SPECIAL REPORT
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Monetary Policy Report: Using Rules for Benchmarking

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Introduction

This special report highlights ongoing work to benchmark the stance of monetary policy using a range of policy rules that are widely employed in studies of monetary economics.[1] We perform the exercise with a specific, publicly available model of the macroeconomy developed by researchers at the Federal Reserve Board of Governors. We then employ this model to explore the expected behavior of economic variables, including the policy rate, under alternative policy rules. The policy rules help to benchmark not only the current stance of the federal funds rate but also guidance on how the path of policy is likely to evolve in the context of the model. Such an exercise as part of a more comprehensive quarterly monetary policy report would enhance communication and promote a more systematic approach to monetary policy.

We begin with an overview of the economy and then discuss the benchmark model we use to generate our forecasts with different policy rules. The remainder of the report highlights the outcomes of different robust policy rules and discusses why policymakers might choose to deviate from the rules.

[1] The views expressed here are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

Economic Overview

Despite weaker foreign growth and financial market volatility, to name two of many recent headwinds, the U.S. economy continues to chug along, fueled by solid fundamentals. After lackluster real gross domestic product growth of 1.1 percent in the fourth quarter of 2015, the economy now appears to be growing modestly, although still somewhat below its trend pace of 2.0 percent. What we consider a more accurate picture of U.S. economic activity, GDPplus, puts fourth quarter growth at 1.7 percent.[2] In the current quarter, activity appears to be rebounding, with nowcasts generally placing first quarter 2016 growth at approximately 2.0% and forecasts showing slight acceleration over the remainder of the year.

The latest data on retail sales place consumption on a somewhat lower trajectory over the near term, given that January's initially reported 0.2 percent rise in retail sales was significantly downgraded to a decline of 0.4 percent. But fundamentals such as job growth, personal income growth, and reasonably healthy consumer balance sheets point to continued solid growth from this sector. All told, many forecasters still project consumer spending growth of upward of 2.5 percent in 2016, which remains reasonably healthy. Lending confidence to this viewpoint, turmoil in financial markets has abated, with equity prices having recovered all of their losses from early in the year and the price of West Texas Intermediate crude oil having risen to close to $40 per barrel.

Underpinning much of the first quarter's modest rebound is continued robust growth in employment, with January and February's net new jobs averaging 207,000. Also, the unemployment rate has declined to 4.9 percent, putting it at or below many economists' estimate of the natural rate. Labor force participation has also ticked up, by 0.2 percentage point, with job openings at record levels and quits almost at their prerecession rates. The only somewhat weak news in the February employment report was the decline in average hourly wages. However, as described in a recent newsletter from the Federal Reserve Bank of San Francisco, much of the weakness in wage growth over this recovery is attributable to compositional effects as large numbers of relatively highly paid workers retire and are replaced by younger workers earning lower wages and as lower-wage workers begin to shift from part-time to full-time jobs.[3] Looking at median weekly earnings growth for those continuously employed full-time over a 12-month period, one sees wage growth of around 4.0 percent. The Federal Reserve Bank of Atlanta's wage growth tracker, which reports the median percent

[2] For a detailed analysis of this variable, see "Real-Time Performance of GDPplus and Alternative Model-Based Measures of GDP: 2005–2014," https://www.philadelphiafed.org/-/media/research-and-data/publications/research-rap/2014/real-time-performance-of-gdpplus.pdf?la=en.

[3] See "What's Up with Wage Growth," http://www.frbsf.org/economic-research/publications/economic-letter/2016/march/slow-wage-growth-and-the-labor-market/.

change in the hourly wage of individuals at 12-month intervals, indicates wage growth of 3.2 percent as of February 2016.[4] Thus, the overall labor market picture remains one of robustness and dynamism that should continue to underpin solid growth in consumer spending.

Even though consumer spending has weakened a bit of late, sales of light vehicles continue to be exceptionally robust, with 17.4 million unit sales at an annual rate in February. That robust activity is consistent with the latest readings on consumer confidence, which remain high.

The housing sector continues its somewhat steady upward trajectory. Although pending home sales declined 2.5 percent in January, in part influenced by the effects of winter storm Jonas, housing starts rose 5.2 percent in February to 822,000, which is the highest level during the recovery. Thus, January's entire decline was reversed in February. Single-family permits also exhibited renewed strength, increasing 0.4 percent in February, and December and January's totals were revised higher as well. House prices continue to increase at a steady pace, with the CoreLogic house price index up 6.9 percent over the past 12 months in January. Taken together, the data suggest that residential construction is continuing its upward trend in the first quarter.

