REVISIONS TO PCE INFLATION MEASURES:
IMPLICATIONS FOR MONETARY POLICY

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November 2007

I thank Amanda Smith and Kati Simmons for outstanding research assistance on this project. I also thank participants at the 2007 CIRANO workshop on data revisions, the University of Richmond Economics department seminar series, and participants at the Missouri Valley Economics Association, as well as Carlo Altavilla. This paper was written in part while the author was a visiting scholar at the Federal Reserve Bank of Philadelphia. The views expressed in this paper are those of the author and do not necessarily represent the views of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

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ABSTRACT

This paper examines the characteristics of the revisions to the inflation rate as measured by the personal consumption expenditures price index both including and excluding food and energy prices. These data series play a major role in the Federal Reserve's analysis of inflation.

We examine the magnitude and patterns of revisions to both PCE inflation rates. The first question we pose is: What do data revisions look like? We run a variety of tests to see if the data revisions have desirable or exploitable properties. The second question we pose is related to the first: can we forecast data revisions in real time? The answer is that it is possible to forecast revisions from the initial release to August of the following year. Generally, the initial release of inflation is too low and is likely to be revised up. Policymakers should account for this predictability in setting monetary policy.

REVISIONS TO PCE INFLATION MEASURES:

IMPLICATIONS FOR MONETARY POLICY

In 2000, the Federal Reserve changed its main inflation variable from the consumer price index (CPI inflation) to the inflation rate in the personal consumption expenditures price index (PCE inflation). The Fed cited three main reasons for the switch: (1) PCE inflation is not subject to as much upward bias as the CPI because of substitution effects; (2) PCE inflation covers a more comprehensive measure of consumer spending than the CPI; and (3) PCE inflation is revised over time, allowing for a more consistent time series.[1] Then, in 2004, the Federal Reserve changed its main inflation variable from the PCE inflation rate to the inflation rate as measured by the personal consumption expenditures price index excluding food and energy prices (core PCE inflation). The core PCE inflation measure was preferred because it "is better as an indicator of underlying inflation trends than is the overall PCE price measure previously featured."[2] In 2007, the Fed decided that it should forecast both overall PCE inflation and core PCE inflation.[3] These series now play a major role in the Federal Reserve's analysis of inflation and are the inflation variables that are forecast by the FOMC governors and presidents and are presented in the Fed chairman's semi-annual testimony before Congress. If the Federal Reserve moves to a system of inflation targeting, one of these inflation measures might become the variable being targeted.

Unlike the inflation rate based on the consumer price index (CPI), the PCE inflation rate and the core PCE inflation rate are subject to revision, as are all the components of the national income and product accounts. While one might argue in favor of forecasting the CPI inflation

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[1] Monetary Policy Report to the Congress, February 2000, p. 4.

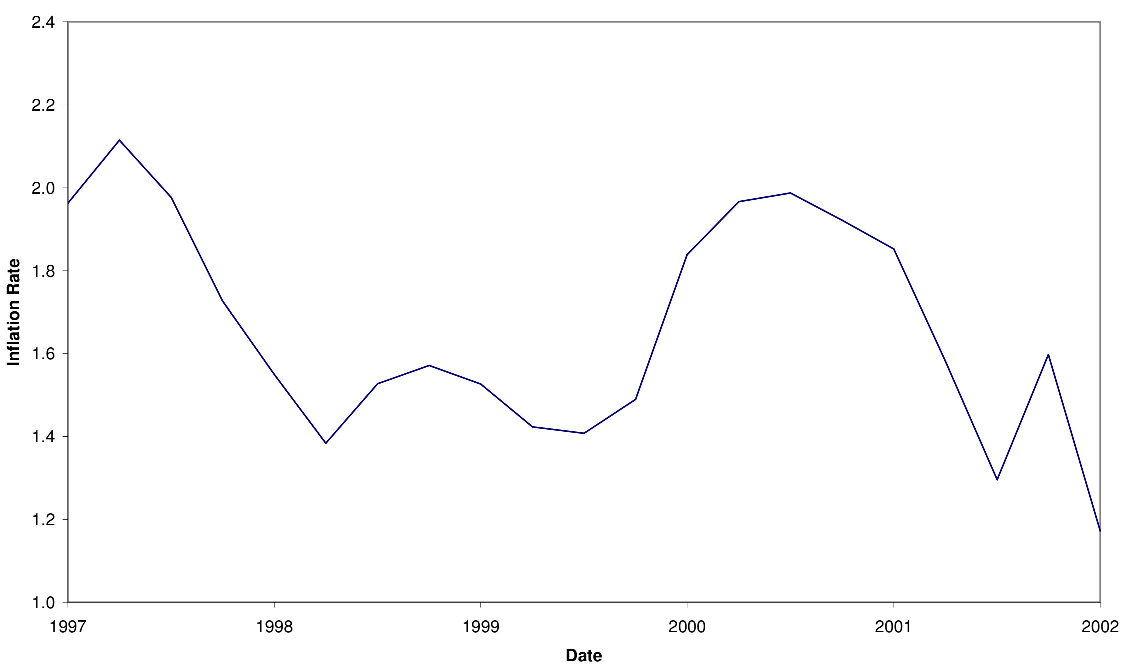
[2] Monetary Policy Report to the Congress, July 2004, p. 3.

[3] Bernanke, Ben S. "Federal Reserve Communications." Speech at the Cato Institute, November 14, 2007.

rate because it is not revised, the lack of revision probably means that the CPI inflation rate is less accurate than the PCE inflation measures as a representation of true inflation. The revisions to the PCE inflation rates occur because of additional source data that are better able to determine the nominal level of personal consumption expenditure and how that level is broken down between real consumption and changes in consumer prices.

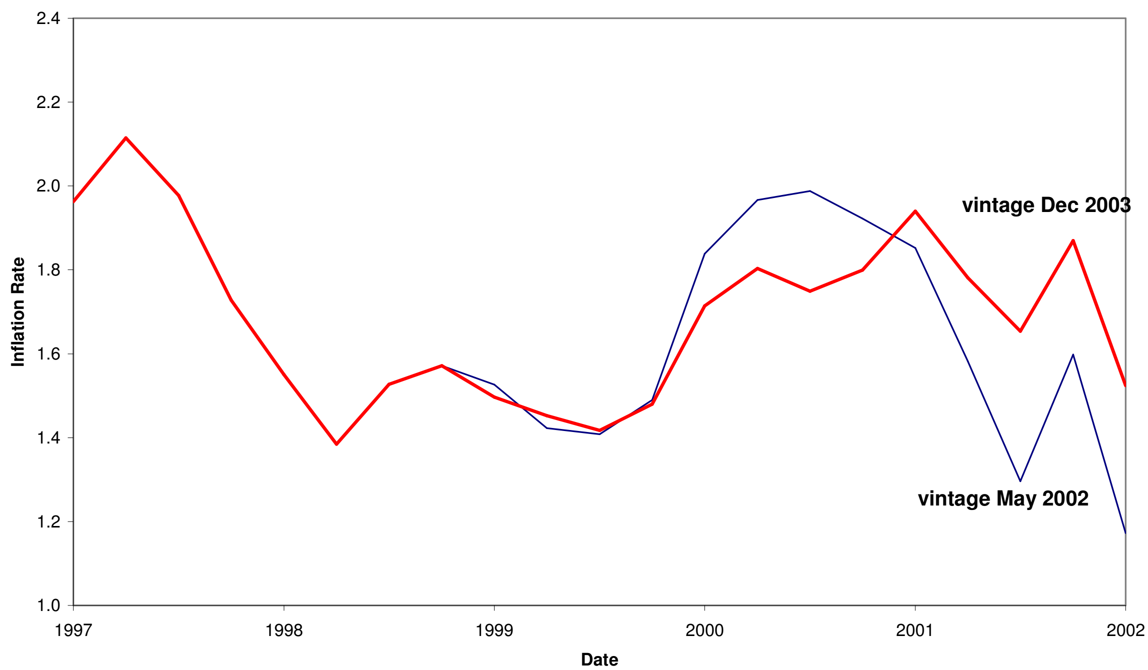
Monetary policymakers use data on the PCE inflation rate and core PCE inflation rate in making decisions. But if they put too much weight on initial data releases, which are subsequently revised, they may make severe errors in setting policy. For example, consider the core PCE inflation rate as it appeared in May 2002. At the time, inflation (measured as the percentage change in the price level from four quarters earlier) appeared to be falling sharply, as Figure 1 shows.

