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 Board of Governors of the Federal Reserve System. 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.

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[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. We thank Brie Coellner for her assistance.

Economic Overview

Economic growth accelerated in the third quarter to 3.2 percent, and with unexpected strength in the most recent Quarterly Services Survey, that pace is likely to be revised upward. Job growth remains robust, and there has been some increased momentum in wage growth. Buoyed by solid income growth, consumption growth has remained a key driver of current economic activity. Housing is expected to contribute modestly to future growth, though investment in nonresidential structures remains weak and shows little sign of any near-term improvement. The same appears true for manufacturing and business fixed investment. Nowcasts indicate some deceleration in overall economic growth this quarter, with net exports becoming a significant drag. Manufacturing activity remains relatively flat, although several recent manufacturing surveys point to some possible improvement. Inflation continues to move ever so slowly toward the 2.0 percent target set by the Federal Open Market Committee (FOMC). Post election, the stock market has risen markedly, the dollar has appreciated against most major currencies, and oil prices have risen above $50 per barrel.

The most recent consumer spending data were a bit weaker than expected. Consumption rose just 0.1 percent in October. However, September's spending growth was revised upward, personal income growth remained solid in October, and there were upward revisions to income growth in both the second and third quarters. Some of the weakness was weather-related, as a warmer than normal October led to a decline in spending on utilities. Other categories of consumption remained strong, especially durable goods purchases, and both retail sales and motor vehicle sales in November support the view that consumption will remain the key driver of overall GDP growth. Additionally, consumer sentiment continues to improve, with readings at or above their highest levels for the recovery.

The economy continues to add jobs at a fairly robust pace. November's employment report indicated a net increase of 178,000 jobs. Over the past three months, job gains have averaged 176,000, and the unemployment rate now stands at 4.6 percent, which is below most economists' view of its natural rate. A dominant factor in the fall in unemployment was the decline in the labor force participation rate. Due largely to demographics, that variable should continue along a slow downward trend. Continued robust job gains will further reduce unemployment. Additionally, average hourly earnings have been rising steadily at around 2.5 percent.

Data from the Job Openings and Labor Turnover Survey (JOLTS) continue to indicate dynamism in the labor market, with healthy readings for October on the job openings and quits rates and the layoff rate reaching a new historic low. Contacts in our region continue to express difficulty finding workers with sufficient skills, and salary increases for skilled workers appear to be more prevalent.

Residential real estate data continue to be mixed. Housing starts had been extremely strong in October, up 25.5 percent, but much of that growth was reversed in November. Most of the decline was in the lower-priced multifamily sector, while single-family starts remained at a fairly healthy level and continue to slowly trend higher. Single-family housing permits also continued along a modest upward trend. We have also seen high levels of mortgage purchase applications. Yet, sales of new single-family homes declined in October, and the trend remains rather weak. All told, the recent data indicate that residential investment's contribution to growth is likely to remain small. Prices of new homes continue to rise at a moderate pace of slightly above 5.0 percent, according to all major indexes. Fundamentals remain healthy: Incomes are growing, and mortgage rates remain low.

The latest Institute for Supply Management manufacturing index remained in positive territory for the second straight month, increasing to 53.2 in November, with new orders, employment, and production all in positive territory. The production index, at 56.0, attained its highest level in almost two years. Many regional surveys confirm an increase in activity. Most notably, the Federal Reserve Bank of Philadelphia's Manufacturing Business Outlook Survey current activity index is now in solid expansion territory, increasing from 7.6 to 21.5 in December. The survey's future activity index jumped to 52.6, its highest reading since January 2015. Businesses in the region can be viewed as "awkwardly optimistic," according to one of our contacts. Turning back to the national picture, the latest data on factory orders showed an increase of 2.7 percent, although core orders increased much more modestly, by 0.2 percent, and core shipments declined 0.1 percent. Taking all the data into account, it appears that manufacturers are poised to grow and that we may soon get the first increase in business equipment spending in over a year.

Inflation continues to firm, albeit at a very slow pace, with the core PCE price index firming in October to 1.7 percent year over year and with headline PCE growing at 1.4 percent year over year. The core CPI index continues to hover in the low 2 percent range. Inflation expectations as measured by the spread between nominal Treasury yields and Treasury Inflation-Protected Securities (TIPS) continue to rise and are now at approximately the FOMC's 2 percent target. These market-based inflation expectations are now in line with survey measures of longer-run expectations, such as those in the Survey of Professional Forecasters. Given the accommodative stance of monetary policy and the recent run-up in energy prices, we continue to believe that inflation will slowly converge to target.

