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Working Paper 8718

THE NATURE OF GNP REVISIONS

by John Scadding

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The author thanks Professor K.W. Mork for providing a copy of the Parker data and for the forecast series used in the last section of this paper.

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December 1987

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THE NATURE OF GNP REVISIONS

I. Introduction

The U.S. Department of Commerce, Bureau of Economic Analysis (BEA) issues its first estimate of quarterly GNP two to three weeks after the quarter ends. This 15-day estimate (formerly known as the preliminary estimate) is followed in relatively rapid succession by the 45-day and 75-day estimates, which incorporate revisions to the source data underlying the 15-day estimate and add new data that were not available earlier. Revisions do not end with the 75-day estimate. Additional revisions usually are published for the succeeding three Julys, and there are further "benchmark" revisions as data from the Census Bureau's economic and population surveys are incorporated.[1]

Because timely data is needed for forecasting purposes, it is a frequent practice to treat the first three early, or provisional, estimates of GNP as adequate representations of the final, or "true," numbers and to revise forecasts on the basis of this assumption.[2] For macropolicy purposes as well, it is often customary to treat the initial estimates as if they were reliable indicators of what the final numbers will show, again for reasons of timeliness.

In both instances, practitioners are very much aware of the risks involved in such assumptions. Revisions of the early estimates are often substantial. For example, the mean revision without regard to sign from the 15-day to the final estimate over the 1974-1984 sample period used in this paper is 1.6 percentage points at an annual rate, compared to a mean growth rate aver the period of 2.9 percent. In addition, the early estimates sometimes show the wrong direction for real GNP growth (Young, 1987).

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Over the last few years, some research has suggested that the provisional estimates of real GNP growth can be characterized as rational forecasts of the final numbers (Walsh, 1985; Mankiw and Shapiro, 1986). This, of course, provides some justification for the way these provisional estimates are typically used. However, this paper argues that the test used to come to this conclusion has very low power even if the early GNP estimates are efficient forecasts of the final numbers, which is one of the implicit conditions of the test. Moreover, the evidence of correlation between successive "final" errors--the differences between the final numbers and the provisional estimates--suggests that the early numbers, if they are forecasts, are not efficient forecasts.

The evidence of sequentially correlated final errors is equally consistent with the hypothesis that the provisional estimates are measurements of the final numbers contaminated with error, or "noise." This paper proposes and implements a test that suggests that the provisional estimates of real GNP growth are contaminated with noise. One implication of this conclusion is that it should be possible to filter the early GNP estimates to obtain better estimates of the final GNP numbers. Section VI of this paper illustrates one application of filtering the provisional estimates of real GNP growth. In particular, the evidence of bias and inefficiency that Mork (1987a) finds in the provisional estimates is absent from the filtered estimates.

II. Forecasts Versus Observations

The practice of treating new GNP estimates as the final numbers would be on a more secure foundation if, at a minimum, these early numbers were unbiased estimators and if they provided no information about the subsequent "final revision"--that is, the difference between the final number and the

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early estimate itself. In other words, using the 15-day estimate, y^P, as an example, and letting y denote the final value of real GNP growth:

(1a) $E(y - y^P) = 0$,

(1b) $E(y - y^P)y^P = 0$,

where E is the expectations operator conditional on y^P.

Under these conditions, there would be no information in the provisional estimate itself that would allow one to estimate the subsequent revision. In that sense y^P (and its companion 45-day and 75-day estimates, $y^{r'}$ and y^{r2}) could be considered rational forecasts of the final number (Walsh, p. 7).

As noted earlier, current practice is somewhat schizophrenic. Forecasters and policymakers frequently use the provisional estimates as if they were rational forecasts. But often the early numbers are described as if they had information about subsequent revisions. Thus, very large or very small initial estimates are often viewed with suspicion. This view of the numbers is consistent with a characterization of them as observations of the final number measured with error. If this characterization is expressed in terms of a classical-errors-in-variables model, the provisional estimates will be unbiased estimates of the final number, and the final revision will be uncorrelated with the final number itself. On the other hand, as noted above, the final revision will be correlated with the provisional estimate. Thus:

(2a) $E(y - y^P) = 0$,

(2b) $E(y - y^P)y = 0$,

(2c) $E(y - y^P)y^P \neq 0$.

