A Summary of the Conference on Real-Time Data Analysis

BY TOM STARK

In October 2001, the Federal Reserve Bank of Philadelphia hosted a conference on the use of real-time data by macroeconomists. The conference focused on five topics: data revisions, forecasting, policy analysis, financial research, and macroeconomic research. Below, Tom Stark presents a summary of the conference papers.

Almost nine years ago, the Research Department of the Federal Reserve Bank of Philadelphia began a project to investigate the importance of revisions to economic data. In its early stages, the project consisted of collecting economic data as they existed at various points of time in the past. We assembled an initial data set of key macroeconomic variables — called the real-time data set for macroeconomists — and made the data available on our web site.[1] As part of its research program, the department hosted a two-day conference in October 2001 on the use of real-time data in economics. Economists from the Federal Reserve System and academia presented nine papers, many of which relied on the Philadelphia Fed's data set, illustrating the importance of data revisions in economic analysis. This article summarizes the research presented at the conference.

As anyone who follows the economy knows, economic data are revised often. In fact, many economic variables undergo a nearly continuous process of revision. And those revisions can be very large, sometimes large enough to change economists' view of economic conditions in the past — and sometimes large enough to change the results of empirical studies. So, what are real-time data? Simply put, real-time data are the data as they existed prior to subsequent revisions. Since the data undergo many revisions, a real-time data set is one that tracks the values of observations as those values are revised over time.

Research on the effect of data revisions on economic analysis has been ongoing since at least the early 1960s, but such research has never really been in the forefront of economic analysis. Indeed, as noted in the opening paragraph of Frank Denton and John Kuiper's often cited 1965 study: "The problem of measurement error has received rather limited attention in the estimation of econometric models and the application of such models to forecasting. *The customary treatment has been to ignore the problem altogether, or else refer to it and then hastily assume, for the purpose at hand, that such errors do not exist*" (italics added).[2] One reason for such neglect is that analyzing the effect of data revisions is not easy to do: It is time-consuming to collect all the data necessary to track how economic observations change over time. However, in recent years, researchers, such as those at the Philadelphia Fed, have begun to assemble the real-time data required for such analyses. As a consequence, economic researchers are beginning to place more emphasis on the problems associated with revising data. As we will see below, researchers are using real-time data to study the efficiency with which government statisticians construct early releases of data, to see how revisions affect forecasts, to show how economic

[1] For more information on the real-time data set for macroeconomists, see the article by Dean Croushore and Tom Stark, "A Funny Thing Happened on the Way to the Data Bank: A Real-Time Data Set for Macroeconomists," Federal Reserve Bank of Philadelphia *Business Review*, September/October 2000.

[2] For more information on this study, see the article by Frank T. Denton and John Kuiper, "The Effect of Measurement Errors on Parameter Estimates and Forecasts: A Case Study Based on the Canadian Preliminary National Accounts," *Review of Economics and Statistics* (May 1965), pp. 198-206.

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policymakers (such as the members of the Federal Open Market Committee) make their decisions, to examine whether financial assets are priced according to economic fundamentals, and to test how well previous economic studies stand up to revisions in the data.

DATA REVISIONS

A logical precursor to any study of the effect of data revisions on economic analysis is to ask: What is the nature of such revisions? Are the revisions big or small? Are they predictable? And how does the data revision process compare across different countries? Jon Faust, of the Federal Reserve Board, presented a paper that shed some light on these issues. Faust and his co-authors John H. Rogers and Jonathan Wright use the Organization for Economic Cooperation and Development's *Main Economic Indicators* to assemble a data set of preliminary announcements of real GDP growth in the seven largest industrial countries. They define a revision as the difference between "final" real GDP growth, as measured in 1999's data, and the preliminary announcement. The study's sample begins in 1965:Q1 for the United States, Canada, and the United Kingdom, 1970:Q1 for Japan, 1979:Q4 for Italy and Germany, and 1987:Q4 for France and ends in 1997:Q4.

Faust, Rogers, and Wright report that the root-mean-square error of revisions is large for all countries. Indeed, their data indicate that over the full sample "the final annualized growth rate is more than a percentage point different from the preliminary at least half the time in these data." This is an important finding because it suggests that data revisions have the potential to change the way economists view the state of the economy, when that view is based on data that have been revised many times — a theme that some of the other conference papers expanded on.