Figure 1
Core PCE Inflation Rate from 1997Q1 to 2002Q1, Vintage May 2002



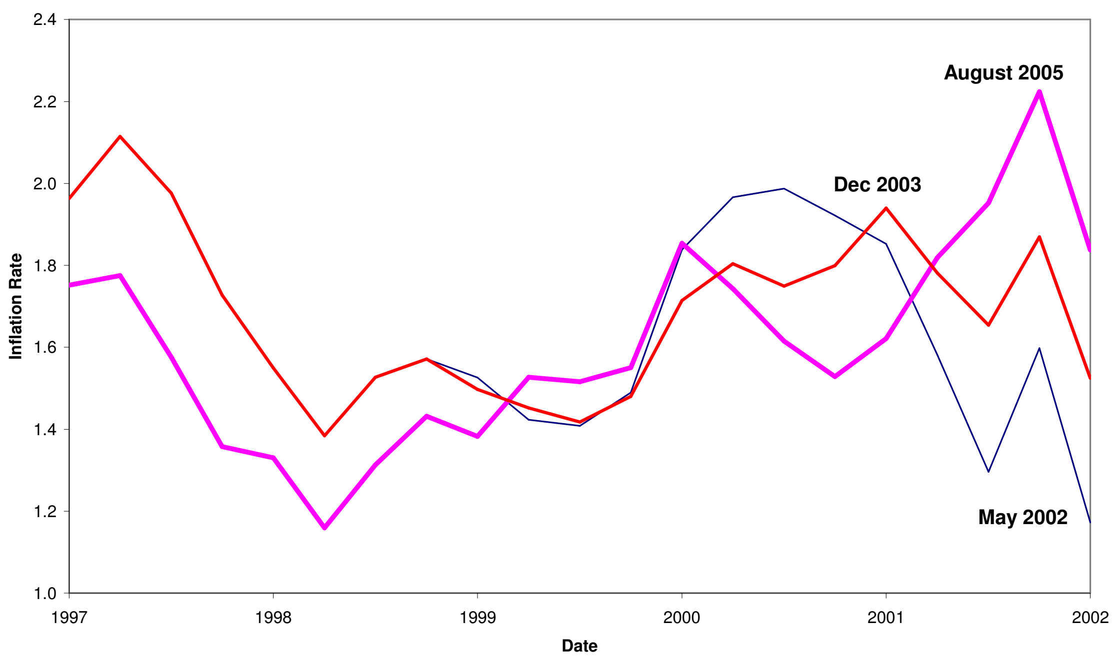
By May 2003, the statement released after the FOMC meeting noted that there could be "an unwelcome substantial fall in inflation." In a few years, though, the Fed's worries about the fall in inflation seen in this figure would dissipate—not just because the Fed's easy monetary policy would lead to an increase in inflation, but because the decline in inflation from 2000 to 2002 would soon be revised away. For example, in December 2003, the language in the statement after FOMC meetings began to note that the worries about an unwelcome fall in inflation had begun to diminish. As Figure 2 shows, inflation in 2001 and early 2002 had been revised up by December 2003, so the drop in inflation in early 2002 did not look nearly as worrisome as it had in May 2002.

Figure 2
Core PCE Inflation Rate from 1997Q1 to 2002Q1, Vintages May 2002 and December 2003



In fact, a few years later, the worries about a drop in inflation in early 2002 seem completely misplaced; if anything, the Fed's worry should have been about an unwelcome rise in inflation from 2000 to late 2001, as Figure 3 shows.

Figure 3
Core PCE Inflation Rate from 1997Q1 to 2002Q1, Vintages May 2002, Dec. 2003, Aug. 2005



Because the PCE inflation rates are revised, as this example illustrates, policymakers need to understand the magnitude of those revisions. This paper seeks to examine those revisions, to determine their overall characteristics, and to investigate the extent to which the revisions might be forecastable. We begin by discussing the data on PCE inflation and its revisions, then analyze a number of tests on the revisions to see if the revisions have desirable characteristics. We use this analysis as a guide to forecasting revisions to PCE inflation in real time. We then discuss the implications of these revisions for monetary policymakers.

RELATED LITERATURE

Economists have been studying the empirical properties of data revisions since Zellner (1958). Mankiw, Runkle, and Shapiro (1984) found that revisions to the money stock data were reductions of measurement error, so that the initial release of the data was not an optimal forecast of the later revised data. Mankiw and Shapiro (1986) introduced the terminology distinguishing between noise revisions (such as those that occur for the money stock), whose revisions are predictable, and news revisions, which are not forecastable. They find that the initial releases of nominal output and real output data are optimal forecasts of the revised data, and thus have news revisions. Mork (1987) suggests that in fact the data released by the government may fit neither the polar case of noise nor the polar case of news, but may be a weighted average of sample information and optimal forecasts. Thus, a test of the correlation of data revisions with information known at the time the data were released provides a general test of well-behavedness of the data; Mork finds the initially released data on real GNP growth to be not well behaved, as they are biased downwards and tend to follow their trends more than they should, so that revisions to the data are correlated with existing data known at the time the initial release is produced.

Faust, Rogers, and Wright (2005) examine data on real output growth for six countries, showing that the revisions are mainly noise. Based on regressions of revised data from initial release to two years later, they are able to predict revisions to the data for most countries. Similarly, Garrett-Vahey (2004) use predictability of UK GDP revisions to provide better out-of-sample forecasts of business cycle turning points, using a similar regression approach.

With results like Mork's, which show that revisions are correlated with existing data, it should be possible for the revisions to be predicted in real time. Attempts to forecast such revisions, however, have not always been successful. Much of the time the correlation of revisions with existing data is only known in-sample for a long sample period, but could not be exploited in real time, perhaps because it owes only to outliers. Howrey (1978) showed how to adjust the observation system in a state space model to account for data revisions. With a similar idea, Conrad and Corrado (1979) used the Kalman filter to form better estimates of revised data on industrial production. Patterson (1995) shows how to exploit the information in past revisions to forecast future revisions using a state space model. A recent analysis by Aruoba (2007) finds that most U.S. data revisions are neither pure news nor noise, as suggested by Mork. Aruoba also finds that revisions are predictable out of sample, using a state space model. However, Croushore (2006) notes that the use of the Kalman filter requires an assumption about the process followed by data revisions; that is, specification of a particular ARIMA process. Given the non-stationary nature of revisions across benchmarks found in Croushore and Stark (2001, 2003), there may be no ARIMA process that works in state space models without introducing additional noise, which would reduce the ability to predict revisions with such a method.