Although there is abundant evidence of modest economic strength, the manufacturing and energy sectors continue to struggle. However, manufacturing may be turning the corner, as manufacturing industrial production rose 0.5 percent in January and 0.2 percent in February. The potential turnaround is reflected in a number of regional indices, such as ones reported by the Federal Reserve Bank of New York, the Federal Reserve Bank of Richmond, and the Federal Reserve Bank of Philadelphia. After remaining below zero for six months, our *Manufacturing Business Outlook Survey*'s general activity index returned to positive territory in March, at 12.4. Increased optimism was also reflected in a solid gain in the future general activity index. Buttressing the evidence of a first quarter turnaround was a 1.6 percent increase in new orders for factory goods in January.

On the inflation front, there are signs of firming, as the dollar has stopped appreciating, and oil and gas prices have stabilized and are even beginning to rebound a bit. Consumer price inflation excluding food and energy continued to firm in February, with core CPI rising at a 2.3 percent rate over the past 12 months. This is the highest reading in four years. Additionally, the core PCE index was up 1.7 percent over the past 12 months in January, and February's core CPI reading may point to additional firming in this index as well. With the dollar appreciating somewhat recently and gas prices firming a bit, it is likely that headline numbers will start converging to core readings. Meanwhile, inflation expectations as measured by the spread between nominal Treasury yields and Treasury Inflation-Protected Securities (TIPS) remain below the 2 percent target set by the Federal Open Market Committee (FOMC), although they

[4] The tracker can be found at https://www.frbatlanta.org/chcs/wage-growth-tracker.aspx?panel=1.

have rebounded a bit of late. Given the high correlation of this measure with gasoline prices, we expect that inflation expectations will continue to converge to target.

Overall, this quarter's economic growth remains steady at its approximate 2.0 percent trend rate, and most forecasters as well as FOMC participants expect slightly above-trend growth over the near term. The economy is characterized by solid fundamentals, and although headline inflation remains muted, there are some signs of a firming in price pressures. We continue to believe that the economy has returned to a fairly normal state of activity.

Given the fairly unchanged view of the economy, the decision to ratchet down the expected path of tightening in the Summary of Economic Projections (SEP) may have come as a bit of a surprise to some, but it likely reflects the continued presence of a number of downside risks. China's growth has slowed somewhat, and the outlook for Europe has been downgraded a bit. Growth worldwide is still far from healthy. However, we have seen a marked reversal in equity prices and stabilization in financial markets. For our part, we are increasingly confident in U.S. economic prospects, as the economy has shown resilience in the face of a number of negative shocks.

The Benchmark Model

To create our forecasts and to carry out our monetary policy benchmarking exercises, we use a structural forecasting model called Estimated Dynamic Optimization (EDO) developed by researchers at the Board of Governors. This medium-scale model shares many features of standard New Keynesian Dynamic Stochastic General Equilibrium (NKDSGE) models that are at the forefront of macroeconomic modeling and forecasting. The EDO model features households and firms that are forward looking and that make decisions facing resource constraints. The model includes multiple sectors, a rich menu of shocks, and adjustment costs that make wages and prices less than fully flexible in responding to changes in economic conditions. Detailed documentation on the model structure and computer programs that implement model simulations can be found at the Board of Governors' website at www.federalreserve.gov/econresdata/edo/edo-models-about.htm. We generate forecasts from a version of this model using several different monetary policy rules to provide a sense of how the economy might perform under a reasonable set of policy paths, given current and expected economic conditions.

The key parameters that we change under the various policy alternatives are those that govern the response of the short-term interest rate to changes in economic conditions. The monetary policy response function is of the form

$$R_t = \rho R_{t-1} + (1-\rho)[\Psi_\pi(\pi_{t|t-4} - \pi^*) + \Psi_y ygap_t] + \varepsilon_t^R ,$$

where R_t is the deviation of the effective federal funds rate from its long-run equilibrium value, $\pi_{t|t-4}$ is the four quarter change in core PCE inflation, and $ygap_t$ is a measure of the output gap.[5] We run forecast simulations under four different versions of the basic rule shown here:

Table 1

Rule	$\boldsymbol{\rho}$	$\boldsymbol{\Psi_\pi}$	$\boldsymbol{\Psi_y}$
Baseline	0.83	1.46	0.26
Taylor (1993)	0.0	1.50	0.50
Taylor (1999)	0.0	1.50	1.0
Inertial Taylor (1999)	0.85	1.50	1.0

The baseline rule uses parameter values that are estimated from the data using the full EDO model. That is, the baseline rule depicts the historical behavior of monetary policymakers. The Taylor rule alternatives are parameterizations of the policy rule taken from the economics literature and are widely used in simulations of macroeconomic models.