But perhaps the most surprising finding is the degree to which these large data revisions are predictable, in some countries, on the basis of data *available at the time of the preliminary announcement.* In an initial analysis, the authors found that the preliminary announcement itself explained more than 40 percent of the variation in data revisions in Italy, Japan, and the United Kingdom. This result is notable because it suggests that the statistical agencies in those countries may not be using information efficiently when they construct their preliminary estimates. However, some agencies may be better than others in processing information: The study concludes that there's some evidence of predictability of revisions in Canada, France, Germany, and the U.S., but "the measured degree of predictability is rather modest."

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In the conference's second paper on data revisions, Karen E. Dynan, of the Federal Reserve Board, presented very detailed evidence on the behavior of data revisions in the United States. A particularly timely analysis given the recent performance of the U.S. economy, Dynan's paper, co-authored with Douglas W. Elmendorf, uses the Philadelphia Fed's real-time data set to study whether the provisional estimates of the Bureau of Economic Analysis (BEA) are susceptible to revision around cyclical turning points. Dynan began her talk by discussing the timing of the BEA's data releases for the national income and product accounts, noting that early releases are based on incomplete source data and, consequently, incorporate the BEA's "judgmental assumptions and trends." The authors posit that the BEA's use of extrapolations to estimate missing source data might yield provisional estimates that are too optimistic at cyclical peaks and too pessimistic at troughs.

The Fed researchers began their investigation by examining revisions to real output growth around peaks and troughs, as defined by the National Bureau of Economic Research (NBER). However, they quickly discovered that their ability to pin down precise estimates of the behavior of revisions at turning points was hindered by the small number of business cycles in the U.S. data. Noting that their basic theory also suggests provisional estimates should be particularly prone to revisions during periods of accelerating or decelerating growth, Dynan and Elmendorf investigated the relationship between revisions to provisional estimates of growth and changes in the rate of growth, the latter measured in the data available in the second quarter of 2000. Their statistical analysis indicates that the BEA's provisional estimates do not fully capture accelerations and decelerations in growth, suggesting "some tendency to miss economic turning points."

Discussant David DeJong, of the University of Pittsburgh, noted that there are many ways to define a data revision, depending on the vintage of data taken to represent the revised value, and questioned the emphasis both papers placed on using the most current data for that purpose. In particular, DeJong suggested that policymakers, forecasters, and other economic decision-makers might be more interested in the properties of data revisions constructed on the basis of revised values that are

released at a date closer to the date of the preliminary value.

FORECASTING

Data revisions can present particularly thorny problems for econometric model builders and forecasters. Recent research suggests that failure to account for data revisions when building a model can often result in suboptimal specification decisions. And revisions to a model's initial values can often change that model's forecasts. Two papers at the conference discussed these issues.

Evan Koenig, of the Federal Reserve Bank of Dallas, Sheila Dolmas, and Jeremy Piger, of the Federal Reserve Bank of St. Louis, present theoretical and empirical evidence on a novel way to use the observations of a real-time data set to produce highly accurate short-run forecasts for the growth rate of U.S. real output. Koenig first noted the theoretical implications for forecast accuracy of assuming that the revisions to a forecasting equation's dependent and independent variables are unforecastable. In such a case, Koenig noted, forecast accuracy improves when an analyst estimates his model using *preliminary* observations on the dependent variable and values for the right-hand-side variables measured *at the same time* the dependent variable is measured.

In other words, Koenig and his co-authors find that forecast accuracy is enhanced when an analyst estimates his model using as many vintages of data as there are observations in the sample. That result is striking because it stands at odds with the practice of professional forecasters, who estimate their models on the basis of the latest available observations, not the preliminary observations.

The authors test their theoretical results using the data by building a small-scale forecasting model for predicting within-quarter real output growth. The model relates the growth rate of real output to the growth rates of monthly industrial production, real retail sales, and nonfarm payroll employment. The authors find confirming evidence that their novel way of using real-time observations to estimate a model yields gains in forecast accuracy — as suggested by their theoretical results — compared with how professional forecasters estimate their models. Though some questions may remain about how well this result holds up with alternative sample periods, models, and variables, Koenig, Dolmas, and Piger's analysis has the potential to change the way economists implement estimation and forecasting methods — and the manner in which economists collect their observations.