III. Previous Studies

Prior work on the properties of the GNP estimates goes back at least to Zellner (1958). A good summary of work in this area can be found in Young

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(1987). The specific issue of whether the revisions behave more like forecast errors or observation errors has been explicitly addressed only recently. Mankiw and Shapiro (1986), drawing on a methodology they and Runkle had devised earlier to examine the nature of money-supply announcements (Mankiw, et al., 1984), concluded that the early GNP estimates behaved more like forecasts. This result contrasted sharply with their earlier finding that preliminary money-supply announcements appeared to behave more like observations than forecasts. Walsh (1985), using a different sample, also concluded that the early GNP estimates appeared to behave like forecasts.

However, Walsh found evidence that the early GNP estimates were inefficient, because they did not incorporate information from prior revisions that was helpful in predicting final GNP. In the same vein, Mork (1987a) found evidence of bias and inefficiency in the provisional GNP estimates. As he explains, this makes the Mankiw-Shapiro tests problematic, since they are tests of the joint hypothesis that early GNP estimates are efficient forecasts of the final number.

The evidence of inefficiency is equally consistent with the observations model being true and the errors in successive estimates being serially correlated. This framework of sequentially correlated revision errors has been successfully applied to the analysis of retail sales (Conrad and Corrado, 1979) and inventory investment (Howrey, 1984). Retail sales data are an important component of the early GNP numbers, while the inventory numbers are often an important source of the variance in the GNP numbers. Thus, evidence that the overall GNP numbers behave in the same way as two of their important components would remove one obvious anomaly between the two sets of results.[3]

Under circumstances of correlated revisions, the Mankiw-Shapiro tests cannot discriminate between the forecasts and observations hypotheses.

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However, the correlation structure between successive GNP revisions will be quite different under the two hypotheses, and this difference can be exploited to discriminate between the two characterizations of the data. First, however, we examine why the Mankiw-Shapiro test is not likely to be of much help in discriminating between the two explanations even when all of its maintained conditions are met.

IV. Testing the Two Explanations

The test devised by Mankiw, et al. to discriminate between the forecasts and observations models was simple and ingenious. If the observations model were correct, then according to equation (2b) a regression of yp on the final revision $y - y^p$ should yield a nonzero coefficient.[4] By the same token, the regression of y on the revision should be zero. The difficulty with this test is that asymptotic results suggest that it has low power. To illustrate, the ordinary least squares estimate of the slope coefficient of regressing y^p on $y-y^p$ is:

$$(3) \qquad b_0 = \frac{\Sigma(y - y^p)y^p}{\Sigma(y^p)^2} .$$

If the observations model is correct, so that $y^p = y + u$, where u has zero mean and is uncorrelated with y, then (3) can be rewritten:

$$(3') \qquad b_0 = \frac{\Sigma(y^2)}{\Sigma(y^p)^2} \cdot b_1 - \frac{\Sigma u^2}{\Sigma(y^p)^2},$$

where b_1 is the regression coefficient from the alternative test, that is, from the regression of $y - y^p$ on y. Taking probability limits, we have:

$$(4) \qquad \text{plim} b_0 = \frac{\sigma_u^2}{\sigma_y^2 + \sigma_u^2},$$

where, under the observations model, the expected value of b_1 is zero, and

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σ_y^2 and σ_u^2 are the variances of the final estimate of GNP growth and the observations error. Two items are worth noting about this result. First, as a practical matter, the term on the right-hand side of (3') is likely to be small. Thus, the precision of b_0 is likely to be critical. This will be a problem, however, because the regressor is measured with error. Small sample properties of b_0 are not available. However, Dhrymes (1978) has shown that ordinary least squares estimates of the goodness of fit will be biased downward asymptotically, leading to a tendency, in this case, to accept the null hypothesis even when it is false (Dhrymes, p. 263).

The practical result is that OLS estimates of the two slope coefficients, b_0 and b_1, may indicate that <u>both</u> are zero. The results in table 1 suggest that this is not simply a theoretical curiosity. Table 1 shows the results of performing the Mankiw, et al. tests on the same body of data for the three different samples used by Mankiw-Shapiro, Walsh, and this study. For two of the three sample periods, the results, interpreted literally, would mean rejecting neither the forecasts nor observations hypothesis. The one exception is the set of estimates from the Walsh sample. But the sensitivity of the estimates to small variations in the sample period clearly shown by table 1 raises a serious question about the robustness of this one set of results.

