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

We start with an overview of the U.S. economy and then turn to some of the heightened risks that could impact the economy going forward. After a lull in the early fall, employment growth has regained its robust momentum with 211,000 net new jobs added in November, following the addition of 298,000 net new jobs in October. The recent strength has brought the unemployment rate down to 5.0 percent, a rate that is consistent with most analysts' views of the natural rate of unemployment. With the exception of mining and drilling, job gains were broad based. Additionally, the number of job openings remains elevated, and a broader measure of labor market slack, U6 — which includes marginally attached workers and those who report that they are working part time for economic reasons — continued to decline to 9.9 percent. Although still somewhat elevated relative to its prerecession level, U6 has declined by 1.4 percent since January. The strong job growth has yet to translate into strong wage growth, but there is increasing anecdotal evidence of wage pressures in select job categories. Thus, the overall labor market picture is fairly bright and should continue to underpin solid growth in consumer spending.

The continued moderate strength in consumer spending was reflected in the latest retail sales report. Over the past three months, core sales have grown at a fairly healthy annual rate of 3.9 percent. Core sales came in unexpectedly strong in November at 0.6 percent after two fairly lackluster months. Additionally, sales of light vehicles have been especially robust, averaging 18.1 million units at an annual rate over the past three months. Strong growth in real disposable income, which has grown by 4.1 percent over the past three months, coupled with continued improvement in household balance sheets, should help consumer spending continue to grow above trend. Thus, consumption appears to be advancing in line with strong fundamentals, and consumer confidence remains high.

The housing sector continues to improve at a steady if unspectacular rate. New home sales rebounded by a strong 10.7 percent in October almost entirely reversing the weak September data. Further, construction spending rose 1.0 percent in October and remains on a fairly strong trajectory, increasing by 13.0 percent over the past 12 months. Additionally, housing starts rose 10.5 percent in November, offsetting much of the weak activity in the previous month. Of note is that single-family starts were at their highest levels since the beginning of the recovery, and single-family permits posted their best readings in eight years. Housing prices continue to increase at a steady pace with the Federal Housing Finance Agency (FHFA) monthly index rising by 6.1 percent year over year and the S&P/Case-Shiller national home price index rising 4.9 percent over the same period. Taken together, the data suggest that residential construction appears to gaining momentum in the fourth quarter.

On a negative note, total industrial production was down in November, yielding a three-month average annualized growth rate of -4.2 percent. The declines were especially severe in mining at -17.7 percent, largely as a result of the continued decline in energy prices, and utilities at -20.3 percent because of unseasonably warm weather. Manufacturing activity faired a bit better coming in flat in November, implying a rather weak three-month average growth rate of 0.6 percent. Dollar appreciation continues to take its toll, especially with regard to firms that rely heavily on exports. Weakness in manufacturing has also been reflected in recent regional surveys, most notably those performed by the Federal Reserve Banks of Philadelphia, New York, and Kansas City. For example, the December Philadelphia Fed's general activity index came in negative at -5.6, and the future general activity index dropped a substantial 20 points to 23.0, its lowest reading since November 2012. Weakness is also apparent in the national ISM manufacturing index, which declined to 48.6 in November. On a brighter note, core orders rose 1.3 percent in October after increasing 0.5 percent in September. Further, third quarter inventory investment was estimated to be $57 billion, implying that much of the inventory correction is over. On net, the manufacturing sector is expected to be a small drag on the economy over the near term. In contrast, the service sector appears to be in solid shape with an ISM nonmanufacturing index reading of 55.9 in November, down from 59.1 in October. While the November number is no longer near all-time highs, it still points to underlying strength in this sector of the economy. That strength is most evident in the readings for business activity (58.2) and new orders (57.5).

On the inflation front, there is little sign of inflationary pressures. The headline consumer price index (CPI) was flat in November and has risen only 0.5 percent over the past year. In contrast, core CPI ticked up a bit and has increased by 2.0 percent over the past 12 months; however, core personal consumer expenditures (PCE) inflation remains more muted. The comparable increase is 1.3 percent. A smaller weight on rents and the inclusion of health-care payments by third-party providers, whose prices have not risen as sharply, account for most of the disparity in the two indices. Meanwhile, inflation expectations as measured by the spread between nominal Treasury yields and Treasury Inflation-Protected Securities (TIPS) remain below the Federal Open Market Committee (FOMC)'s 2 percent target.

