SPECIAL REPORT

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.

Economic Overview

After a lackluster first quarter in which GDP grew a mere 1.2 percent, the economy appears to be headed for a significant bounce back. Numerous nowcasts put second quarter growth approaching 3.0 percent. Some of that resurgence is due to residual seasonality problems in the measurement

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of GDP that generally have been making first quarter growth appear weaker and second quarter growth appear stronger than may actually be the case. However, many other economic indicators also appear somewhat stronger, although some of the most recent data indicate a slowing in momentum.

Much of the projected growth in output is based on solid increases in consumption, although we also continue to see signs of a rebound in manufacturing activity and indications that business fixed investment is picking up as well. This growth will be supported by continued strength in the labor market. Economic conditions in the rest of the world appear to be improving, and there is substantial optimism among domestic consumers and firms alike. Inflation remains below the Federal Open Market Committee's target, and the risks to the economy appear largely balanced. These factors are giving FOMC members more confidence in the ongoing stability of the expansion, and they raised the federal funds rate by 25 basis points at their June meeting, the second such increase this year. The rate is intended to trade in the 100 to 125 basis points range, and the move was well anticipated. Market reaction has been positive, with U.S. stock prices at all-time highs.

Providing some foundation for expenditure growth is the continued growth in jobs, although momentum in employment growth has waned somewhat. May's employment rose by a disappointing 138,000 jobs, and March and April's gains were revised downward by 66,000 jobs. Over the past three months, employment growth has averaged only 121,000 net new jobs. Because of falling labor force participation, the unemployment rate declined to 4.3 percent, the lowest rate in 16 years. Average hourly earnings continue to grow modestly, increasing 2.5 percent over the past 12 months. Solid wage growth is also reflected in the Atlanta Fed's Wage Growth Tracker, which has risen 3.4 percent over the same period.

Additionally, the labor market continues to show dynamism. The job openings rate remains at its historical high, as hiring and quits rates are at healthy levels. The layoffs rate remains historically low. Contacts in our region continue to express difficulty in finding workers, especially skilled workers. The healthy labor market is supporting strong income growth, with personal income growing 3.6 percent over the past 12 months to April and a healthy 0.4 percent in the first month of this quarter.

The most recent data on personal consumption expenditures show a gain in real expenditures of 0.2 percent in April, with March's data revised upward to 0.5 percent. The modest pullback in consumption was largely accounted for by weaker growth in services, most notably in electricity usage. The personal consumption data are broadly consistent with what we are seeing in retail sales, although the most recent data in May were disappointing. Core sales in May were flat, but April's sales were revised upward to 0.4 percent, and growth in March was a healthy 0.7 percent.

Spending on autos remains at healthy levels, and overall the data point to a rebound in consumer activity.

The housing sector continues to grow, although a bit more sluggishly than anticipated. Housing starts declined in May for both single-family and multifamily construction. Single-family permits declined for the third straight month in May, indicating less momentum in this sector than previously thought. Thus, second quarter residential investment will be modest at best. The data on new home sales are also consistent with a moderation in residential investment. New single-family home sales declined 11.4 percent in April from their cyclical high in March. Overall, the housing sector appears to have lost some of its earlier momentum despite solid income growth and improvements in household balance sheets.

The optimistic survey data we have witnessed in the manufacturing sector appears to be percolating into the latest hard data if one averages through that data. As with retail sales, the May industrial production data were unexpectedly weak, though they followed on the heels of a very strong April. Thus, industrial production remains on solid footing. Focusing on manufacturing IP, it actually declined 0.4 percent in May after growing 1.1 percent in April. So, while it is volatile, its trend also remains on an upward trajectory. After struggling for much of 2015 and 2016, mining has also rebounded quite strongly. With respect to survey data, the headline ISM manufacturing survey reading remained roughly constant in May at 54.9. Although a bit weaker than earlier in the year, the index remains firmly in expansion territory, as do most of its subindexes. Many regional indexes are also reflecting solid manufacturing activity. The most recent Philadelphia Fed manufacturing index remained positive at 27.6 in June after attaining a robust 38.8 in May.