V. Correlated GNP Revisions

Walsh's evidence of inefficiency suggests that the Mankiw, et al. tests have even less power than when the implicit conditions of the test are met. To illustrate, a stylized representation of Walsh's finding is:

(4) $$y_t - y_t^{r'} = a_1(y_t^p - y_t^{r'}) + e2_t, \quad a_1 \text{ nonzero.}$$

This evidence of "inefficiency" could just as easily be consistent with

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the observations model. Equation (4) is observationally equivalent to an observations model in which successive errors of measurement are serially correlated with each other. To see this, define $a_1 = a_0/1-a_0$, and use this to rewrite (4) as:

(4') $$y_t - y_t^{r'} = a_0(y_t - y_t^p) + e'2_t.$$

Performing prior regressions of the form (4), (4') and then carrying out the Mankiw, et al. tests on the residuals clearly will not work, because the regressions estimates of e2 and e'2 by construction will be orthogonal to $y^{r'}$ and y, respectively. However, the relationship between successive errors is quite different under the two hypotheses, and this difference can be used to discriminate between the two models. To illustrate, consider the structure of revisions to GNP if the forecasting model is correct. It is easiest to think of this relationship as being between successive interim revisions, that is, $r1 = y^{r1}-y^p$, $r2 = y^{r2}-y^{r1}$, and $r3 = y-y^{r2}$.[5] If earlier revisions provide information about later ones, the most general structure of the revisions will be:

(5) $$\begin{bmatrix} 1 & -\alpha_{12} & -\alpha_{13} \\ 1 & 1 & \alpha_{23} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} r3 \\ r2 \\ r1 \end{bmatrix} = \begin{bmatrix} e3 \\ e2 \\ e1 \end{bmatrix},$$

with the eis being mutually uncorrelated white noise. To facilitate comparison with the observationq model specification, rewrite (5) in terms of the final errors, $u1 = y-y^p$, $u2 = y-y^{r1}$, $u3 = y-y^{r2}$, by noting that:

(6) $$\begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} r3 \\ r2 \\ r1 \end{bmatrix} = \begin{bmatrix} u3 \\ u2 \\ u1 \end{bmatrix}.$$

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Combining (5) and (6) yields:

$$(7)\quad \begin{bmatrix} 1+\alpha_{12} & -\alpha_{12}+\alpha_{13} & -\alpha_{13} \\ 0 & 1+\alpha_{23} & -\alpha_{23} \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} u3 \\ u2 \\ u1 \end{bmatrix} = \begin{bmatrix} e3 \\ e2 \\ e1 \end{bmatrix},$$

or, in matrix notation,

$$(8)\qquad \underline{\tilde{\alpha} u} = \underline{e}, \qquad \underline{\tilde{\alpha}} = \underline{\alpha}\, D^{-1},$$

where D is the triangular matrix in (6).

The comparable representation for the observations model with sequentially correlated measurement errors is:

$$\begin{bmatrix} 1 & -a_{12} & -a_{13} \\ 0 & 1 & -a_{23} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u3 \\ u2 \\ u1 \end{bmatrix} = \begin{bmatrix} e3 \\ e2 \\ e1 \end{bmatrix},$$

or, in matrix notation,

$$(9)\qquad A\underline{u} = \underline{e}.$$

The test strategy pursued here is a simple one. If (9) is correct, then the off-diagonal elements in the estimated variance-covariance matrix of $\underline{e}$ should be zero. By the same token. estimating (7) should yield nonzero off-diagonal elements because:

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(10) $A\tilde{\alpha}^{-1}\tilde{\alpha}\underline{u} = \underline{e}$,

or

(11) $\tilde{\underline{\alpha}}\,\underline{u} = \underline{\alpha}A^{-1}\underline{e}$.

The regression estimates of equations (7) and (9) are reported in table 2. The restrictions on the coefficients imposed by the forecasts model (part a) yield a much poorer fit to the data, with the exception, of course, of equation (3a). But this exception has no significance because equation (3a), like its counterpart (3b), is simply a normalization condition defining the base for the structure of succeeding errors.

