Monetary Policy Lessons from the Greenbook

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Abstract: From 1987 through 2012, the Federal Open Market Committee appears to have set its federal funds rate target with reference to Greenbook forecasts of the output gap and inflation and to have made further adjustments to the funds rate as those forecasts were revised. If viewed in the context of the Taylor (1993) Rule, discretionary departures from the settings prescribed by a Greenbook forecast-based version of the rule consistently presage business cycle turning points. Similarly, estimates from an interest rate rule with time-varying parameters imply that, around such turning points, the FOMC responds less vigorously to information contained in Greenbook forecasts about the changing state of the economy. These results .J-Tj2 Tc 0.02 Tw 1.3570.31[.)14..4 (31.5 (-3.5 (2823.4 (]TJ.4 (sTJp)-197.5 (31.ss4 (]18.4 -30.5 (o2

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aggregates.

JEL Codes: E31, E32, E37, E43, E47, E51, E52, E58, E65.

Introduction

More than thirty years ago, Allan Meltzer (1987, p.1) noted that the "tradition in which many of us were raised is that policymakers should adjust policy actions based on forecasts of the future path of the economy and their best judgments." Meltzer went on to show, however, that Federal Reserve staff forecasts of economic performance were so imprecise that predictions just one quarter into the future could not distinguish statistically between the likelihood of strong economic performance or a recession. Sinclair, Joutz, and Stekler (2010) affirmed these earlier results and reported that the Fed appears to have accurate impressions of economic performance in the current quarter but cannot predict the state of the economy one quarter ahead. Results in Romer and Romer (2000) and Gamber and Smith (2009) showed somewhat better performance, with the Fed's Greenbook forecasts being superior to private sector forecasts, especially with respect to inflation; Romer and Romer (2000), based on their finding, recommended that the Fed share its forecasts with the public in an effort to enhance private sector decisionmaking. Most recently, however, Sinclair, Stekler, and Carnow (2015) found Greenbook forecasts of real GDP growth, inflation, and the unemployment rate to be similar to those reported by the Survey of Professional Forecasters. Perhaps because this evidence is so mixed, or perhaps because as Meltzer also noted, "traditions die slowly," the Fed's policymaking Federal Open Market Committee (FOMC) continues to use some, not fully specified, mix of forecasts and judgments to set its target for the federal funds rate.

This paper takes another look at the Fed's Greenbook forecasts, but not in terms of their accuracy relative to alternatives generated by the private sector or by specific econometric models. Instead, the aim here is to characterize more sharply the role that forecasts play in the Fed's policymaking process and thereby identify potential improvements that could be made within the existing strategic framework.

The analysis begins by incorporating Greenbook forecasts of the output gap and inflation into a forward-looking version of the Taylor (1993) Rule. Sinclair, Gamber, Stekler, and Reid (2012) and Tien, Sinclair, and Gamber (2016) point out that if FOMC decisions are shaped by such a rule, errors in Greenbook forecasts will translate into errors in setting the federal funds rate target that may, in turn, have implications for the realized values of output and inflation. If the FOMC uses information in the Greenbook forecasts to inform its policy decisions, it also is interesting to examine whether and how the FOMC responds to these forecast errors when setting future values for the federal funds rate target. The statistical tests performed here indicate that, indeed, over a twenty-five-year period spanning 1987 and 2012, the FOMC appears not only to have set its target for the federal funds rate with consistent reference to Greenbook forecasts for the output gap and inflation, but also to have made further adjustments to the funds rate target in response to forecast revisions made as incoming data revealed errors in the initial economic projections.

Regarding the FOMC's use of judgment in the policymaking process, additional results show that deviations of the actual federal funds rate from the values prescribed by a forecast-based Taylor rule display consistent patterns over the business cycle. Throughout the 1987-2012 sample period, the FOMC appears to have held the funds rate "too low for too long" during cyclical expansions, generalizing the pattern that Taylor (2009) associates with the episode between the recession of 2001 and the financial crisis of 2007-2008.[1] On the other hand, periods during which the FOMC held the funds rate above the target prescribed by the forecast-based Taylor rule presage all three of the cyclical peaks in 1990, 2001, and 2007.

Estimates of a Greenbook forecast-based interest rate rule with time-varying parameters, obtained by adapting the Bayesian methods of Cogley and Sargent (2005), Primiceri (2005), and Belongia and Ireland (2016b) to a single-equation context, provide additional insights into the nature and sources of deviations from the standard Taylor Rule. These estimates show that the federal funds rate became less responsive to changing Greenbook forecasts around business cycle turning points, implying that the FOMC has been hesitant to react both to signs of economic weakness that appear before cyclical peaks and signs of improvement that emerge as the economy starts to recover. All of these patterns

[1] See Branch (2014), however, for an alternative interpretation of these events that attributes the FOMC's preference for setting the funds rate below levels prescribed by the Taylor Rule to an asymmetric loss function that reflects its members' caution against overpredicting inflation and the output gap.

suggest that if the Fed conducts policy according to something like a Taylor Rule and continues to do so in the future, gains would accrue from placing more consistent weight on evolving Greenbook forecasts and correspondingly less weight on judgmental deviations from the Rule.

The paper's final set of results concerns the FOMC's focus on interest rates, to the exclusion of the monetary aggregates, in the monetary policymaking process. As discussed by Belongia and Ireland (2015), several lines of economic research came together during the 1990s to generate a professional consensus that information contained in the monetary aggregates can safely be ignored in business cycle and monetary policy analyses. First, widely read and cited articles by Bernanke and Blinder (1992) and Friedman and Kuttner (1992) presented evidence suggesting that previously-stable relationships between the monetary aggregates and measures of economic activity had broken down in the 1980s and that various interest rates, including the federal funds rate, and interest rate spreads, possessed stronger predictive power for those same macroeconomic variables.[2] Second, Taylor's (1993) influential article showed how Federal Reserve policy during the late 1980s and early 1990s could be described surprisingly well by a strikingly simple rule – now known as the Taylor Rule – for setting the federal funds rate with reference to estimates of the output gap and inflation. Third, the New Keynesian model developed by Clarida, Gali, and Gertler (1999) and Woodford (2003), among others, demonstrated how a complete and coherent account of the dynamic, stochastic behavior of the output gap, inflation, and interest rates – including the role of monetary policy in shaping that behavior – could be given without any reference to money supply or demand. Bernanke (2006) summarizes these historical developments and discusses how they led the FOMC to downgrade the role of the monetary aggregates in its policymaking strategy.

Other studies, however, have raised questions regarding the foundations for this consensus. Thoma and Gray (1998) point out that the findings from Bernanke and Blinder

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[2] Milton Friedman's (1983, 1985) wildly inaccurate forecasts of a return to high inflation in the late 1980s, based on accelerating growth rates of simple-sum M1, also were influential in discrediting the usefulness of money as an indicator of aggregate activity. As noted by Barnett (2012, pp.107-111), the same indications of renewed inflation were not present in the Divisia monetary aggregates.

(1992) and Friedman and Kuttner (1992) favoring interest rates over money in forecasting economic activity are sensitive to the inclusion or exclusion in the sample of several influential data points from 1974. Belongia (1996) and Hendrickson (2014), meanwhile, demonstrate that results from those same studies can be overturned simply by replacing the Federal Reserve's official, "simple-sum" measures of money with their superlative (Divisia) counterparts.[3] Most recently, Anderson, Chauvet, and Jones (2015), Belongia and Ireland (2015, 2016a), El-Shagri, Giesen, and Kelly (2015), and Keating, Kelly, Smith, and Valcarcel (forthcoming) all found evidence of important statistical information about the stance of monetary policy in the Divisia monetary aggregates, even after accounting for information conveyed by interest rates.

This paper builds on these previous studies by using tests similar to those employed by Joutz and Stekler (2000) to show that information contained in the monetary aggregates – especially Divisia monetary aggregates – and available in real time, helps forecast Greenbook prediction errors in the output gap and inflation. To the extent that the FOMC's determination of a target for the funds rate depends on the accuracy of Greenbook forecasts, smaller forecast errors made possible by the use of information in the monetary aggregates will imply more precise initial settings of the target or fewer and smaller revisions to the target over time. Second, even if monetary aggregates are not incorporated as part of the Federal Reserve's forecasting exercise, the results still imply that they could serve as a "cross-check" on the behavior of the interest rate target as they have done in the "two-pillar" approach to monetary policy adopted by the European Central Bank.

[3] Barnett (1980) demonstrated that simple-sum monetary aggregates, including the Fed's official M1 and M2 series, mismeasure the true flow of monetary services in an economy where agents can substitute between different liquid assets, paying interest at different rates. Barnett (1980) then used economic aggregation theory to construct Divisia monetary aggregates that successfully internalize substitution effects and thereby track true service flows much more accurately under a wide range of conditions. Barnett (2012) provides an overview of this monetary aggregation theory and a review of evidence that highlights the advantages of Divisia monetary aggregation.

