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Revisions in the "Flash" Estimates of GNP Growth: Measurement Error or Forecast Error?

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This paper examines the Department of Commerce's "flash" estimate of real GNP growth. Differences between the flash and the final real GNP figures are often large, but the flash is shown to provide an unbiased forecast of the final GNP figure. Other preliminary estimates of GNP are also released by the Department of Commerce, and these are shown to provide unbiased, but inefficient, forecasts of the final real GNP growth rate.

Fifteen days before the end of each quarter, the Department of Commerce releases its "flash" estimate of that quarter's economic activity, including the real GNP growth rate.[1] Even though these flash estimates are prepared before the quarter is over, they are widely used as early indicators of the current state of the economy. The flash estimates are also used to update and revise forecasts of future real GNP growth and price inflation, although they are frequently subject to large revisions. This paper looks at whether the revisions to flash GNP growth estimates are due to forecast or measurement error, since the type of error bears directly on the usefulness of the flash for forecasting or policy analysis.[2]

The differences between the actual growth rate of real GNP[3] and the flash estimate are plotted in the chart for the period from the first quarter of 1976 through the fourth quarter of 1983. While the average revision in the growth rate was less than 1 percentage point, in comparison with the average actual GNP growth rate of 2.9 percent over the period, the flash differed from the final growth rate by 3 percentage points or more in five of the thirty-two quarters.

At times, the flash has even incorrectly signalled the direction of GNP growth. For example, the flash estimate of real GNP growth in the first quarter of 1978 was a negative 1.3 percent, in contrast to the final figure of a positive 3.4 percent. This represented the second largest difference between the GNP flash and the final figure during the 1976–1983 period.

There are two alternative ways to view the revisions shown in the chart. One approach is to think of the flash estimate as equal to the true, but as yet unobserved, growth rate, plus some measurement error. This measurement error could be due, for example, to the limited data available at the time the flash estimates were made. If, in a particular quarter, the measurement error were positive, then the flash figure would overstate the actual growth rate and land above the final figure. If the error were negative, the flash would be too low and fall below the final. In other words, the flash estimates would be positively correlated with the measurement error.

The second approach views the flash estimates as forecasts, as opposed to measures, of the final figures. In such a case, the errors plotted in the chart are forecasting errors, rather

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than measurement errors, with properties that distinguish them from measurement errors.

If a forecast has been based on all the relevant information available at the time it was made, any forecast errors would arise only because of unpredictable events or developments that were not incorporated into the forecast because they were, by definition, unpredictable. Forecast errors therefore should have no systematic correlation with the forecast. If they did, the forecast could have been improved by taking the correlation into account. Forecasts that are uncorrelated with their forecast errors are called rational forecasts. If the flash estimate of GNP growth is a rational forecast, then there should be no correlation between the flash and subsequent revisions.

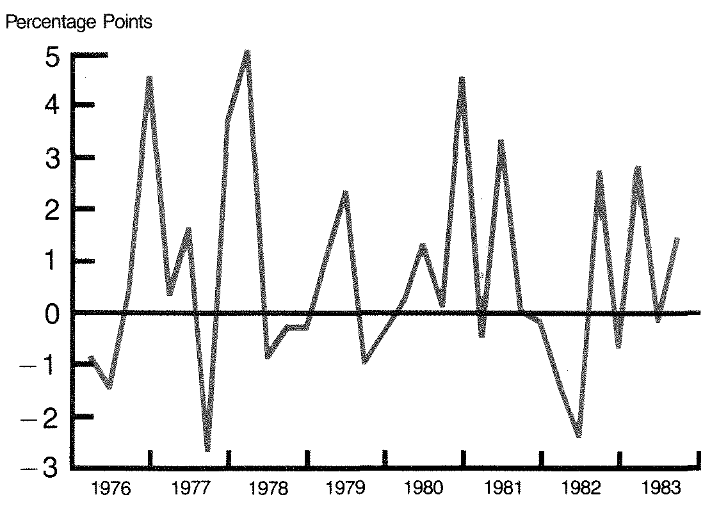
Interpreting revisions to flash estimates as measurement errors or forecasting errors has different implications for how the flash can best be used in forecasting or policy analysis. For example, suppose the flash estimate of the current quarter's GNP growth were used to help forecast next quarter's GNP growth. The subsequent forecast error would depend, in part, on the revision to the flash. If revisions are best viewed as necessitated by measurement error, the forecast error in predicting the next quarter's GNP growth will be correlated with the current flash since the flash is correlated with the measurement error. This means that using the flash produces forecasts that are systematically in error and that do not use information efficiently; the forecasts will not be rational.