The numbers in part c of table 2 provide the telling evidence. Here the estimated variance-covariance matrices clearly indicate that the data do not support the restrictions implied by the forecasting model. The off-diagonal elements in the matrix for the observation equations are either zero or trivially different from zero. The covariances from the forecasts model, on the other hand, are uniformly larger, and in one instance--the covariance between el and e2--the implied correlation is close to unity. Thus, on balance, the evidence strongly suggests that the final revisions do not behave like pure forecast errors and contain significant elements of measurement errors.

VI. Filtering GNP Estimates

As noted at the beginning of this paper, acknowledging elements of observation error in the preliminary data suggests filtering the provisional numbers to obtain better estimates of what the final GNP numbers will show. A companion paper (Scadding, 1988) constructs filtered estimates of GNP for the same period used in this analysis.

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Filtering the data allows estimates of the final revisions, $y-y^p$, etc., to be made as the provisional estimates of GNP become available. Thus, if y_1 is the filtered value of the 15-day estimate of GNP, the estimated final revision error, $y-y^p$, is y_1-y^p. Similarly, y_2 and y_3 are the filtered estimates of the 45- and 75-day provisional GNP numbers, and the estimated final revision errors conditional on these values are y_2-y^{r1} and y_3-y^{r2}, respectively.

These results of filtering the data can be used to reexamine Mork's findings that the early GNP estimates were "ill-behaved" (Mork, 1987a). Specifically, Mork found that the final revisions had a nonzero mean and were correlated with a publicly available outside forecast and with provisional estimates from the previous quarter.[6] These findings are replicated for the sample period used in this period and are shown in the first two lines of table 3.

If filtering is possible, Mork's question becomes whether the final revisions <u>relative to the estimates made of those revisions from the filtered data</u> show the signs of ill-behavior he described. The third and fourth equations in table 3 address this question by adding the filtered estimates of the final revisions, y_1-y^p, etc., to the regressions. The results are dramatically different. The constants and the coefficients on the lagged values of y^{r1} become trivially different from zero, and the accompanying F statistics show that the data cannot reject the hypothesis that these coefficients are zero. Of course, these results do not in any way contradict Mork's findings; the problems he notes do appear to be unattractive features of the provisional estimates of real GNP growth. However, at the same time, the results in table 3 indicate that these problems are easily corrected by filtering.

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VII. Conclusion

Recent work has indicated that revisions to early estimates of GNP can be regarded as forecast errors. The evidence presented here suggests that if one has to choose between two polar characterizations--the forecast versus the observation error representations--the observations model appears better suited to the data. In reality, of course, the estimates are most likely a mixture of both, since the Bureau of Economic Analysis draws upon both sample data and extrapolations when sample data are not available. Research by Mork (1987b), which reexamines Mankiw, Runkle, and Shapiro's earlier work on the nature of money-supply announcements, suggests they are a mixture of observations and forecasts, with observations accounting for a little over 50 percent of the published figure.

The companion paper by Scadding that examines the usefulness of filtering the early GNP estimates provides indirect results that are qualitatively the same. The procedure used in that paper decomposes the final revision into an estimate of the observation error, and a residual element that is orthogonal to the filtered GNP estimate--in other words, an element that behaves like a forecast error. Although the results clearly indicate that some of the final revision to real GNP growth is observation error and can be removed by filtering, they also suggest that the residual forecast-like error remains substantial.

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Footnotes

1. An excellent, comprehensive description of the methods and data used in computing the different estimates of GNP is contained in Carson (1987).

2. Clearly no "final" estimate is in fact ever final. This article follows the usual practice and treats the latest available figure after the 75-day estimate as the final figure. The data are from the BEA's GNP revision study prepared before the 1985 rebenchmarking; these data were specially prepared by the BEA staff to abstract definitional changes and reclassifications. The data for the 15- and 45-day estimates go back to the second quarter of 1968. However, regular releases of the 75-day estimate began in the second quarter of 1974, and for this series Parker's data have no corresponding "final" estimates after the first quarter of 1984. These two constraints define the sample used in this study.

3. Mankiw and Shapiro reconcile the difference by arguing that the errors in GNP components wash out in the aggregate. At the same time, they acknowledge that their findings may be "due to a lack of statistical power" (Mankiw and Shapiro, p. 25).