Greenbook Forecasts and the Taylor Rule

The Federal Reserve's "Greenbook" forecasts for the output gap and inflation are recorded in the Greenbook data set maintained by the Federal Reserve Bank of Philadelphia. These forecasts are produced by the research staff at the Board of Governors and presented to the FOMC for consideration when decisions are made about setting a target for the federal funds rate. Here, the data begin in 1987:3, the first date for which forecasts of the output gap are available. This allows the analysis to sidestep issues, discussed first by Orphanides (2001, 2004) and more recently by Nikolsko-Rzhevskyy and Papell (2012) concerning the sources of the Fed's estimates of potential output during earlier periods. Also, because the Greenbook only began to report forecasts for inflation based on the price index for personal consumption expenditures in 2000, the series for inflation is based on the Consumer Price Index (CPI), which the Greenbook reports from 1987 forward.

Quarterly time series for both the output gap and CPI inflation are based on observations drawn from the first Greenbook produced in each quarter. The output gap forecast, $y_{t+4|t}$, is the one made at the beginning of quarter *t* for the same quarter of the following year, hence four quarters ahead. The inflation forecast $p_{t+4|t}$, meanwhile, is constructed by averaging forecasts of quarter-to-quarter inflation made at the beginning of quarter *t* for each of the next four quarters: hence, it is a forecast of year-over-year inflation four quarters ahead. Each series terminates in 2012:4, because of the five-year embargo on the release of Greenbook forecasts.

These series of year-ahead forecasts are compared to updated series for the same variables constructed four quarters later on the basis of updated information. For the output gap, $y_{t|t}$ corresponds to the Board's estimate of the output gap for quarter *t* made at the beginning of quarter *t*. For inflation, $p_{t|t}$ is constructed as the average of the Greenbook's projection of CPI inflation for the current quarter *t* and the Greenbook's "historical value" of inflation from the previous three quarters. Note that even the historical values for CPI inflation may differ from those in the most recent vintage of data because of revisions made later; likewise, both revisions to the series for real GDP and shifting estimates of potential GDP imply that the Greenbook series for the "actual" output gap will differ from economists' best estimates of the output gap made today, with the benefit of additional information that has accumulated over the years since those initial estimates were made.

For simplicity, the discussion that follows refers to the series $y_{t|t\text{-}4}$ and $p_{t|t\text{-}4}$ as the "forecasts of the output gap and inflation for period *t*," while the series $y_{t|t}$ and $p_{t|t}$ are the updated "nowcasts" of the same variables. The changes in these series, denoted as $y_{t|t} - y_{t|t\text{-}4}$ and $p_{t|t} - p_{t|t\text{-}4}$, are "forecast revisions" made on the basis of information that accumulates between $t - 4$ and t. These revisions also correspond to "forecast errors" made at $t - 4$, computed using information available through t.

Figure 1 plots these series and Table 1 reports descriptive statistics for the forecast revisions for both the full sample period 1987:3 through 2012:4 and a shorter subsample that ends in 2007:4 to remove the influence of the financial crisis and Great Recession that followed. Though forecast revisions for both variables have means near zero, the graphs and summary statistics show that the initial forecasts have, at times, been subject to large errors. Even before the financial crisis, the absolute value of forecast errors were as large as 3 percentage points for the output gap and 2.5 percentage points for inflation. These results echo those from Meltzer (1987) and Sinclair, Joutz, and Stekler (2010), which show that the Fed often has difficulty discerning whether the economy will be experiencing a boom or recession one year ahead. When data from the financial crisis and its aftermath are added to the sample, the errors exceed six percentage points for the output gap and four percentage points for inflation. This increase in the magnitude of forecast errors over the extended sample is consistent with the transcripts of FOMC meetings from early 2008 that suggest the crisis was largely unanticipated. The Jarque-Bera statistics indicate that the data from the full sample also are characterized by significant skewness and kurtosis.[4]

[4] Since the Jarque-Bera statistic has an asymptotic chi-square distribution with two degrees of freedom, having a 5 percent critical value of approximately 6, under the null hypothesis that the errors are normally distributed, strictly speaking there is evidence of excess skewness and kurtosis in the inflation forecasts even in the sample that ends in 2007:4.

Whether and by how much these errors influence monetary policy decisions of the FOMC is unknown because, despite all of the research on monetary policy rules, it still is unknown whether target values for the funds rate are determined primarily by a rule, discretion, or some mix of the two. Nonetheless, both the Fed's statutory dual mandate and the Taylor (1993) Rule suggest that the funds rate target should be adjusted in response to movements in the output gap and the inflation rate. In this context, a forward-looking monetary policy process that acknowledged lags between a central bank's actions and the response of its goal variables would lead one to expect the FOMC to set the funds rate target with reference to forecasts of these variables. A monetary policy process of this type also would imply the use of Greenbook forecast values in lieu of actual or real-time data in any empirical exercise designed to estimate the Taylor Rule's coefficients or the implications of its use to conduct monetary policy.

As a first step in examining whether and how Greenbook forecasts may have been used by the FOMC, each row of Table 2 presents results from Granger causality tests that assess the relationship between the funds rate and both Greenbook forecasts and the revisions to them.[5] On one hand, finding unidirectional causality from a given forecast variable to the funds rate would indicate that the forecast contained some significant information about future movements in the funds rate; from this, one might infer that the forecast variable has been incorporated into decisions about settings for the funds rate. Conversely, unidirectional causation from the funds rate to the forecast variable could be interpreted as the Federal Reserve staff's assessment of how a change in the funds rate is expected to affect future movements in inflation or output.

The binding zero lower bound constraint on the federal funds rate from 2008 through 2015 makes these Granger causality tests most informative for the pre-crisis subsample ending in 2007:4; for the sake of completeness, however, Table 2 also shows results for the full sample

[5] Data on the federal funds rate are taken from the Federal Reserve Bank of St. Louis' FRED database. Each observation corresponds to the average value of the effective federal funds rate during the first month of the quarter.

running through 2012:4. Reported *F*-statistics apply to the null hypothesis that, together, four lags of the independent variable are unhelpful in forecasting the dependent variable. With respect to the forecasts of inflation, the output gap and the revision to the output gap, the first and third rows of the table show strong unidirectional causation running from these forecast values to the funds rate. These results are consistent with the notion that the FOMC sets the funds rate with at least some reference to something like a Taylor Rule. The tests also detect significant causation running from the federal funds rate to forecasts of the output gap. Note, however, that the apparent absence of strong effects running from the funds rate to the forecasts of the inflation rate does not imply that monetary policy is powerless to affect the aggregate price level. Indeed, if the Fed successfully uses monetary policy to stabilize expected inflation, there should be little or no statistical connection between the lagged funds rate and the forecasts in Table 2.

Since, as suggested by Tien, Sinclair, and Gamber (2016), errors in year-ahead forecasts of the output gap and inflation translate, in turn, into errors in the FOMC's setting for the funds rate, it also is of interest to ask whether there is any further evidence that the FOMC adjusts its funds rate target to correct these errors. Indeed, there is. Table 2 also shows that in the pre-crisis sample period, revisions to forecasts of the output gap, $y_{t|t}$ - $y_{t|t-4}$, have predictive power for the federal funds rate r_t. On the other hand, the tests in Table 2 point to statistical causality running from the federal funds rate r_t to revisions in the forecast for inflation $p_{t|t}$ - $p_{t|t-4}$ when the sample is extended through 2012:4 to cover the financial crisis and Great Recession.[6] The first result suggests that the FOMC attaches greater importance to unexpected strength or weakness in the real economy as monetary policy decisions evolve over time. The second result implies the FOMC makes decisions on the basis of a miscalibrated or

[6] To be clear, this result shows that values for the funds rate r_{t-j}, for lags j = 1,2,3,4, have statistically significant explanatory power for the inflation forecast revision $p_{t|t}$ - $p_{t|t-4}$ made between periods t-4 and t. Since the values r_{t-1}, r_{t-2}, and r_{t-3} are observed after the initial forecast $p_{t|t-4}$ is made, the result implies only that adjustments to the funds rate made in quarters t-1, t-2, and t-3 fail to bring period t inflation back to the rate that was expected as of period t-4; unlike the regressions presented in the next section, these do not imply that the forecasts inefficiently ignore information that is available when they are first made.

misspecified model of the Phillips curve as changes in the funds rate taken to stabilize the output gap apparently fail to have their expected effects on future inflation. Taken together, these relationships characterize a monetary policy dynamic in which the FOMC attempts to "manage" the output gap but, in doing so, succeeds only partially in stabilizing inflation.

To distinguish further between the FOMC's use of forecasts and judgments in setting the funds rate target, Figure 2 plots the prescriptions of the Taylor (1993) Rule

for the funds rate target , using the year-ahead Greenbook forecasts as inputs for inflation and the output gap. In this standard form of the Taylor Rule, both the inflation target and the steady-state real rate of interest are assumed to equal 2 percent, and stabilization weights of 1.5 and 0.5 are attached to deviations of inflation from target and the output gap, respectively. As shown in the graph and as noted by Nikolsko-Rzhevskyy and Papell (2013), this original Taylor Rule, unlike other variants that place larger weights on the output gap, does not call for deeply negative nominal interest rates during or after the financial crisis; Nikolsko-Rzhevskyy and Papell also emphasize that this version of the Taylor Rule is the one preferred strongly by John Taylor himself.