If, in contrast, the revisions to the flash estimates are themselves rational forecast errors, this problem does not arise. Errors in predicting future real growth will still be affected by revisions to the current flash, but because the revisions are not correlated with the flash, no systematic bias is introduced. Thus, if flash estimates are to be used to measure current economic activity, to forecast future prices or output, or to forecast future Federal Reserve policy actions, it is important to determine which view of the errors is most appropriate.

This paper sets forth some recently proposed tests for distinguishing between measurement error and forecast error and applies these tests to the flash estimate of real GNP growth.[4] Subsequent estimates of GNP, such as the preliminary, first revised, and second revised figures are also released before the final figures are published, and these data also are analyzed.

Chart 1

Difference Between Flash and Final Growth Rate of Real GNP



The test results clearly support the view that revisions to the flash, preliminary, and revised real GNP growth estimates are forecast errors and not measurement errors. They imply that using the flash, and other preliminary estimates of real GNP growth, for forecasting purposes will not lead to the biases that would occur if measurement error accounted for the revisions. However, some evidence is found that the revised real GNP growth estimates are inefficient forecasts of final GNP growth in the sense that they do not incorporate readily available information.

The remainder of this paper provides a technical development of these points. In the first section, the test for distinguishing between the measurement error and rational forecast error views is discussed. This test was originally proposed by Mankiw, Runkle, and Shapiro who applied it to preliminary data on the money stock and found that the differences between final and preliminary money stock numbers are best viewed as due to measurement error. Test results using data on real GNP growth are presented in Section II.

I. Analytical Framework

This section discusses the method that will be used to test whether the revisions between final and flash data are better characterized as measurement error in a classical errors-in-variables model (EVM) or as forecast error in a rational forecast model (RFM). The implications of using the flash data in forecasting applications are briefly considered and shown to depend on whether EVM or RFM is the true model.

To understand why it is important to distinguish between alternative interpretations of the flash estimates, consider the use of flash estimates as an input into a forecast of future real GNP growth. In general terms, suppose x_t is the true value of some random variable (i.e., the growth rate of real GNP), and let x_t^p denote a preliminary estimate of x_t. Suppose that one wishes to forecast x_{t+1} using a model, estimated from historical data, of the form

$$x_{t+1} = a + bx_t + c\,Z_t + \varepsilon_t \qquad (1)$$

where Z_t is a vector of additional variables with coefficient vector c, and ε is a random disturbance term. For the purposes of this illustration, the variables in Z_t are assumed to be known and uncorrelated with both x^p and ε. Since x_t is not yet known, suppose x_t^p is used in its place in forecasting x_{t+1}. Letting x_{t+1}^f denote the forecast of x_{t+1},

$$x_{t+1}^f = a + bx_t^p + c\,Z_t. \qquad (2)$$

From equations 1 and 2, the error in forecasting x_{t+1} can be written as

$$x_{t+1} - x_{t+1}^f = b(x_t - x_t^p) + \varepsilon_t \qquad (3)$$

Equation 3 shows how the error in forecasting x_{t+1} depends on the difference between x_t and x_t^p. The properties of the errors in the forecast of x_{t+1} will thus depend crucially on the properties of $x_t - x_t^p$. As demonstrated below, the errors-in-variables model and the rational forecast model make different predictions about the potential presence of systematic bias in the forecast error $x_{t+1} - x_{t+1}^f$.

Errors in Variables Model

Cast within the classical errors-in-variables model (EVM)[5], x^p is viewed as equal to the true value of x plus a measurement error, u, with mean zero:

$$x_t^p = x_t + u_t. \qquad (4)$$

In this formulation, u and x are taken to be uncorrelated. Consequently, x^p and u will be positively correlated. Thus, in equation 3, $x_{t+1} - x_{t+1}^f = -bu_t + \varepsilon_t$ and the covariance of $(x_{t+1} - x_{t+1}^f)$ and x_t^p is $-b\sigma_u^2 \neq 0$, where σ_u^2 is the variance of u. Using x^p to forecast x_{t+1} leads to forecast errors that are systematically related to x^p. This implies that x_{t+1}^f will be an inefficient, and biased, forecast of x_{t+1}.[6] If x_t^p

is high, it will tend to be so in part because of a measurement error that is positive. Since x_t^p overestimates x_t, x_{t+1}^f will also overestimate x_{t+1}. (This assumes b is positive.) The errors in x^p produce systematic errors in forecasting x_{t+1}.