THE DATA

The real-time data set of the Federal Reserve Bank of Philadelphia, created by Croushore and Stark (2001), is the seminal source for data revisions in U.S. macroeconomic data.[4] The data set contains quarterly observations on nominal personal consumption expenditures and real personal consumption expenditures. We use the ratio of these two series to create a real-time data series on the PCE price index, which we call PPCE. The data set does not contain data on the personal consumption expenditures price deflator excluding food and energy prices, hereafter abbreviated PPCEX. Following the Croushore-Stark methodology and checking all data against the ALFRED database at the St. Louis Fed, the PPCEX series was created for every monthly vintage of the data from its inception in February 1996 to February 2007. Data within any vintage are the exact data available to a policymaker at any given date; generally vintages are based on the data available at mid-month.[5] The data show the index value of the core PCE price index in each quarter.

From the data on PPCE and PPCEX, we create two measures of inflation for each variable, for each observation date and each vintage date, one based on the quarterly inflation rate, and a second based on the inflation rate over the preceding four quarters. Our notation for these concepts is $\pi(p, v, t)$ for the PCE inflation rate and $\pi^x(p, v, t)$ for the core PCE inflation rate. The first term, p, is the period over which the inflation rate is calculated, with $p = 1$ for quarterly inflation and $p = 4$ for inflation over the preceding four quarters. The second term, v, is the vintage of the data, which is the date on which a policymaker would observe the data; there is a new vintage every month. The third term, t, is the date for which the inflation rate applies. Thus π(4, 2006M12, 2006Q3) describes the PCE inflation rate from 2005Q3 to 2006Q3, as observed in mid-December 2006, while π^x(1, 2006M12, 2006Q3) describes the annualized core PCE

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[4] See Croushore and Stark (2001) for a description of the overall structure of the real-time data set. Go to the Philadelphia Fed's web site for the data: www.philadelphiafed.org/econ/forecast/reaindex.html.
[5] The only exception is the first vintage, which was released February 19, 1996; the other vintages were usually released near the end of the preceding month.

inflation rate from 2006Q2 to 2006Q3, as observed in mid-December 2006. If PPCE(v, t) describes the level of the price index relevant to date t observed in vintage v, then:

$$\pi(1, v, t) = \{[(\frac{PPCE(v,t)}{PPCE(v,t-1)})^4] - 1\} \times 100\%\ ,$$

and

$$\pi(4, v, t) = \{[\frac{PPCE(v,t)}{PPCE(v,t-4)}] - 1\} \times 100\%\ .$$

With these two concepts of PCE inflation and core PCE inflation in hand, we can now describe revisions to the data. Almost always, new data are initially released at the end of January (for the 4th quarter), April (1st quarter), July (2nd quarter), and October (3rd quarter). The data are revised in each of the following two months after their initial release, then revised in July of each of the subsequent three years, and revised again in benchmark revisions, which occur about every five years. For the first two monthly revisions and the annual July revisions (recorded in our August vintage each year), the government agency gains access to additional source data that help produce better values for the data. Benchmark revisions incorporate new data from economic censuses, and cause the base year to change, though the change in the base year does not affect the inflation data in the chain-weighted era, which is the period of our entire data set.

Because many revisions occur, we examine a number of different concepts. A variable in the national income and product accounts probably undergoes its greatest revision between its initial release and the August vintage of the following year, which reflects the revision issued in late July. That August vintage is the key vintage because the government has access to income-tax and social-security records, and is thus able to form a much more precise measure of the variable. A natural revision to consider is that from the initial data release to the latest available series, which for us consists of data from vintage February 2007. In addition, we can consider the data revision from the following year's August vintage to the latest available data. However, these concepts have the potential problem that periodically there is a change in the methodology used to create the data, which can occur during benchmark revisions. Because the government agency that creates the data must form a series based on a consistent methodology, it cannot be expected to foresee methodological changes. Thus a finding of a positive mean average revision could occur when a variable is redefined. To keep our results from being overly sensitive to such redefinitions and methodological changes, we also consider the data revision from initial release to the last vintage before a benchmark revision. In our data sample, benchmark revisions occurred in January 1976, December 1980, December 1985, November 1991, January 1996, October 1999 and December 2003. We call our "pre-benchmark revision vintage" as the last vintage before each of these benchmark revisions occurs.

Our notation describing the revisions is described as follows. Let $i(1, t)$ = the initial release of $\pi(1, v, t)$ and $i(4, t)$ = the initial release of $\pi(4, v, t)$. Note that these are released at the same time (in the same vintage), but we cannot describe the vintage as "$t + 1$" because the vintages are monthly while the data are quarterly.

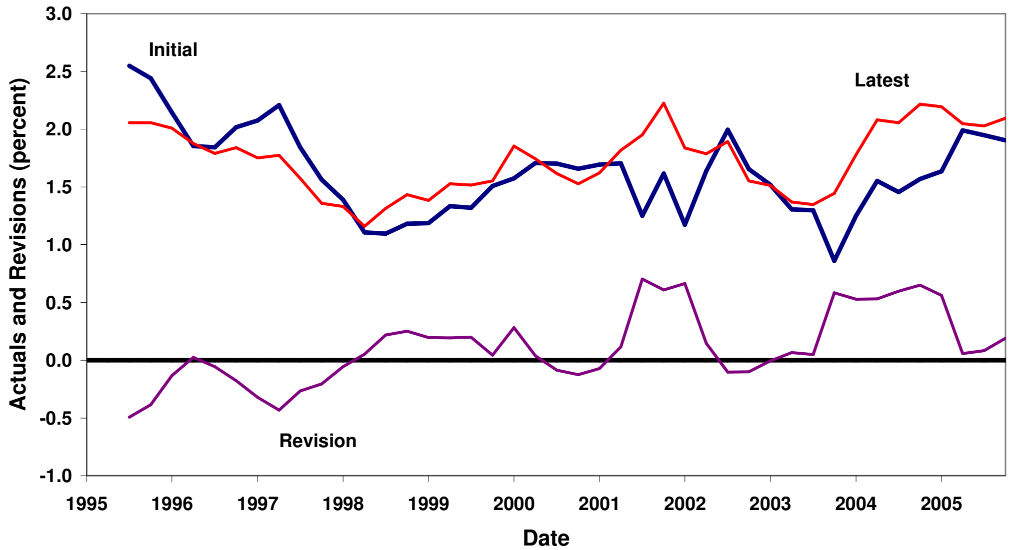
Let the August release of the following year be described as $A(1, t) = \pi(1, v, t)$ and $A(4, t) = \pi(4, v, t)$, where v is the vintage dated August in the year after t. When t is a first quarter date, the initial release of the data shows up in our May vintage, so the following August revision occurs 15 months later. Similarly, when t is a second quarter date, the following August revision occurs 12 months later; for t in the third quarter, it occurs 9 months later; and for t in the fourth quarter, it occurs 6 months later (from February vintage initial release to August vintage). In a few cases, because of upcoming benchmark revisions, there was no August revision, in which case the August revision is the same as the benchmark revision.

For the last vintage before a benchmark revision, let $b(1, t) = \pi(1, v, t)$ and $b(4, t) = \pi(4, v, t)$, where v is the vintage dated in the vintage before the benchmark revision occurs. The latest available data come from data vintage August 2007 and are given by $l(1, t) = \pi(1, \text{Aug. } 2007, t)$ and $l(4, t) = \pi(4, \text{Aug. } 2007, t)$.