Model Forecasts Under the Baseline

We first generate forecasts assuming that monetary policy follows the baseline policy rule. The forecast is generated using observed data through the fourth quarter of 2015 and a nowcast for the first quarter of 2016. The forecast begins in the second quarter of 2016 and extends through the fourth quarter of 2018. The forecasts under the baseline and the alternative policy rules are shown in Figures 1 through 4. The baseline forecast is represented by the dark solid line. The colored bands around the baseline forecast represent 10 percent confidence intervals of the predictive distribution around the median of the baseline forecast.[6]

The key features of the baseline forecast are as follows:

- Real output is forecast to grow at an average pace of about 2.7 percent in 2016, 2017, and 2018.
- Core PCE inflation averages 1.7 percent in 2016, rising to 2 percent in 2017 and 2.1 percent in 2018.

[5] The model calibration implies that the long-run equilibrium value of the federal funds rate is 4.1 percent. The output gap is calculated using the Beveridge-Nelson decomposition, which decomposes a data series into stochastic trend and stationary cycle components. The gap is then measured by the cycle component. It is important to note that the output gap is computed as part of the model solution and is not an exogenous input into the simulations.

[6] The forecast simulations are generated using Bayesian methods. The fan charts show 10 percent quantiles around the median of the posterior predictive distribution.

- The unemployment rate falls to a low of 4.4 percent in the fourth quarter of 2017 and remains at about that level through the end of 2018.[7]
- The federal funds rate rises to 0.5 percent in the second quarter of 2016 and reaches 1.1 percent by the end of the year. At the end of 2017, the funds rate is at 2.1 percent, and it hits 2.8 percent at the end of 2018.
- Compared with the December forecast, real GDP growth and inflation are slightly weaker over the horizon — more so in 2016 (Figure 5).

The baseline forecast calls for output growth to accelerate from 2 percent in the first quarter of 2016 to 2.7 percent in early 2018. Output growth then hovers around 2.7 percent over the remainder of 2018.[8] The unemployment rate continues to decline, reaching 4.4 percent at the end of 2017 and holding near that level through the end of 2018. Moderately strong growth and anchored long-run inflation expectations lead to an acceleration of core PCE inflation from 1.4 percent in the first quarter of 2016 to 2.2 percent in the fourth quarter of 2018. Under the baseline policy parameterization, the output growth and inflation outcomes correspond to a gradually rising federal funds rate over the next three years. The model predicts that the funds rate continues to rise from the zero lower bound, reaching 0.5 percent in the second quarter of 2016 and 1.1 percent by year-end. Thereafter, the funds rate rises at a gradual but steady pace to 2.8 percent by the end of 2018.

The baseline forecast is somewhat stronger than the median projections from the fourth quarter 2015 *Survey of Professional Forecasters* (*SPF*). In that survey, the respondents expected real output growth of 2.1 percent in 2016, 2.4 percent in 2017, and 2.7 percent in 2018. (Note that the *SPF* reports GDP growth as annual average over annual average). The *SPF* core PCE inflation forecast is 1.6 percent (Q4/Q4) for 2016, 1.8 percent for 2017, and 1.9 percent for 2018. The forecasters' path for the unemployment rate is a bit higher than in the baseline model: The median *SPF* forecast for the unemployment rate averages 4.8 percent in 2016, falling slightly to 4.6 percent in 2017 and 2018.

The March 2016 SEP by FOMC participants shows the median projection for output growth in 2016 at 2.2 percent, falling to 2.1 percent in 2017 and to 2 percent in 2018. The median forecast of the unemployment rate is 4.7 percent in the fourth quarter of 2016, falling to 4.6 percent in the fourth quarter of 2017 and 4.5 percent in the fourth quarter of 2018. Core PCE inflation is projected at 1.6 percent in 2016, rising to 1.8 percent in 2017 and 2 percent in 2018.

[7] The baseline unemployment rate forecast is add-factored to more accurately reflect our views on the likely evolution of labor market conditions. The modifications to the baseline forecast are kept in place when the model is simulated under the alternative policy rules.

[8] The model estimates long-run real per capita output growth of about 2 percent. We then assume that population growth averages 1 percent per year over the forecast horizon.

Headline inflation is weaker in 2016 at 1.2 percent, but as energy prices stabilize, headline inflation is expected to run at a similar pace as core inflation in 2017 and 2018. The model's baseline forecast for the funds rate (Figure 4) is generally within the central tendency of the March 2016 SEP over the forecast horizon and remains well above market expectations for the funds rate, which are about 1.1 percent for the fourth quarter of 2018. The model generally suggests a somewhat more rapid pace of policy normalization compared with market expectations to keep the output gap, inflation gap, and interest rate aligned as per the baseline rule parameterization.