Before discussing how this forecast-based version of the Taylor Rule may have influenced FOMC decisions about settings for its funds rate target, Figure 3 compares its implied values to those generated by the standard version of the Taylor (1993) Rule based on *ex post*, revised data.[7] In addition to the issues associated with real-time data discussed by Orphanides (2001), *ex post* data do not embody the forward-looking nature of policy decisions made today in an attempt to influence future economic activity. As the figure illustrates, the two versions of the rule often differ in magnitude by several percentage points, often have different turning points and occasionally move in the opposite direction. It seems clear that

[7] To deduce the funds rate target implied by the *ex post* Taylor Rule, the percentage change in the CPI over the previous four quarters is used to measure inflation and the percentage deviation of the current quarter's level of real GDP from the Congressional Budget Office's estimate of potential real GDP is used to measure the output gap. These *ex post* data are taken from the FRED database.

any attempt to characterize the thought process of the FOMC is sensitive to choice of the inflation and output gap data one assumes are the basis for policy decisions.

Going back to the forecast-based version of the Taylor Rule, Figure 2 shows that its prescriptions share a similar general pattern with that of the funds rate itself. Over the 1987:3-2012:4 sample period, the average deviation between the two series is less than 20 basis points. In addition, the Granger causality tests from Table 2 show a strong tendency for the federal funds rate to move towards the value indicated by the Taylor Rule. Together, these results again suggest that the Greenbook forecasts are important inputs to the FOMC's policy decisions and appear to be used in a policy framework that is in the spirit of the Taylor Rule.[8]

Differences between the two series illustrated in the bottom panel of the Figure 2, however, highlight features masked to some degree by their shared broad movements. First, over the 1987:3-2012:4 sample period, the actual federal funds rate at times rises more than 3 percentage points above and falls nearly 2.5 percentage points below the Taylor Rule values. The standard deviation of the difference between the two series is almost exactly 1 percentage point. Second, the deviations display a distinct cyclical pattern. Extended periods during which the FOMC held the funds rate below the level prescribed by the Taylor Rule appear after each of the three recessions of 1990-1991, 2001, and 2007-2009. This shared pattern suggests that Taylor's (2009) critique of the Fed for holding interest rates "too low for too long" after the 2001 recession extends to the FOMC's decisions following the other two downturns as well.

Even more striking, each of the three recessions included in the sample is preceded by settings for the funds rate that are substantially above those implied by the Greenbook forecast-based Taylor Rule. Table 2 shows, in fact, that there is a highly significant statistical connection between lagged values of deviations from the Taylor Rule and business cycle peaks

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[8] Asso, Kahn, and Leeson (2010) find numerous references to the Taylor Rule in FOMC transcripts beginning in 1995; the causality test results here confirm their intuition that these references did indeed help shape the Committee's decisions for setting the funds rate, even though as Asso, Kahn, and Leeson also emphasize, some Committee members remained hesitant to follow the strict prescriptions of the Rule.

as identified by the National Bureau of Economic Research.[9] The reason the values for the two funds rate series diverge so sharply can be seen in the top panel of Figure 2, where the funds rate under the Greenbook version of the Taylor Rule begins to decline several periods before each business cycle peak. If deviations from the Taylor Rule are interpreted as periods where the FOMC emphasized discretionary judgments to determine the most appropriate stance of monetary policy, these observations suggest that judgmental deviations have tended to amplify, rather than stabilize, cyclical fluctuations. And to the extent that policy decisions made under discretion are destabilizing, it appears as if the FOMC might be better-served by responding to signals of emerging macroeconomic strength and weakness embodied in Greenbook forecasts and achieve its stabilization objectives more reliably as well by adhering more closely to the prescriptions of the Taylor Rule.

An Estimated Greenbook Forecast-Based Taylor Rule with Time-Varying Parameters

Belongia and Ireland (2016b), using a Bayesian vector autoregression with time-varying parameters estimated with the most recent vintage of *ex post* data on inflation and the output gap, find evidence of shifting emphasis away from inflation towards output gap stabilization as well as departures from rule-like behavior over the period from 2000 through 2007. The same methods, adapted from Cogley and Sargent (2005) and Primiceri (2005), can be applied to detect shifting policy priorities based on an estimated Greenbook forecast-based version of the Taylor Rule with time-varying parameters and stochastic volatility.[10,11] The estimated rule takes the form

[9] These business cycle dates are tabulated on the NBER's own website and also can be downloaded from the FRED database.

[10] In commenting on earlier work by Cogley and Sargent (2001), Sims (2001) and Stock (2001) both emphasize the need to allow simultaneously for time-varying parameters and stochastic volatility to disentangle the effects of both sources of changing dynamics on macroeconomic time series.

[11] An extensive literature, beginning with Clarida, Gali, and Gertler (2000), looks for evidence of time-variation in the parameters of estimated Taylor Rules. Most closely related to the present study, Boivin (2006) and Murray, Nikolsko-Rzhevskyy, and Papell (2015) use Greenbook

where, as above, r_t denotes the federal funds rate at the beginning of period t and $p_{t+4|t}$ and $y_{t+4|t}$ are one-year-ahead Greenbook forecasts for inflation and the output gap made at the beginning of period t. The serially uncorrelated shock x_t has the standard normal distribution; hence, s_t denotes the time-varying volatility of deviations from this estimated rule. The specification also allows for interest-rate smoothing, captured by the term involving the lagged funds rate on the right-hand side, to account for the gradual adjustment of the funds rate back to the target implied by the original Taylor (1993) Rule seen in Figure 2. Here, as in Boivin (2006), the identifying assumption that allows this estimated equation to be interpreted as describing the FOMC's policy response to changing macroeconomic conditions is that the shock x_t is uncorrelated with the Greenbook forecasts $p_{t+4|t}$ and $y_{t+4|t}$. This assumption would hold if, for example, Greenbook forecasts for period t are assembled without knowledge of the FOMC's judgmental deviation from the time-varying rule in the same period t.

The four time-varying coefficients from this policy rule are collected into the 4x1 vector

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which is assumed to follow a random walk

where the vector of innovations n_t is normally distributed, independently of x_t, with mean zero and covariance matrix Q. The log of the time-varying volatility parameter also follows a random walk,

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forecasts to estimate forward-looking versions of the rule to detect shifts that are more complex or subtle than the one-time change in 1979 considered by Clarida, Gali, and Gertler (2000). Boivin (2006) estimates a model with continuous parameter drift using data that run from 1969 through 1998; the analysis here can viewed as extending his analysis to cover the period from 1987 through 2007. Murray, Nikolsko-Rzhevskyy, and Papell (2015) estimate a Markov-switching model that identifies, among others, a single regime covering the most recent period from 1985 through 2007. By allowing for continuous parameter drift over the same interval, the model used here can characterize more sharply the short-lived but recurring changes in policy that, in Figure 2, appear to have occurred around business cycle turning points.

where h_t is normally distributed, independently from both x_t and n_t, with mean zero and variance w. Normal priors for the initial values

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and inverse Wishart priors for Q and w,

and

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are calibrated by setting

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$k_Q = 0.00035^{1/2}$, and $k_W = 0.02$.

The prior mean B for B_0 implies long-run coefficients $b_p/(1-b_r)$ and $b_y/(1-b_r)$ on inflation and the output gap equal to the values 1.5 and 0.5 that appear in the original Taylor (1993) Rule and an intercept term consistent with earlier assumptions that the steady-state real interest rate and inflation target both equal 2 percent. The diagonal elements of V_B then imply that the prior standard deviation of each element of B_0 equals its prior mean. The prior mean for log s_0 is based on the notion that typical deviations from the time-varying rule should be of magnitude similar to 0.25 percentage points, though the large prior variance admits considerable uncertainty regarding the scale of these deviations. Finally, while the setting for k_Q is taken directly from Cogley and Sargent (2005), the slightly larger value k_W was chosen to allow for the possibility of greater time variation in the shock volatility parameter.

Together with these priors, quarterly data, starting in 1987:3 and truncated in 2007:4 to avoid complications associated with the period of near-zero interest rates beginning in 2008, are fed through a "Metropolis-within-Gibbs" sampling algorithm to draw blocks of parameters from their conditional posterior distributions. First, the multi-move routine outlined by Carter and Kohn (1994) and Fruhwirth-Schnatter (1994) generates draws for the sequence of coefficients in B_t. Next, Kim, Shephard, and Chib's (1998) algorithm, which approximates the true, log chi-squared distribution for each of the volatility coefficients with a mixture of seven normal distributions, yields a sequence of draws for s_t. Within this algorithm, the state variable selecting the specific normal distribution from which each parameter is drawn gets sampled before the value for the volatility parameter itself; Del Negro and Primiceri (2015) emphasize the importance of this ordering of the steps. Also as suggested by Del Negro and Primiceri (2015), a Metropolis-Hastings step is added to this part of the algorithm to account for the error between the true distribution of the volatility parameters and the mixture-of-normals approximation. Finally, updated draws for the parameters in Q and W are taken from their inverse Wishart conditional posterior distributions.

