t c_{t-2} - E_t y_{t-2})$ .AND. $(E_t \Delta y_{t-1} < E_t \Delta y_t$ .OR. $E_t \Delta y_{t-1} < E_t \Delta y_{t+1})$					
	$\frac{11}{4}$ 0.51 3.10***	$\frac{32}{26}$ 0.19 2.02**		$\frac{13}{2}$ 0.36 2.29**	$\frac{37}{21}$ 0.09 1.03
$DUM_t = 1$ if $(E_t c_{t-2} - E_t y_{t-2}) > (E_t c_{t-1} - E_t y_{t-1})$ .AND. $(E_t c_t - E_t y_t) > (E_t c_{t-1} - E_t y_{t-1})$					
	$\frac{15}{4}$ 0.43 4.15***	$\frac{28}{26}$ 0.19 1.86*		$\frac{15}{4}$ 0.23 2.73***	$\frac{35}{19}$ 0.11 1.15

Notes:

1. Sample Period: 1976:1-1994:4
2. Cell Contents:
   (a) $\frac{\text{\# of positive errors}}{\text{\# of negative errors}}$
   (b) % mean forecast error (m.f.e.)
   (c) t-statistic for zero m.f.e.
3. Significance Levels: * 10%; ** 5%; *** 1%

TABLE 2.

CONSUMPTION FORECASTS
SUPPLEMENTARY TESTS

Total Consumption		Non-Durables & Services	
$DUM_t = 1$	$DUM_t = 0$	$DUM_t = 1$	$DUM_t = 0$
Small ECT Changes Eliminated from Sample $DUM_t = 1$ if $(E_t c_{t-1} - E_t y_{t-1}) - (E_t c_{t-2} - E_t y_{t-2}) < -0.0035$ $DUM_t = 0$ if $(E_t c_{t-1} - E_t y_{t-1}) - (E_t c_{t-2} - E_t y_{t-2}) > +0.0035$			
$\frac{18}{7}$ 0.40 3.56***	$\frac{14}{11}$ 0.16 1.24	$\frac{20}{5}$ 0.24 2.40**	$\frac{16}{9}$ 0.04 0.39
Small Forecast Errors Eliminated from Sample $DUM_t = 1$ if $(E_t c_{t-1} - E_t y_{t-1}) < (E_t c_{t-2} - E_t y_{t-2})$ .AND.			
$\lvert ERROR_t \rvert > 0.24$		$\lvert ERROR_t \rvert > 0.18$	
$\frac{20}{4}$ 0.51 4.23***	$\frac{16}{10}$ 0.27 1.44	$\frac{17}{6}$ 0.27 2.32**	$\frac{15}{12}$ 0.12 0.68

Notes:

1. Sample Period: 1976:1-1994:4
2. Cell Contents:
   (a) $\frac{\text{\# of positive errors}}{\text{\# of negative errors}}$
   (b) % mean forecast error (m.f.e.)
   (c) t-statistic for zero m.f.e.
3. Significance Levels: * 10%; ** 5%; *** 1%

TABLE 3.

GNP FORECASTS

ALL Obs.	$DUM_t = 1$	$DUM_t = 0$
$DUM_t = 1$ if $(E_t c_{t-1} - E_t y_{t-1}) < (E_t c_{t-2} - E_t y_{t-2})$		
$\frac{38}{33}$ 0.18 2.61***	$\frac{21}{13}$ 0.30 3.16***	$\frac{17}{20}$ 0.06 0.62
$DUM_t = 1$ if $(E_t c_{t-1} - E_t y_{t-1}) < (E_t c_{t-2} - E_t y_{t-2})$ .AND. $(E_t \Delta y_{t-1} < E_t \Delta y_t$ .OR. $E_t \Delta y_{t-1} < E_t \Delta y_{t+1})$		
	$\frac{10}{5}$ 0.41 2.77**	$\frac{28}{28}$ 0.11 1.41
$DUM_t = 1$ if $(E_t c_{t-1} - E_t y_{t-1}) < (E_t c_{t-2} - E_t y_{t-2})$ .AND. $(E_t c_t - E_t y_t) > (E_t c_{t-1} - E_t y_{t-1})$		
	$\frac{12}{7}$ 0.31 2.42**	$\frac{26}{26}$ 0.14 1.64

Notes:

1. Sample Period: 1976:1-1994:4
2. Cell Contents:
   (a) $\frac{\text{\# of positive errors}}{\text{\# of negative errors}}$
   (b) % mean forecast error (m.f.e.)
   (c) t-statistic for zero m.f.e.
3. Significance Levels: * 10%; ** 5%; *** 1%

TABLE 4.