Inflation weakened a bit in April, with the 12-month gain in the core personal consumption expenditures (PCE) price index falling to 1.5 percent, its lowest value since December 2015. The latest consumer price index (CPI) numbers indicate that May's core PCE is likely to have fallen further, as the 12-month change in the core CPI declined two-tenths of a percent to 1.7 percent, the lowest reading since May 2015. The softening in inflation no longer appears to be transitory despite the economy operating at full employment. The behavior of inflation may merit scrutiny by policymakers over the rest of the year.

Turning to monetary policymakers' views, the economic forecasts in June's Summary of Economic Projections (SEP) were little changed from March and indicate that the majority of FOMC members expect the economy to grow a bit above its projected longer-run trend of 1.8 percent. Members also expect inflation to return to target in 2018. Notably, there remains a consensus for three rate hikes in 2018, and the federal funds rate is expected to reach 2.9 percent by the end of 2019. That would leave the funds rate very close to the median projection for the long-run neutral funds rate, which is similar to what members had thought in March. Of note, the FOMC signaled that balance sheet normalization will most likely begin by the end of this year.

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 (DSGE) 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:

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

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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.

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 first quarter of 2017. The forecast begins in the second quarter of 2017 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 2.8 percent (Q4/Q4) in 2017, 2.7 percent in 2018, and 2.6 percent in 2019.

- Core PCE inflation reaches 1.8 percent (Q4/Q4) in 2017, rising to 2 percent in 2018 and to 2.2 percent in 2019.

- The unemployment rate falls to 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 1.5 percent at the end of 2017, 2.6 percent at the end of 2018, and 3.2 percent at the end of 2019.

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

The baseline forecast calls for output growth to accelerate from 1.2 percent in the first quarter of 2017 to 3.7 percent in the second quarter and then edge down to a 3 percent pace at the end of 2017. The model forecast for the second quarter of 2017 is stronger than suggested by the incoming data. The Federal Reserve Bank of Atlanta's GDPNow forecast for the second quarter of 2017 currently stands at 2.9 percent, while the Federal Reserve Bank of New York's Staff Nowcast

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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.

is at 1.9 percent. The DSGE model output forecast is made using quarterly data from the first quarter of 2017 and earlier. The incoming data since March 2017 have generally been pointing to slower growth in the second quarter.

The baseline model shows output growth steadily declining from about 2.8 percent in the first quarter of 2018 to about 2.6 percent in 2019. The unemployment rate falls to 4.2 percent by the first quarter of 2018 and then edges up to 4.3 percent in mid-2019.[5] Moderately strong growth and anchored long-run inflation expectations lead to an acceleration of core PCE inflation from 1.7 percent in the second quarter of 2017 to 2 percent by the second quarter of 2018. Core inflation then overshoots the FOMC target of 2 percent, reaching 2.3 percent at 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 1.5 percent at the end of 2017 and then increases on a modest path to 2.6 percent at the end of 2018 and 3.2 percent at the end of 2019.

The baseline forecast is stronger than the median projections from the second quarter 2017 SPF. In that survey, the respondents expected real output growth of 2.1 percent in 2017, 2.5 percent in 2018, and 2.1 percent in 2019. (Note that the SPF reports GDP growth as annual average over annual average.) The SPF's core PCE inflation forecast is 1.9 percent (Q4/Q4) for 2017 and 2 percent for 2018 and 2019. 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 4.5 percent in 2017, 4.3 percent in 2018, and 4.4 percent in 2019.

The June 2017 SEP by FOMC participants shows the median projection for output growth at 2.2 percent in 2017, 2.1 percent in 2018, and 1.9 percent in 2019. The median forecast of the unemployment rate in the fourth quarter of 2017 is 4.3 percent, edging down to 4.2 percent in 2018 and 2019. Core PCE inflation is projected at 1.7 percent in 2017, rising to 2 percent in 2018 and 2019. Headline inflation is now projected to run at about the same pace as core inflation over the forecast horizon. The forecast model's baseline forecast for the federal funds rate (Figure 4) is now at the top of the central tendency of the June 2017 SEP over the forecast horizon and remains well above market expectations, which are below 2 percent for the fourth quarter of 2018. The model generally suggests a 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.

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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.

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 suggest that the federal funds rate should rise at a fairly rapid pace over the next three years — more rapidly than suggested by financial markets.

- The more accommodative monetary policies are associated with more rapid output growth and higher inflation.