Equation 4 can be viewed as a regression equation in which the intercept term is equal to zero and the slope coefficient on x_t is equal to one. That is, we can write a more general version of equation 4 in the form

$$x_t^p = a + bx_t + u_t \tag{4a}$$

where a = 0 and b = 1 if equation 4 is the true model. Under the null hypothesis that EVM is the true model, x and u are uncorrelated. Thus, we can estimate equation 4a by OLSQ and test the restrictions a = 0, b = 1.

Rational Forecast Model

As an alternative to the errors-in-variables model, suppose x^p is a forecast of x. In the rational forecast model (RFM), the difference between x and x^p is a forecasting error that is uncorrelated with the forecast x^p. Thus, we can write

$$x_t = x_t^p + v_t \tag{5}$$

where v_t is the forecast error. Any correlation between v and x^p would imply forecast errors that are systematically related to the forecast, and one property of rational forecasts is the absence of such systematic errors. Hence, if x^p is a rational forecast, x^p and v will be uncorrelated. Equation 3 shows that using x^p to forecast x_{t+1} produces an error of $bv_t + \varepsilon_t$ that is uncorrelated with x_t^p. In this case, x_t^p is not systematically related to the error in estimating x_t. A high x_t^p is just as likely to underestimate as overestimate x_t. Consequently, no systematic error is introduced into the forecast of x_{t+1}.

Just as was done with equation 4, equation 5 can be viewed as a regression equation in which the intercept is zero and the slope coefficient is one. A more general version of equation 5 is

$$x_t = a + bx_t^p + v_t. \tag{5a}$$

Under RFM, a = 0 and b = 1. Since x^p and v are uncorrelated under RFM, equation 5a can be estimated by OLSQ and the restrictions on a and b can be tested.

Mankiw, Runkle and Shapiro propose estimating both equations 4a and 5a and testing the null hypothesis that the intercept is equal to zero and the slope coefficient is equal to one in each equation. For the money stock, they find that the null hypothesis could be rejected for 5a but not for 4a. The preliminary money stock appears, therefore, to be an example of classical errors-in-variables. In the next section, we report the results of estimating 4a and 5a for real GNP growth.

II. Test Results

In this section, EVM and RFM are tested by estimating equations 4a and 5a. Recall that under the errors-in-variables model (EVM), the intercept should be zero and the slope coefficient one in a regression of a preliminary estimate on the final value. Under the rational forecast model (RFM), the intercept should be zero and the slope coefficient one in the reverse regression of the final value on each preliminary estimate.

This test can be applied to the flash estimate of real growth, and to subsequent estimates released by the Department of Commerce. In fact, there are at least three subsequent estimates of GNP growth before the final values are established, and the tests outlined above can be applied to each.

The variables analyzed in this paper are defined in Table 1: y denotes the final real GNP growth rate, while y(t) denotes an earlier estimate of y released t days after the end of the quarter. Four estimates of the annual percentage growth rates of real quarterly GNP plus the final figures are used, and the data are from 1976:Q1 to 1983:Q4.[7] The data are given in the Appendix.

TABLE 1

Definitions		
$y_t(-15)$	=	flash estimate of the percentage growth rate of real GNP from quarter $t-1$ to quarter t, expressed at an annual rate. This figure is released 15 days *before* the end of quarter t.
$y_t(15)$	=	preliminary estimate, released 15 days *after* the end of quarter t.
$y_t(45)$	=	first revised estimate, released 45 days after end of quarter.
$y_t(75)$	=	second revised estimate, released 75 days after end of quarter.
y_t	=	final value of growth rate during quarter t, taken as the value reported as of July 1985.