4. The originally formulated test regressed y on y^P, and y^P on y, but the ones used here are obviously equivalent.

5. In principle, the lagged value of rl, etc., could be included in the information set used for forecasting, but in fact, interquarter revisions appear to be uncorrelated.

6. The forecast used by Mork, and denoted by y^f in table 3, is the median forecast from the National Bureau of Economic Research/American Statistical Association quarterly survey. Mork examined the performance of all three provisional estimates, but found that the 15-day and 45-day estimates had the major problems, and they therefore are the ones examined here. Mork also examined the estimates' performances over a longer sample period than considered here, as well as over two subsamples, the latter of which roughly corresponds to the one used here. The results reported in part a of table 3 correspond closely to Mork's results for his later subsample, even though he used generalized method of moments estimation rather than the ordinary least squares estimation used in this paper.

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Table 1: Estimates of Slope Coefficients

Walsh sample: 1976:IQ - 1983:IVQ

Dep. var.	Regressors y^p	Y
$Y - y^p$	-0.010	0.185*
$y - y^{r1}$	y^{r1} -0.004	y 0.126*
$y - y^{r2}$	y^{r2} 0.006	y 0.125*

Mankiw-Shapiro sample: 1976:IIQ-1982:IVQ

Dep. var.	Regressors y^p	y
$Y - y^p$	-0.061	0.132
$y - y^{r1}$	y^{r1} -0.075	y 0.570
$y - y^{r2}$	y^{r2} -0.076	y 0.500

Sample used in this paper: 1974:IIQ - 1984:IQ

Dep. var.	Regressors y^p	Y
$Y - y^p$	-0.055	0.116
$y - y^{r1}$	y^{r1} -0.066	y 0.050
$y - y^{r2}$	y^{r2} -0.069	y 0.039

*Statistically different from zero at the 5-percent level.

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Table 2: Estimates of Error Structure

a. Forecasts model

(1a) $u3 = \underset{(0.45)}{0.110} + \underset{(0.48)}{0.192}(u3-u2) - \underset{(-1.93)}{0.591}(u2-u1)$ s.e.e. = 1.517

(2a) $u2 = \underset{(1.02)}{0.246} + \underset{(-1.73)}{0.550}(u2-u1)$ s.e.e. = 1.570

(3a) $u1 = \underset{(1.60)}{0.175} + \underset{(16.63)}{1.117}u2$ s.e.e. = 0.720

b. Observations model

(1b) $u3 = \underset{(-1.64)}{-0.114} + \underset{(5.65)}{0.783}u2 + \underset{(0.95)}{0.109}u1$ s.e.e. = 0.552

(2b) $u2 = \underset{(-0.92)}{-0.085} + \underset{(16.63)}{0.773}u1$ s.e.e. = 0.601

(3b) $u1 = \underset{(2.05)}{0.583}$ s.e.e. = 1.930

c. Variance-covariance of estimated residuals

Forecasts model

	e3	e2	e1
e3	2.210		
e2	-0.281	2.408	
e1	-0.251	2.149	0.510

Observations model

	e3	e2	e1
e3	0.298		
e2	0.000	0.353	
e1	0.056	-0.043	0.298

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Table 3: predictions of Final Revisions

a. Without filtering

(1a) $y_t - y_t^p$ $\quad 0.839 - 0.173y_{t-1}^{r2} + 0.128y_t^f$ $\quad F = 2.887^*$

(2.29) (-1.96) (1.01)

(2a) $y_t - y_t^{r1}$ $\quad 0.624 - 0.129y_{t-1}^{r2} + 0.071y_t^f$ $\quad F = 3.039^*$

(2.02) (-1.73) (0.68)

b. With filtering

(1b) $y_t - y_t^p = -0.005 + 0.975(y_{1t} - y_t^p) - 0.017y_{t-1}^{r2}$

(-0.01) (2.82) (-0.17)

$+ 0.068y_t^f$ $\quad F = 0.172^{**}$

(0.59)

(2b) $y_t - y^{r1}t = -0.050 + 0.982(y_{2t} - y_t^{r1}) - 0.023y_{t-1}^{r2}$

(-0.13) (2.48) (-0.28)

$+ 0.093y_t^f$ $\quad F = 0.385^{**}$

(0.95)

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*Test that all coefficients are zero; significant at 5-percent confidence level.

**Test that all coefficients except provisional estimate of final revision are zero; not significant at 5-percent level.

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