Getting the Noise Out: Filtering Early GNP Estimates

by John Scadding

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Introduction

Real, or inflation-adjusted, gross national product (GNP) is the most inclusive measure of the nation's economic activity. As such, it is probably the most closely monitored economic barometer for the information it contains about the economic well-being of the economy and about the economy's prospects. It is the central focus of most macroeconomic models and their forecasts, and it plays a decisive role in shaping monetan and fiscal policy decisions.

Given the critical role that GNP plays. it is not surprising that the accuracy of GNP estimates is crucial if informed decisions are to be made by both private agents and government policymak-ers. There is a trade-off, however. between the estimates' accuracy and their *timeliness*. Delays in reporting and revising data as more inclusive information becomes available means later esti-mates will typically be more accurate than earlier ones: but waiting longer entails forgoing the opportunin to take action sooner, when that may be a critical factor.

In the United States, the first offical estimate for a particular quarter's GNP is released by the U. S. Department of Commerce approximately three weeks *after* that quarter has ended. Much of the data needed to construct GNP are still not available at that point, even though the quarter

has ended. The missing data therefore must be estimated by the U.S. Department of Commerce's Bureau of Economic Analysis (BEA), which is responsible for compiling the official estimate of GNP. This first estimate is followed in relatively rapid succession by two additional estimates, one and two months after the initial number is released, Thereafter, the delays in revisions become much longer. Estimates are usually sub-ject to three further annual revisions. After that, an estimate is usually subject to further so-called benchmark revisions every five years as data from the Bureau of Census' quinquennial eco-nomic census are incorporated. At each stage, source data are incorporated that had not been available previously, and revisions to previous data are incorporated as well.[1]

It is clear from this description that there is never a final estimate of GNP that could be equated with the "truth." Nevertheless, the three early preliminary or *provisional* estimates are obviously distinct from the later ones in terms of their timeliness. Although based on' incomplete and preliminary information, the provisional esti-mates have the advantage that they are available

much sooner than the later. more comprehensive. and presumably more accurate numbers. It is relevant, therefore. to examine their accuracy in predicting the later numbers. As Allan Young, director of the Bureau of Economic Analysis, noted in a recent comprehensive survey of the properies of GNP estimates: "Much of the concern with the reliability of GNP comes down to whether the early ... quarterly estimates ... provide a useful indicator of the estimates ... When complete and final source data are available." (Young [1987], p. 18)

T A B L E 1

Final Revisions to Real GNP Growth and Components, 1974:IIQ – 1984:IQ

	Final Revisions		Estimated Observation Error		Residual Forecast Error	
	Mean	Variance	Mean	Variance	Mean	Variance
Final minus 15-day	0.630	4.087	–0.630	0.76-1	0.00	3.323
Final minus 45-day	0.413	2.876	–0.413	0.694	0.00	3.183
Final minus –5-day	0.205	2.742	–0.205	0.890	0.00	1.852

SOURCE: Author.

One important strand of the literature examining this question has concluded that the early numbers can be viewed as *rational* forecasts of the actual numbers. The term *rational* is used in the sense that the differences between a final GNP growth number and its corresponding preliminary estimates are uncorrelated with the preliminan numbers themselves (Mankiw and Shapiro [1986]; Walsh [1985]). On the face of it, this is a surprising result. It denies the intuitively appealing, and perhaps prevalent. view that if a preliminary estimate showed large positive growth for real GNP in a quarter, for example. it would be more likely than not that later estimates would be revised donn — in other words, that the final GNP number would be smaller than its preliminary estimate. And. similarly, a large (in absolute value) negative preliminary estimate would be revised upward subsequently.

In a preliminan analysis reexamining this question. Scadding (1987) concluded that the statistical test used in the analyses mentioned above could not discriminate v e n well between the rational forecasts hypothesis and the alternative view

that subsequent revisiuns to the GNP numbers would be correlated with the preliminary estimates. This alternative view implies that the early GNP numbers are estimates of the final number, but estimates that are contaminated with error.