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

- By mid-2018, 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 the policy rules reaches about 2.7 percent by the end of 2018, which is well above current market expectations of what the federal funds rate will be at that time.

The alternative policy rules suggest different near-term levels of the appropriate federal funds rate. [7] The baseline puts the funds rate at 1.2 percent in the third quarter of 2017, compared with 1.6 percent for the Taylor (1993) rule. The Taylor (1999) rule suggests a federal funds rate of 1.1 percent in the third quarter — near its current level. The inertial Taylor rule suggests a funds rate of 0.9 percent in the third quarter of 2017, a bit below the actual current target. At 1.1 percent, the current target 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 fourth quarter of 2017, the funds rate stands at 1.9 percent for the Taylor (1993) rule, 1.7 percent for the Taylor (1999) rule, and 1.3 percent for the inertial Taylor rule. Thus, the rules see up to three additional tightenings this year. With ongoing normalization, all the rules suggest that the federal funds rate should be 2 percent

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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.

or higher by mid-2018. So, even though the inertial Taylor rule calls for a somewhat lower funds rate this quarter, the accommodation is fairly short lived.

The path of output growth is weakest over the near term under the Taylor (1993) rule, which calls for the highest near-term interest rate, with output growth at 2.8 percent over the next few quarters. The inertial Taylor (1999) rule, which over the forecast horizon is the most accommodative policy, has real output growth at 4.8 percent in the second quarter of 2017 and 3.9 percent in the third quarter. Note, though, that the output growth forecasts largely converge by the first quarter of 2018. 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 1.8 percent (Q4/Q4) in 2017 and shows little dispersion over the forecast horizon across the alternative policies. Core inflation is slightly lower over the forecast horizon compared with the March 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 baseline DSGE model uses historical correlations in the data to generate its forecasts and does not incorporate judgmental adjustment. The DSGE model also does not take account of data after the first quarter of 2017. Given those constraints, the model predicts a strong near-term performance for output growth. However, as seen from the fan charts in Figure 1, a large degree of uncertainty is associated with the forecast. Data since March 2017 now seem consistent with a somewhat more moderate near-term pace of growth than the model projects.

The policy alternatives suggest that the actual current level of the funds rate is generally near the the rules-based recommendations, although the underlying model has output growing somewhat faster than currently expected. The inertial Taylor rule suggests the funds rate should be about 30 basis points lower than its current setting, while the Taylor (1993) rule suggests the funds rate should be about 50 basis points higher. The alternative policy rules agree that the federal funds rate should rise steadily over the next three years to about 3.3 percent at the end of 2019. This represents a more aggressive policy normalization compared with financial market expectations.