Overall, economic growth remains steady at its approximate 2.0 percent trend rate, and slightly above trend growth is expected over the near term by most forecasters as well as by most FOMC participants. The economy is characterized by solid fundamentals, and although inflation remains muted, we continue to believe that the economy has returned to a fairly normal state of activity. As we discuss here, our benchmarking indicates that the Fed's start toward monetary policy normalization was, if anything, overdue. As noted in our previous report, downside risks remain. China's growth has slowed somewhat, and a substantial decline in commodity prices has accompanied that occurrence. Growth worldwide, while expected to

improve, is still far from healthy, and the recent stock market runoff has negatively impacted household wealth. Thus, the global outlook appears subject to downside risks. Further, disinflationary pressures are a global phenomenon, and the low-interest rate environment implies that monetary authorities have less of an ability to deal with this situation than they have had historically. That said, despite a run of what can be interpreted as negative shocks, the U.S. economy is weathering these shocks, indicating significant underlying strength.

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 of the Federal Reserve System. 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.[2] We run forecast simulations under four different versions of the basic rule shown here:

[2] 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.

Table 1

Rule	ρ	Ψ_π	Ψ_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 third quarter of 2015. The forecast begins in the fourth quarter of 2015 and extends through the fourth quarter of 2017. 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.[3]

The key features of the baseline forecast are as follows:

- Real output is forecast to grow at an average pace of about 2.5 percent in 2015, 2.8 percent in 2016, 2.6 percent in 2017, and 2.8 percent in 2018.
- Core PCE inflation averages 1.5 percent in 2015, rising to 1.9 percent in 2016 and 2 percent in 2017 and 2018.
- The unemployment rate falls to a low of 4.5 percent in the first quarter of 2017 and then remains at about that level through the end of 2018.[4]
- The federal funds rate begins rising immediately and reaches 0.5 percent in the fourth quarter of 2015, 1.7 percent in the fourth quarter of 2016, 2.6 percent in the fourth quarter of 2017, and 3.1 percent in the fourth quarter of 2018.

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

[4] 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.

- Compared with the September forecast, weaker real GDP growth and inflation are anticipated in 2015. Going forward, the path for real output growth is about unchanged, while the path for inflation is slightly higher. The path for the funds rate is somewhat steeper (Figure 4).

The baseline forecast calls for output growth to accelerate from 2.1 percent in the third quarter of 2015 to 3.4 percent in the fourth quarter of 2015. Output growth then edges down to toward its longer-term value of about 3 percent.[5] The unemployment rate continues to decline, reaching 4.5 percent in early 2017 and then 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 1.3 percent in the third quarter of 2015 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 federal funds rate lifts off from the zero bound immediately, reaching 0.8 percent in the first quarter of 2016. Thereafter, the federal funds rate rises at a gradual but steady pace to 3.1 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 expect real output growth of 2.4 percent in 2015 and about 2.6 percent in 2016 and 2017 (note that the *SPF* reports GDP growth as annual average over annual average). The *SPF* core PCE inflation forecast is 1.4 percent (Q4/Q4) for 2015, 1.6 percent for 2016, and 1.8 percent for 2017. The forecasters' path for the unemployment rate is a bit higher than the baseline model: The median *SPF* forecast for the average unemployment rate is 4.8 percent for 2016 and 4.7 percent for 2017 and 2018.

The December 2015 Summary of Economic Projections (SEP) by FOMC participants shows the central tendency for output growth in 2015 at 2.1 percent, rising to 2.3 to 2.5 percent in 2016 and then edging down to 2 to 2.3 percent in 2017. The central tendency of the unemployment rate falls to a range of 4.6 to 4.8 percent for the fourth quarter of 2016 and then running in about that range through the fourth quarter of 2018. Core PCE inflation is projected at 1.3 percent in 2015, rising to 1.5 to 1.7 percent in 2016, and 1.7 to 2 percent in 2017. For 2018, core PCE inflation runs between 1.9 and 2 percent. The model's baseline forecast for the federal funds rate (Figure 4) is generally within the central tendency of the December 2015 SEP for the fourth quarter of 2017 and the fourth quarter of 2018 and well above market expectations for the federal funds rate for the fourth quarter of 2018 (which is about 1.7 percent). The model generally suggests a somewhat more rapid pace of policy normalization

[5] 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.

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.[6]

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

- All of the policy rules suggest that the federal funds rate should be well off the zero lower bound in the first quarter of 2016.
- 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 first 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 fourth quarter of 2015. The Taylor (1993) rule calls for the most policy tightening, with the federal funds rate averaging 0.9 percent over the fourth quarter. The Taylor (1999) rule has the federal funds rate at -0.2 percent. In implementing the model, we have not 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 in the third quarter of 2015. The inertial Taylor (1999) rule puts the federal funds rate at 0.2 percent. Note, though, that all of the rules suggest that the funds rate should be close to 2 percent by the first quarter of 2017. So, even though

[6] 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.

the Taylor (1999) rule calls for more near-term policy easing, the extra accommodation is fairly short lived.