Given these definitions, the revisions are: $r(i, A, 1, t) = A(1, t) - i(1, t)$, $r(i, A, 4, t) = A(4, t) - i(4, t)$, $r(i, b, 1, t) = b(1, t) - i(1, t)$, $r(i, b, 4, t) = b(4, t) - i(4, t)$, $r(i, l, 1, t) = l(1, t) - i(1, t)$, $r(i, l, 4, t) = l(4, t) - i(4, t)$, $r(A, b, 1, t) = b(1, t) - A(1, t)$, $r(A, b, 4, t) = b(4, t) - A(4, t)$, $r(A, l, 1, t) = l(1, t) - A(1, t)$, $r(A, l, 4, t) = l(4, t) - A(4, t)$, $r(b, l, 1, t) = l(1, t) - b(1, t)$, and $r(b, l, 4, t) = l(4, t) - b(4, t)$. We define these revisions for the dates, t, from 1995Q3 to 2007Q2. Some of the definitions of revisions will not be defined over the complete period, as fairly recent data have not yet had an August revision. For revisions to core inflation measures, we use the same symbols, but add a superscript "x", for example, $r^x(b, l, 4, t)$ is the revision to the four-quarter core inflation rate between the last benchmark vintage and the latest available vintage at date t.

Visualizing all the various actuals and revisions is difficult, because there are so many. Figure 4 shows one particularly interesting revision series, which is $r^x(i, l, 4, t)$, shown from 1995Q3 to 2005Q4. In the figure, you can see a number of large revisions to the data from 2001 to early 2002, and late 2003 through 2004. Inflation was revised up by about 0.5 percentage point, which is a large change, given that the original inflation rate was around 1.0 percent on a number of those dates.

Figure 4
Four Quarter Inflation Rate in PPCEX
Initial to Latest Revision and Actuals

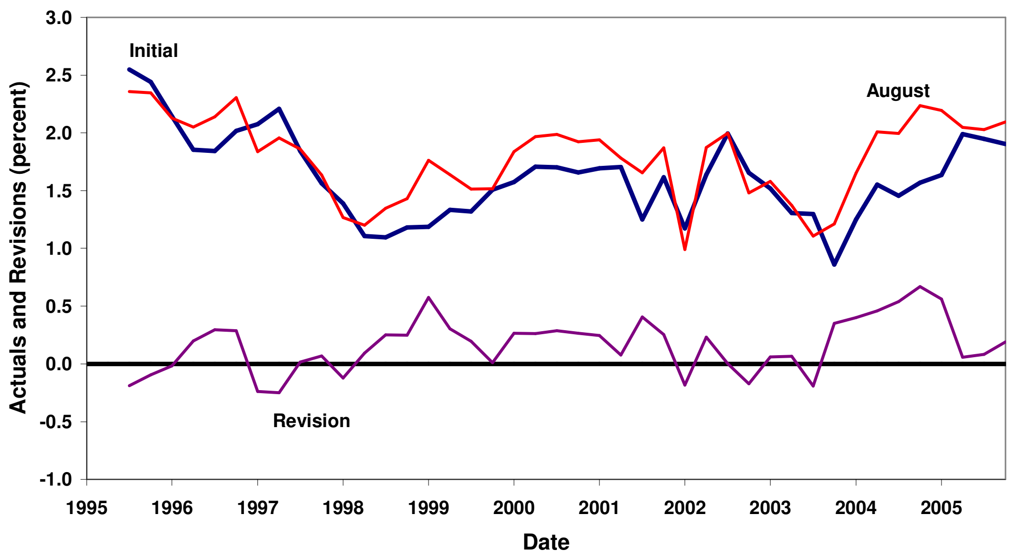


Given that some of the revisions in Figure 4 may have arisen from benchmark revisions, which might include changes in definitions that would be difficult for a policymaker to anticipate, another interesting figure to examine is the revisions from the initial release to the August revision. These revisions avoid most of the benchmark changes that might be difficult to anticipate; they are pure revisions caused by additional sample information (except on the few occasions where there was no August revision because of a benchmark revision). Figure 5 shows the revisions to the core inflation rate from initial to August revisions, which is $r^x(i, A, 4, t)$, in our notation.

This figure is somewhat disturbing, as it shows that most of the core PCE inflation numbers were revised up from their initial release to the first August revision. Some revisions are large; for example, in 2004Q4, the four-quarter core inflation rate was revised up by 0.7 percentage point from its initial release in January 2005 to August 2005. Overall, a quick look at

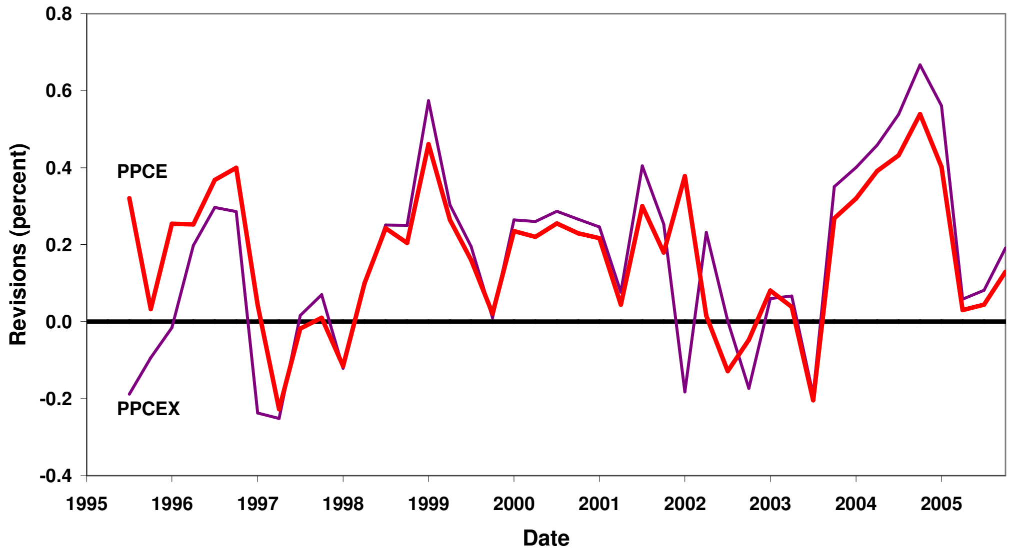
Figure 5 suggests that a policymaker could improve on the initial release of the inflation rate by assuming that it would increase by about 0.15 percentage point by the following August.

Figure 5
Four Quarter Inflation Rate in PPCEX
Initial to August Revision and Actuals



Finally, we note that revisions to PPCE and PPCEX are broadly similar. For example, Figure 6 shows the relationship between revisions from initial release to August revision, for the four quarter inflation rate in both PPCE and PPCEX. Both show the same undesirable property that the average revision is positive. Taking the revision series as broadly similar for both variables, we take advantage of the fact that the PPCE series has been available for much longer (since vintage November 1964), to investigate whether problems with the PPCEX revisions occur just because the history of the variable is so short.

Figure 6
Revisions to Four Quarter Inflation Rate in PPCE and PPCEX
Initial to August Revision



To formalize the ideas suggested by these figures, we proceed to examine the data formally through a variety of statistical tests.