Athanasios Orphanides, of the Federal Reserve Board, and Simon van Norden, of Ecole des Hautes Etudes Commerciales, Montreal, and CIRANO, study the effect of data revisions on measures of the output gap and the reliability of inflation forecasts that are based on those measures. The study uses the Philadelphia Fed's real-time data set to construct 12 alternative measures of the output gap, finding that (almost) all of these measures appear to be related to future rates of inflation *when the analysis is conducted in-sample.* That result is reassuring because many theoretical models of the economy predict such a relationship. However, when the analysis is extended to an out-of-sample setting, using real-time estimates of the output gap measures, the study finds virtually no evidence that any measure of the output gap helps to predict inflation. Orphanides and van Norden conclude that their results "bring into question the practical usefulness of output-gap-based Phillips curves for forecasting inflation and the monetary policy process." The results also demonstrate rather nicely the pitfalls associated with any model specification process that ignores the presence of data revisions.

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Sharon Kozicki, of the Federal Reserve Bank of Kansas City, discussed both forecasting papers. In commenting on the Koenig, Dolmas, and Piger paper, Kozicki questioned whether the paper's results would hold in all forecasting situations. Regarding Orphanides and van Norden's analysis, Kozicki wondered how closely the paper's simulated real-time forecasts would match actual real-time forecasts. In particular, Kozicki noted that many of the paper's specification decisions might not have been made in real time. Kozicki also noted that none of the paper's proposed measures of the output gap were formed on the basis of the production-function measures of potential output that were sometimes used in the past, and she argued for "real-time econometric techniques — not just real-time data."

POLICY ANALYSIS

In recent years, there has been an explosion of interest in estimating how the Fed reacts to changes in the economy — estimates such as the well-known Taylor rule, which relates the federal funds rate to the rate of inflation and the output gap — and evaluating the stabilization properties of such rules. However, much of that work assumes, either explicitly or implicitly, that real-time data issues are

not very important and that Fed policy can be adequately described as depending on just a few variables. Two conference papers questioned these assumptions.

Ben S. Bernanke, of Princeton University, and Jean Boivin, of Columbia University, analyze past monetary policy decisions within a statistical framework that permits policymakers to possess extremely large information sets. Boivin noted that Fed policymakers have a reputation for looking at a large set of variables in setting monetary policy — that is, Fed policymakers appear to operate within a "data-rich environment." That stands in contrast to the approach taken in traditional empirical analyses of the Fed's behavior, which, for statistical reasons, usually assumes the Fed's information set consists of just a few variables.

Bernanke and Boivin overcome the statistical difficulties associated with large data sets by using a dynamic factor model to summarize the information contained in each of several different data sets, the largest of which contains 215 variables. The authors find: (1) the choice between real-time data and current data is not as important for forecast accuracy as conditioning the forecasts on a large number of variables; and (2) Federal Reserve Greenbook forecasts could have been made more accurate by using factor-model methods. These results are interesting because they suggest that policymakers who make decisions on the basis of forecasts might make better decisions if those forecasts reflect the information from a very large set of variables.

In an analysis of the Fed's monetary policy decisions, Bernanke and Boivin show how to use factor-model methods to obtain estimates of policy feedback parameters when the policymaker uses a large information set. They also show how to test for the limited-information-set restrictions imbedded in Taylor-type policy rules. These results constitute important breakthroughs in the analysis of policy rules because traditional analyses do not permit the policymaker to use large information sets and may thus mismeasure the magnitudes of feedback parameters. The Bernanke and Boivin methodology may also lead to improved estimates of monetary policy shocks, permitting economists to better understand important features of the economy.

Yash Mehra, of the Federal Reserve Bank of Richmond, examines the ability of the Taylor rule to describe Fed policy over two periods: 1968:Q1 to 1979:Q2 and 1979:Q3 to 1987:Q4, corresponding to periods in which U.S. inflation accelerated and decelerated, respectively. Although the Taylor rule has been the subject of extensive investigation, Mehra finds the existing literature lacking in several important respects. First, some analyses are constructed on the basis of feedback parameters not estimated on real-time data. Second, some analyses rely on predictions from the Taylor rule that are not conditioned on the (real-time) observations that policymakers would have known when their decisions were made. Third, some analyses rely on questionable real-time estimates of the output gap.