After a burn-in period consisting of 1 million sweeps through this algorithm, the results are based on a sampling phase in which draws from one out of every ten of the next 2.5 million sweeps are saved, making a total of 250,000 draws for each parameter. Convergence and adequate mixing of the Markov Chain Monte Carlo scheme is verified by initializing the algorithm from different randomly chosen starting points to confirm that none of the results is affected and, more formally, by monitoring the convergence diagnostic and relative numerical efficiency statistics described by Geweke (1992).

Figure 4 illustrates how each parameter is estimated to vary over time, with solid blue lines tracking the median of the posterior distributions and dashed red lines showing the associated 16-84 percentile bands. Despite allowing for the possibility of more substantial stochastic volatility through the larger setting for k_W, the shock volatility coefficient s_t appears very stable over the entire sample period, following a smooth and very slight downward trend from 0.17 in 1987:3 to 0.16 in 2007:4. The estimated response coefficients, however, display time variation that adds detail to the Granger causality test results discussed in the previous section.

Specifically, the top two panels of Figure 4 reveal a consistent pattern according to which the FOMC's immediate concern for movements in the output gap forecast, as measured by the response parameter $b_{y,t}$, increases relative to its concern for inflation, as measured by $b_{p,t}$, shortly before, during, and after each of the last three recessions. The left-hand panel of the middle row shows, however, that the estimated interest-smoothing parameter $b_{r,t}$ also exhibits marked declines during the same episodes, so that in the bottom row, the implied long-run responses $b_{p,t}/(1- b_{r,t})$ and $b_{y,t}/(1- b_{r,t})$ to both inflation and output forecasts decline as well.

These results reinforce the impression, gleaned from Figure 2, that by hesitating to respond to signs of weakness in the economy just prior to the onset of recessions, and then by failing to raise rates more quickly in response to an improving economy during recoveries, the FOMC may have worked to amplify, rather than ameliorate, business cycle fluctuations. Hetzel (2012) characterizes the Federal Reserve's "stop-go" policies of the 1960s and 1970s in similar terms, with the FOMC's practice of keeping the federal funds rate elevated after cyclical peaks constituting the "stop" phase and then holding the funds rate down following cyclical troughs as representing the "go" phase.[12] To eliminate these vestiges of stop-go, the results suggest, once again, that there may be gains to the Fed from adhering to an unchanging interest rate rule like Taylor's (1993), with response coefficients on inflation and the output gap that remain constant over the business cycle.[13]

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[12] Meltzer (1991) characterizes the monetary policy of the 1960s and 1970s in similar fashion with special emphasis on the practices that led, in his analysis, to a procyclical policy that exacerbated business cycle fluctuations.

[13] A more detailed, structural model of the macroeconomy would be needed to provide a complete, quantitative analysis of the counterfactual scenario in which the FOMC abandoned discretion entirely and adhered, instead, to the strict prescriptions of a Taylor Rule with constant response coefficients on inflation and output gap forecasts. That same structural model also could be used to characterize a fully optimal monetary policy rule that might differ in important ways from Taylor's (1993) original specification. The adoption of a constant coefficient benchmark rule analysis here, however, deliberately avoids imposing the restrictive and potentially controversial assumptions required to construct and estimate a structural model of that kind and still suggests that better macroeconomic performance could have been achieved by closer adherence to that benchmark rule.

Greenbook Forecasts and Money Growth

The results from the previous sections indicate that, over the period from 1987:3 through 2012:4, the FOMC continued to follow in the tradition identified by Meltzer (1987), basing its policy decisions on some mixture of quantitative forecasts and individual judgments. Bernanke (2006) describes how, over that same period, the FOMC gradually downgraded the role of the monetary aggregates in its policymaking process. Indeed, even after the federal funds rate target approached its zero lower bound in 2008, the FOMC's focus shifted to longer-term interest rates, rather than measures of money growth, as alternative signals of the stance of monetary policy.[14]

New Keynesian models like those developed by Clarida, Gali, and Gertler (1999) and Woodford (2003) provide a theoretical justification for assigning this subsidiary role to the money stock. In those models, the current and expected future path of the federal funds rate summarizes completely the effects that monetary policy has on the output gap and inflation. The economy's dynamics can therefore be fully described by three equations – the New Keynesian IS and Phillips Curves, together with the Taylor Rule for interest rate policy – none of which makes any reference to the behavior of money. A fourth equation, describing money demand, can be appended to the model, but this relation serves only to determine the money stock residually, given the behavior of output, inflation, and interest rates.

If, as seems likely, this view of the transmission mechanism also underlies the construction of Greenbook forecasts, its adequacy can be tested by asking whether information contained in the monetary aggregates, and available at the time that the forecasts are made, helps predict errors or revisions that are subsequently made. Joutz and Stekler (2000) outline and employ an econometric procedure that can be used to implement this test.

As above, let $f_{t|t}$ denote the Greenbook nowcast of a variable, either the output gap y or year-over-year inflation p, made for quarter t in quarter t. Likewise, let $f_{t|t\text{-}4}$ denote the forecast of that same period-t variable, made four quarters earlier. Finally, let $m_{t\text{-}4|t\text{-}4}$ denote year-over-

[14] See, e.g., Belongia and Ireland (2018).

year money growth, observed at the beginning of quarter t-4 for the period beginning four quarters earlier, that is, the annual rate of money growth from quarter t-8 through t-4. The null hypothesis that the Greenbook forecasts and nowcasts efficiently incorporate all useful information available at the time they are made can then be tested by estimating the regression

and verifying that the coefficient on money growth c is insignificantly different from zero. Because, in the data set employed here, forecasts are made for period t at the beginning of period t-4, the standard error and associated t-statistic used in performing this test must correct for up to fourth-order autocorrelation in error term e_t; this correction is made using the modified Bartlett weights recommended by Newey and West (1987).

Three sets of monetary data are used to perform these tests. First, “real-time” data on the Federal Reserve’s official M1 and M2 aggregates are constructed from series available in the Federal Reserve Bank of Philadelphia’s Real-Time Data Set. This data set provides monthly series on M1 and M2 in quarterly “vintages” that replicate exactly the information possessed by the Federal Reserve quarter-by-quarter extending backward in time. For each aggregate, the reading for $m_{t-4|t-4}$ is formed from the quarter t-4 vintage as the annual rate of money growth over the twelve months preceding the start of quarter t-4. Thus, for example, real-time M1 growth for 2000:1 is based on the 2000:1 vintage and is computed as the rate of M1 growth between 1998:12 and 1999:12. Second, series for “simple-sum” M1 and M2 are constructed in the same way, but using the most recent vintage of data available from the Federal Reserve Bank of St. Louis’ FRED database. The top two panels of Figure 5 compare the real-time series for M1 and M2 to the updated simple-sum series to show that the effects of definitional updates for the aggregates themselves and revisions to the data have yielded very minor changes in each measure of money, going all the way back to 1980. This highlights one of the advantages of working with monetary data: small revisions make the real-time data relatively free of vintage effects.

Third, Divisia measures of M1, M2, and the broader aggregates MZM and M4 now are provided through the Center for Financial Stability's website and described in detail by Barnett, Liu, Mattson, and van den Noort (2013). These series are also monthly, allowing readings for $m_{t-4|t-4}$ to be constructed in exactly the same fashion for the Divisia aggregates as they are for the official M1 and M2 aggregates. Divisia M1 and M2 include the same assets that form the Federal Reserve's official M1 and M2 aggregates, but are assembled using the monetary aggregation theory outlined by Barnett (1980, 2012), accounting explicitly for differences in the flows of monetary services provided by currency and various types of bank deposits. The Divisia measures correct, as well, for the proliferation throughout the 1990s of "sweep" programs through which banks were allowed to reclassify, for accounting purposes, funds held in demand deposits as saving account balances and thereby reduce their holdings of required reserves. As discussed by Cynamon, Dutkowsky, and Jones (2006) and as shown in the middle row of Figure 5, these sweep programs introduced large distortions into the official M1 series, which the Federal Reserve did not account for. More generally, the graphs from the middle row of Figure 5 illustrate that large differences between simple-sum and Divisia money growth appear quite regularly over the post-1980 period, echoing Belongia (1996) and Hendrickson's (2014) findings that "measurement matters" in any empirical work that attempts to link movements in money to changes in other macroeconomic variables.

The Center for Financial Stability also provides monthly series for Divisia MZM and M4. The former subtracts the small time deposit component from M2 but adds institutional money market mutual fund shares to obtain an aggregate of liquidity services provided by all assets that can be converted to a medium of exchange on demand. This modification to the M2 aggregate was first proposed by Motley (1988) and given its name – "money, zero maturity" – by Poole (1991). The latter, Divisia M4, is the broadest measure assembled by the Center for Financial Stability and combines all of the assets in M2 and MZM with other highly liquid assets including large time deposits, repurchase agreements, commercial paper, and Treasury bills to form an aggregate with components similar to that of the Federal Reserve's discontinued L aggregate of liquidity. Plots of the growth rates for these two additional series appear in the bottom row of Figure 5.

Unfortunately, "real time" versions of the series for the Divisia monetary aggregates are unavailable. Moreover, the Federal Reserve Board itself has never assembled alternatives to its own, simple-sum aggregates.[15] Since 2013, however, the Center for Financial Stability has produced monthly readings on the Divisia aggregates with only a two-week lag; presumably, the Federal Reserve Board, with its greater resources and access to underlying source data, could do the same.