If this alternative view is correct. then it is possible in principle to make estimates of the error in the preliminary numbers and to adjust the latter to remove the error—in other words, to filter out the "noise." This paper investigates one method of doing this. The results suggest there is scope for adjusting the provisional GNP growth rate numbers to make them better predictors of what the final numbers will turn out to be.

I. The Data

Table 1 has estimates of the *final revisions* for real GNP growth—that is, the difference between the final estimate and the three provisional estimates. There are three final revisions, corresponding to the difference between the final numbers and each of the three provisional numbers. For the sample period used in this paper (1974-1984), the early estimates came out 15 days. 45 days, and 75 days after the quarter ended, and the usual nomenclature is to refer to them as the 15-day estimate, and so on. Correspondingly. there is the 15-day final revision, which is the difference between the final number and the 15-day estimate, and so on. I follow the usual practice and define the "final" number as the currently available final number as of the quarter in question. Thus. final estimates in the earlier pan of the sample will have been through more revisions than those later in the sample."

For the 15-day estimate of GNP, many of the source data are not complete and are subject to revision. The data available for this estimate are monthly data, like retail sales, manufacturers' shipments of machinery and equipment, and merchandise trade figures. Some of these data, like retail sales. are based on surveys, and typically are revised substantially. In addition, some of the monthly source data are not available for all three months of the quarter. For example, only one to two months of data are available for estimating consumer spending on services, which is about one-half of total consumer spending. And there are no monthly data at all for

2 The data are from a study prepared by the Bureau of Economic Analysis and are the data used by Mankiw and Shapiro (1986). Mork (1987) and Walsh (1985) The data were adjusted to abstract from the effects of definitional changes and the change in the base year for calculating constant-dollar GNP. See Young (1987), p. 25. I am indebted to Professor Mork for providing me with a copy of these data.

about 40 percent of spending on services. This component, therefore, is estimated by the Department of Commerce, either by extrapolating by related series or by judgmental projection.

The succeeding 45- and 75-day estimates incorporate new monthly data unavailable for the 15-day estimate. and as well incorporate revisions to the monthly data that were included in the 15-day number. As well, these two estimates include new information available only on a quarterly basis—domestic corporate profits. balance of payments figures. and data on financial assets from the Federal Reserve Board's flow of funds accounts. The latter two sources are incorporated in the 75-day estimate only (Carson [1987], p. 107).

As table 1 shows. the final revisions are not trivial. On average for the sample they are positive, suggesting a systematic tendency for the preliminary numbers to understate the final estimates, a phenomenon that has been noted elsewhere (Mork [1987]). The deviations implied by the sample variance estimates reported in table 1 are large when measured against the the mean growth of real GNP for the period. which was 7.9 percent. Thus, plus or minus one standard error about a preliminan estimate equal to this trend growth translates into an economy that, with equal probability. could be enjoying near boom-like conditions or behaving as if it was close to recession.

II. The Nature of the Provisional GNP Estimates

As discussed briefly in the introduction. one possible way of thinking of the early GNP growth numbers is as forecasts of what the final estimate will turn out to be. Thus. suppose X_t^* is the final estimate of GSP growth for quarter t: that estimate of course will not be made until some time after quarter t. In the meantime. however, a provisional estimate (in fact three). call it X_t, will be available soon after quaner t has ended. This provisional estimate X_t can be thought of as a forecast of what X_t^* will be. From that perspective. it is natural to ask whether X_t is a *good* forecast in the sense that. at a minimum, it is unbiased and is uncorrelated with the forecast error, which is equal to the final revision. $X_t^* - X_t$. If this des ription fits X_t. then

$$(1) \quad X_t^* = X_t + z_t,$$

where z_t is a zero-mean. serially uncorrelated forecast error (white noise) that is uncorrelated with X_t.

Walsh (1985) defines these to be the proper ties of a rational forecast. The competing charac terization of X_t is that it is an early observation or "reading" of what X_t^* will be. but an obser vation measured with error. Thus.

$$(2) \quad X_t = X_t^* + u_t$$

where u_t is also white noise. and uncorrelated with X_t^* in this case. Note that this characteriza tion implies that the final revision *is* correlated with the provisional estimate: in other words:

$$(3) \quad E(X_t^* - X_t) \ X_t = -E u_t^2$$
$$= -\sigma_u^2,$$

where σ_u^2 is the variance of the observation error u.