TABLE 2

Tests of the Two Models[1]

Errors-in-Variables Model
$y(t) = a + by$, where $t = -15, 15, 45$, and 75
Test: $a = 0, b = 1$

Dependent Variables	Intercept	y	F	M.S.[2]
1. y(−15)	−0.030 (0.37)[3]	0.735 (0.07)	11.00	.0003
2. y(15)	−0.036 (0.39)	0.815 (0.07)	4.79	.016
3. y(45)	−0.052 (0.33)	0.874 (0.06)	3.26	.052
4. y(75)	0.255 (0.32)	0.875 (0.06)	2.35	.113

Rational Forecast Model
$y = a + by(t)$, $t = -15, 15, 45$, and 75
Test: $a = 0, b = 1$

Intercept	y(−15)	y(15)	y(45)	y(75)	F	M.S.
5. 0.634 (0.43)	1.081 (0.10)				2.69	0.085
6. 0.602 (0.42)		0.990 (0.09)			1.29	0.289
7. 0.431 (0.34)			0.996 (0.07)		1.02	0.371
8. 0.095 (0.34)				1.006 (0.07)	0.082	0.921

1. Sample period is 1976:Q1–1983:Q4.
2. The Marginal Significance level is the probability of observing an F-statistic greater than or equal to the reported value.
3. Numbers in parentheses are standard errors.

Rows 1–4 in Table 2 present the results of testing the EVM for preliminary real GNP growth estimates. For the flash, y(−15), and the preliminary, y(15), the hypothesis that a = 0, b = 1 can be rejected at the 5 percent significance level. The hypothesis that a = 0, b = 1 for the first revision, y(45), can be rejected at the 6 percent level. For the second revision, y(75), however, the F value is 2.35 with a marginal significance level of 11.3 percent. Except for y(75), the data clearly reject the errors-in-variables interpretation of early estimates of the growth rate of real GNP. The failure to reject EVM for y(75) is perhaps explained by the fact that revisions between y(75) and y are small, which suggests that the power of the test may be low.

Rows 5–8 of Table 2 present the tests of RFM. In striking contrast to the results for EVM, the hypothesis that the preliminary announcements of GNP growth are rational (unbiased) forecasts cannot be rejected at the 5 percent level of significance for any of the GNP estimates. Unlike the results for preliminary money stock numbers reported by Mankiw, Runkle and Shapiro, the preliminary real GNP numbers seem to be rational forecasts of the final rate of growth in GNP.

In addition to being viewed as an estimate of the final growth rate of real GNP, the flash is also viewed as an estimate of subsequent estimates of GNP growth. Thus, we investigated whether the flash is better represented as a rational forecast of subsequent revised estimates or as equal to future estimates plus some measurement error. The EVM regressions of y(−15) on each subsequent revised estimate of y are given in the top half of Table 3. The null hypothesis under EVM can be rejected in each case. The lower half of Table 4 presents the test statistics under the RFM. At the 5 percent significance level, the hypothesis that y(−15) is a rational forecast of y(15) and y(45) cannot be rejected. It can be rejected, however, for y(75).

Efficiency of Forecasts

The bulk of the evidence from Tables 2 and 3 favors the RFM interpretation of the preliminary GNP growth rate estimates. These results, however, do not shed much light on the *efficiency* of the preliminary estimates as forecasts of the final growth rate (a forecast is efficient if it correctly incorporates all relevant information). If x_t^p is an efficient estimate of x_t, then the prediction error $x_t - x_t^p$ should be uncorrelated with *any* information available at the time x_t^p is formed. In a regression of $x_t - x_t^p$ on known information, all the coefficients should be zero.

The hypothesis that preliminary announcements of real GNP growth are efficient forecasts implies, at a minimum, that the prediction error of each estimate should be uncorrelated with earlier revisions in the estimate. For example, y − y(75) should be uncorrelated with y(75) − y(45), y(45) − y(15), and y(15) − y(−15). Similarly, y − y(45) should be uncorrelated with y(45) − y(15) and y(15) − y(−15), while y − y(15) should be uncorrelated with y(15) − y(−15). These hypotheses are tested in Table 4.