The first row of Table 3 gives results from estimating a constrained version of the regression without the additional term for money growth, that is, with $c = 0$. In this form, the estimated regression can be used to test the null hypothesis that $a = 0$ and $b = 1$ that Mincer and Zarnowitz (1969) associate with the efficiency and unbiasedness of a forecast, in this case the initial Greenbook forecast of the output gap. In fact, the F-statistic from this test fails to reject the null. Subsequent rows of Table 3 show, however, that when either real-time M2, simple-sum M2, or Divisia M1 are added to the same regression, a t-test rejects the null hypothesis that $c = 0$. In each case, this result indicates that information in money growth, available from a time period before the initial forecast was made, helps predict subsequent revisions to the forecast. Curiously, for both real-time and simple-sum M2, the estimated value of the regression coefficient c takes the "wrong" sign, associating more rapid money growth with a subsequent downward revision in the output gap forecast. For Divisia M1, however, the estimated coefficient is positive and highly significant.

When the focus shifts to forecasts of CPI inflation, the results in Table 3 show that lagged rates of Divisia M2, MZM, and M4 growth all help predict subsequent forecast errors. Again, however, the estimated coefficients on these variables take the unexpected, negative sign, with more rapid money growth presaging downward revisions to the inflation forecast.

[15] The Federal Reserve Bank of St. Louis briefly reported Divisia measures of money, which it referred to as "monetary services indices," but these series were not made available consistently throughout the 1987:3-2012:4 sample period and were discontinued entirely in 2013.

Since the Mincer-Zarnowitz regression also rejects its null of forecast unbiasedness and efficiency for inflation, these results may be symptomatic of broader challenges in forecasting inflation, particularly over a sample period that encompasses the financial crisis, Great Recession, and slow recovery that followed.

To investigate more fully whether possibly unexploited information exists in data on money growth, Tables 4 through 6 extend the Greenbook forecast and nowcast series back to 1980:1, but also terminate the sample period at 2007:4 to exclude what may be special effects of the crisis and Great Recession. As noted previously, Greenbook forecasts for the output gap are available only from 1987:3, but forecasts for year-over-year growth in real GDP and for the unemployment rate four quarters in advance can be extracted from the Philadelphia Fed's Greenbook dataset. The top rows of Table 4 show that lagged growth rates for all four of the Divisia aggregates – M1, M2, MZM, and M4 – help predict subsequent errors in the forecasts for real GDP; the bottom rows show that Divisia M1 growth has significant predictive power for errors in the forecasts for unemployment as well. Moreover, each of the statistically significant coefficients takes the expected sign, associating more rapid rates of money growth in the past with accelerating GDP growth and falling unemployment that the Greenbook forecasts failed to anticipate. And while, in Table 5, none of the money growth series helps predict forecast errors in inflation, as measured using either the CPI or the GDP deflator, Table 6 shows that Greenbook forecast errors in year-over-year nominal GDP growth are anticipated by available information in Divisia M1 and the real-time measure of its simple sum counterpart. Overall, the results indicate that monetary data, especially Divisia aggregates, would enhance Greenbook forecasts and, in so doing, enable the FOMC to set its funds rate target more accurately.

Conclusion

Although the Federal Reserve has never officially outlined the details of its policymaking strategy, in practice FOMC members appear to base their decisions on a mixture of forecasts prepared by research staff at the Federal Reserve Board and their own personal judgments.

Results presented here confirm that the Fed's Greenbook forecasts for the output gap and inflation exert a significant influence on the FOMC's settings for the federal funds rate target, and that revisions to or errors in these forecasts also prompt subsequent adjustments to the target.

While the FOMC's policy response to both inflation and a measure of real economic activity is consistent with the Fed's statutory dual mandate and the prescriptions of a Taylor Rule, comparisons between the actual federal funds rate and the values predicted by a Taylor Rule based on Greenbook forecasts occasionally reveal substantial deviations between the two, presumably reflecting the use of judgment or discretion by the FOMC Chair and the Committee's individual members. Over a twenty-five year period spanning 1987 through 2012, these deviations display a consistent cyclical pattern, according to which the FOMC holds the funds rate below the value prescribed by the Taylor Rule during expansions and above the value prescribed by the Rule as the Greenbook forecasts signal weakness before business cycle peaks. Estimates of an interest rate rule with time-varying parameters indicate that these deviations reflect an underlying hesitancy for the FOMC to adjust its federal funds rate target in response to changing economic conditions both before and after recessions, behavior reminiscent of the more extreme, "stop-go" policies of the 1960s and 1970s. These observations suggest that if the Fed retains its current approach to monetary policymaking, in which Greenbook forecasts serve as inputs to the process for setting a target for the federal funds rate, the FOMC would achieve better stabilization outcomes by placing more weight on the Greenbook's assessments of changing economic conditions and less weight on its own individual judgments. In this sense, the results offer support to one component of recently proposed legislation that would require the FOMC to make its policy decisions with more consistent reference to a form of the Taylor Rule with more stable coefficients.

The results also point to a need to reconsider the role of the monetary aggregates in the FOMC's policymaking strategy. The information conveyed by movements in Divisia M1, in particular, appears important in anticipating future movements in variables including the output gap, real and nominal GDP, and the unemployment rate over sample periods excluding and including the financial crisis and Great Recession and extending back to 1980. Yet the Federal Reserve continues to publish series only for simple-sum monetary aggregates and never has corrected its official M1 series for the distortionary effects of retail deposit sweep programs adopted by banks during the 1990s. The allocation of more resources towards assembling reliable monetary statistics would provide better information to the public and, at minimum, give the Federal Reserve an additional indicator variable about the potential long run, nominal consequences of its short run decisions about targets for the federal funds rate. Used in this manner, as a nominal "cross-check," the Fed could benefit by using money in a manner similar to that of the European Central Bank's "two-pillar approach." This additional information can be acquired by supplementing the kind of macroeconomic analysis that presently underlies the construction of Greenbook forecasts with a review of monetary conditions based on the quantity-theoretic interaction between money supply and demand.

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Table 1. Descriptive Statistics for Greenbook Nowcast-Forecast Revisions

	Sample	
	1987:3 – 2012:4	1987:3 – 2007:4
Output Gap		
Mean	-0.20	0.06
Standard Deviation	1.51	1.27
Maximum	2.80	2.80
Minimum	-6.10	-3.10
Skewness	-1.12	-0.55
Kurtosis	4.98	2.93
Jarque-Bera Statistic	36.35	3.90
CPI Inflation		
Mean	0.24	0.22
Standard Deviation	1.15	0.91
Maximum	3.15	2.68
Minimum	-4.03	-1.33
Skewness	-0.32	0.81
Kurtosis	4.87	3.18
Jarque-Bera Statistic	16.51	8.96

Note: Statistics refer to differences between the nowcast of the output gap or year-over-year inflation made for quarter *t* in quarter *t* and one-year-ahead forecasts of the same variable for quarter *t* made in quarter *t* - 4.

Table 2. Patterns of Granger Causality Between Greenbook Forecasts, Forecast-Nowcast Revisions, and the Federal Funds Rate

		Sample			
		1987:3 – 2012:4		1987:3 – 2007:4	
Dependent Variable	Independent Variable	Granger Causality	*p*-value	Granger Causality	*p*-value
Federal Funds Rate	Output Gap Forecast	2.97	0.02	8.64	0.00
Output Gap Forecast	Federal Funds Rate	1.29	0.28	2.41	0.06
Federal Funds Rate	CPI Inflation Forecast	3.73	0.01	3.29	0.02
CPI Inflation Forecast	Federal Funds Rate	0.64	0.64	0.60	0.66
Federal Funds Rate	Output Gap Revision	1.41	0.24	4.48	0.00
Output Gap Revision	Federal Funds Rate	0.47	0.76	0.84	0.51
Federal Funds Rate	CPI Inflation Revision	0.83	0.51	0.54	0.71
CPI Inflation Revision	Federal Funds Rate	2.72	0.03	1.34	0.26
Federal Funds Rate	Taylor Rule	9.62	0.00	11.56	0.00
Taylor Rule	Federal Funds Rate	1.53	0.20	1.59	0.19
NBER Peak	Taylor Rule Deviation	3.01	0.02	2.71	0.04

Note: Granger causality tests are based on a regression of the dependent variable on four of its own quarterly lags and four quarterly lags of the independent variable.