Mehra uses the Philadelphia Fed's real-time data set for constructing improved (real-time) estimates of the output gap and for estimating and forecasting the Taylor rule. On this basis, he finds: (1) in the 1960s and 1970s, monetary policy, as measured by the Taylor rule, responded to rising inflation in a far "too timid" fashion, a result not found in some previous studies; (2) the speed with which monetary policy adjusts to changes in fundamentals, as given in the Taylor rule, is much higher than estimated in previous studies. Mehra attributes these differences to his use of real-time data.

Discussant Athanasios Orphanides, of the Federal Reserve Board, suggested that an understanding of past policy decisions is vital for identifying periods in which monetary policy may have erred. Such knowledge, Orphanides argued, is key for improving future policy decisions. Toward that end, Orphanides suggested several avenues for future research on monetary policy rules, including the proper concept of the output gap, the appropriate measure of inflation, the functional form, and whether the rule should be forward or backward looking. Orphanides also suggested that researchers could gain valuable insights into past monetary policy decisions by studying the historical transcripts of FOMC meetings.

FINANCIAL RESEARCH

Perhaps no field of study in economics is potentially as sensitive to the choice between real-time data and revised data as financial economics. Financial economists have a long history of studying how macroeconomic news announcements affect asset prices. However, to date, much of that research has rested on measures of announcements taken from revised data. But because the revised observations are available only well after the fact, there is reason to view the results of such studies with some skepticism. Two papers at the conference reported on how financial asset prices are affected by news on macroeconomic variables, such as prices and output, when those variables are measured in real time.

Peter Christoffersen, of McGill University, and CIRANO, Eric Ghysels, of the University of North Carolina, and CIRANO, and Norman R. Swanson, of Purdue University, use real-time and revised data from the Philadelphia Fed's data set and apply Chen, Roll, and Ross's 1986 methodology to study whether

macroeconomic risks are rewarded in the stock market.[3] Christoffersen et al. follow Chen, Roll, and Ross in measuring risk on the basis of the covariance between an equity portfolio's return and the unanticipated component of macroeconomic news announcements (for real output, inflation, and credit risk), but they diverge from that methodology in considering alternative ways to measure news. As in the Chen, Roll, and Ross study as well as many others, they measure news using revised values of macroeconomic data. However, Christoffersen et al. theorize that measuring news in that way carries the potential for "serious mismeasurement of macroeconomic news." So, they also measure the news content of macroeconomic data releases using unrevised (real-time) data. The researchers also consider two alternative measures of expectations for constructing the unanticipated component of macroeconomic news releases, one based on constant expectations and the other on expectations given by an autoregressive process.

The study finds important differences in the estimated return to macroeconomic risks when the risks are estimated using revised data and when they are measured using unrevised data. For example, when the news value of macroeconomic releases depends on revised data and constant expectations, the authors estimate that the financial markets do not price real output risks. However, that finding is reversed when real-time data are used. Another important finding is that the measure of expectations — fixed or autoregressive — plays an important role in estimating how markets price risk. In summarizing their results, Christoffersen, Ghysels, and Swanson conclude that "real-time macroeconomic data should not be overlooked when carrying out a variety of empirical analyses for which the timing and availability of macroeconomic information may matter."

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Frank Diebold, of the University of Pennsylvania and the NBER, presented some findings on the link between high-frequency exchange-rate movements and economic fundamentals, a topic of considerable importance, since some research suggests little link between the two. Diebold and co-authors Torben G. Andersen, of Northwestern University and the NBER, Tim Bollerslev, of Duke University and the NBER, and Clara Vega, of the University of Pennsylvania, construct an extensive data set on U.S. dollar spot exchange rates and macroeconomic news announcements to study how exchange rates respond to new information. The data set consists of nearly 500,000 observations on continuously recorded five-minute exchange-rate returns for the U.S. dollar exchange rates for the mark, pound, yen, Swiss franc, and the euro over the period January 3, 1992, to December 30, 1998. This novel data set also contains a rather extensive set of "news" measures, defined as the standardized difference between an announcement and market expectations for the announcement, collected from the International Money Market Services' real-time data set. These news measures are for U.S. and German data releases and cover variables such as employment, retail sales, industrial production, and consumer prices. The data set includes 40 such measures.