Overall, fourth quarter growth appears to be slightly below trend, and employment growth remains solidly above the rate that would imply no change in the unemployment rate. Most forecasts, including those by FOMC participants, continue to anticipate around-trend economic growth and a gradual return of inflation to target. This view seems much more realistic than it did a few months ago.

The economic forecasts in December's Summary of Economic Projections indicate that the majority of FOMC members expect the economy to grow at a roughly trend-like rate of 2.0 percent and for inflation to gradually return to target. Notably, there was a 25 basis point increase in the appropriate path of tightening, with the funds rate attaining a level of 2.9 percent by the end of 2019. That would leave the funds rate slightly below the median projection of the long-run neutral funds rate of 3 percent, which is 0.1 percent above what the members had projected in September but down from their estimate of 3.5 percent in December 2015.

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

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[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	$\varPsi_\pi$	$\varPsi_y$
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 2016. The forecast begins in the fourth quarter of 2016 and extends through the fourth quarter of 2019. 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 about 1.9 percent (Q4/Q4) in 2016, rising to 2.6 percent in 2017, 2.8 percent in 2018, and 2.9 percent in 2019.

- Core PCE inflation reaches 1.9 percent (Q4/Q4) in 2016, rising to 2.2 percent in 2017 and to 2.3 percent in 2018 and 2019.

- The unemployment rate falls to a low of 4.2 percent in the first quarter of 2018 and then edges up to 4.3 percent by the end of 2019.[4]

- The federal funds rate rises to 0.75 percent at the end of 2016 and reaches 1.9 percent at the end of 2017, 2.8 percent at the end of 2018, and 3.3 percent at the end of 2019.

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[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 June forecast, real GDP growth is slightly stronger, inflation is about unchanged, the unemployment rate is about unchanged, and the federal funds rate path is slightly weaker over the forecast horizon (Figures 5 a, b).

The baseline forecast calls for output growth to decelerate from 3.2 percent in the third quarter of 2016 to 2.2 percent in the fourth quarter. Growth then edges up to 2.7 percent at the end of 2017 and to 2.9 percent at the end of 2018.[5] The unemployment rate continues to decline, reaching 4.2 percent at the start of 2018 and then edging up to 4.3 percent at the end of 2019. Moderately strong growth and anchored long-run inflation expectations lead to an acceleration of core PCE inflation from 1.7 percent in the third quarter of 2016 to 2 percent by the second quarter of 2017. Core inflation then slightly overshoots the FOMC target of 2 percent, reaching 2.3 percent by mid-2018. Core inflation then runs at that pace through the end of 2019. 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 rises to 0.75 percent at the end of 2016 and then increases on a modest path to 1.9 percent at the end of 2017 and 3.3 percent at the end of 2019.

The baseline forecast is somewhat stronger than the median projections from the fourth quarter 2016 SPF. In that survey, the respondents expected real output growth of 1.5 percent in 2016, 2.2 percent in 2017, and 2.1 percent in both 2018 and 2019. (Note that the SPF reports GDP growth as annual average over annual average.) The SPF core PCE inflation forecast is 1.8 percent (Q4/Q4) for 2016, 1.9 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 4.7 percent in 2017, 4.6 percent in 2018, and 4.7 percent in 2019.

The December 2016 SEP by FOMC participants shows the median projection for output growth at 1.9 percent in 2016, 2.1 percent in 2017, 2 percent in 2018, and 1.9 percent in 2019. The median forecast of the unemployment rate is 4.7 percent in the fourth quarter of 2016, falling to 4.5 percent in the fourth quarter of 2017, and then staying at 4.5 percent in 2018 and 2019. Core PCE inflation is projected at 1.7 percent in 2016, rising to 1.8 percent in 2017 and to 2 percent in 2018 and 2019. Headline inflation is weaker in 2016 at 1.5 percent, but as energy prices stabilize, headline inflation is expected to run at a similar pace as core inflation over 2017–2019. The forecast model's baseline forecast for the federal funds rate (Figure 4) remains somewhat above the central tendency of the December 2016 SEP over the forecast horizon and remains well above market expectations for the funds rate, which are below 2 percent for the fourth quarter of 2018. The model generally suggests a somewhat more rapid pace of policy normalization compared with

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[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.