Economic conditions are consistent with a gradual tightening of policy, according to the various rules we analyze. Accompanying this gradual tightening, the economy remains slightly below full employment and inflation remains close to its long-run target.
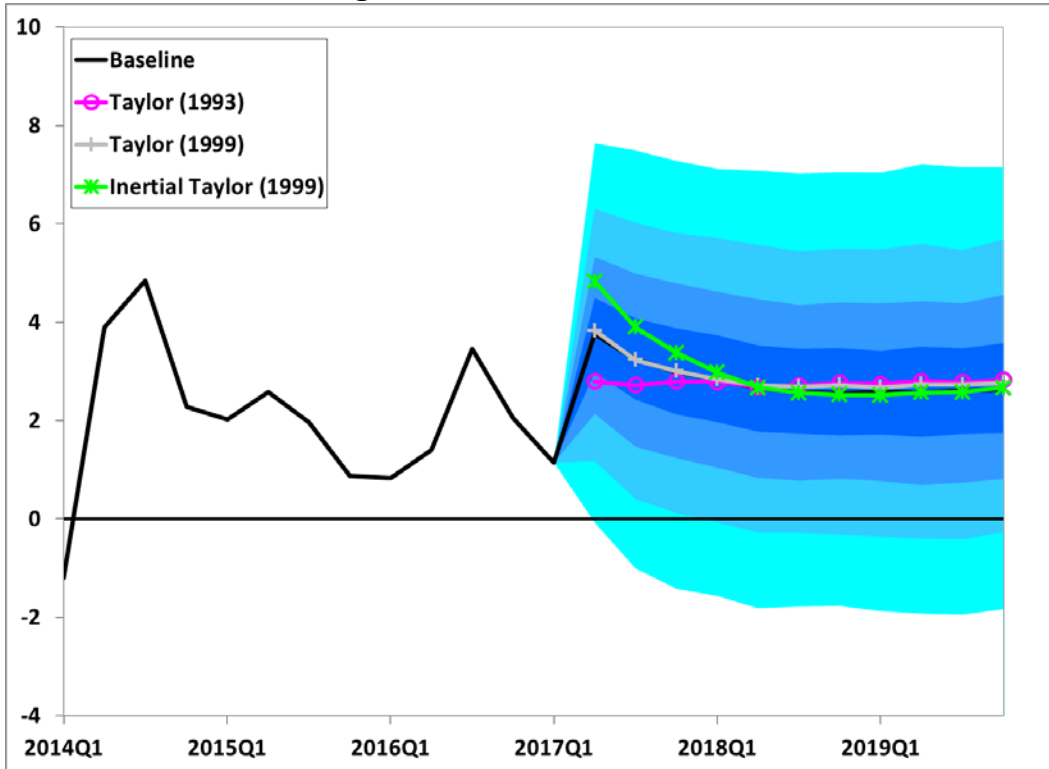
Figure 1: Real GDP Growth
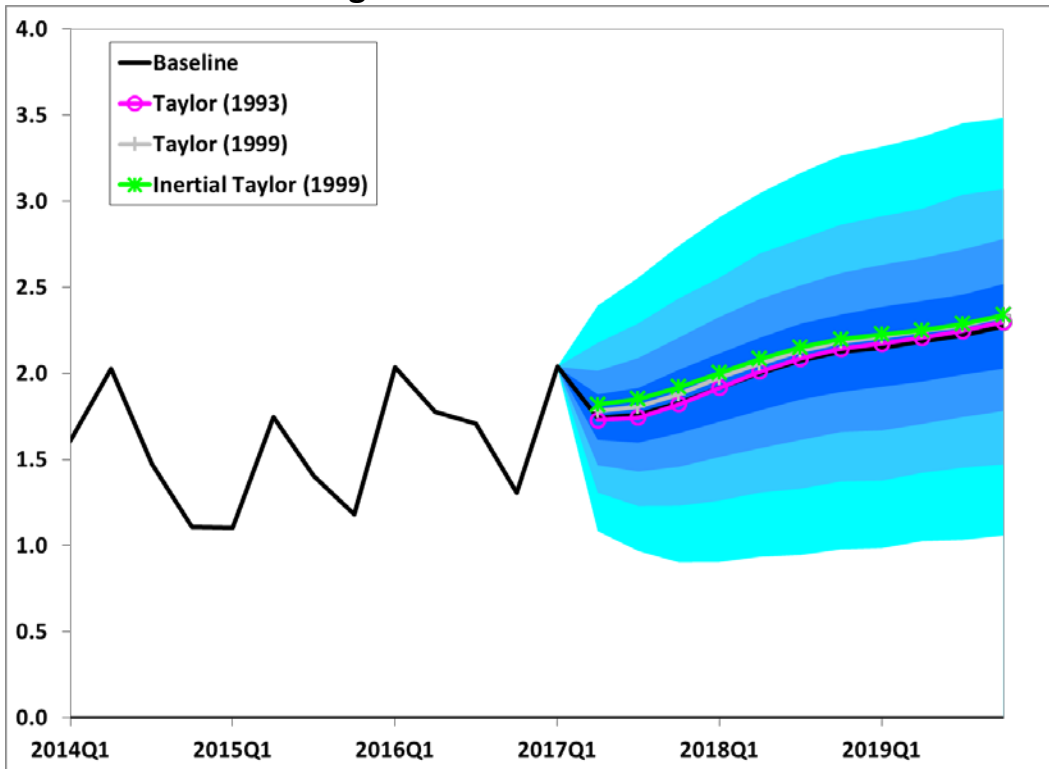