Behavior Under Alternative Taylor Rules

To gauge the robustness of the model's benchmark prescription for monetary policy, we also generate forecasts assuming that the policymaker adopts one of the alternative Taylor rules shown in Table 1.[9]

The key features of the forecasts under the alternative policy rules are as follows:

- All of the policy rules suggest that the funds rate should rise at a fairly rapid pace over the next three years — much more rapidly than suggested by financial markets.
- The more accommodative monetary policies are associated with more rapid output growth, lower unemployment, and higher inflation.
- Most of the differences among the forecasts appear in output growth and not in inflation or unemployment. The model estimates somewhat persistent inflation measures that respond sluggishly to shocks.
- By the first quarter of 2017, the forecasts for output, inflation, and the federal funds rate have largely converged across the policy alternatives. The entire future path of the interest rate — rather than the current rate — is key for the dynamics of the economy.
- The federal funds rate under all of the alternative rules nears 2 percent by the third quarter of 2017, which is well above current market expectations of what the funds rate will be at that time.

The alternative policy rules suggest somewhat different near-term levels of the appropriate federal funds rate starting with the second quarter of 2016. The Taylor (1993) rule calls for the most policy tightening, with the funds rate averaging 1 percent over the second quarter. The Taylor (1999) rule has the funds rate at -0.18 percent. In implementing the model, we have not

[9] When generating the forecasts under the alternative policy rules, we assume that the state of the economy up to and including the third quarter of 2014 is the same as that implied by the baseline rule calibration of the model. Given the state variable history, we then switch rules and forecast under the alternatives beginning in the fourth quarter of 2014. In this framework, the switch in policy rules is not anticipated by the model agents, and they expect the new rule to be in place for all future periods.

constrained the federal funds rate to be nonnegative. Consequently, the Taylor (1999) rule suggests that monetary policy should be eased further in response to the weak output growth and inflation readings up through the first quarter of 2016. The inertial Taylor (1999) rule puts the federal funds rate at 0.22 percent. Note, though, that all of the rules suggest that the funds rate should be close to 2 percent by the third quarter of 2017. So, even though the Taylor (1999) rule calls for more near-term policy easing, the extra accommodation is fairly short lived.

The path of output growth is slightly weaker under the Taylor (1993) rule, which calls for the highest near-term interest rate, with output growth at 2.6 percent in the second quarter of 2016. The inertial Taylor (1999) rule, which over the forecast horizon is the most accommodative policy, has real output growth at 4.7 percent in the second quarter of 2016. Note, though, that the output growth forecasts largely converge by the middle of 2017. The alternative policy rules have little impact on the future path of inflation. Inflation adjusts gradually to shocks in the model and depends on the expected future path of the economy, which is similar across the policy rules in the medium and longer runs. Core inflation runs at about 1.7 percent (Q4/Q4) in 2016 and shows little dispersion over the forecast horizon across the alternative policies. The inflation paths are all close to the baseline path and show relatively small differences across paths over the next three years.

Summary

The policy alternatives continue to give somewhat mixed signals about the appropriate near-term stance of monetary policy — but the discrepancy remains short lived. The baseline rule and Taylor (1993) rule suggest that the federal funds rate should be somewhat higher in the second quarter than its current prevailing rate of about 0.38 percent. The inertial Taylor (1999) rule suggests that current policy is slightly tight. The Taylor (1999) rule suggests that policy should be more accommodative. However, the alternative policy rules agree that the funds rate should be somewhere in the range of 0.8 to 1.2 percent by the end of 2016 and so call for more aggressive tightening compared with financial market expectations. Note that this prediction is now in line with the central tendency for the federal funds rate in the SEP for the December FOMC meeting.

Even though inflation is below the FOMC's longer-run target, economic conditions are still consistent with a gradual tightening of policy according to the various rules we analyze. Accompanying this gradual tightening, the economy is expected to transition to full employment and to achieve its long-run inflation target.