The evidence on which characterization better describes the nature of the provisional estimates is decidedly mised. Mankiw and Shapiro (1986) adduce evidence in favor of the position that preliminary numbers are rational forecasts, on the criteria just described: However. I have argued in a technical companion piece to this paper (Scadding [1987]) that their test is likely to have little power. They themselves raise this possibil in because of the apparent contradiction of their conclusion with evidence elsewhere that two important data sources for the GNP estimates—retail sales and inventories—have significant measurement errors in them (Howrey [1984] and Conrad and Corrado [1979]).

Walsh, using a slightly different sample from Mankiw and Shapiro, finds corroborating evidence for their result. but this conclusion is compromised by his additional finding that the provisional estimates are inefficient forecasts. In addition. Mork, using different estimation techniques from the other studies. found evidence that the provisional estimates were biased downwards, and that the final revisions were correlated with previous-quarter GNP growth and a forecast of GNP growth from a publicly available survey of private forecasters.

III. Filtering the Early Data

I have argued elsewhere (Scadding [1987]) that Walsh's evidence of inefficient forecasting is equally compatible with the view that provisional GNP numbers are observations rather than forecasts, with the observation errors in the three provisional numbers being sequentially correlated. Howrey (1984) found this to be a useful characterization of the inventory investment component of GNP. In my earlier paper, I

devised a test for discriminating between an inef-ficient forecasts model and a serially correlated measurement error model based on restrictions on the variance-covariance matrix of the final revisions. The results of that test suggest that the provisional estimates of real GNP growth contain measurement error.

The purpose of this paper is to estimate the amount of observation (measurement) error in the provisional GNP growth numbers and sub-tract that error to obtain modified, or filtered, provisional GNP estimates that have the proper-ties of a rational forecast. Let $\hat{X}_t^*$ be the filtered estimate; then the estimated measurement and forecast errors are defined by

(4a) $\quad \hat{u}_t = X_t - \hat{X}_t^*$ and

(4b) $\quad \hat{z}_t = X_t^* - \hat{X}_t^*.$

The definitions (4a and 4b) implicitly define the decomposition of a final revision, $X_t^* - X_t$, into its measurement and forecast error component:

(5) $\quad X_t^* - X_t = \hat{z}_t - \hat{u}_t$

Nonrecursive Kalman filtering, described below, is used to specify equations for estimat-ing $\hat{X}_t^*$. Least-squares estimation of these equa-tions yields an $\hat{X}_t^*$ series with the desired fore-casting properties:

(6a) $\quad E(X_t^* - \hat{X}_t^*) = 0$ and

(6b) $\quad E(X_t^* - \hat{X}_t^*)\hat{X}_t^* = 0.$

A5 well, the estimated measurement and fore-cast errors are onhogonal to each other:

(6c) $\quad E(\hat{u}_t \, \hat{z}_t) = 0.$

Summary statistics for the final revisions and the estimated measurement and forecast errors are shown in table 1. Clearly. the filtering im-proves the forecasting precision of provisional numbers. The sample variance of the forecasting error after filtering is on the order of 25 to 30 percent lower than the variance of the unfiltered final revision. Nevertheless, the residual forecast variance is still quite large.

The improvement in forecasting precision would appear to be based on two factors. First, the filtered estimates are derived by combining the provisional estimates with a simple time-series forecast of GNP growth. Mork has noted that the prior quarter's GNP has information

about the size of the final revision in the current quaner. The time-series forecast presumably is picking up this information. In addition. filtering improves the precision of forecasting by exploit-ing the fact that pan of the final revision is meas-urement error and therefore can be forecast from the provisional estimates.

Note the uniformly negative means of the estimated observation errors. indicating a syste-matic tendency of the provisional GNP estimates to underpredict the final numbers. This tendency has been noted by Mork, who ascribes it to con-cern by the Department of Commerce that the provisional estimates not be seen as being too optimistic and therefore serving some political agenda.