Table 3. Greenbook Forecast Efficiency Tests: 1987:3 – 2012:4

Forecasted Variable	Additional Predictor	*a* (se)	*b* (se)	*c* (se)	Test Statistic (*p*-value)
Output Gap		-0.19	1.01		*F* = 0.25
		(0.30)	(0.08)		(0.78)
Output Gap	Real-Time M1	-0.43	1.18	0.11	*t* = 1.45
		(0.38)	(0.15)	(0.07)	(0.15)
Output Gap	Real-Time M2	0.69	1.02	-0.18	*t* = -2.02
		(0.45)	(0.07)	(0.09)	(0.05)
Output Gap	Simple-Sum M1	-0.41	1.16	0.09	*t* = 1.36
		(0.37)	(0.14)	(0.07)	(0.17)
Output Gap	Simple-Sum M2	0.87	1.02	-0.21	*t* = -2.50
		(0.42)	(0.07)	(0.08)	(0.01)
Output Gap	Divisia M1	-1.11	1.12	0.19	*t* = 2.45
		(0.53)	(0.10)	(0.08)	(0.02)
Output Gap	Divisia M2	0.09	1.00	-0.06	*t* = -1.06
		(0.39)	(0.08)	(0.05)	(0.29)
Output Gap	Divisia MZM	-0.03	1.01	-0.03	*t* = -0.66
		(0.29)	(0.08)	(0.04)	(0.51)
Output Gap	Divisia M4	0.42	1.08	-0.11	*t* = -1.39
		(0.42)	(0.10)	(0.08)	(0.17)
CPI Inflation		1.29	0.59		*F* = 4.10
		(0.45)	(0.16)		(0.02)
CPI Inflation	Real-Time M1	1.23	0.60	0.01	*t* = 0.44
		(0.48)	(0.15)	(0.03)	(0.66)
CPI Inflation	Real-Time M2	1.53	0.57	-0.03	*t* = -0.65
		(0.61)	(0.17)	(0.05)	(0.51)
CPI Inflation	Simple-Sum M1	1.25	0.60	0.01	*t* = 0.26
		(0.48)	(0.15)	(0.03)	(0.79)
CPI Inflation	Simple-Sum M2	1.41	0.58	-0.02	*t* = -0.32
		(0.61)	(0.17)	(0.05)	(0.75)
CPI Inflation	Divisia M1	1.69	0.55	-0.05	*t* = -1.11
		(0.59)	(0.15)	(0.05)	(0.27)
CPI Inflation	Divisia M2	2.02	0.50	-0.10	*t* = -1.87
		(0.58)	(0.15)	(0.05)	(0.06)
CPI Inflation	Divisia MZM	2.11	0.50	-0.11	*t* = -2.97
		(0.41)	(0.12)	(0.04)	(0.00)
CPI Inflation	Divisia M4	1.67	0.60	-0.08	*t* = -1.93
		(0.39)	(0.15)	(0.04)	(0.06)

Notes: The coefficients *a*, *b*, and *c* are from a regression of the nowcast of a variable made for quarter *t* in quarter *t* on a constant, the one-year-ahead forecast of the same variable for quarter *t* made in in quarter *t* - 4, and the annual rate of money growth between quarters *t* - 8 and *t* - 4. Standard errors, *F*-statistics for the null hypothesis *a* = 0 and *b* = 1, and *t*-statistics for the null hypothesis *c* = 0 are corrected for serially correlated errors following Newey and West (1987).

Table 4. Greenbook Forecast Efficiency Tests: 1980:1 – 2007:4

Forecasted Variable	Additional Predictor	*a* (se)	*b* (se)	*c* (se)	Test Statistic (*p*-value)
Real GDP Growth		0.85 (0.73)	0.69 (0.25)		*F* = 0.80 (0.45)
Real GDP Growth	Real-Time M1	0.73 (0.74)	0.66 (0.24)	0.04 (0.05)	*t* = 0.79 (0.43)
Real GDP Growth	Real-Time M2	0.59 (0.83)	0.69 (0.24)	0.05 (0.10)	*t* = 0.46 (0.65)
Real GDP Growth	Simple-Sum M1	0.75 (0.74)	0.67 (0.24)	0.04 (0.05)	*t* = 0.70 (0.48)
Real GDP Growth	Simple-Sum M2	0.72 (0.80)	0.68 (0.25)	0.02 (0.10)	*t* = 0.25 (0.80)
Real GDP Growth	Divisia M1	0.06 (0.66)	0.58 (0.22)	0.19 (0.05)	*t* = 3.87 (0.00)
Real GDP Growth	Divisia M2	0.56 (0.72)	0.55 (0.26)	0.14 (0.08)	*t* = 1.86 (0.07)
Real GDP Growth	Divisia MZM	0.68 (0.70)	0.52 (0.24)	0.12 (0.05)	*t* = 2.57 (0.01)
Real GDP Growth	Divisia M4	0.27 (0.85)	0.59 (0.24)	0.16 (0.09)	*t* = 1.70 (0.09)
Unemployment Rate		0.38 (0.72)	0.92 (0.13)		*F* = 0.44 (0.64)
Unemployment Rate	Real-Time M1	0.22 (0.80)	0.96 (0.15)	-0.02 (0.02)	*t* = -0.90 (0.37)
Unemployment Rate	Real-Time M2	0.35 (0.75)	0.90 (0.12)	0.03 (0.04)	*t* = 0.60 (0.55)
Unemployment Rate	Simple-Sum M1	0.25 (0.79)	0.95 (0.15)	-0.02 (0.02)	*t* = -0.78 (0.43)
Unemployment Rate	Simple-Sum M2	0.31 (0.77)	0.90 (0.12)	0.04 (0.04)	*t* = 0.87 (0.39)
Unemployment Rate	Divisia M1	0.54 (0.66)	0.96 (0.12)	-0.08 (0.03)	*t* = -2.56 (0.01)
Unemployment Rate	Divisia M2	0.78 (0.70)	0.89 (0.11)	-0.05 (0.05)	*t* = -1.02 (0.31)
Unemployment Rate	Divisia MZM	0.66 (0.65)	0.91 (0.11)	-0.04 (0.03)	*t* = -1.13 (0.26)
Unemployment Rate	Divisia M4	0.84 (0.77)	0.90 (0.12)	-0.06 (0.05)	*t* = -1.08 (0.28)

Note: See notes to Table 3.

Table 5. Greenbook Forecast Efficiency Tests: 1980:1 – 2007:4

Forecasted Variable	Additional Predictor	*a* (se)	*b* (se)	*c* (se)	Test Statistic (*p*-value)
CPI Inflation		0.95	0.72		F = 2.26
		(0.46)	(0.13)		(0.11)
CPI Inflation	Real-Time M1	0.97	0.72	-0.01	t = -0.20
		(0.46)	(0.14)	(0.03)	(0.84)
CPI Inflation	Real-Time M2	1.06	0.73	-0.02	t = -0.49
		(0.50)	(0.13)	(0.05)	(0.62)
CPI Inflation	Simple-Sum M1	0.98	0.73	-0.01	t = -0.33
		(0.46)	(0.14)	(0.04)	(0.74)
CPI Inflation	Simple-Sum M2	1.04	0.73	-0.02	t = -0.41
		(0.50)	(0.14)	(0.05)	(0.68)
CPI Inflation	Divisia M1	1.23	0.72	-0.05	t = -1.09
		(0.53)	(0.14)	(0.04)	(0.28)
CPI Inflation	Divisia M2	1.25	0.69	-0.04	t = -0.69
		(0.58)	(0.13)	(0.06)	(0.49)
CPI Inflation	Divisia MZM	1.40	0.67	-0.05	t = -1.35
		(0.54)	(0.13)	(0.04)	(0.18)
CPI Inflation	Divisia M4	1.51	0.68	-0.08	t = -1.06
		(0.62)	(0.12)	(0.08)	(0.29)
GDP Price Inflation		0.34	0.84		F = 4.06
		(0.24)	(0.07)		(0.02)
GDP Price Inflation	Real-Time M1	0.30	0.83	0.02	t = 0.79
		(0.25)	(0.07)	(0.02)	(0.43)
GDP Price Inflation	Real-Time M2	0.36	0.84	-0.00	t = -0.15
		(0.27)	(0.07)	(0.03)	(0.88)
GDP Price Inflation	Simple-Sum M1	0.30	0.83	0.01	t = 0.70
		(0.25)	(0.07)	(0.02)	(0.49)
GDP Price Inflation	Simple-Sum M2	0.37	0.84	-0.01	t = -0.25
		(0.27)	(0.07)	(0.03)	(0.81)
GDP Price Inflation	Divisia M1	0.43	0.84	-0.01	t = -0.77
		(0.26)	(0.07)	(0.02)	(0.44)
GDP Price Inflation	Divisia M2	0.56	0.82	-0.03	t = -0.94
		(0.36)	(0.07)	(0.03)	(0.35)
GDP Price Inflation	Divisia MZM	0.66	0.80	-0.04	t = -1.59
		(0.35)	(0.08)	(0.02)	(0.11)
GDP Price Inflation	Divisia M4	0.65	0.82	-0.04	t = -1.10
		(0.40)	(0.07)	(0.04)	(0.27)

Note: See notes to Table 3.