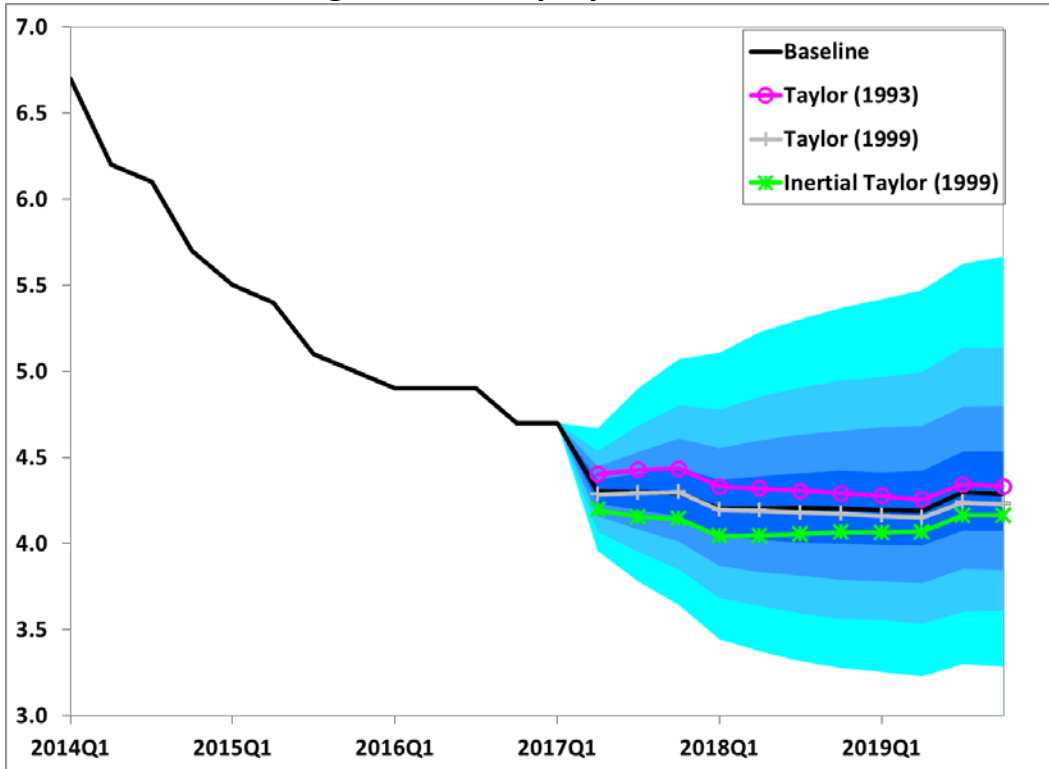## Figure 2: PCE Core Inflation

Figure 3: Unemployment Rate

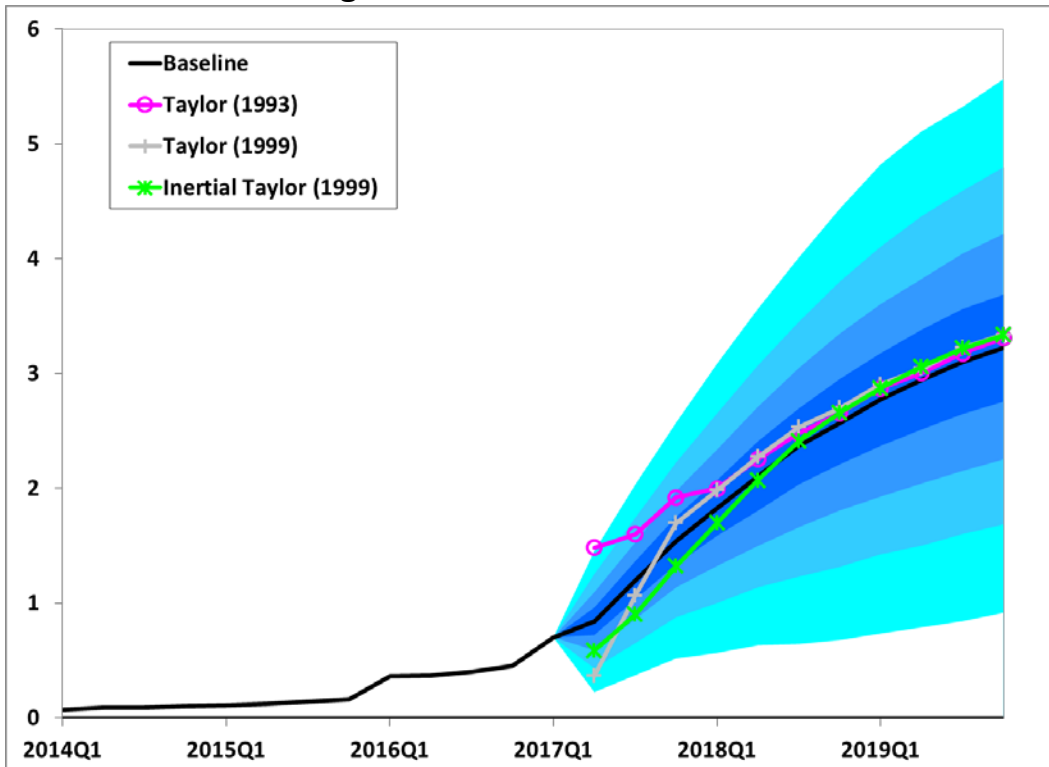## Figure 4: Federal Funds Rate