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:

- The policy rules continue to suggest that the federal 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.

- The major difference between the forecasts is in output growth and not in inflation or unemployment. The model estimates somewhat persistent inflation measures that respond sluggishly to shocks.

- By the end 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 the alternative rules reaches about 2 percent by the end of 2017, which is well above current market expectations of what the federal funds rate will be at that time.

The alternative policy rules suggest different current levels of the appropriate federal funds rate. The baseline puts the funds rate at 0.75 percent in the fourth quarter of 2016, compared with 1.3 percent for the Taylor (1993) rule. The Taylor (1999) rule suggests a more accommodative policy, with the federal funds rate at 0.1 percent in the fourth quarter of 2016.[7] The inertial Taylor rule suggests a funds rate of 0.4 percent in the fourth quarter of 2016, a bit below the actual current setting. At 0.66 percent, the current setting lies within the range of the model rules, but all of the rules suggest gradual and ongoing tightening of policy over the next three years. For the first quarter of 2017, the funds rate stands at 1.2 percent for the Taylor (1993) rule, 0.6 percent for the Taylor (1999) rule, and 0.7 percent for the inertial Taylor rule. With ongoing normalization, all the

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[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.

[7] We have not constrained the model to have a nonnegative interest rate in the estimation or simulation.

rules suggest that the federal funds rate should be close to 2 percent by the end of 2017. So, even though the Taylor (1999) rule calls for a somewhat lower funds rate this quarter and next, the extra accommodation is fairly short lived.

The path of output growth is slightly weaker over the near term under the Taylor (1993) rule, which calls for the highest near-term interest rate, with output growth at 2.3 percent in the first quarter of 2017. The inertial Taylor (1999) rule, which over the forecast horizon is the most accommodative policy, has real output growth at 3.7 percent in the first quarter of 2017. Note, though, that the output growth forecasts largely converge by the fourth quarter 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 2.2 percent (Q4/Q4) in 2017 and shows little dispersion over the forecast horizon across the alternative policies. Core inflation is about unchanged over the forecast horizon compared with the September projection. 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 is short lived. The baseline rule and Taylor (1993) rule suggest that the federal funds rate should be somewhat higher than its current prevailing rate of about 0.66 percent in December. 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 federal funds rate should be somewhat above 1 percent in the second quarter of 2017 and call for more aggressive policy normalization compared with financial market expectations.