Table 6. Greenbook Forecast Efficiency Tests: 1980:1 – 2007:4

Forecasted Variable	Additional Predictor	*a* (se)	*b* (se)	*c* (se)	Test Statistic (*p*-value)
Nominal GDP Growth		1.65	0.69		F = 1.10
		(1.12)	(0.21)		(0.34)
Nominal GDP Growth	Real-Time M1	1.92	0.58	0.08	t = 1.93
		(1.11)	(0.21)	(0.04)	(0.06)
Nominal GDP Growth	Real-Time M2	1.56	0.61	0.10	t = 0.89
		(1.12)	(0.21)	(0.11)	(0.38)
Nominal GDP Growth	Simple-Sum M1	1.88	0.60	0.07	t = 1.71
		(1.12)	(0.21)	(0.04)	(0.09)
Nominal GDP Growth	Simple-Sum M2	1.58	0.64	0.07	t = 0.60
		(1.12)	(0.21)	(0.11)	(0.55)
Nominal GDP Growth	Divisia M1	0.77	0.69	0.16	t = 2.80
		(1.10)	(0.19)	(0.06)	(0.01)
Nominal GDP Growth	Divisia M2	1.41	0.71	0.03	t = 0.28
		(1.13)	(0.19)	(0.10)	(0.78)
Nominal GDP Growth	Divisia MZM	1.24	0.73	0.04	t = 0.58
		(1.12)	(0.20)	(0.07)	(0.56)
Nominal GDP Growth	Divisia M4	1.39	0.71	0.03	t = 0.24
		(1.35)	(0.20)	(0.14)	(0.81)

Note: See notes to Table 3.

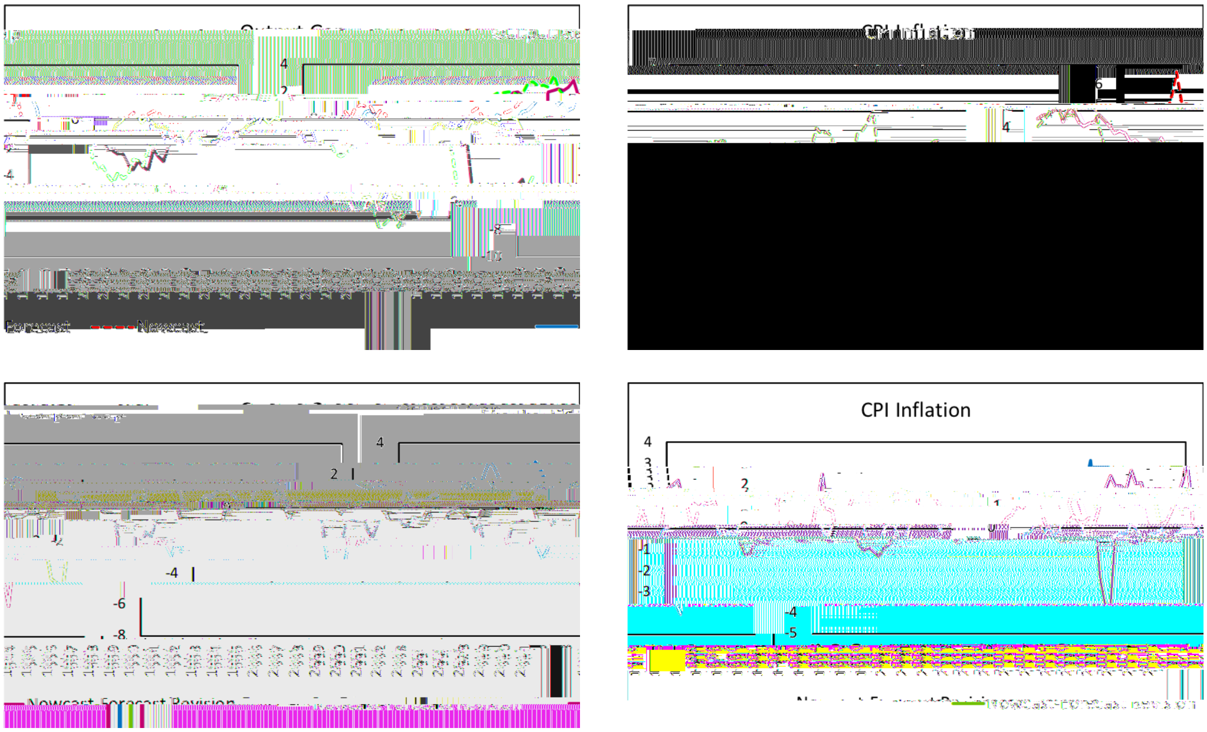

Figure 1. Greenbook Forecasts, Nowcasts, and Nowcast-Forecast Revisions. Forecasts of the output gap and year-over-year CPI inflation for quarter *t* are made in quarter *t* -4; nowcasts for quarter *t* are made in quarter *t*; revisions correspond to the difference between the two.

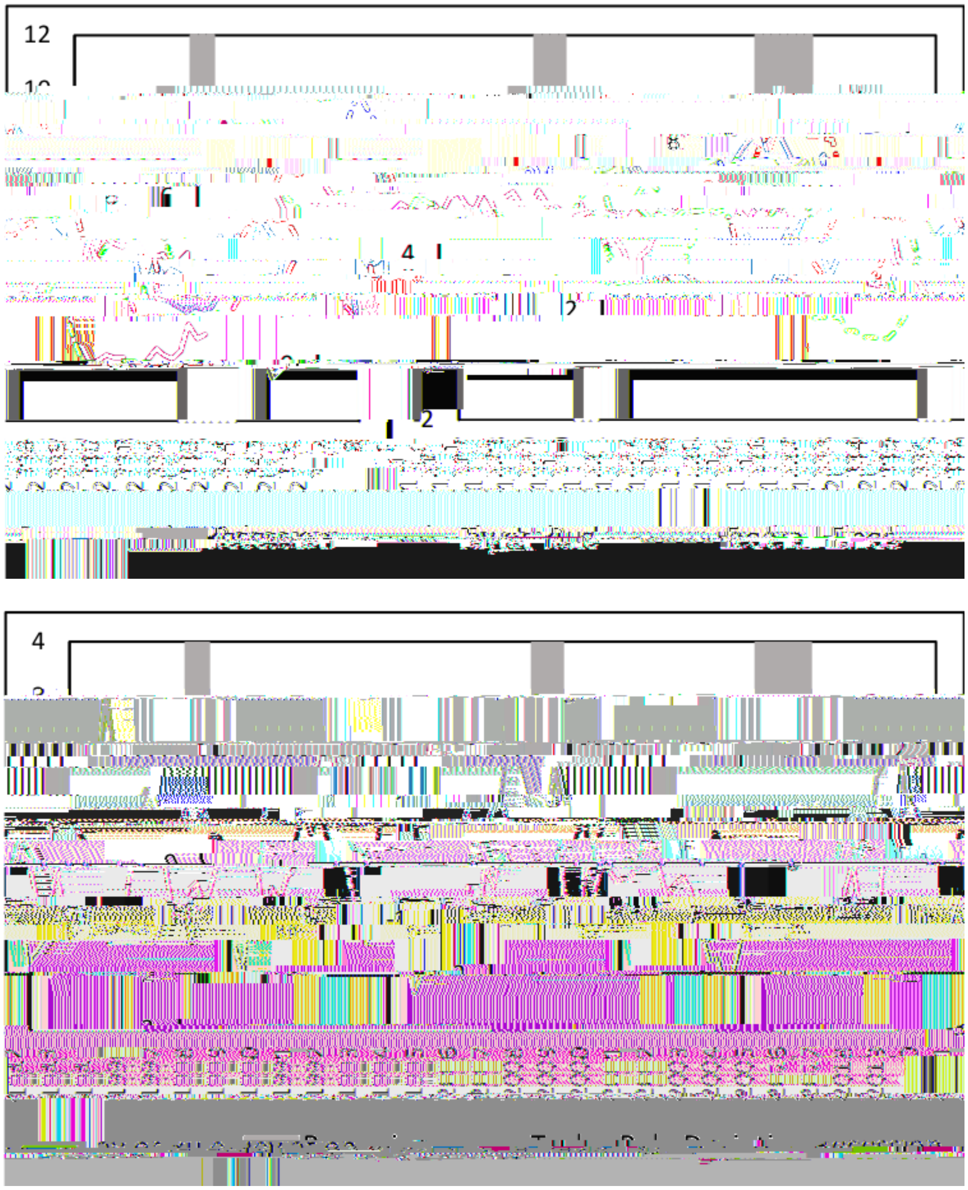

Figure 2. Greenbook Forecast-Based Taylor Rule and Deviations. The top panel compares the setting for the federal funds rate prescribed by a version of the Taylor (1993) Rule, using year-ahead Greenbook forecasts for the output gap and CPI inflation, to the actual funds rate. The bottom panel plots the difference between the actual funds rate and the value indicated by the Taylor Rule. Recessions, as identified by the NBER, are shaded in gray.