The path of output growth is weaker under the Taylor (1993) rule, which calls for the highest near-term interest rate, with output growth at 2.7 percent in the fourth quarter of 2015. The inertial Taylor (1999) rule, which over the forecast horizon is the most accommodative policy, has real output growth at 4.9 percent in the fourth quarter of 2015. Note, though, that the output growth forecasts largely converge by the end of 2016. 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 run. Core inflation runs at about 1.9 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 are now giving somewhat mixed signals about the appropriate current stance of monetary policy. The baseline rule and Taylor (1993) rule suggest that the federal funds rate should be somewhat higher than its current prevailing rate of about 0.38 percent. The inertial Taylor (1999) rule suggests that current policy is about appropriate. The Taylor (1999) rule suggests that policy should be more accommodative (compared with that rule's prediction in September and with the other policy rules). However, the alternative policy rules agree that the federal funds rate should be somewhere in a range of 1.7 to 1.9 percent by the end of 2016, calling for more aggressive liftoff from the zero lower bound 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

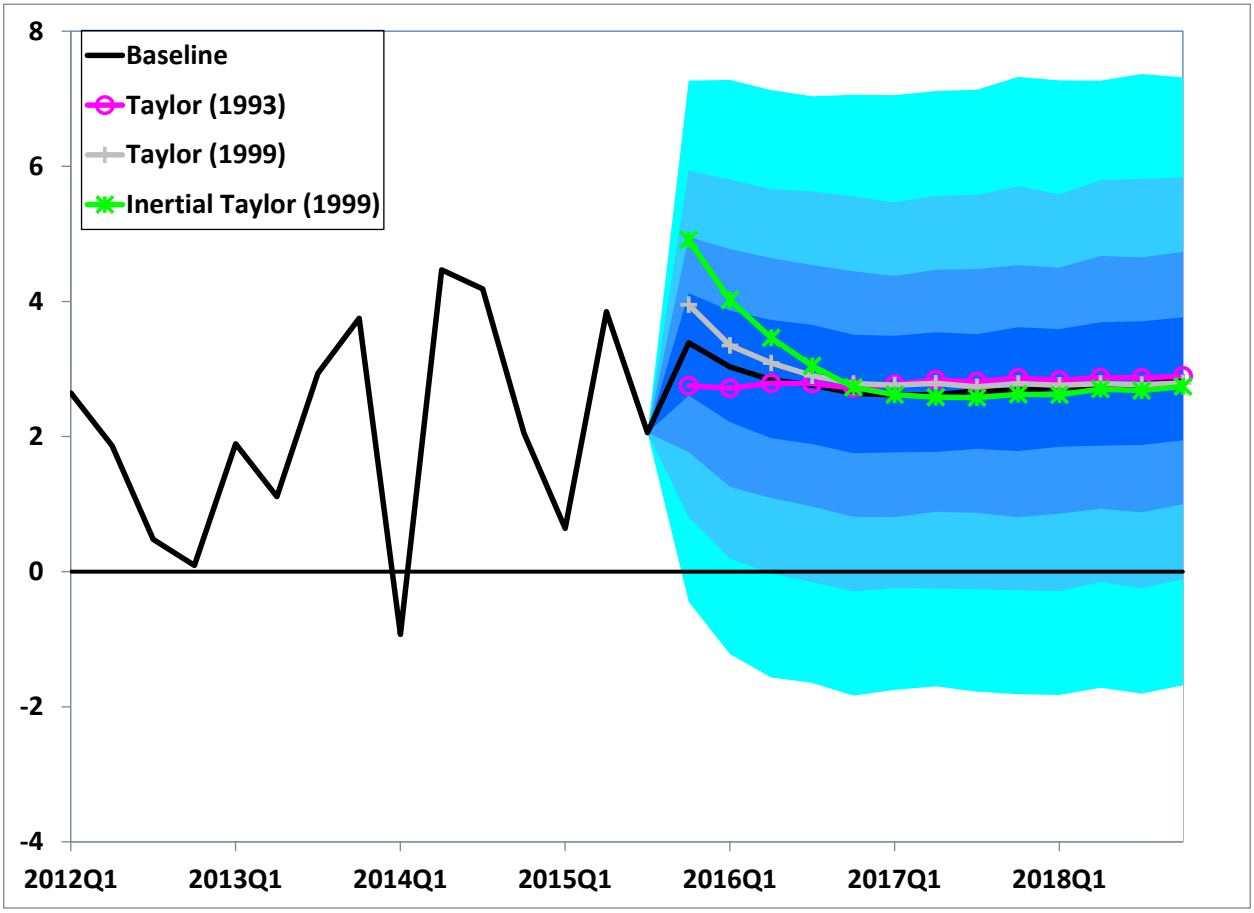

Figure 2: Core PCE Inflation

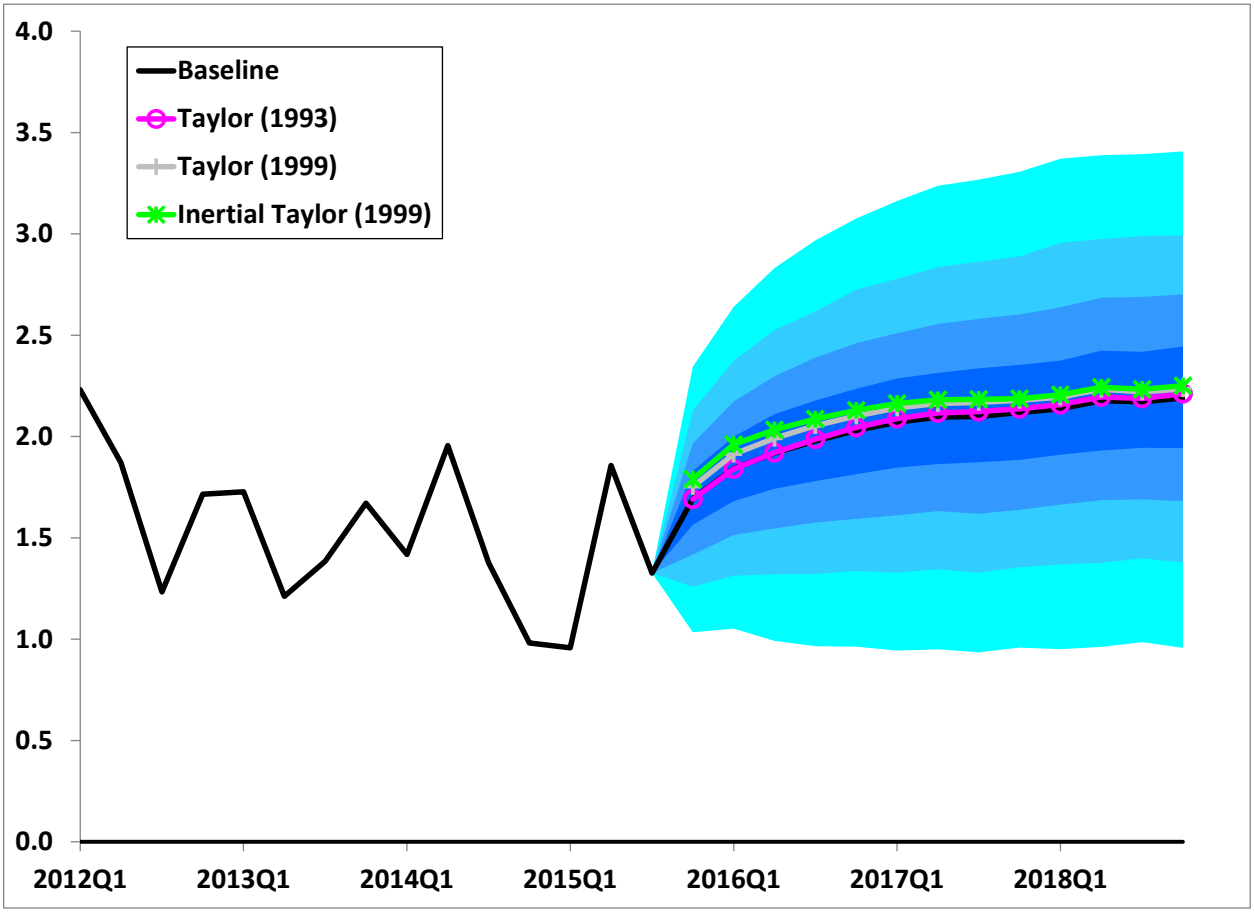

Figure 3: Unemployment Rate

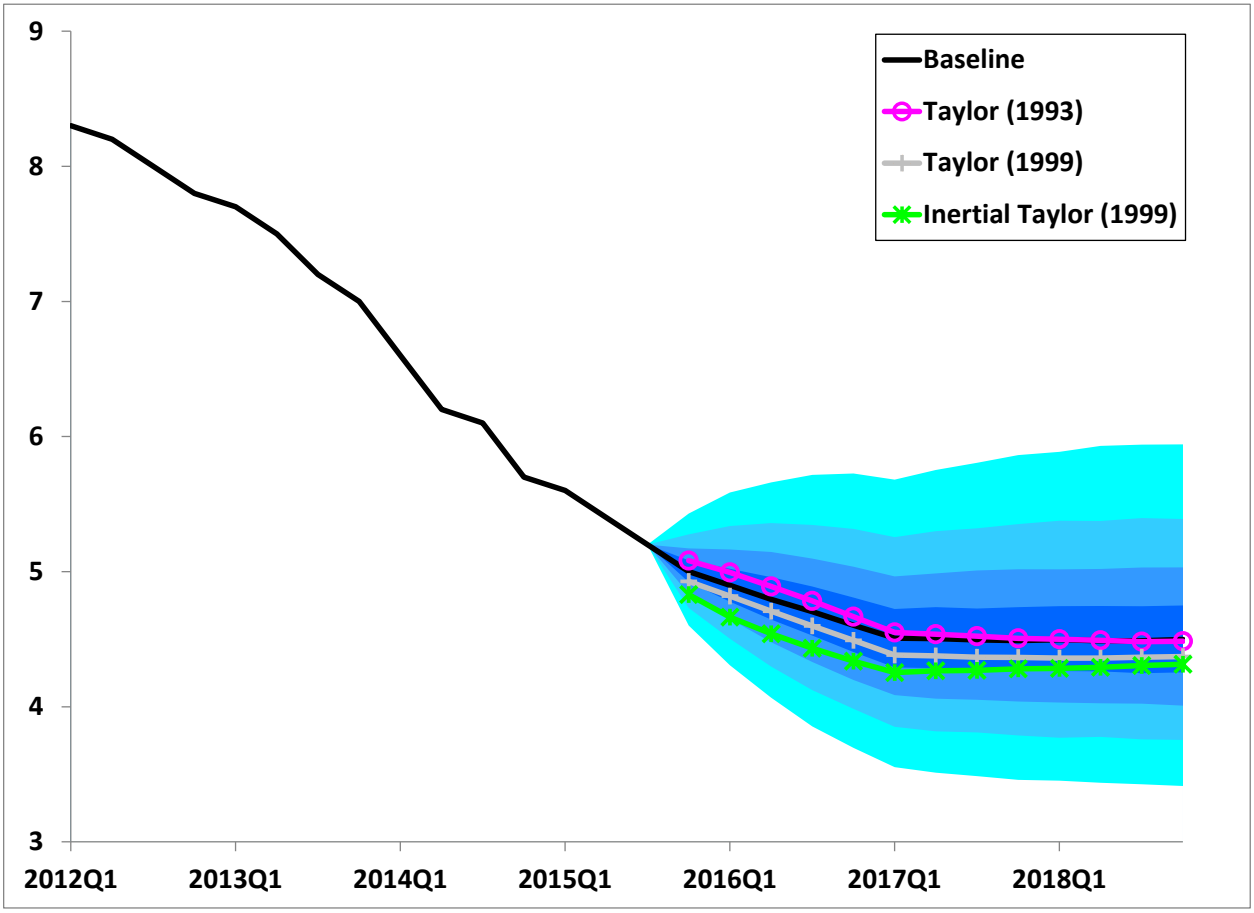

Figure 4: Federal Funds Rate

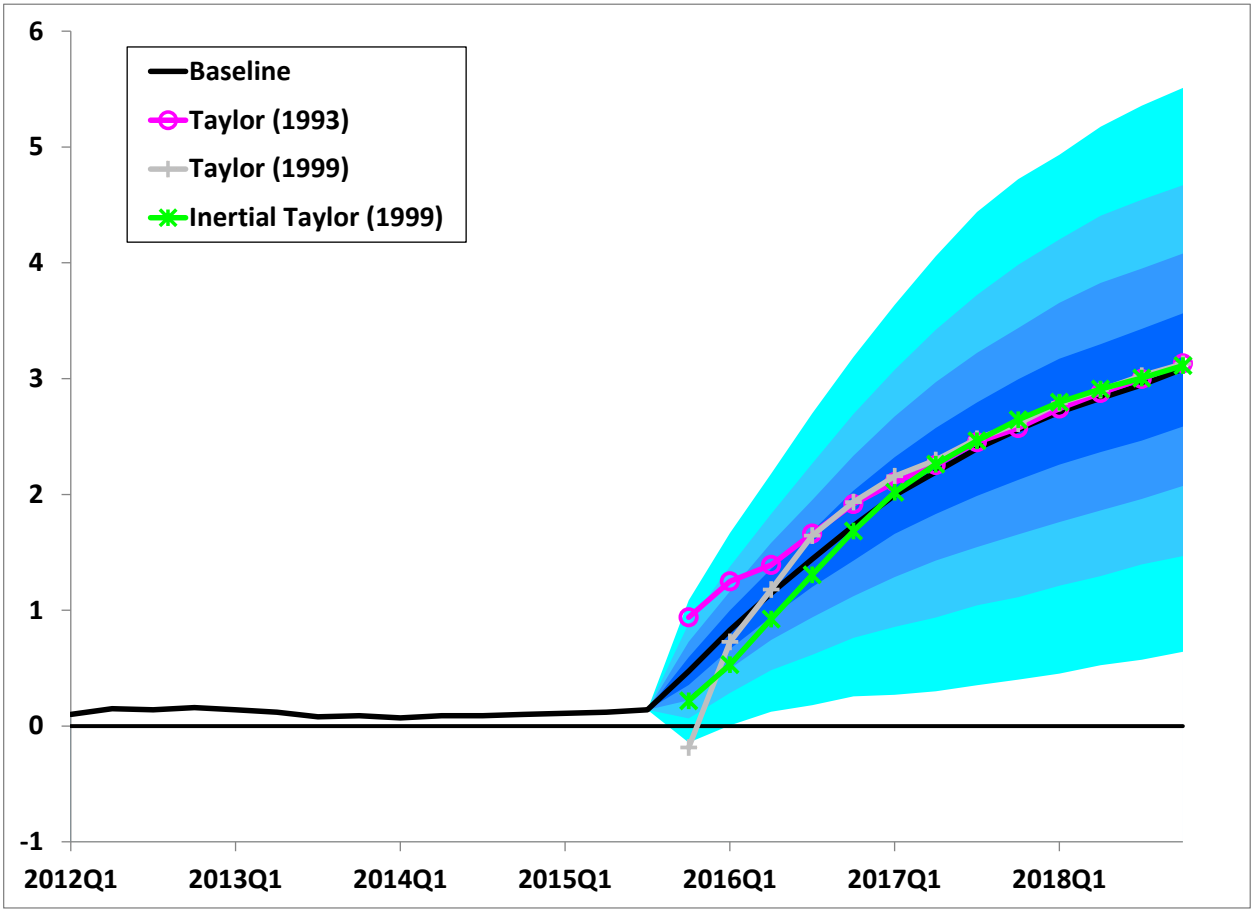