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.
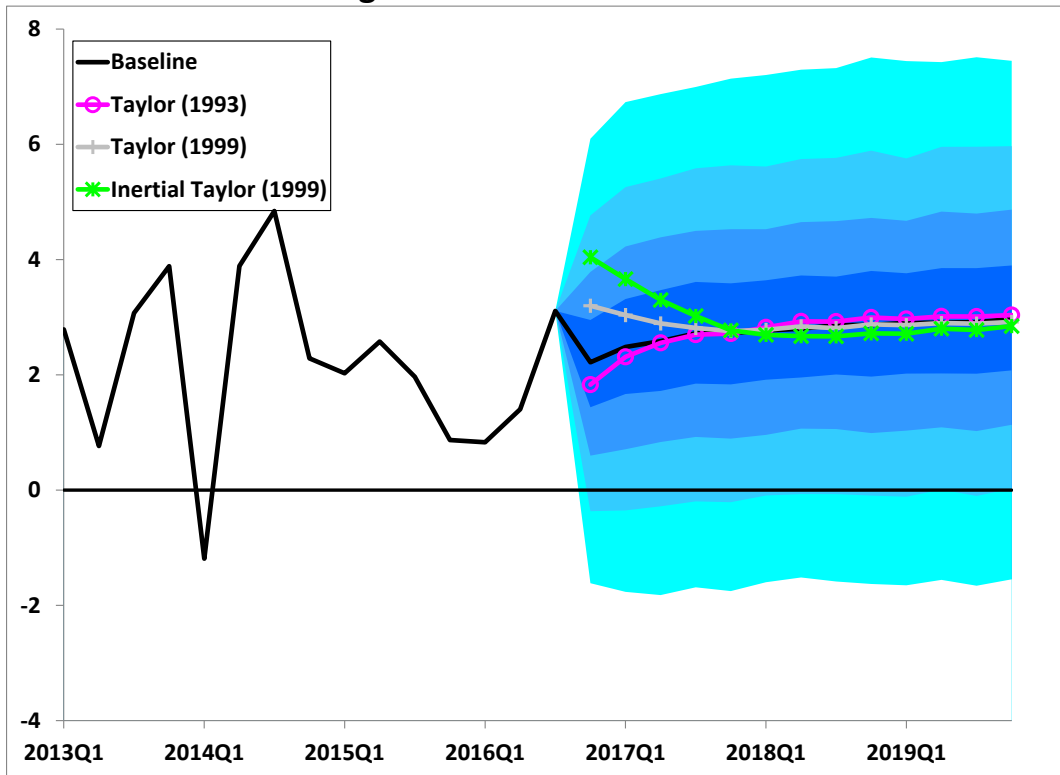
Figure 1: Real GDP Growth
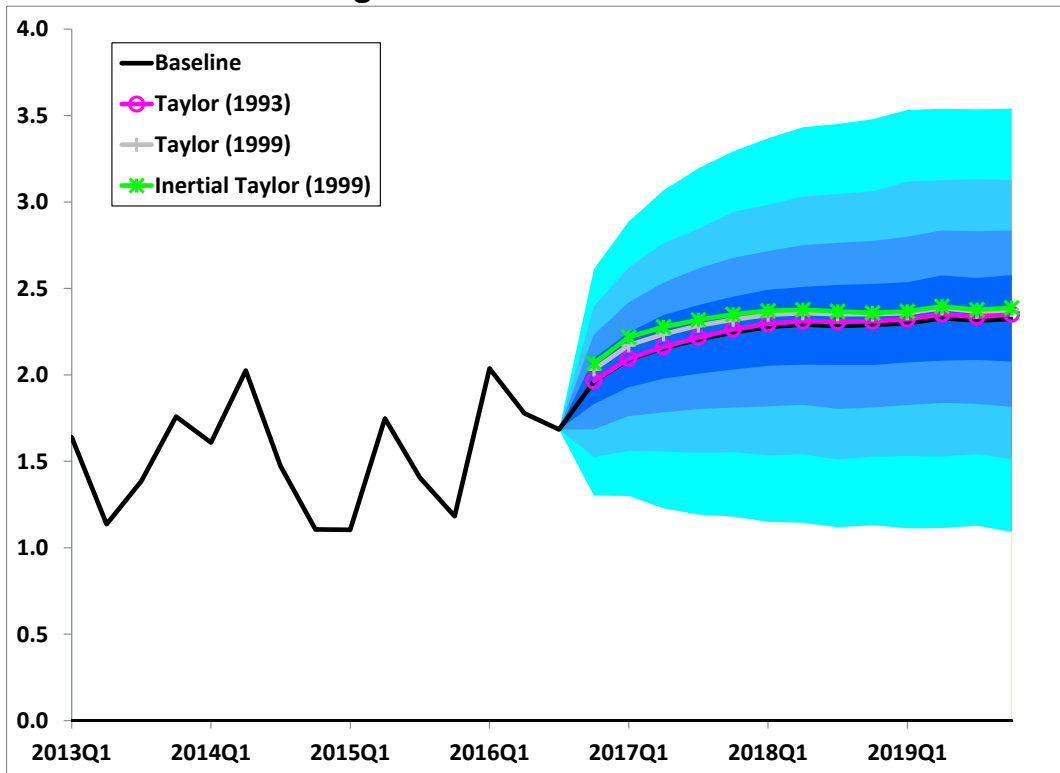