Figure 5: Baseline Forecast Comparisons
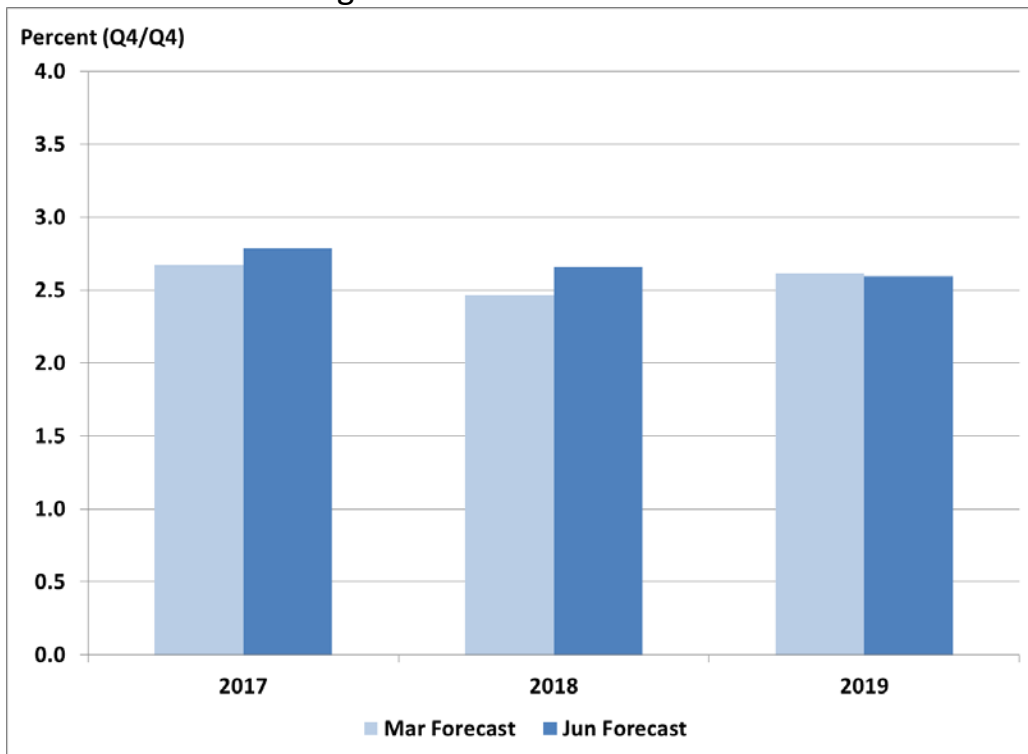
Figure 5a: Real GDP Growth
