Monetary Policy Report:
Using Rules for Benchmarking

Michael Dotsey
Executive Vice President and Director of Research

Keith Sill
Senior Vice President and Director, Real-Time Data Research Center

Federal Reserve Bank of Philadelphia

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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

Economic activity in the first quarter grew 2.2 percent, but according to many nowcasts, growth is accelerating in the current quarter and will likely exceed 3.0 percent and perhaps even top 4.0 percent. The upsurge is being supported by continued strength in business fixed investment and

improved consumer spending. The labor market continues to add jobs at a healthy clip, and overall economic fundamentals are sound. There are, however, a number of risks on the horizon, most notably surrounding policies involving foreign trade.

Real personal consumption expenditures are displaying solid positive momentum. They rose 0.4 percent in April following a 0.5 percent increase in March. The welcome return of the consumer was supported by solid gains in income growth. Consistent with this report, core retail sales increased 0.6 percent in May, with upward revisions to April's core retail sales growth as well. The strength displayed by the report was broad based. So far this year we are seeing growth in total sales of 5.4 percent. And although sales of light vehicles have been trending downward of late, declining to 16.8 million units at an annual rate in May, they still reflect solid demand for autos. Additionally, consumers continue to be optimistic as both June's preliminary University of Michigan's Consumer Sentiment Index at 99.3 and the Conference Board's May Consumer Confidence Index at 128.0 remain in elevated territory. Further, the report's current conditions index, which includes the percentage of respondents who believe jobs are plentiful and the percentage who think jobs are hard to get, attained its highest reading since March 2001.

Underpinning the rebound in consumption growth is the continued strong performance of the labor market. Nonfarm payroll employment grew by 223,000 net new jobs in May and has averaged 179,000 net new jobs over the last three months to May. The unemployment rate ticked down one-tenth of a percent as well and now stands at 3.8 percent, the lowest reading since 1969. Broader measures of unemployment have continued to decline, and the improved labor market picture has been experienced by all ethnic groups. Of note, for the first time since the data began being collected, job openings now exceed the number of people seeking jobs. Moreover, average hourly earnings continue to grow modestly, and we are hearing more reports of firms increasing wages. However, as yet there is no hard evidence of significant wage pressures.

The housing sector has weakened of late. Single-family home starts rose 35,000 in May, but single-family permits declined and remain at lackluster levels. The multifamily sector has been noticeably weaker, with starts declining by 50,000 units in April. Further evidence of weakness was displayed by existing home sales, which declined 2.5 percent in April. Year-to-date sales have declined 0.7 percent from last year. Rising mortgage rates and unseasonably cold weather may in part be responsible, but we are hearing anecdotes of serious supply constraints as well. All told, residential investment is anticipated to contribute little if anything to growth over 2018.

Manufacturing has picked up recently, and the revival is reflected in survey data, hard data, and anecdotes from industrial contacts. Core factory orders rose 1.0 percent in April, reversing the March decline. While not a robust report, orders are trending upward. The May report on industrial production (IP) was also a bit on the weak side, with IP excluding motor vehicles increasing 0.3 percent while total IP slipped 0.1 percent. The decline in auto assemblies was in

large part due to a major fire at an important supplier of parts for truck assemblies. The decline in manufacturing IP was also largely due to the effects of the fire. Overall, the recent trend in industrial production has been fairly solid, and most forecasters are anticipating strong growth over the remainder of the year. Survey data confirm the momentum in this sector, with the ISM manufacturing index rising to 58.7 in May. Many of the important subindices displayed gains as well, and the national survey reflects the renewed optimism expressed in many of the Federal Reserve's regional surveys.

Inflation has begun to firm, with headline PCE inflation reaching 2.0 percent on a 12-month basis and core PCE inflation coming in at 1.8 percent in April. The May consumer price index (CPI) report confirms the slow but steady increase in inflation, with the 12-month core CPI rising to 2.2 percent, its highest reading in over a year. The details of the report indicate that core PCE inflation is most likely rising as well. Inflation expectations also appear well anchored, and it looks like the Fed is poised to achieve this half of its dual mandate for the first time in approximately six years.

It also appears that risks to the economy have increased. Those risks include the possibility of a trade war as other countries respond to the recent increases in U.S. tariffs on steel and aluminum. There has also been little movement toward solidifying NAFTA; should agreement fail to materialize, it would be enormously costly to the U.S. economy.