IMPORT FORECASTS

ALL Obs.	$DUM_t = 1$	$DUM_t = 0$
$DUM_t = 1$ if $(E_tc_{t-1} - E_ty_{t-1}) > (E_tc_{t-2} - E_ty_{t-2})$		
$\frac{56}{17}$ 1.69 3.79***	$\frac{34}{5}$ 2.31 3.80***	$\frac{22}{12}$ 0.89 1.36
$DUM_t = 1$ if $(E_tc_{t-1} - E_ty_{t-1}) > (E_tc_{t-2} - E_ty_{t-2})$ .AND. $(E_t\Delta y_{t-1} < E_t\Delta y_t$ .OR. $E_t\Delta y_{t-1} < E_t\Delta y_{t+1})$		
	$\frac{21}{2}$ 2.14 4.88***	$\frac{35}{15}$ 1.42 2.27**
$DUM_t = 1$ if $(E_tc_{t-1} - E_ty_{t-1}) > (E_tc_{t-2} - E_ty_{t-2})$ .AND. $(E_tc_t - E_ty_t) > (E_tc_{t-1} - E_ty_{t-1})$		
	$\frac{12}{1}$ 2.58 4.13***	$\frac{44}{16}$ 1.50 2.86***

Notes:

1. Sample Period: 1976:1-1994:4
2. Cell Contents:
   (a) $\frac{\text{\# of positive errors}}{\text{\# of negative errors}}$
   (b) % mean forecast error (m.f.e.)
   (c) t-statistic for zero m.f.e.
3. Significance Levels: * 10%; ** 5%; *** 1%

Residuals of Co-integrating Regressions

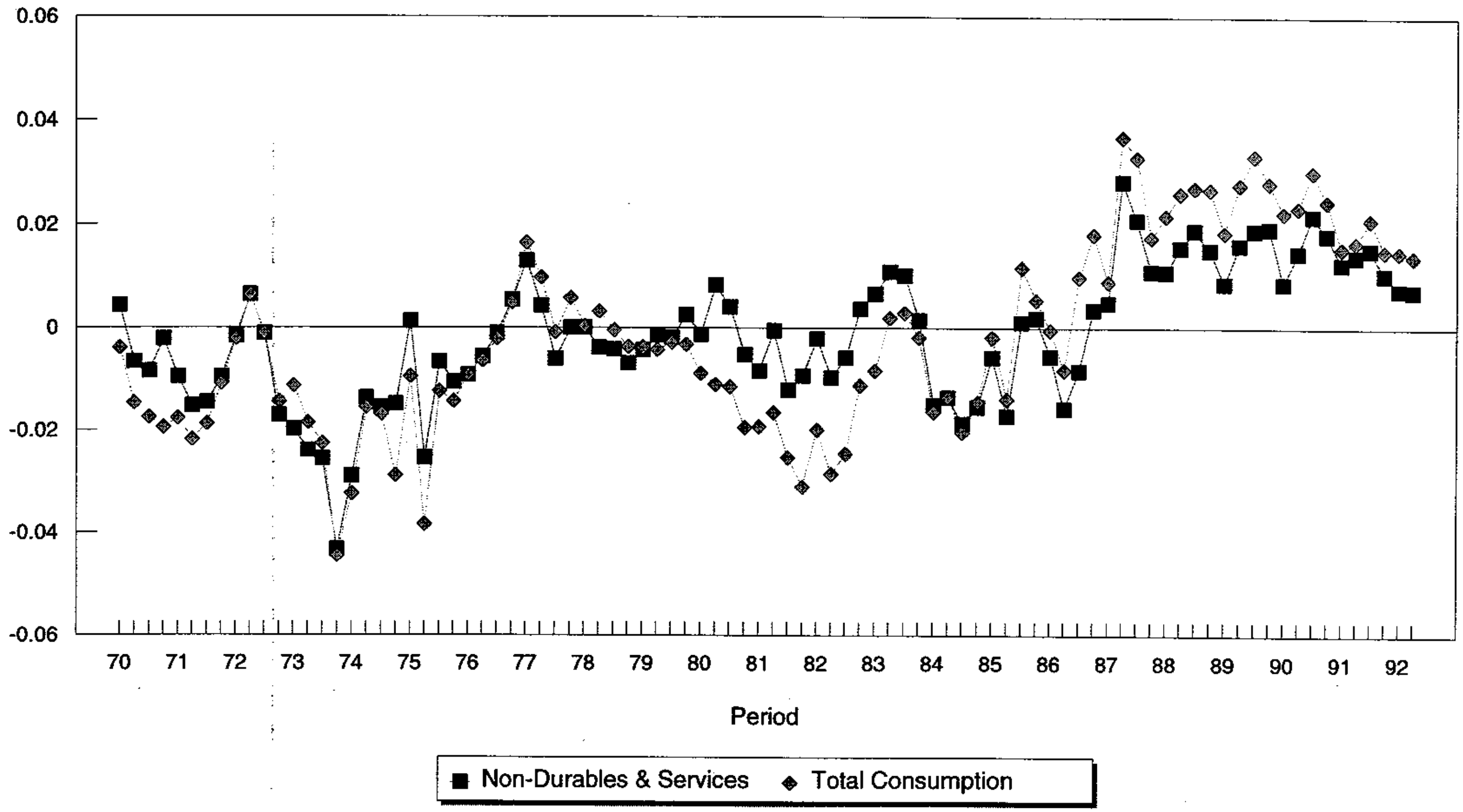

FIGURE 1.
Sample: 1953:1-1992:2. Source: CITIBASE and author's calculations.

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