The hypothesis that y − y(15) is uncorrelated with y(15) − y(−15) clearly cannot be rejected. However, the hypotheses that y − y(45) and y − y(75) are uncorrelated with earlier revisions is rejected by the data. Rows 2 and 3 of Table 4 show that y − y(45) and y − y(75) are related to the difference between both the first revised and the preliminary estimates, y(45) − y(15), and the preliminary and flash estimates, y(15) − y(−15). If the first revision, y(45), shows one percentage point more estimated GNP growth than did the preliminary estimate, y(15), i.e., y(45) − y(15) = 1 in rows 2 and 3, then both the first and second revised estimates, y(45) and y(75), will tend to underestimate the final growth rate, y, by 1.1 percentage points. This evidence of inefficiency is consistent with the earlier results which showed both y(45) and y(75) to be rational forecasts of y. Table 2, for example, shows that the unconditional expectation of y − y(t) is zero for t = 45, 75. Table 4, however, shows that the expectation of y − y(t), conditional on y(45) − y(15) and y(15) − y (−15), is not zero. Hence, these estimates do not use all prior information as efficiently as possible.

The results reported in this paper support the view that the flash, and other early estimates of real GNP growth, are rational forecasts of actual GNP growth. Generally similar conclusions apply to estimates of the percentage change in the GNP Price Deflator.[8] The flash numbers provide unbiased forecasts of the final figures. Although the revisions that are subsequently made to the flash are often quite large, the problems that would occur if these revisions were due to measurement error do not apply.

TABLE 3
The Flash and Subsequent Estimates*

Errors-in-Variables Model
$y(-15) = a + by(t),\ t = 15, 45, 75$
Test: $a = 0, b = 1$

Intercept	y(15)	y(45)	y(75)	F	M.S.
1. 0.033 (0.16)	0.889 (0.03)			6.42	.005
2. 0.003 (0.22)		0.845 (0.05)		7.99	.0023
3. −0.246 (0.25)			0.841 (0.05)	10.53	.0003

Rational Forecast Model
$y(t) = a + by(-15),\ t = 15, 45, 75$
Test: $a = 0, b = 1$

Dependent Variable	Intercept	y(−15)	F	M.S.
4. y(15)	0.067 (0.18)	1.076 (0.04)	2.69	.084
5. y(45)	0.192 (0.25)	1.090 (0.06)	2.82	.075
6. y(75)	0.535 (0.27)	1.075 (0.06)	4.98	.014

* See notes to Table 2

TABLE 4

Tests of Efficiency*
Test that all coefficients are zero

Dependent Variable	Intercept	y(75)−y(45)	y(45)−y(15)	y(15)−y(−15)	F	M.S.
1. y − y(15)	0.646 (0.37)			−0.297 (0.40)	0.559	.461
2. y − y(45)	0.390 (0.27)		1.082** (0.39)	−0.601** (0.29)	4.972	.014
3. y − y(75)	0.098 (0.30)	−0.056 (0.48)	1.114** (0.38)	−0.622** (0.28)	3.89	.019

* See notes to Table 2.
** Significantly different from zero at the 5% level.

APPENDIX

TABLE A.1

Estimates of Percentage Change in Real GNP (Annual Rates)*

	y(−15)	y(15)	y(45)	y(75)	y
1976:1	5.0	6.4	7.3	7.5	9.1
1976:2	3.6	5.0	4.9	5.1	2.7
1976:3	3.8	3.9	3.7	3.8	2.3
1976:4	3.2	2.9	2.3	2.5	3.7
1977:1	4.4	5.5	6.5	7.1	8.9
1977:2	6.4	6.3	6.0	6.0	6.7
1977:3	5.2	3.9	4.9	5.2	6.8
1977:4	3.5	3.9	3.6	3.5	0.8
1978:1	−0.3	0.5	0.6	1.0	3.4
1978:2	6.0	6.3	6.9	7.6	11.0
1978:3	4.2	4.3	4.3	3.5	3.3
1978:4	5.8	6.9	7.2	7.7	5.5
1979:1	1.4	0.8	0.4	0.8	1.1
1979:2	−1.9	−2.7	−1.8	−1.8	−0.9
1979:3	2.5	3.5	4.5	4.1	4.8
1979:4	1.7	1.6	2.3	2.2	0.7
1980:1	2.3	1.5	1.0	1.6	1.9
1980:2	−9.2	−9.8	−9.8	−10.3	−9.0
1980:3	−0.5	0.5	0.3	2.4	0.8
1980:4	3.7	5.0	4.0	3.8	3.8
1981:1	5.5	6.5	8.4	8.6	10.0
1981:2	0.0	−1.9	−2.4	−1.6	−0.5
1981:3	−0.5	−0.6	0.6	1.4	2.8
1981:4	−5.4	−5.2	−4.7	−4.5	−5.4
1982:1	−4.4	−3.9	−4.3	−3.7	−4.7
1982:2	0.6	1.7	1.3	2.1	−0.8
1982:3	1.5	0.8	0.0	0.7	−0.9
1982:4	−2.2	−2.5	−1.9	−1.0	0.5
1983:1	4.0	3.1	2.5	2.6	3.3
1983:2	6.6	8.7	9.2	9.7	9.4
1983:3	7.0	7.9	7.7	7.6	6.8
1983:4	4.5	4.5	4.8	5.0	5.9

*Variables are defined in Table 1 of the text. Source: Department of Commerce, Bureau of Economic Analysis.