CHARACTERISTICS OF THE REVISIONS

To get a feel for the different revisions and how large they are, Table 1 shows the standard error of each revision concept for 1-quarter inflation rates and 4-quarter inflation rates, for both PCE inflation (PPCE) and core PCE inflation (PPCEX). The table also indicates the interval containing the middle 90 percent of the revisions. We expect that the standard error will increase (as will the 90% interval) as we look at revisions with more time between measurement dates. So, we expect the standard error to rise as we move from *i_A* to *i_b* to *i_l*, or as we move from *A_b* to *A_l*, or as we move from *b_l* to *A_l* to *i_l*. Broadly speaking, these patterns do occur, except that in the cases of *i_A* to *i_b* and from *b_l* to *A_l*. This oddity may occur because the

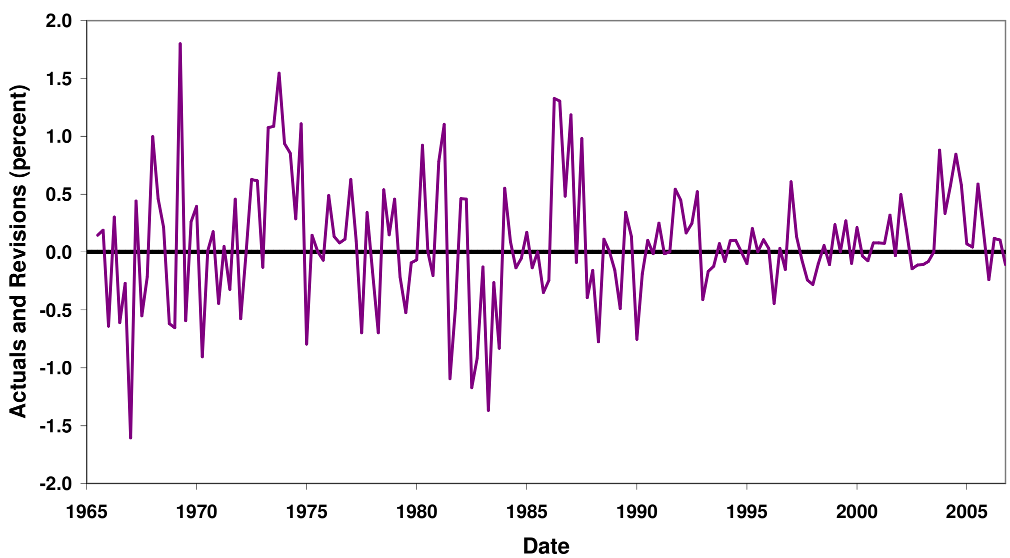
August revisions are irregular, they sometimes occur at the same time as a benchmark revision, and sometimes they occur after a benchmark revision. If these crossover observations occur often enough, that could be sufficient to reverse the ordering of the standard error and the confidence intervals.

Figure 5 above suggested that the revision from initial release to August release in the following year was positive, on average, for core PCE inflation. Formal tests for a zero mean in the revisions to both PCE and core PCE inflation are presented in Table 2. The table's results are consistent with what appears to the eye in Figure 5: that the mean revision from initial to August is significantly above zero. However, this may be an artifact of the small sample (only ten years of data), as the intial-to-August revisions to PPCE from 1965 to 2002 are not significant and have a smaller mean. If we look at the underlying series on nominal PCE (expenditures) and real PCE, we see that the revisions to these series (not shown in the table) are significant only for revisions from initial or August or benchmark to latest available, which suggests that only benchmark revisions cause the mean revision to be non-zero. Thus, despite the appearance of Figure 5, it appears that it would not be useful for policymakers to forecast a revision to PCE inflation based on a non-zero mean.

A test that is often used in evaluating forecast errors is to examine the signs of forecast errors; we can use the same test to evaluate data revisions. The formal sign test has the null hypothesis that revisions are independent with a zero median, which can be tested by examining the number of positive revisions relative to the number of observations, assuming a binomial distribution. Results of the sign test applied to various definitions of revisions are shown in Table 3. Most of the results are consistent with those in Table 2, as zero mean revisions are often accompanied by zero median revisions. And the only case with a significant non-zero sample mean, which is $r^x(i, A, 1, t)$, also fails the sign test, as a significant number of revisions are positive. But the longer sample from the PPCE suggests that this is a feature of the short sample of PPCEX, as it passes the sign test. However, one result is quite surprising—that variable $r(A, b, 1, t)$ has a significant number of negative revisions. For whatever reason, revisions following the first August revision, but prior to a benchmark revision, tend to be negative far more often than they are positive. But the revisions are small in magnitude, so they do not result in a mean revision that is significantly negative. This result bears further investigation to find the source.

The finding of some issues with the sign test suggests that we may need to test for a correlation of revisions across periods. That is, we would like to know, if a revision for one period occurs, is it likely that revisions to nearby periods also occur (positive correlation), or are nearby periods likely to be revised down (negative correlation)? To test this, we calculate the autocorrelations of the various revisions to both variables, with results shown in Table 4. The results show just the first autocorrelation, to conserve space. We test whether there is serial correlation using a Ljung-Box test, with the Q-statistic shown in the table. The results suggest a number of positive autocorrelations of revisions. For core PCE inflation, revisions from initial to latest, initial to benchmark, and benchmark to latest all show evidence of significant autocorrelations. However, given the short sample for core PCE inflation, we look for corroboration by looking at overall PCE inflation. The only revision variable that shows significant autocorrelations for both inflation variables is the revision from initial to benchmark. It has a first autocorrelation coefficient of 0.10, and subsequent autocorrelations of 0.14, 0.15, and 0.12. The large autocorrelation coefficients in the PPCEX sample may be an artifact of the small sample size, as the first autocorrelation on the PPCE revision from initial to benchmark is the largest of all the PPCE revisions in the longer sample. A look at the revisions themselves (Figure 7) shows a number of periods (1972-1974, 1983-1984, 1986-1987, 1992, and 2004), in which many revisions have the same sign and appear correlated.

Figure 7
One Quarter Inflation Rate in PPCE
Initial to Benchmark Revision



If we think of early releases of the data as forecasts of the latest available data (or possibly the last vintage before a benchmark revision occurs), we can examine the root-mean-squared error (RMSE) of each actual series. Table 5 shows calculations of these RMSEs. For forecasting the latest available data, the RMSE declines as we move from initial release to August release to pre-benchmark release, as we might expect. The improvement in the RMSEs is quite large for core PCE inflation, perhaps in part because of the short sample period. The improvement is much more modest for PCE inflation. For forecasting the pre-benchmark revision, we again see some improvement between the initial release and the August release, though for PCE inflation there improvement is quite small. Still, the results suggest that gaining additional data indeed reduces the forecast error, when taking the early release as a forecast of the later release.

An alternative way to think about this forecasting ability of early releases is to calculate the signal-to-noise ratio, suggested by Öller and Teterukovsky (2007). The signal-to-noise ratio, also shown in Table 5, is calculated as:

$$SNR = 1 - \frac{MSE_l}{s_L^2},$$

where l is a vintage between 1 and L, L is the latest available vintage, and

$$MSE_l = \frac{1}{T}\sum_{t=1}^{T}(y_{lt} - y_{Lt})^2 \text{ , } l = 1, 2, \ldots, L.$$

The results show that, compared with other variables, the signal-to-noise ratio for PCE inflation and core PCE inflation is fairly high, exceeding 90%. Later vintages of core PCE inflation have higher signal-to-noise ratios than earlier vintages, as we might expect. However, for PCE inflation itself, there is not much difference in the signal-to-noise ratio across vintages, which is surprising, though consistent with the RMSE result of very small differences in the RMSEs. The cause of this result warrants further investigation.

Since the seminal papers of Mankiw, Runkle, and Shapiro (1984) and Mankiw and Shapiro (1986), researchers have distinguished between data revisions that are characterized as either containing news or reducing noise. In Croushore-Stark (2003), we found that many components of GDP were a mix of news and noise. The distinction is an important one, because a variable whose revisions can be characterized as containing news are those for which the government data agency is making an optimal forecast of the future data. Then a revision to the data will not be correlated with the earlier data. On the other hand, a variable that is one for which the revisions reduce noise is one in which the revisions are correlated with the earlier data.