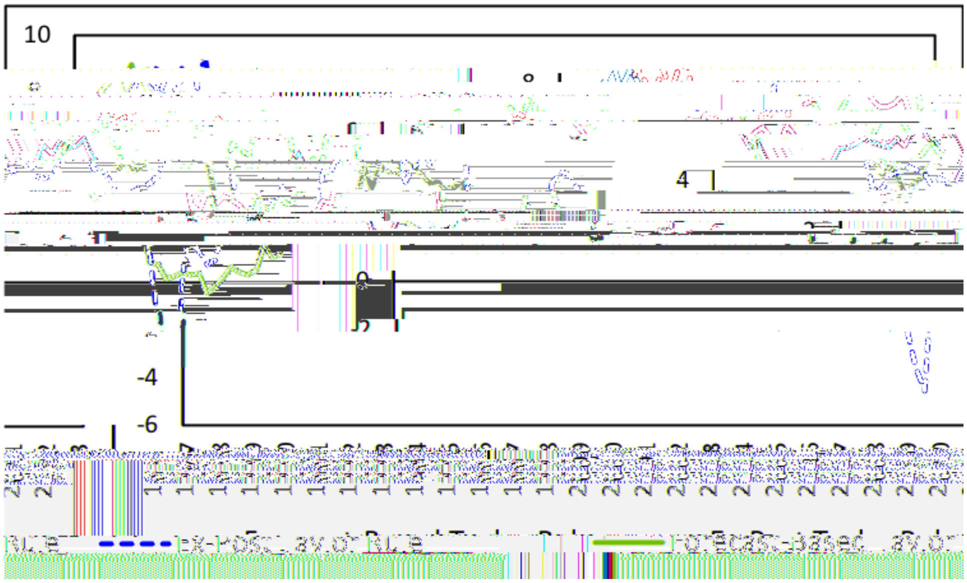

Figure 3. Comparison of Taylor Rules Based on Greenbook Forecasts and *Ex Post* Data.

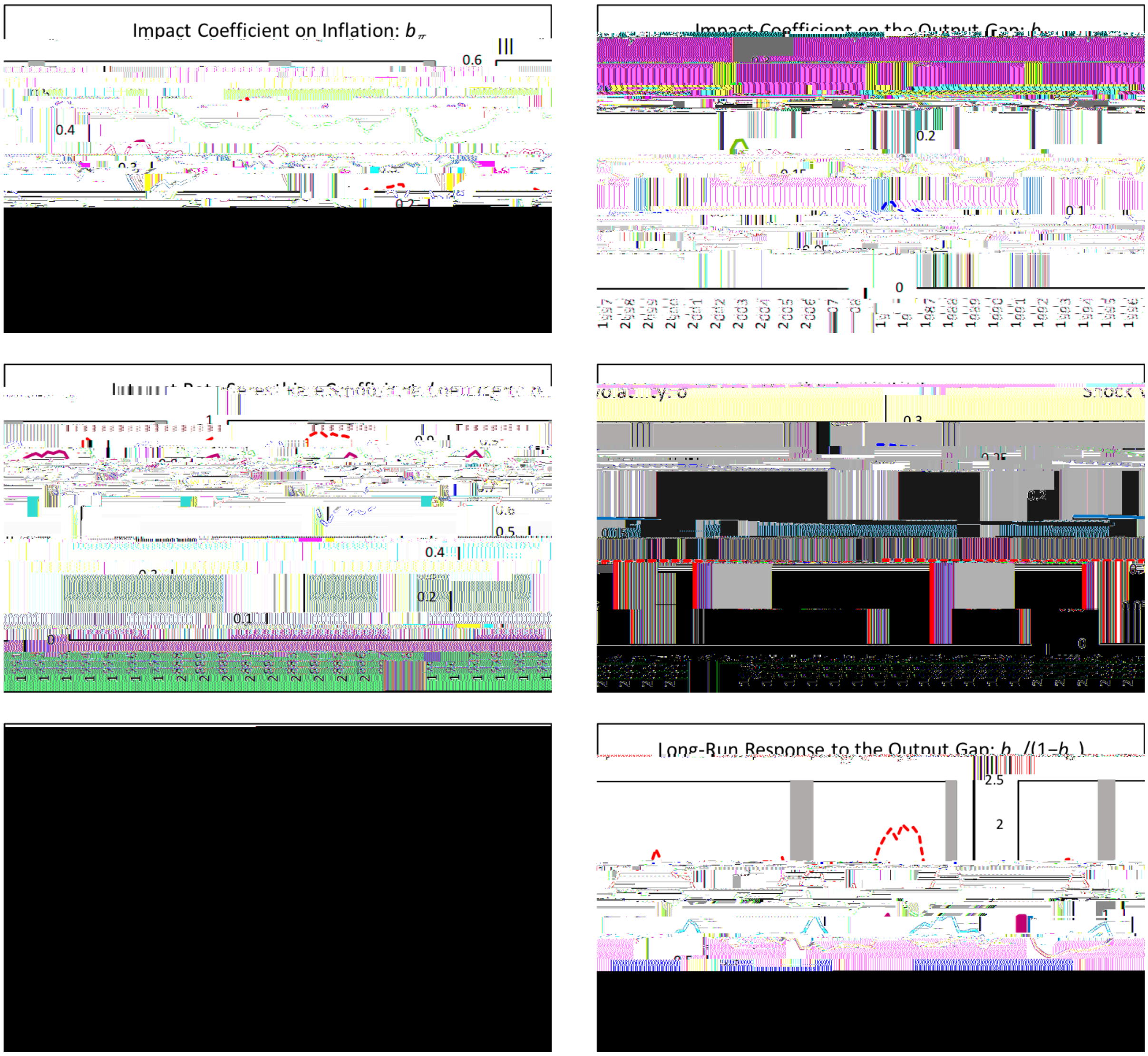

Figure 4. Time-Varying Parameters from an Estimated Greenbook Forecast-Based Taylor Rule. Each panel shows the median (solid blue line) and 16th and 84th percentiles (dashed red lines) for the indicated parameter at the indicated date. Recessions, as identified by the NBER, are shaded in gray.

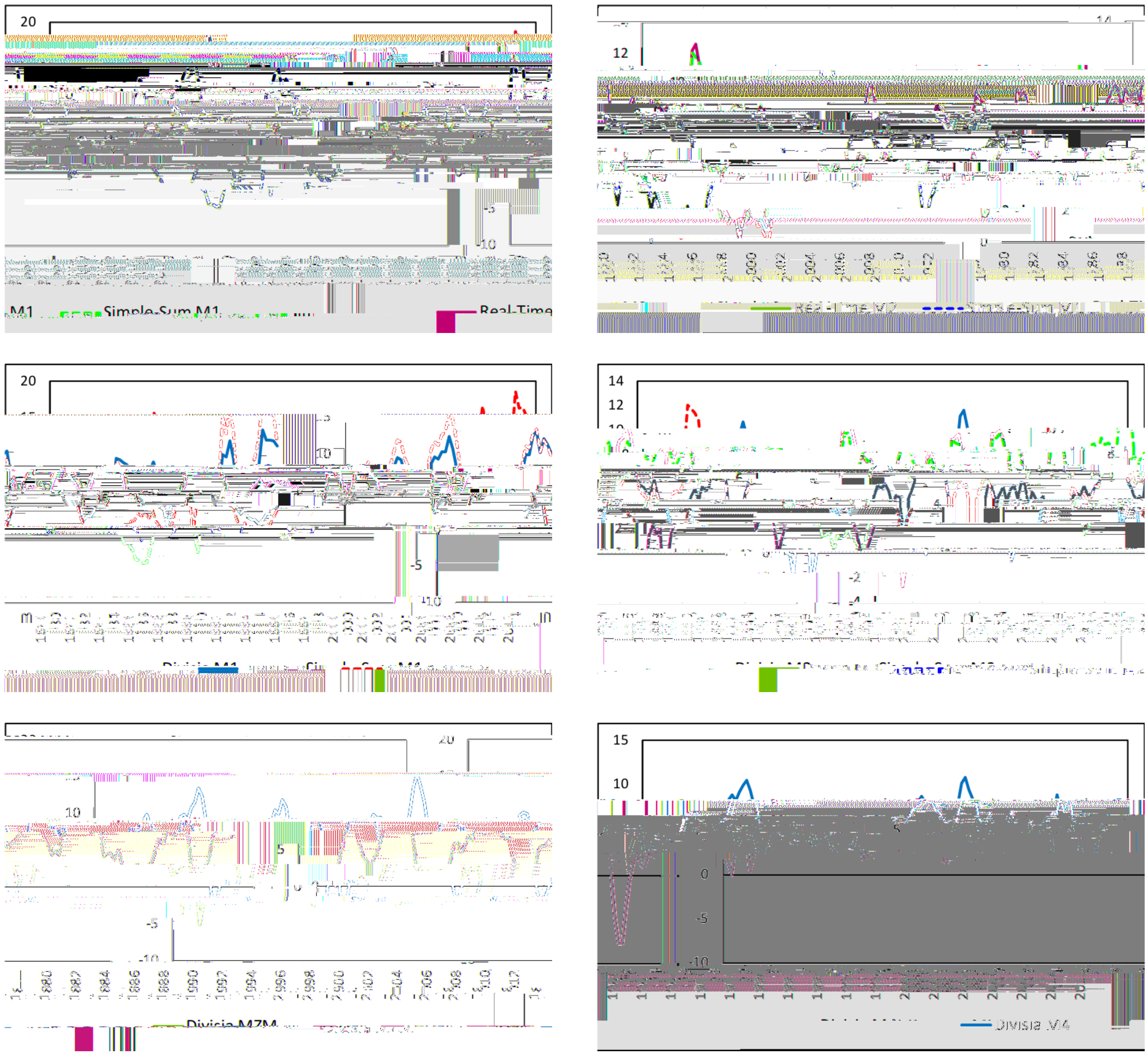

Figure 5. Real-Time, Simple-Sum, and Divisia Money Growth. Each panel plots the growth rate of the indicated monetary aggregate over the previous four quarters.