Figure 1: Real GDP Growth

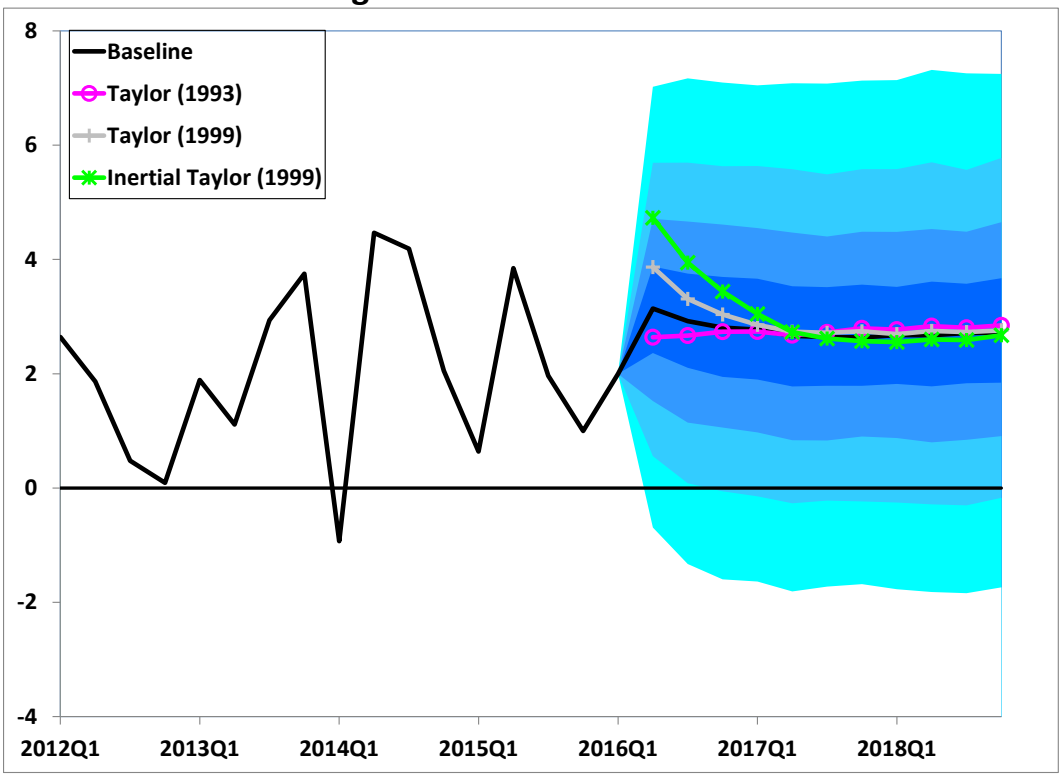

Figure 2: PCE Core Inflation

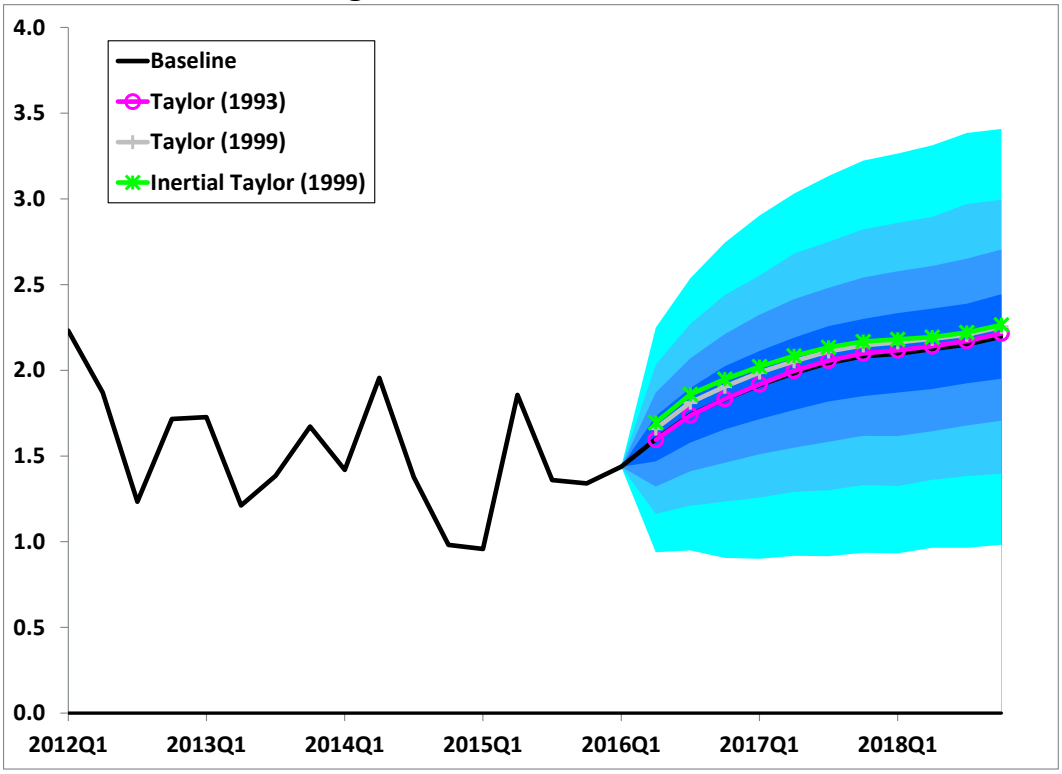