The presence of serially correlated measure-ment errors makes it relatively easy to predict *interim* revisions—in other words, from the 11-day to the 45-day. and so on—compared to final revisions. As we shall see, the standard errors of the regression predicting the provisional esti-mates are about 50 percent lower than the standard errors of the equations predicting the final GNP estimates. Thus, the methodology out-lined here provides forecasters with a relatively accurate way of forecasting subsequent prelimi-nan estimates. More generally, this result sug-gests that the provisional estimates are more like each other than they are like the later estimates, a point that has been made by McNees (1986).

Many economists presumably would be offended by the notion that any attention should be paid to forecasting the provisional estimates themselves when what obviously matters is get-ting a good estimate of the final or "true" num-ber. However, that is "obvious" only to the extent the Federal Reserve or private agents, in reacting to new provisional estimates, discount the measurement error in them. an assumption that is not obvious on its face at least. It is cus-tomary to test market forecasts of GNP by their ability to predict final GNP; it would be interest-ing to inquire whether they do a better job of forecasting provisional GNP estimates.

A final observation suggested by this paper's result is that the frequent practice by forecasters of discarding their GNP growth forecast for a quaner when the first provisional estimate for that quarter becomes available probably is not efficient. The filtering technique used in this paper combines the provisional estimates of GNP growth with a forecast from a simple time-series model. The results suggest that the fore-cast still has information about final GNP growth even after the preliminary estimates become available. As McNees has noted: "...the distinc-tion between forecasts and 'actual' data is often

exaggerated. Both are estimates based on partial, incomplete information." (McNees [1986], p. 3)

IV. The Filtering Framework

The general idea of filtering data is easily sketched out. Suppose the variable we are interested in, X^* (which in our case is the final estimate of GNP growth), evolves over time according to the law of motion

$$(7) \quad X_t^* = \phi X_{t-1}^* + u_t,$$

where ϕ is a fixed parameter and u_t is a random. serially uncorrelated term with zero mean and constant variance (white noise).

We cannot observe X^* directly but have measurements of it. X, that involve error (here X would be a provisional estimate of GNP growth).

$$(8) \quad X_t = b X_t^* + u_t,$$

where b is a fixed parameter and u is also white noise.

The Kalman filter optimally weights the forecast of X^* from equation (7) with the observation to form the best linear unbiased predictor of X^*, called the filtered value:

$$(9) \quad \hat{X}_t^* = \overline{X}_t + K_t(X_t - b\overline{X}_t),$$

where $\overline{X}$ is the forecast and $\hat{X}^*$ is the filtered value. The weighting coefficient. K, is called the *Kalman* gain, and is a function of the variances of u, u, and of b. The filtered value is used to update the forecast. Csing (7). this new forecast is combined with the next observation to calculate the next filtered value.

$$(10a) \quad \overline{X}_{t+1} = \phi \hat{X}_t^*$$

$$(10b) \quad \hat{X}_{t+1}^* = \overline{X}_{t+1} + K_{t+1}(X_{t+1} - b\overline{X}_{t+1})$$

Two modifications are necessary to apply this algorithm to the program at hand. First. the three provisional estimates of GNP growth are repeated observations on the same final estimate. Thus, *within* the quarter, the law of motion is

$$(11) \quad X_{t,n}^* = A'_{t,}$$

for $n = 1. 2, 3,$ where $n = 1$ refers to the 15-day estimate. $n = 3$ to the *ti·day* estimate. and $n = 3$ to the *75·day* estimate. Similarly,

$$(12a) \quad X_{t,1} = X_t^* + u_{1t},$$

$$(12b) \quad X_{t,2} = X_t^* + u_{2t}. \text{ and}$$

$$(12c) \quad X_{t,3} = X_t^* + u_{3t}.$$

where the $X_{t,n}$'s are the provisional estimates and the $u_{n,t}$'s are the corresponding measurement errors. Thus, within the quarter. the ϕ in equation (7) is unity. as is b in (8). while the intraquarter u's are uniformly zero.

The other modification follows from the fact that preliminary estimation suggests that the u's (12) are sequentially correlated. This serial correlation structure is shonn in table 3.