News revisions have the property that the standard deviation of the variable over time rises as the variable gets revised; noise revisions have standard deviations that decline as the variable gets revised. So, one simple test of news and noise is to examine the pattern of the standard deviation across degrees to which data have been revised, as we show in Table 6. For core PCE inflation, the standard deviation declines as we move from initial release to August release to pre-benchmark release to latest-available data, which suggests that revisions to PPCEX are characterized as reducing noise. For the longer sample period of the PPCE, the same is not true. The standard deviation rises between the August release and the pre-benchmark release, but falls between the initial release and pre-benchmark, as well as between the pre-benchmark release and latest data. This suggests that revisions between August and benchmarks contain news.

A second test of news or noise comes from an examination of the correlation between revisions to data and the different concepts of actuals. If there is a significant correlation between a revision and later data, then the revisions fit the concept of adding news. But if there is a significant correlation between a revision and earlier data, then the revisions fit the concept of reducing noise. Correlations for core PCE inflation and PCE inflation are shown in Table 7. For core PCE inflation, the results are consistent with the results from Table 6 that suggest that the revisions are mainly reducing noise. Nine (out of 10 possible) correlations between revisions and earlier data are significantly different from zero; zero (out of 4 possible) correlations between revisions and later data are significantly different from zero. For PCE inflation, the results are not as clear, as seven (out of 10 possible) correlations between revisions and earlier data are significantly different from zero; one (out of 4 possible) correlations between revisions and later data is significantly different from zero. The mixed results for PPCE in Table 7 are consistent with the mixed results from Table 6, suggesting that the revision from August to pre-benchmark data reflects news, while the other revisions reflect noise.

Overall, the news-noise results suggest that it may be possible to predict the revisions between the initial release and August release and between the pre-benchmark release and latest-available data.

FORECASTABILITY OF THE REVISIONS

Can we use the results on the characteristics of the revisions to make forecasts of the revisions? One possibility is to use the negative correlation between the initial release of the data and the revision, shown in Table 7, to try to forecast the revision. If the correlation is strong enough, we should be able to reduce the root-mean-squared error of the revision from the values shown in Table 5. The problem, of course is that the correlations shown in Table 7 can only be observed after the fact from the complete sample. The question is, could we, in real time, calculate the correlations between earlier release and known revisions and then use that correlation to make a better guess about the value of the variable after revision?

Given that the revision from the initial release to the August revision was characterized as reducing noise, we proceed to forecast the initial-to-August revision in the following way. Consider a policymaker in the second quarter of 1985 who has just received the initial release of the PCE inflation rate for 1985Q1.[6] First, use as the dependent variable in a regression all the data on revisions from initial release to the August release that you have observed through the current period, which in this case gives a sample from 1965Q3 to 1983Q4. Regress these revisions on the initial release for each date and a constant term:

$$r(i, A, 1, t) = \alpha + \beta\, i(1, t) + \varepsilon(t). \tag{1}$$

Use the estimates of α and β to make a forecast of the August revision that will occur in 1986:

$$\hat{r}(i, A, 1, 1985Q1) = \hat{\alpha} + \hat{\beta} \cdot i(1, 1985Q1).$$

Repeat this procedure for every new initial release from 1985Q2 to 2006Q4. Now, based on this forecast of a revision, formulate a forecast of the value of the August revision for each date from 1985Q1 to 2006Q4, based on the formula:

$$\hat{A}(1, t) = i(1, t) + \hat{r}(i, A, 1, t). \tag{2}$$

Finally, we ask the question, is it better to use this estimate of the revision based on equation (2), or would assuming no revision provide a better forecast of the August release? We examine this by looking at the root-mean-squared-forecast error, taking the actual August release value as the object to be forecasted, and comparing the forecast of that value given by equation (2) with the forecast of that value assuming that the initial release is an optimal forecast of the August release. Results of conducting such a forecast-improvement exercise are shown in panel A of Table 8.

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[6] We start with the observation for 1985:Q1 to allow enough observations at the start of the period to prevent having too small of a sample period for the regressions that follow, yet still have enough out-of-sample periods to provide a meaningful test. Also, the small sample size for core PCE inflation makes it impossible to do any useful prediction of revisions, so in this section we focus only on overall PCE inflation.

The results show that it is indeed possible to forecast the revision that will occur in August. Regression coefficients of equation (1) show a positive constant term and a negative slope coefficient (across all of the regressions, each with a different real-time data vintage used in the regression). The root-mean-squared error declines about 8 percent, which is indicated by the Forecast Improvement Exercise Ratio of 0.922, which is the ratio of the RMSE based on equation (2) to the RMSE based on forecasting no revision from initial release to August revision.

We attempted a similar forecast improvement exercise for forecasting the revision that occurs from each pre-benchmark release to the latest-available data. The difficulty in this exercise is that, in real time, the vintage of the data that is "latest available" changes over time. Since our interest is in forecasting based on real-time vintages, we must follow a procedure that someone might engage in without peeking at future data. We proceed as follows:

(1) For each pre-benchmark date (vintages dated 1985Q4, 1991Q4, 1995Q4, 1999Q3, and 2003Q4), run a regression on the sample of data for all observations for which you have a benchmark observation that has subsequently been revised. For example, when you get the 1985Q4 vintage, data between 1965Q3 and 1980Q3 have both a pre-benchmark value (based on vintage 1980Q4) and were revised in the benchmark revision of December 1980 and thus have different values in the current vintage of 1985Q4. Regress the revisions from that benchmark vintage to the current vintage on the benchmark release values for each date and a constant term:

$$r(b, \text{v1985Q4}, 1, t) = \alpha + \beta\, b(1, t) + \varepsilon(t). \qquad (3)$$

Use the estimates of α and β to make a forecast of the revision from benchmark to latest available data that will occur in the future. For example, the forecasted revision for observation 1985Q1 is:

$$\hat{r}(b,l,1,1985Q1) = \hat{\alpha} + \hat{\beta} \cdot b(1,1985Q1) .$$

Repeat this procedure for every new benchmark value from 1985Q2 to 2003Q3.[7] Now, based on this forecast of a revision, formulate a forecast of the value of the revision from benchmark to latest available data for each date from 1985Q1 to 2003Q3, based on the formula:

$$\hat{l}(1,t) = b(1,t) + \hat{r}(b,l,1,t) . \tag{4}$$

Results of this exercise are shown in Table 8. Unlike forecasting the revisions from initial to August, this forecast improvement exercise fails miserably. The RMSE rises by 38 percent, from 0.681 to 0.940. One reason for this failure to forecast the revisions successfully, even though the news-noise tests suggested noise, is that in real time, the latest available data used in the news-noise test are not available. That is, the news-noise test is made using the full sample. But when a policymaker receives a benchmark revision, and wants to know if she should be able for forecast a future revision, she must use today's vintage as the latest available. Thus a later benchmark revision could change the view of the latest available data.

An additional experiment that we could run would be to consider the point of view of someone just before the time of the most recent benchmark revision, in December 2003, and asking if, based on the current data, the revisions of all the past observations back to 1985Q1 can

[7] Note that the sample period ends in 2003:Q3 because 2003:Q3 is the last date for which a benchmark revision has occurred.

be forecasted. That is, rather than a set of rolling regressions as each subsequent benchmark revision occurs, the policymaker standing in December 2003 wants to predict the outcome of the benchmark revision that is about to occur. In this case, we could assume that the policymaker uses data in vintage 2003Q4, knows the pre-benchmark data for each observation from 1985Q1 to 1999Q2 (all of which has been revised by the benchmark revision that occurred in October 1999), runs regression equation (3) based on using vintage 2003Q4 as latest available data to try to forecast the latest available data that will appear in the release of December 2003, as is recorded in our vintage of 2004Q1. The results of this exercise, shown in panel C of Table 8, are a bit better than the results in panel B, as expected, but suggest that again the attempt to forecast the revision is not successful. In this case, the RMSE rises about 4 percent.