Figure 3: Unemployment Rate

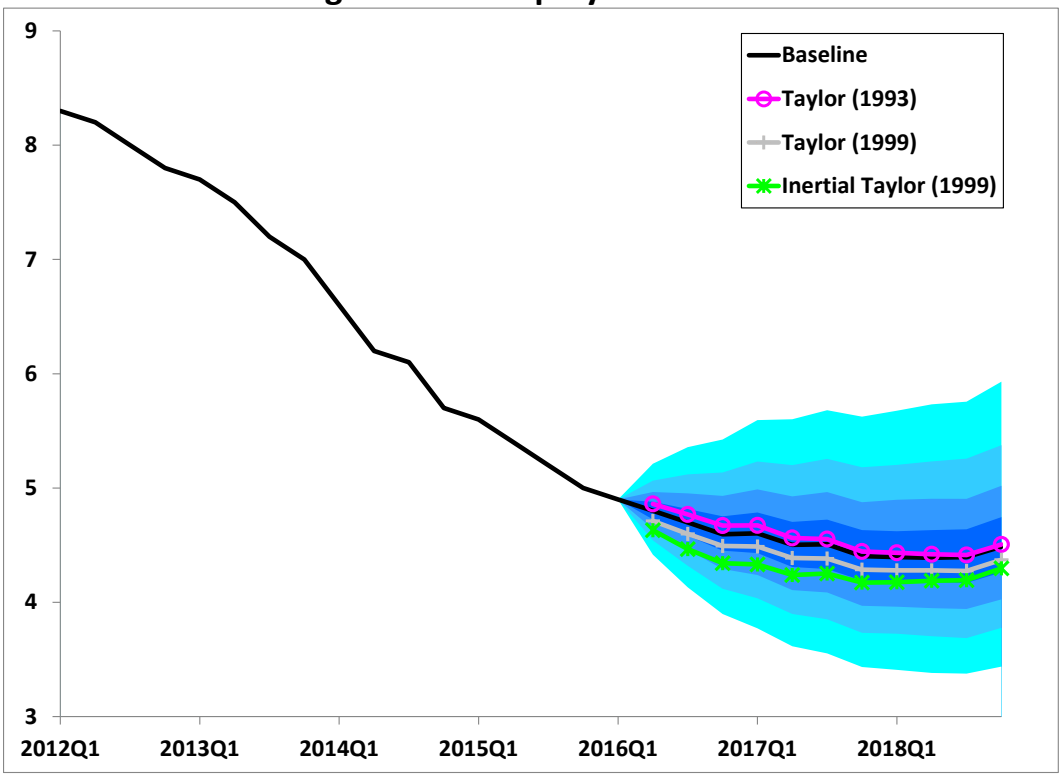

Figure 4: Federal Funds Rate

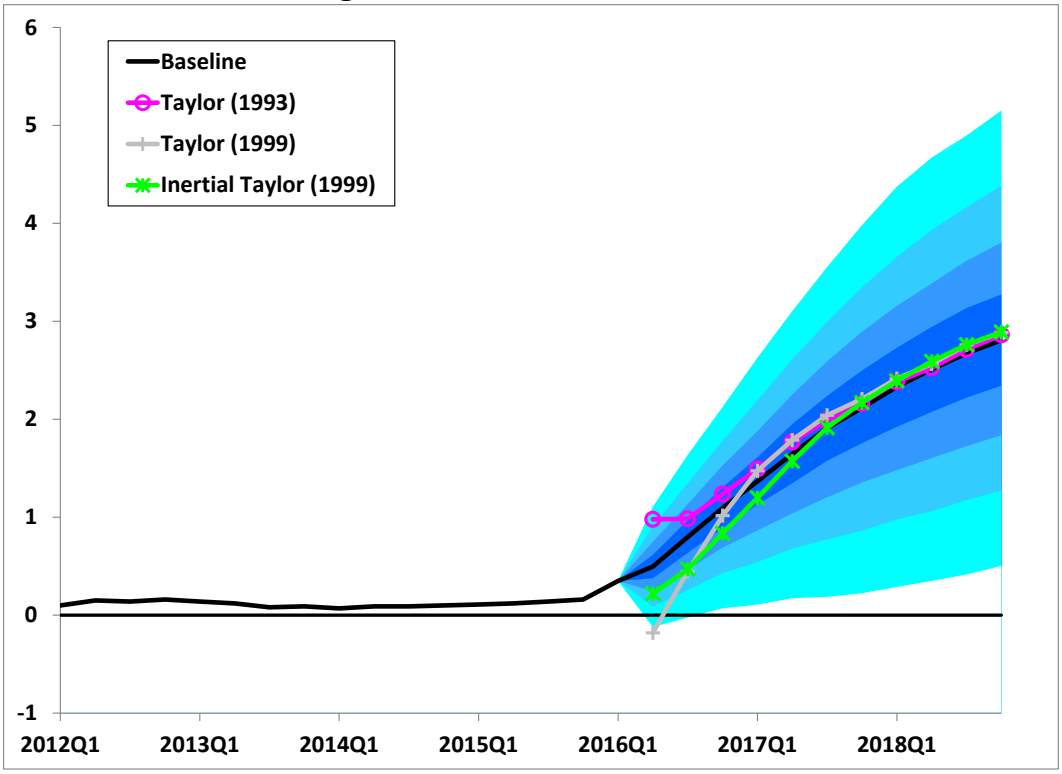