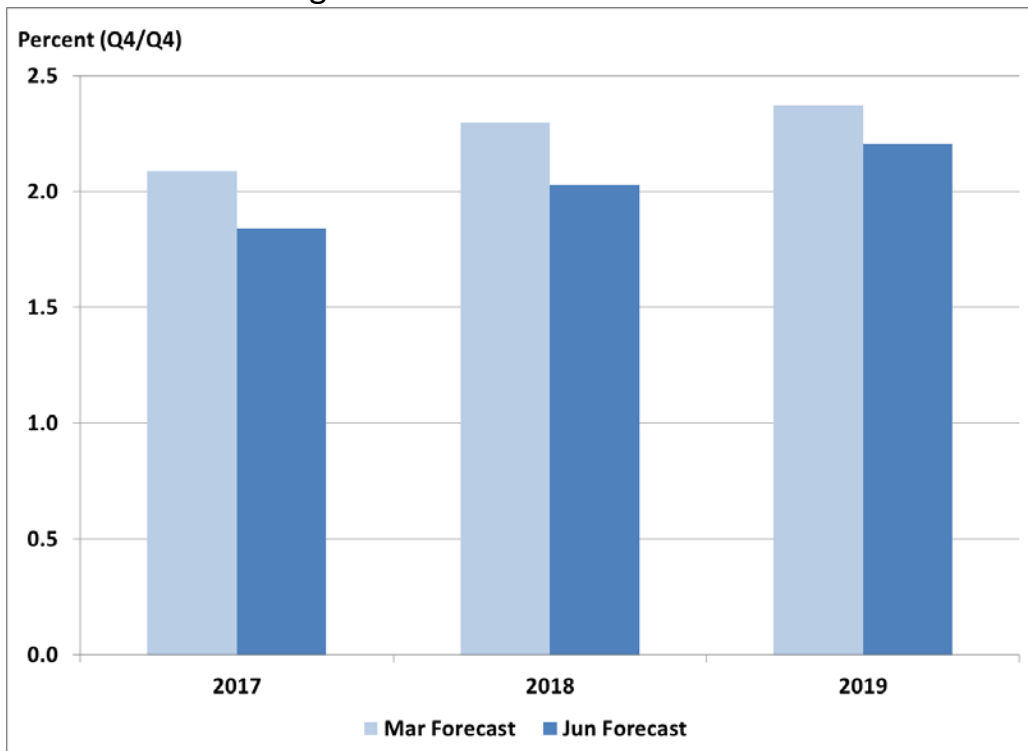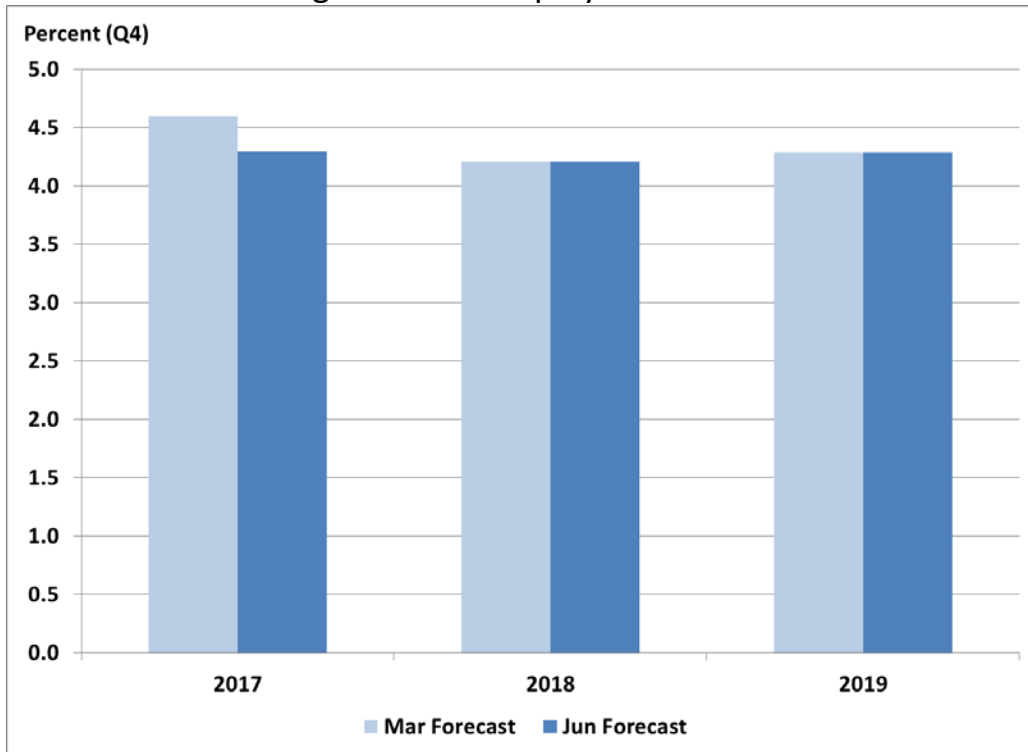

Figure 5b: PCE Inflation Growth

Figure 5c: Unemployment Rate

Figure 5d: Federal Funds Rate