Based on these exercises, it appears that one can forecast revisions from initial data to August release, but not other revisions. For the latest data for the first two quarters of 2007, we can use these results to forecast the values that will appear in the August 2008 release.[8] They are:

	PCE Inflation		Core PCE Inflation	
	Initial Release	Forecast Aug2008	Initial Release	Forecast Aug2008
Date				
2007Q1	3.35%	3.50%	2.24%	2.45%
2007Q2	4.31%	4.40%	1.42%	1.67%

[8] Because the sample period is not long enough to run the appropriate regressions for core PCE inflation, the results that are shown in the table below are based on using the regression coefficients from the regressions for overall PCE inflation, then applying those coefficients to the core PCE inflation data.

The forecasts of the revisions range from 0.09 percentage point to 0.25 percentage point for 2007Q2. So, some revision forecasts are small while others are considerably larger.

Suppose we return to the data reported in Figure 1 for 2002Q1. If we had used the regression method based on equations (1) and (2) in real time, we would forecast that the core inflation rate for 2002Q1 would be revised from 1.17% reported in the May 2002 vintage up to 1.55% in August 2003, an upward revision of 0.38%. In fact, the data were revised up to 1.52% in August 2003, fairly close to our forecast.

Revisions of this size could have a substantial impact on monetary policy. An upward revision of a four-quarter inflation rate by 0.35% is large. If the Fed were following a Taylor rule, for example, anticipation of such a revision could cause the Fed to want to increase its target for the federal funds rate by 50 basis points, relative to its target if it thought the initial release was an optimal forecast of the true inflation rate.

CONCLUSIONS AND IMPLICATIONS FOR POLICYMAKERS

The inflation rate as measured by the percentage change in the PCE price index and core PCE price index are subject to considerable revisions. Monetary policymakers should understand the nature of these revisions and factor in the possibility of revisions to the data in making decisions about monetary policy. Clearly, revisions to the PCE inflation rate data are forecastable, and policymakers should forecast revisions to give them a view of what the inflation picture is likely to look like after the data are revised.

REFERENCES

Aruoba, S. Boragan. "Data Revisions Are Not Well Behaved." *Journal of Money, Credit, and Banking*, forthcoming 2007.

Conrad, William, and Carol Corrado. "Application of the Kalman Filter to Revisions in Monthly Retail Sales Estimates," *Journal of Economic Dynamics and Control* 1 (1979), pp. 177-98.

Croushore, Dean. "Forecasting with Real-Time Macroeconomic Data." In: Graham Elliott, Clive W.J. Granger, and Allan Timmermann, eds., *Handbook of Economic Forecasting* (Amsterdam: North-Holland, 2006).

Croushore, Dean, and Tom Stark. "A Real-Time Data Set for Macroeconomists," *Journal of Econometrics* 105 (November 2001), pp. 111–130.

Croushore, Dean, and Tom Stark, "A Real-Time Data Set for Macroeconomists: Does the Data Vintage Matter?" *Review of Economics and Statistics* 85 (August 2003), pp. 605–617.

Faust, Jon, John H. Rogers, and Jonathan H. Wright. "News and Noise in G-7 GDP Announcements." *Journal of Money, Credit, and Banking* 37 (June 2005), pp. 403–419.

Federal Reserve, Board of Governors, *Monetary Report to the Congress*, February 2000 and March 2004, available on-line at: http://www.federalreserve.gov/boarddocs/hh/

Garratt, Anthony, and Shaun P. Vahey. "UK Real-Time Macro Data Characteristics." Manuscript, November 2004.

Howrey, E. Philip. "The Use of Preliminary Data in Econometric Forecasting," *Review of Economics and Statistics* 60 (May 1978), pp. 193-200.

Krikelas, Andrew C. “Revisions to Payroll Employment Data: Are They Predictable?” Federal Reserve Bank of Atlanta *Economic Review* (Nov./Dec. 1994), pp. 17–29.

Mankiw, N. Gregory, and Matthew D. Shapiro. “News or Noise: An Analysis of GNP Revisions.” *Survey of Current Business* (May 1986), pp. 20-5.

Mankiw, N. Gregory, David E. Runkle, and Matthew D. Shapiro. “Are Preliminary Announcements of the Money Stock Rational Forecasts?” *Journal of Monetary Economics* 14 (July 1984), pp. 15-27.

Mork, Knut A. “Ain’t Behavin’: Forecast Errors and Measurement Errors in Early GNP Estimates,” *Journal of Business and Economic Statistics* 5 (April 1987), pp. 165-75.

Öller, Lars-Erik, and Alex Teterukovsky. “Quantifying the Quality of Macroeconomic Variables.” *International Journal of Forecasting* 23 (2007), pp. 205–217.

Patterson, K. D. “A State Space Model for Reducing the Uncertainty Associated with Preliminary Vintages of Data with an Application to Aggregate Consumption.” *Economics Letters* 46 (1994), pp. 215–222.

Patterson, K. D. “A State Space Approach to Forecasting the Final Vintage of Revised Data with an Application to the Index of Industrial Production.” *Journal of Forecasting* 14 (1995), pp. 337–350.

Patterson, K.D., and S.M. Heravi. “Data Revisions and the Expenditure Components of GDP,” *Economic Journal* 101 (July 1991), pp. 887-901.

Zellner, Arnold. “A Statistical Analysis of Provisional Estimates of Gross National Product and Its Components, of Selected National Income Components, and of Personal Saving,” *Journal of the American Statistical Association* 53 (March 1958), pp. 54-65.

Table 1
Statistics on Revisions

One-Quarter Inflation Rate

	PPCEX		PPCE	
Revision	standard error	90% interval	standard error	90% interval
i_A	0.41	−0.48, 0.79	0.65	−1.02, 1.08
i_b	0.39	−0.48, 0.64	0.54	−0.79, 1.08
i_l	0.46	−0.59, 0.91	0.89	−1.37, 1.48
A_b	0.33	−0.58, 0.38	0.53	−0.98, 0.70
A_l	0.40	−0.71, 0.69	0.84	−1.31, 1.36
b_l	0.31	−0.39, 0.51	0.85	−1.36, 1.41

Four-Quarter Inflation Rate

	PPCEX		PPCE	
Revision	standard error	90% interval	standard error	90% interval
i_A	0.23	−0.19, 0.56	0.32	−0.38, 0.57
i_b	0.26	−0.25, 0.58	0.26	−0.34, 0.56
i_l	0.32	−0.38, 0.65	0.44	−0.59, 0.95
A_b	0.21	−0.50, 0.17	0.29	−0.47, 0.36
A_l	0.24	−0.38, 0.30	0.43	−0.73, 0.83
b_l	0.16	−0.28, 0.30	0.44	−0.91, 0.71

Note: The sample period is 1995Q3 to 2005Q4 for PPCEX and 1965Q3 to 2002Q4 for PPCE.

Table 2
Zero-Mean Test

	PPCEX		**PPCE**	
Revision	$\bar{x}$	*p*-value	$\bar{x}$	*p*-value
i_l	0.09	0.20	0.11	0.12
i_b	0.05	0.42	0.06	0.20
i_A	0.14	0.03*	0.10	0.06
A_b	−0.09	0.08	−0.04	0.31
A_l	−0.05	0.42	0.01	0.85
b_l	0.04	0.37	0.06	0.41

Note: $\bar{x}$ is the mean revision and the *p*-value is for the test that the mean revision is zero. The sample period is 1995Q3 to 2005Q4 for PPCEX and 1965Q3 to 2002Q4 for PPCE. An asterisk highlights a *p*-value less than 0.05. Only the one-quarter revision is tested, as the four-quarter revisions are subject to overlapping-observations problems.