Figure 5: Baseline Forecast Comparisons

Figure 5a: Real GDP Growth

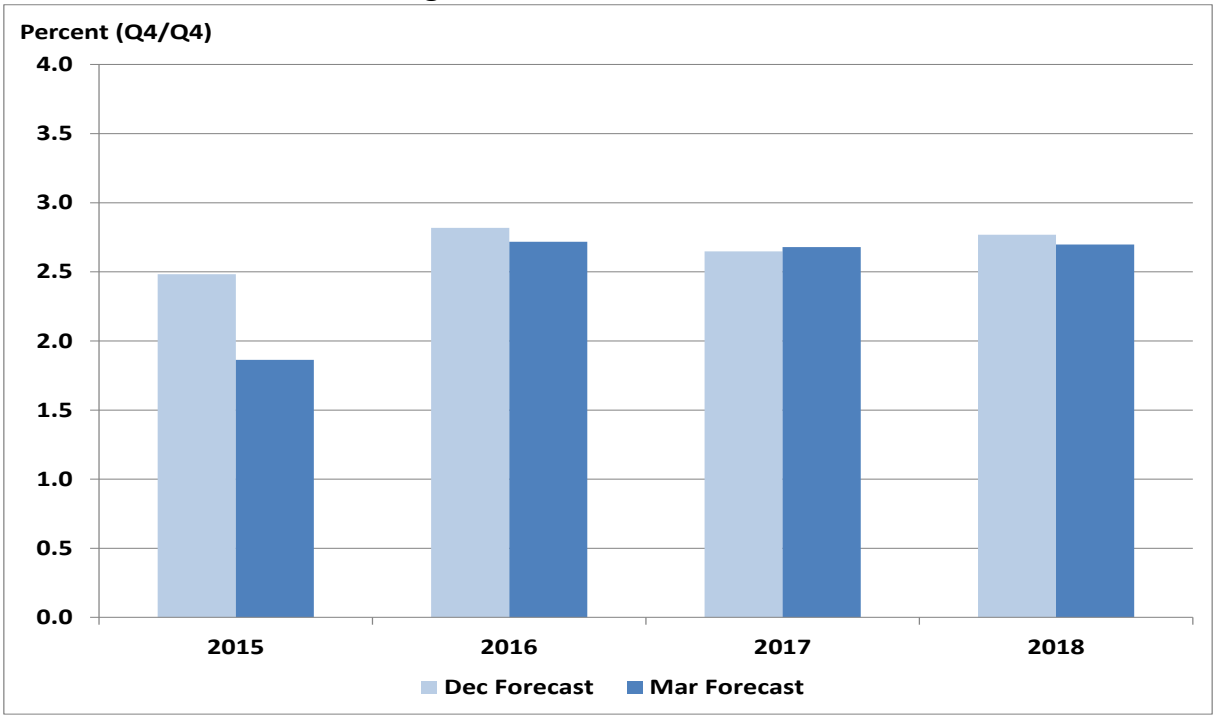

Figure 5b: PCE Inflation Growth