Figure 5: Baseline Forecast Comparisons

Figure 5a: Real GDP Growth

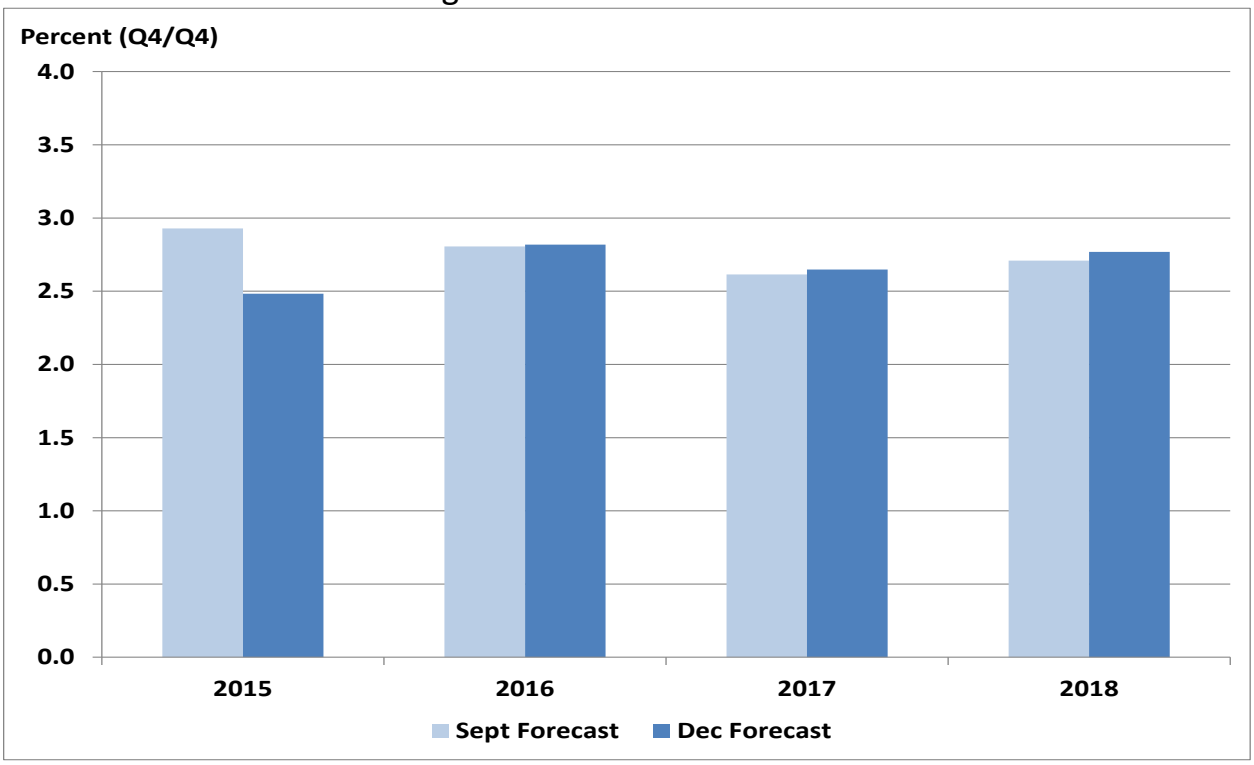

Figure 5b: PCE Inflation Growth

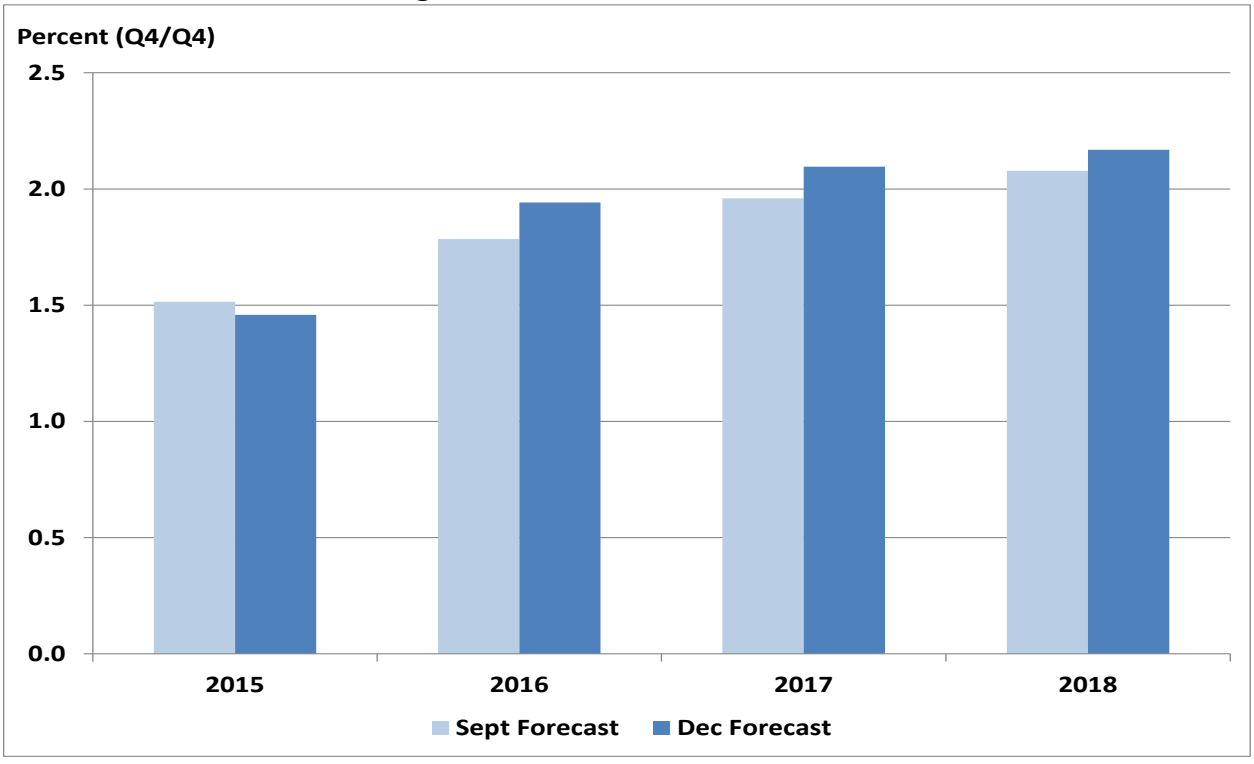

Figure 5c: Unemployment Rate

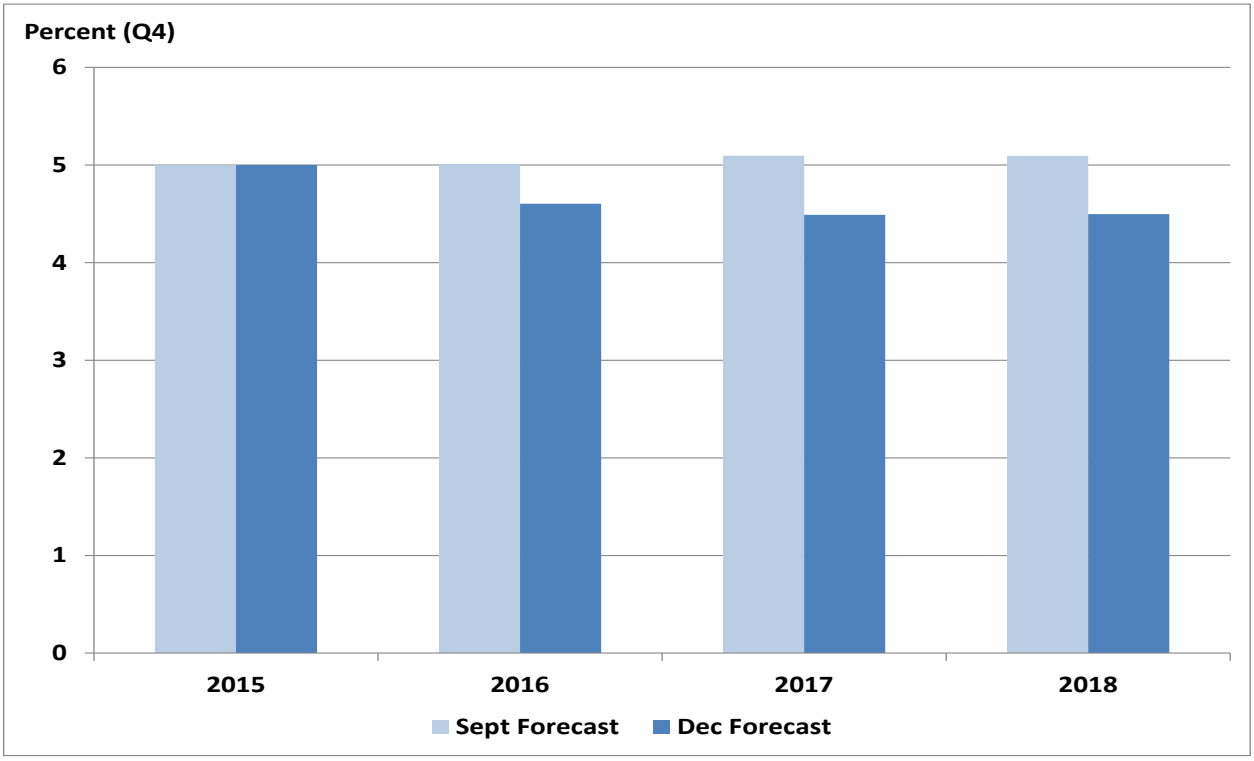
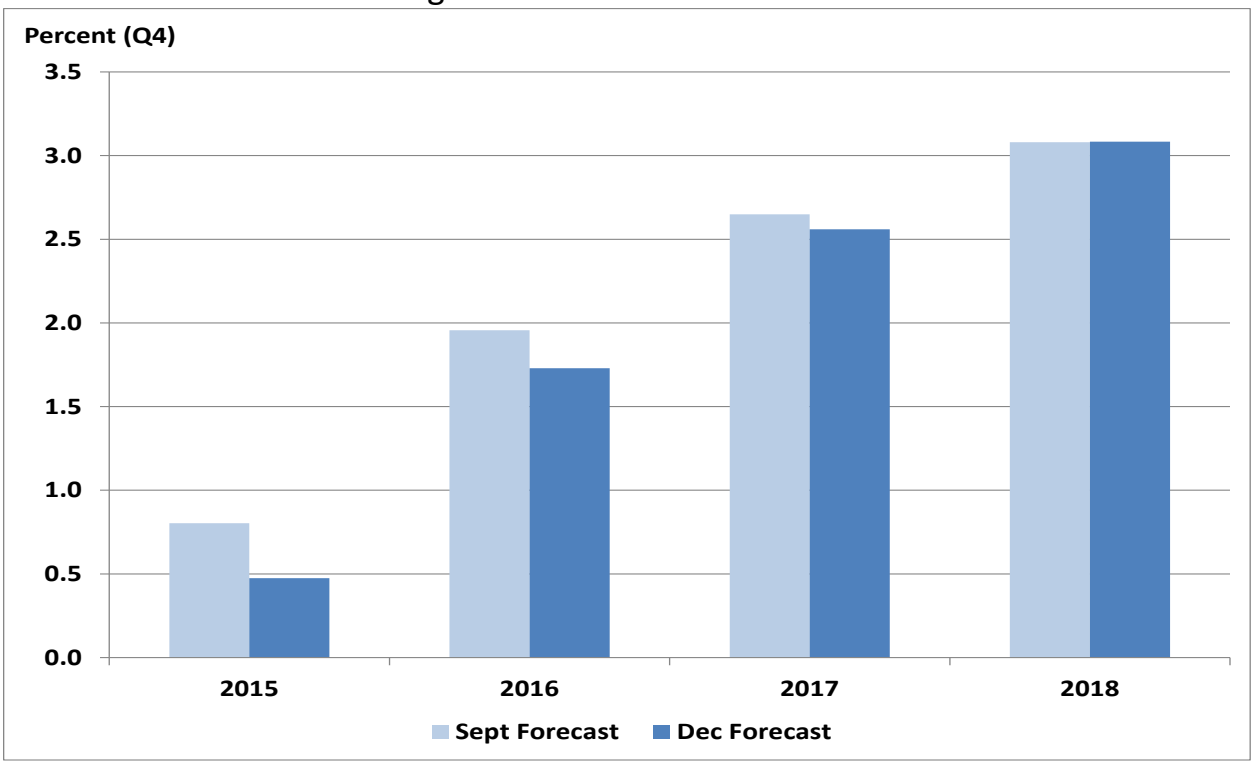
Figure 5d: Federal Funds Rate