The filtering framework is easily adapted to this circumstance by expressing the obsenation variables in quasi-difference form. $A'_{t,,}$ – $a_{12}X_{t/2}$, $X_{t/2} - a_{23}X_{t/1}$, where the a's are the respective serial correlation coefficients of the errors from table 2 (see Bryson and Ho [1969], pp. 400-405). The modified set of filtering equations becomes

$$(13a) \quad \hat{X}_{t,1}^* = \overline{X}_{t,0} + K_1(X_{t,1} - \overline{X}_{t,0}),$$

$$(13b) \quad \hat{X}_{t,2}^* = \hat{X}_{t,1}^* + K_2[(X_{t,2} - a_{23}X_{t,1} - (1-a_{23})\hat{X}_{t,1}^*], \text{ and}$$

$$(13c) \quad \hat{X}_{t,3}^* = \hat{X}_{t,2}^* + K_3[(X_{t,3} - a_{12}X_{t,2}) - (1-a_{12})\hat{X}_{t,2}^*].$$

The initial forecast $\overline{X}_t$, is taken from a simple time-series model for real GNP growth, X^*. Given the forecast and estimates of the K's and a's. one could then calculate the filtered estimates directly. The approach taken here, however. Is to estimate the K's using ordinary least squares to produce a set of estimated measurement errors and residual forecast errors that are uncorrelated.[3] Thus. the estimation equations corresponding to (I?) are

$$(14a) \quad X_t^* = \overline{X}_{t,0} + K_1(X_{t,1} - \overline{X}_{t,0}) + z_{1t},$$

$$(14b) \quad X_{t,2} = a_{,,} X_{t,1} + (1-a_{23})\hat{X}_{t,1}^* + v_{2t},$$

$$(14c) \quad X_t^* = \hat{X}_{t,1}^* + K_2 v_{2t} + z_{2t},$$

$$(14d) \quad X_{t,3} = a_{,,} X_{t,2} + (1-a_{12})\hat{X}_{t,2}^* + v_{3t}, \text{ and}$$

■ **3** Conrad and Conrado (1979) and Howrey (1984) have used the Kalman framework for analyzing retail sales and inventory investment data, respectively.

$(14e)\ X_t^* = \hat{X}_{t\,2}^* + K_3 r_{3t} + z_{3t}\,.$

To complete (14) we append the set of defini tions of the filtered estimates of GNP growth:

$(14a')\ \hat{X}_{t\,1}^* = \overline{A'}_{,,} + K_1(X_{t\,1} - \overline{X}_{t\,1})\,,$

$(14b')\ \hat{X}_{t\,2}^* = \hat{X}_{t\,1}^* + K_2 r_{2t}\,,\ \text{and}$

$(14c')\ \hat{X}_{t\,3}^* = \hat{X}_{t\,2}^* + K_3 r_{3t}\,.$

T A B L E 2

Correlation Structure of Final Revisions

	Standard Error of Estimate
$X_t^* - A'_{,,} = 0.230 + 0.932\ (X_t^* - X_{t,2}) + v_{3t}$ $(2.79)\quad(19.61)$	0.503
$X_t^* - X_{t\,2} = 0.077 + 0.784\ (X_t^* - A'_{,,,}) + v_{2t}$ $(0.76)\quad(16.36)$	0.503
$Sf - A'_{,,\,t} = -0.698 + v_{1t}$ (-2.18)	2.02

SOURCE: Author.

The estimation of (14) proceeds sequentially. First (14a) is estimated. by regressing final GSP growth on the time-series forecast. $X_{t\,0}$. and the 15-day provisional estimate. $X_{t\,1}$. The residual. z_1, is the forecast error for the filtered 15-day estimate. The first filtered estimate of final GNP growth. $\hat{X}_{t\,1}^*$, is calculated using (14a'). The corresponding measurement error in the 15-day provisional GNP growth rate is estimated as

$(15)\ \hat{u}_{1t} = X_{t\,1} - \hat{X}_{t\,1}^* = $
$\qquad (1-K_1)\ (X_{t\,1} - \overline{X}_{t\,0})\,,$

which by construction is uncorrelated with the forecast error.