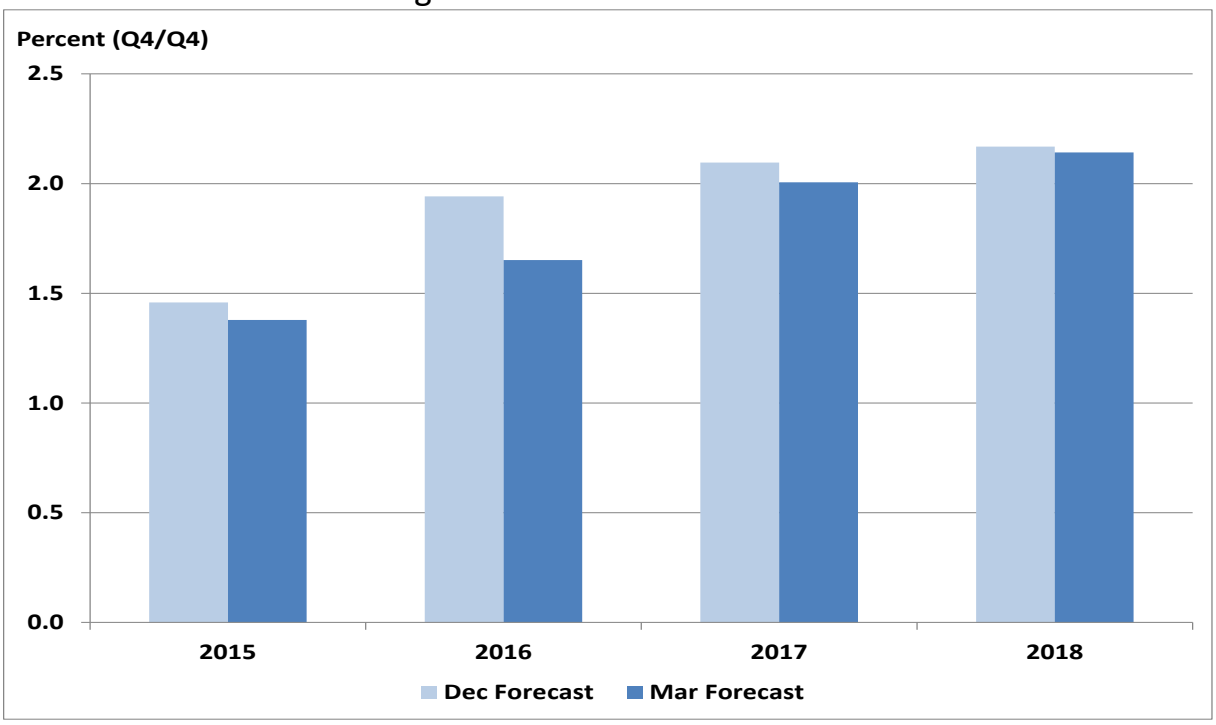

Figure 5c: Unemployment Rate

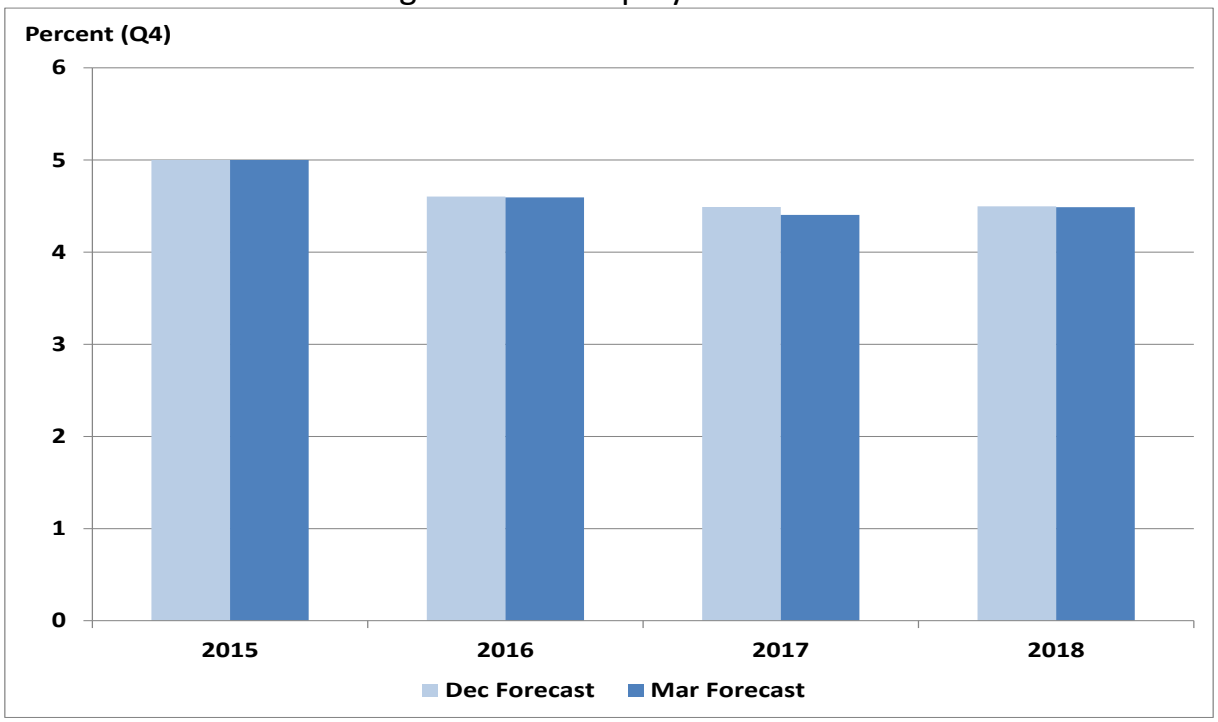

Figure 5d: Federal Funds Rate