FOOTNOTES

1. The second revised estimate of GNP growth in the previous quarter is released at the same time.

2. For a somewhat skeptical view of the usefulness of the flash, see "A Flash in the Pan," *Morgan Economic Quarterly,* September 1985.

3. "Final" or "actual," refers here to the values reported as of July 1985.

4. Similar tests were carried out for the GNP Price Deflator and the results are described in footnote 8.

5. For a general discussion of the errors-in-variables model, see E. Malinvaud, *Statistical Methods of Econometrics* (North Holland, 1970), chap. 10.

6. The unbiased forecast of x_{t+1}, conditional on x_t^p and z_t, *metrics* (North Holland, 1970), chap. 10.

$(\sigma_x^2 + \sigma_u^2)$ is equal to the coefficient b corrected for the ratio of the variance of x to the variance of x^p.

7. The flash estimates have been prepared by the Bureau of Economic Analysis, Department of Commerce, since the mid-1960s. Prior to 1976, the data as originally released is not consistent with the current definition of GNP because of the re-benchmarking of the National Income and Product Accounts in January 1976.

8. Results for the percentage change in the GNP Price Deflator were similar to those for real GNP growth. EVM could not be rejected at the 5% level only for the first revised estimates. However, no evidence of inefficiency was found for the inflation estimates.

TABLE A.2

Estimates of Percentage Change in GNP Price Deflator (Annual Rate)**

	p(−15)	p(15)	p(45)	p(75)	p
1976:1	4.0	3.7	3.6	3.7	3.9
1976:2	4.4	5.0	5.4	5.5	3.8
1976:3	5.0	4.4	4.2	4.5	5.1
1976:4	6.4	6.5	6.0	6.0	6.7
1977:1	5.7	5.6	5.5	5.7	5.9
1977:2	6.5	7.1	7.5	7.6	7.1
1977:3	5.4	5.3	5.1	5.1	6.3
1977:4	6.6	6.6	6.6	6.3	6.5
1978:1	7.5	6.8	6.8	6.8	5.5
1978:2	8.4	10.7	11.5	11.8	12.0
1978:3	7.4	7.4	7.5	7.2	9.0
1978:4	8.9	8.6	8.6	8.7	9.7
1979:1	9.1	8.6	8.8	8.9	8.7
1979:2	9.8	9.1	8.6	8.7	8.4
1979:3	8.2	7.9	7.7	8.3	8.8
1979:4	8.6	8.3	8.2	7.9	7.4
1980:1	10.2	9.4	9.2	9.4	9.8
1980:2	9.7	9.3	9.5	9.5	9.9
1980:3	10.1	9.7	10.5	9.4	8.9
1980:4	12.1	11.7	11.2	11.1	11.7
1981:1	8.3	8.4	10.9	10.6	12.1
1981:2	6.2	5.9	6.5	6.3	6.5
1981:3	9.3	9.4	9.6	10.0	10.3
1981:4	8.3	7.9	8.9	9.1	7.9
1982:1	4.5	3.5	3.4	3.7	4.4
1982:2	5.0	5.4	4.9	4.7	5.5
1982:3	6.6	5.4	4.7	5.1	3.4
1982:4	4.4	4.2	3.6	3.6	3.4
1983:1	4.5	6.0	5.8	5.7	5.2
1983:2	4.3	4.8	3.8	3.6	2.9
1983:3	3.5	3.7	3.5	3.9	3.3
1983:4	4.2	4.1	4.4	4.1	4.7

**Variables are defined analogously to those in Table A.1 (i.e., p(−15) is the flash estimate of p). The percentage change in the GNP Price Deflator was obtained by subtracting the change in Constant Dollar GNP from the change in Current Dollar GNP.

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