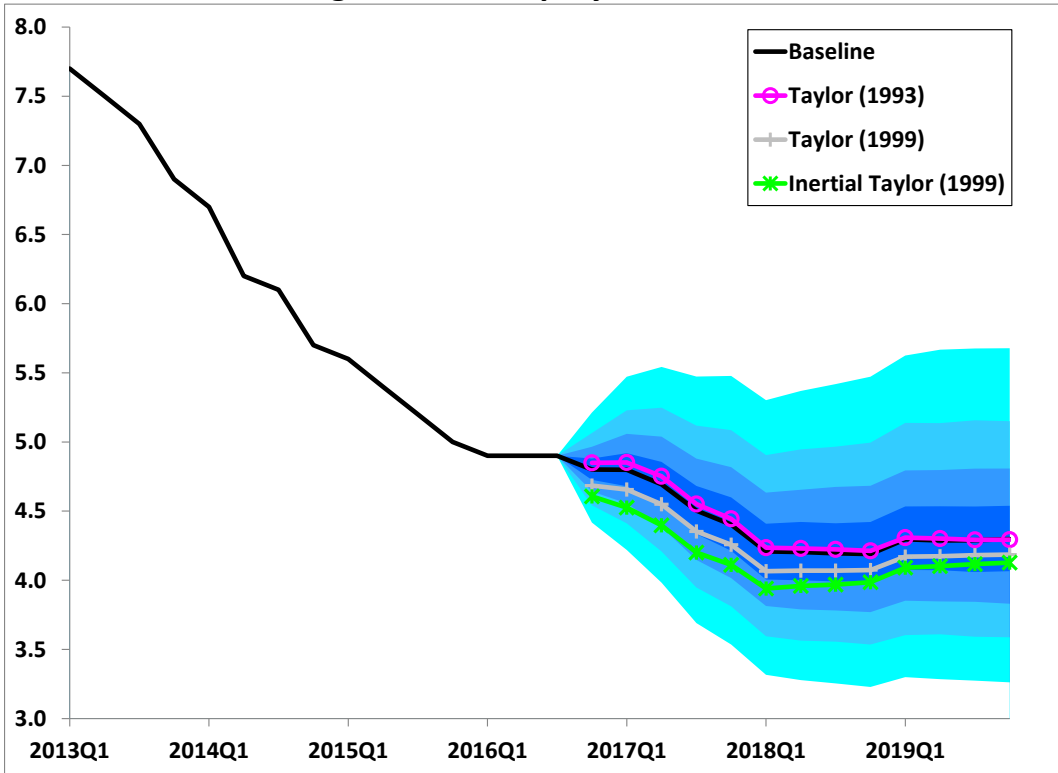## Figure 2: PCE Core Inflation

Figure 3: Unemployment Rate

Figure 4: Federal Funds Rate