Table 3
Sign Test

	PPCEX		**PPCE**	
Revision	*s*	*p*-value	*s*	*p*-value
i_l	0.60	0.22	0.57	0.07
i_b	0.52	0.76	0.52	0.62
i_A	0.67	0.03*	0.57	0.07
A_b	0.45	0.54	0.37	0.00*
A_l	0.43	0.35	0.47	0.41
b_l	0.43	0.35	0.54	0.33

Note: *s* is the proportion of the sample with a positive revision and the *p*-value is for the test that *s* differs significantly from 0.50 under the binomial distribution. The sample period is 1995Q3 to 2005Q4 for PPCEX and 1965Q3 to 2002Q4 for PPCE. An asterisk highlights a *p*-value less than 0.05. Only the one-quarter revision is tested, as the four-quarter revisions are subject to overlapping-observations problems.

Table 4
Autocorrelations of Revisions

	PPCEX		**PPCE**	
Revision	$a1$	p-value	$a1$	p-value
i_l	0.43	0.01*	–0.08	0.55
i_b	0.45	0.00*	0.10	0.03*
i_A	0.02	0.85	–0.04	0.38
A_b	0.30	0.20	0.05	0.44
A_l	0.33	0.18	–0.03	0.45
b_l	0.22	0.02*	0.03	0.80

Note: $a1$ is the first autocorrelation coefficient and the p-value is the value is for the Ljung-Box Q test that has the null of no serial correlation in the revisions. The sample period is 1995Q3 to 2005Q4 for PPCEX and 1965Q3 to 2002Q4 for PPCE. An asterisk highlights a p-value less than 0.05. Only the one-quarter revision is tested, as the four-quarter revisions are subject to overlapping-observations problems.

Table 5
Root Mean Square Errors and Signal-to-Noise Ratios

Actual concept	**RMSEs**		**Signal-to-Noise Ratio**	
	PPCEX	**PPCE**	**PPCEX**	**PPCE**
Forecasting latest				
initial	0.46	0.89	0.935	0.968
August	0.40	0.84	0.952	0.972
pre-benchmark	0.31	0.85	0.970	0.971
Forecasting pre-benchmark				
initial	0.39	0.54	0.952	0.989
August	0.33	0.53	0.962	0.989

Note: *a*1 is the first autocorrelation coefficient and the *p*-value is the value is for the Ljung-Box Q test that has the null of no serial correlation in the revisions. The sample period is 1995Q3 to 2005Q4 for PPCEX and 1965Q3 to 2002Q4 for PPCE. An asterisk highlights a *p*-value less than 0.05. Only the one-quarter revision is tested, as the four-quarter revisions are subject to overlapping-observations problems.

Table 6
Standard Deviations of Inflation Rates
(In Percentage Points)

Data Set	PPCEX	PPCE
Initial Release	0.582	2.757
August	0.578	2.680
Pre-Benchmark	0.536	2.817
Latest	0.478	2.697

Note: Each number in the table is the standard deviation of the growth rate of the variable listed at the top of each column for the data set listed in the first column. If revisions contain news, the standard deviation should increase going down a column; if the revisions reduce noise, the standard deviation should decrease going down a column. The sample period is 1995Q3 to 2005Q4 for PPCEX and 1965Q3 to 2002Q4 for PPCE.

Table 7
Correlations of Revisions with Growth Rates

A. PPCEX

Revisions/Data Set	**Initial**	**August**	**Pre-benchmark**	**Latest**
Initial to August	–0.36†	0.35?	0.08	0.12
	(3.2)	(2.3)	(0.6)	(1.0)
Initial to Pre-benchmark	–0.45†	0.14	0.24	0.16
	(3.2)	(0.1)	(1.6)	(1.2)
Initial to Latest	–0.60†	–0.19	–0.12	0.22?
	(7.6)	(1.1)	(0.7)	(2.0)
August to Pre-benchmark	–0.07	–0.41†	0.18?	0.04
	(0.8)	(3.0)	(2.6)	(0.6)
August to Latest	–0.31†	–0.57†	–0.22?	0.13?
	(3.0)	(5.9)	(2.2)	(2.0)
Pre-benchmark to Latest	–0.32†	–0.29†	–0.47†	0.13
	(2.7)	(2.7)	(4.2)	(1.1)

Note: Each entry in the table reports the correlation of the variable from the data set shown at the top of the column to the revision shown in the first column, with the absolute value of the adjusted t-statistic in parentheses below each correlation coefficient. The sample period is 1995Q3 to 2005Q4 for PPCEX and 1965Q3 to 2002Q4 for PPCE.

An asterisk (*) means there is a significant (at the 5% level) correlation between the revision and the later data, implying "news."

A dagger (†) means there is a significant (at the 5% level) correlation between the revision and the earlier data, implying "noise."

A question mark (?) means there is a significant correlation that does not fit easily into the news/noise dichotomy.

Table 7 (continued)
Correlations of Revisions with Growth Rates

B. PPCE

Revisions/Data Set	**Initial**	**August**	**Pre-benchmark**	**Latest**
Initial to August	–0.23†	0.00	–0.11	–0.09
	(2.5)	(0.0)	(1.3)	(1.1)
Initial to Pre-benchmark	0.01	0.16	0.21	0.14
	(0.1)	(1.3)	(1.7)	(1.2)
Initial to Latest	–0.23†	–0.13	–0.15	0.10
	(2.3)	(1.6)	(1.9)	(1.4)
August to Pre-benchmark	0.30†	0.17†	0.35?	0.26*
	(3.5)	(2.0)	(4.5)	(3.4)
August to Latest	–0.06	–0.14	–0.08	0.18
	(0.7)	(1.5)	(0.8)	(1.8)
Pre-benchmark to Latest	–0.25†	–0.24†	–0.29†	0.01
	(2.4)	(2.3)	(2.7)	(0.1)

Note: Each entry in the table reports the correlation of the variable from the data set shown at the top of the column to the revision shown in the first column, with the absolute value of the adjusted t-statistic in parentheses below each correlation coefficient. The sample period is 1995Q3 to 2005Q4 for PPCEX and 1965Q3 to 2002Q4 for PPCE.

An asterisk (*) means there is a significant (at the 5% level) correlation between the revision and the later data, implying "news."

A dagger (†) means there is a significant (at the 5% level) correlation between the revision and the earlier data, implying "noise."

A question mark (?) means there is a significant correlation that does not fit easily into the news/noise dichotomy.

Table 8

RMSEs for Forecast-Improvement Exercises

	RMSE
Panel A: Actuals = August Release	
Forecast based on initial release, eq. (2)	0.452
Assume no revision from initial	0.490
Forecast Improvement Exercise Ratio	0.922
Panel B: Actuals = Latest Available Release	
Forecast based on pre-benchmark release, eq. (4)	0.940
Assume no revision from pre-benchmark	0.681
Forecast Improvement Exercise Ratio	1.380
Panel C: Actuals = vintage 2004Q1	
Forecast based on pre-benchmark release, eq. (4)	0.713
Assume no revision from pre-benchmark	0.686
Forecast Improvement Exercise Ratio	1.039

Note: the Forecast Improvement Exercise Ratio equals the RMSE for the attempt to forecast the revision divided by the RMSE when no revision is forecasted (that is, taking the earlier vintage as the optimal forecast of the later vintage).