The nest step is to calculate the innovation in the measurement error in the 45-day provisional GNP number. The correlation structure between the measurement errors in the 15-day and 45-day number is

$(16)\ X_{t\,2} - X_t^* = a_{23}\ (X_{t\,1} - X_t^*) + v_{2t}\,.$

where v_{2t} is the innovation in the measurement error. Rearranging (16) and substituting $\hat{X}_{t\,1}^*$ for X_t^* yields (14b). which is then estimated by regressing the 45-day provisional GNP number

on the 15-day estimate and the first filtered estimate of GNP growth.

The innovation in the 45-day number then is used to update the filtered estimate of final GNP growth by regressing the final GNP number on the first filtered estimate and the measurement innovation in the 45-day number (equation 14c). The residual z_{2t} provides an estimate of the forecast error in the 45-day number. The same sequence of estimations is performed to calculate the new filtered estimate of final GNP conditional on having the 75-day provisional GNP estimate, and its corresponding forecast error.

V. Estimation Results

The results of estimating equations (14a)-(14e) are shown in table 3. Almost uniformly, with one important exception discussed later, the estimated coefficients in table 3 are statistically different from zero at the 95 percent confidence level. Perhaps more importantly, again with the Same exception just noted, the restrictions implied by equations (14) are all met. Thus, for example, equation (14a) implies that the sum of coefficients on the time-series forecast and the 15-day provisional estimate sum to one. In other words, the 15-day filtered estimate of real GNP growth is a simple weighted average of the forecast and 15-day GNP number. The last column reports the F-test statistic. and it clearly cannot reject the hypothesis of the 95 percent confidence level that the coefficients sum to unity.

Similarly, the restrictions in equations (14b) and (14d) that the coefficients sum to unity and that the coefficients on the lagged dependent variables equal the estimated correlation coefficients from table 2 are also met. In the case of equation (14d) the coefficient on $\hat{X}_{t\,1}^*$ was not itself statistically significant, even though the joint hypothesis could not be rejected. When the coefficient on $X_{t\,2}$ was constrained to be 0.9322 — its a priori value as indicated by table 2 — the coefficient on $\hat{X}_{t\,1}^*$ became significant, which is the result reported in (14d).

Only equation (14e) gave any significant trouble. In this case, the estimated K_3 was not significantly different from zero, indicating that the 75-day estimate did not have any additional information about the final GNP number that was not already contained in the two preceding provisional estimates and the time-series forecast.

This last result stands in sharp contrast to the information provided by the first two provisional GNP numbers about final GNP. The estimated Kalman gain K_1 and K_2 in (14a) and (14c) are

| T A B L E   3 |
| Estimated Filtering Equations 1974:IIQ - 1984:IQ (T-statistics in parentheses) |

		Standard Error of Estimate	F-Statistic
(14a) $X_t^* = 0.336 + 0.291 \overline{X}_{t,0} + 0.774 X_{t/1} + z_{1t}$ $\quad\quad (0.89) \quad (2.61) \quad\quad (8.45)$		1.823	1.479^a
(14b) $X_{t,2} = -0.047 + 0816 X_{t/1} + 0.236 \hat{X}_{t\ 1}^* + v_{2t}$ $\quad\quad (-.29) \quad (7.33) \quad\quad (199)$		0.714	2.247^b
(14c) $X_t^* = -0.077 + 1.020 X_{t-1} + 1.483 v_{2t} + z_{2t}$ $\quad\quad (-0.28) \quad (19.61) \quad\quad (4.30)$		1.477	2.378^c
(14d) $X_{t,3} = 0.235 + 0.932 X_{t/2} + 0.098 \hat{X}_t^* \ , + v_{3t}$ $\quad\quad (2 54) \quad\quad (5.95)$		0.560	0.578^d
(14e) $X_t^* = 0083 + 0.974 \hat{X}_t \ , + 0.784 v_{3t} + z_{3t}$ $\quad\quad (0.04) \quad (21.86) \quad\quad (1.77)$		1.361	0.339^e

Addendum: time-series forecasting model

$X_t^* = 0.511 + 0.828 X_{t-1} + w_t - 0.415 w_{t-1}$
$\quad\quad (2.19) \quad (7.87) \quad\quad\quad (2.40)$