The researchers specify a statistical model to capture the conditional mean *and* conditional variance dynamics of exchange rates in response to macroeconomic news — though the primary focus is on understanding conditional mean dynamics. The paper's most important finding is that U.S. dollar exchange rates respond quickly and significantly to U.S. news announcements. That result is important because it suggests that "high-frequency exchange-rate dynamics are linked to fundamentals," a result that many existing studies failed to find. Interestingly, the study finds much more limited evidence that German news announcements affect the exchange rate, a result the authors attribute to differences in the extent to which exact release times are known in the respective countries. The study also finds evidence indicating that news announcements have timing, size, and sign effects on exchange rates.

Mark Watson, of Princeton University, discussed both papers. He suggested that Christoffersen et al. should consider how their estimates of the market's valuation of risk would be affected under alternative assumptions about the relationship between real-time and revised data. In particular, Watson noted that under some assumptions, such estimates would be *unaffected* by the choice between real-time and

[3] For more information on this methodology, see the article by Nai-Fu Chen, Richard Roll, and Stephen A. Ross, "Economic Forces and the Stock Market," *Journal of Business* 59 (July 1986), pp. 383-403.

revised data. Watson praised Andersen, Bollerslev, Diebold, and Vega's paper and suggested that their future research might address exchange rates' response to news leaks.

MACROECONOMIC RESEARCH

Dean Croushore and Tom Stark, of the Federal Reserve Bank of Philadelphia, present evidence on the extent to which key studies in empirical macroeconomics hold up under revisions in the data. However, in contrast to most other papers at the conference, in which the focus was on revisions to provisional observations, Croushore and Stark emphasize the process of revisions in going from one benchmark revision — or "vintage" — to another. That distinction is important: revisions to provisional estimates mainly reflect new source data, while benchmark revisions can reflect redefinitions, changes in base years, and changes in weighting techniques, features not usually accounted for in theoretical models of the economy.

Using spectral techniques to study differences in the quarterly growth of variables in the national income and product accounts, the authors find it hard to characterize the benchmark-revision process. In some cases, prominent differences occur at business-cycle frequencies; in other cases, differences show up at seasonal frequencies. One notable result is that benchmark revisions to the *level* of variables in the national income and product accounts appear to follow "the typical spectral shape of macroeconomic data," characterized by high power at low frequencies. On the basis of these results, the authors argue that it is worthwhile to check whether the conclusions of some key studies in macroeconomics are sensitive to *benchmark* revisions.

For each study examined, Croushore and Stark replicate the original results — using a vintage of data from the Philadelphia Fed's real-time data set that is closest to the vintage used in the original study. Then, they test how well their results hold up using different vintages of data. The authors find that some results are sensitive to data revisions and others are not. For example, the results of Kydland and Prescott's 1990 study of key correlations among macroeconomic variables remain intact when tested on additional vintages. However, the conclusions of Robert Hall's 1978 study on consumption behavior appear quite sensitive to data revisions. Croushore and Stark also note some sensitivity of Blanchard and Quah's 1989 structural vector autoregression (VAR) results when the model is estimated on alternative vintages of data, a finding that the Fed researchers trace to the estimation technique used in structural VARs.[4]

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Discussant Ken West, of the University of Wisconsin, opined that real-time data have many important applications, including forecasting and modeling the behavior of economic decision-makers, such as monetary policymakers, whose actions depend on provisional data releases. However, West expressed concern about applying real-time data in more general settings in which the actions of decision-makers may not hinge so crucially on provisional data releases.

SUMMARY

The increased availability of real-time data has stimulated renewed interest in the problems associated with data revisions and the potential benefits of using real-time data in empirical studies. The papers presented at the Philadelphia Fed's October conference highlighted many of the important problems and illustrated how real-time data can be used to gain improved understanding of economic relationships. If the many striking findings reported at the conference are any indication, real-time data analysis is here to stay.

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[4] For more information on the studies mentioned in this paragraph, see the articles by Finn E. Kydland and Edward C. Prescott, "Business Cycles: Real Facts and a Monetary Myth," Federal Reserve Bank of Minneapolis *Quarterly Review*, Spring 1990; Robert E. Hall, "Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence," *Journal of Political Economy* 86 (December 1978), pp. 971-87; and, Olivier Jean Blanchard and Danny Quah, "The Dynamic Effects of Aggregate Demand and Supply Disturbances," *American Economic Review* 79 (September 1989), pp. 655-73.

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These papers are available on our web site at www.phil.frb.org/econ/conf/rtdaconf.html.