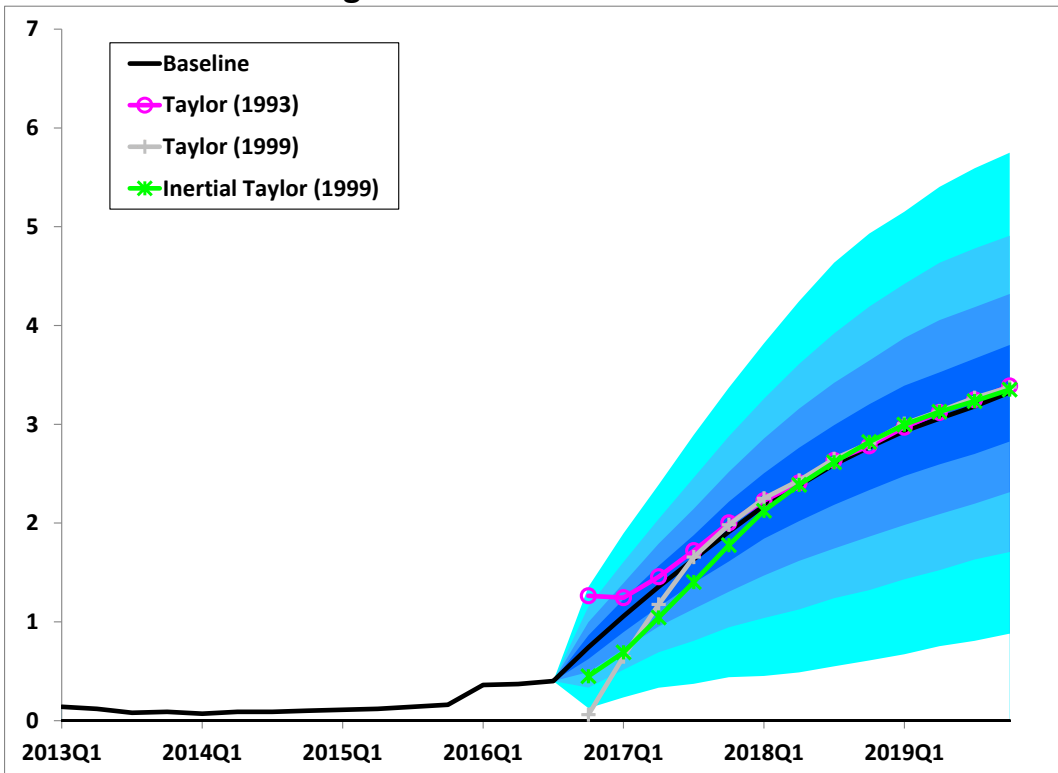
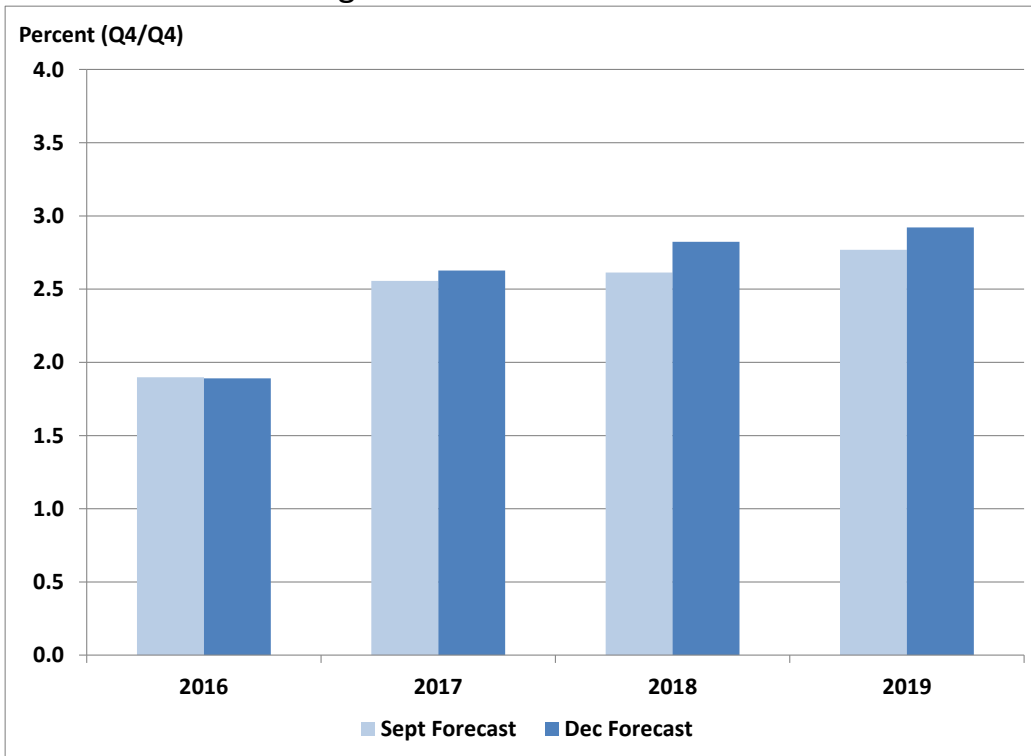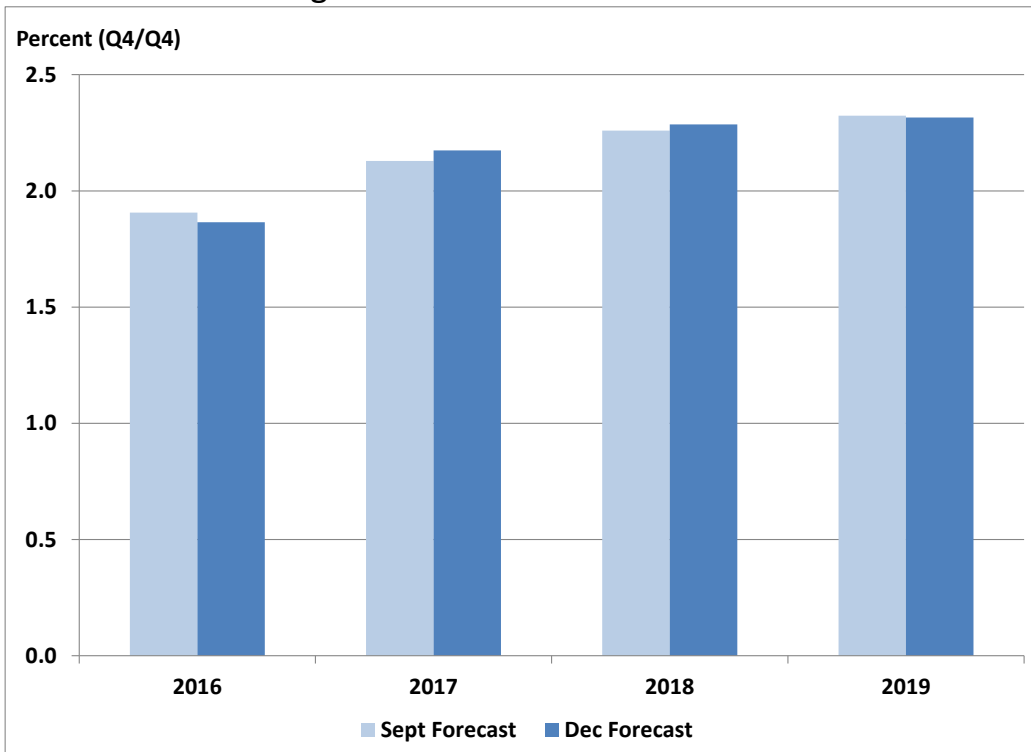# Figure 5: Baseline Forecast Comparisons