Standard error of estimate = 3.323

a. Test that sum of coefficients is unity.
b. Test that coefficient on $X_{t/1} = 0.0784$ and that sum of coefficients is unin.
c. Test that coefficient on $X_t \ ,$ is unity and that $K_2 = 1.234$.
d. Test that coefficient on $X_{t/2}$ is 0.931 and that coefficients sum to unity. The equation was reestimated with coefficient on $X_{t/2}$ re.
stricted to 0.937; the results are the ones reported in (14d).
e. Test that coefficient on $\hat{X}_{t\ 2}^*$ is unity: the restriction that the coefficient was unity and that the coefficient on v_{3t} was nonzero was rejected at the 5 percent confidence level.
SOURCE: Author.

0.774 and 1.483, respectively, and both are statistically different from zero at the 95-percent confidence level. The latter number may seem too high—presumably it should be between zero and one. However, with serial correlation in the measurement errors the constraint is that a_t, K_2 must be less than one. This constraint is satisfied by the calculated theoretical Kalman gains shown in table 4.[4] Clearly, the estimated K, of 1.483 is not statistically different from the theoretical value of 1.234, given the size of its standard error, a conclusion that is substantiated by the results of the F-test in table 3.

The nonzero coefficient on the time-series forecast variable. $\overline{X}$, , , suggests that the provisional estimates do not fully incorporate information about final GNP contained in the previous quar-

ter's estimates[5] This suggests perhaps a tendency on the part of the BEA to be conservative in extrapolating trends in the GNP data. And it also suggests that the typical practice in forecasting and policy analysis to discard forecasts for the immediately prior quarter once the provisional estimates become available may be inefficient.

The fact that the 75-day estimate does not appear to add any additional information about final GNP is interesting given that it is the first estimate to incorporate quarterly data. The high degree of serial correlation between the 45-day and 75-day provisional estimates shown in (14d), with relatively low variance in the residual, indicates, however, that the two estimates are not very different from each other despite the addition of the quarterly information. indeed, to an important extent this is true of all three provisional estimates: they provide more information about each other than they do about the final GNP number.

■ **4** The similarity of the "theoretical" and estimated Kalman gains suggest there would be no advantage from calculating the filtered estimator using the theoretical numbers. There does not appear to be any clear consensus whether regression-based weighting of forecasts is preferable to sample-estimated optimal-weighting. See, for example. Lupoletti and Webb (1986). pp. 279-281.

■ **5** The time-series forecasts used only past data available w the time the new provisional estimator first became available, not past values of the final GNP growth estimator.

TABLE 4

Calculated and Estimated Kalman Gains

	Calculated	Estimated	Standard Error of Estimated Gains
K_1	0.719	0.774	(0.092)
K_2	1.234	1.483	(0.345)
K_3	0.679	0.784	(0.443)

SOURCE: Author.

VI. Conclusion

A recent and interesting analysis of the early GNP estimates has concluded that "they behave neither as efficient forecasts nor as observations measured with error" (Mork [1987], p. 173). The purpose of this paper has been to filter the early GNP numbers, to remove the measurement error, and to produce more accurate predictions of the final GNP growth estimates. In a related paper (Scadding [1987]), I have shown that these filtered estimates do not exhibit the unconditional bias and inefficiency that Mork found for the raw estimates. Another interesting sidelight of the results of this paper is that the Mankiw-Shapiro test for discriminating between observation and forecast errors does a poor job when applied to the estimated observation and forecast errors calculated in this paper. corroborating other indications of the poor power of the test.

For the forecaster. the filtering approach outlined in this paper provides an easy and s)-stematic way of adjusting the provisional numbers to make them better estimates of "actual" GNP growth. It would be intriguing to inquire whether forecasters do in fact adjust the early numbers in a way that is consistent with the approach taken here.

The estimation results reported are model specific in the sense that they depend, to an unknown extent, on the specific forecasting model used to initialize the filtering procedure. Again. it would be interesting to see the extent to which the filtering results were sensitive to the forecasting model by using forecasts from alternative models. One offshoot of such an exercise would be that a particular model's performance could be evaluated in terms of the extent to which its forecasts contributed to improving the forecasting ability of the preliminan GNP numbers.

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