Figure 5a: Real GDP Growth

Percent (Q4/Q4)

Legend: Sept Forecast, Dec Forecast

Years: 2016, 2017, 2018, 2019

Figure 5b: PCE Inflation Growth

Percent (Q4/Q4)

Legend: Sept Forecast, Dec Forecast

Years: 2016, 2017, 2018, 2019

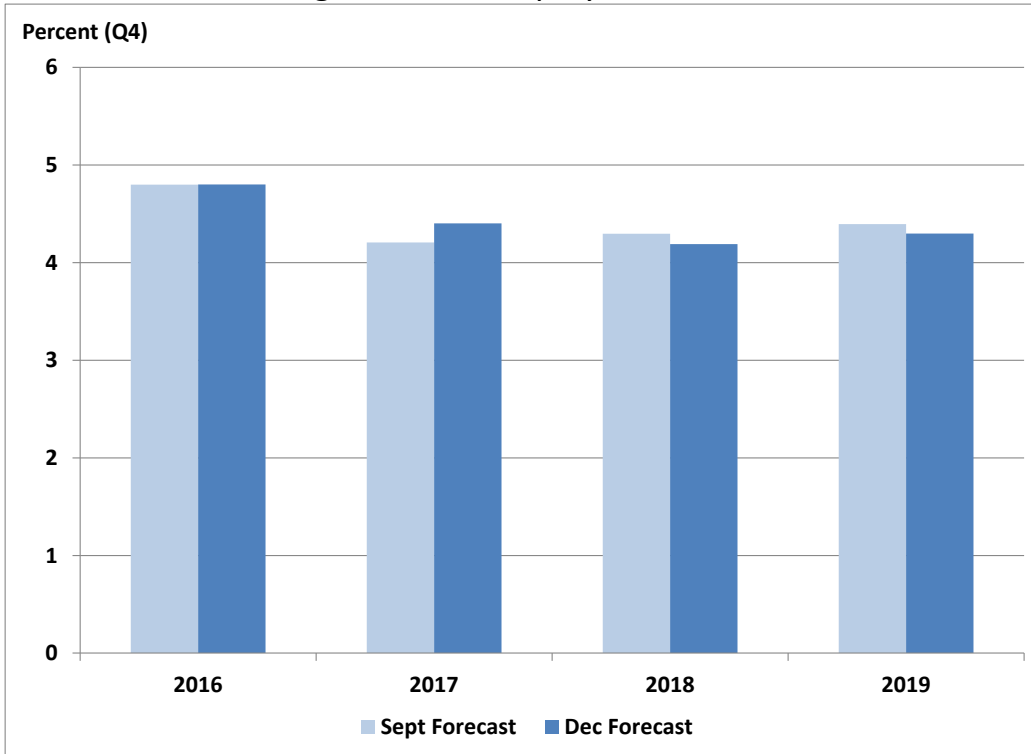## Figure 5c: Unemployment Rate

Percent (Q4)

Legend: Sept Forecast, Dec Forecast

Figure 5d: Federal Funds Rate

Percent (Q4)

Legend: Sept Forecast, Dec Forecast