However, the economic outlook has strengthened. Fiscal policy is supportive of growth, and inflation appears to be slowly moving toward its 2.0 percent target. This view is reflected in June's Summary of Economic Projections (SEP) in which the median projection for growth this year was revised upward by 0.1 percentage points to 2.8 percent and with projected growth slightly above trend over the forecast horizon. Further, Committee members' median forecast sees unemployment falling to 3.6 percent this year before ticking down to 3.5 percent over the succeeding two years. That rate is well below the Committee's view of the long-run natural rate. Additionally, committee members project that inflation, at 2.1 percent, will slightly exceed its 2.0 percent objective this year and next. The underlying strength in the economy and the upward trend in inflation have resulted in a slight tightening in the median projected appropriate funds rate path from three rate hikes in 2018 to four. The change occurred because one participant's view of appropriate policy was altered from three rate hikes to four. Thus, the shift was not that dramatic. The median projection of the future appropriate path for the federal funds rate also moved up by 25 basis points, and the vast majority of the Committee believes that a slight overshooting of the long-run neutral level of the funds rate will also be appropriate. Thus, the Committee appears to be increasingly confident in the strength of the economy and the return of inflation to target, and the slight tightening in the anticipated policy path reflects that confidence.

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 2018. The forecast begins in the second quarter of 2018 and extends through the fourth quarter of 2020. 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 models do not take account of tax reform.

The key features of the baseline forecast are as follows:

- Real output is forecast to grow at about 2.7 percent annual rate over the next three years.

- Core PCE inflation reaches 2.1 percent (Q4/Q4) in 2018, rising to 2.2 percent in 2019 and to 2.4 percent in 2020.

- The unemployment rate averages 3.5 percent in the fourth quarter of 2018, 3.4 percent at the end of 2019, and 3.5 percent at the end of 2020.[4]

- The federal funds rate is at 2.1 percent at the end of 2018, 3 percent at the end of 2019, and 3.6 percent at the end of 2020.

- Compared with the March forecast, real GDP growth is slightly weaker in 2018, inflation is slightly stronger over the forecast horizon, the unemployment rate path is unchanged over the next two years, and the federal funds rate path is unchanged over the forecast horizon (Figures 5 a, b).

The baseline forecast calls for output growth of 3 percent in the second quarter of 2018, moving down to a 2.7 percent pace by the end of 2019. The model forecast for the second quarter of 2018 is weaker than nowcasts. The Federal Reserve Bank of Atlanta's GDPNow forecast for the second quarter of 2018 currently stands at 4.8 percent, while the Federal Reserve Bank of New York's Staff Nowcast is at 3.1 percent. The DSGE model output forecast is made using quarterly data from

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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.

the first quarter of 2018 and earlier. The incoming data since April 2018 have generally been pointing to a pace of underlying growth for the second quarter that is stronger than what we saw in the first quarter.

The baseline model shows output growth edging down steadily from about 3 percent currently to 2.7 percent at the end of 2020.[5] The unemployment rate averages 3.9 percent in the second quarter of 2018 and then moves down to 3.5 percent by year-end. The unemployment rate bottoms out at 3.4 percent in 2019 and then rises to 3.5 percent at the end of 2020. Moderately strong growth and anchored long-run inflation expectations lead to an acceleration of core PCE inflation from 2 percent in the second quarter of 2018 to 2.3 percent by the end of 2019. The inflation path is slightly higher this time compared with the March baseline forecast because of recent improved readings on core PCE inflation. Core inflation overshoots the FOMC's target of 2 percent, reaching 2.4 percent by the end of 2020. 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 2.1 percent at the end of 2018 and then increases at a modest pace to 3 percent at the end of 2019 and to 3.6 percent at the end of 2020. This is the same path as in the March forecast.

The baseline forecast is similar to the median projections from the second quarter 2018 Survey of Professional Forecasters (SPF) over the next two years, and stronger in 2020. The respondents expected real output growth of 2.8 percent in 2018, 2.7 percent in 2019, and 1.9 percent in 2020. (Note that the SPF reports GDP growth as annual average over annual average.) The SPF's core PCE inflation forecast is 2.2 percent (Q4/Q4) for 2018 and 2.1 percent for 2019 and 2020. 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 3.9 percent in 2018, falling to 3.7 percent in 2019, and 3.9 percent in 2020.

The June 2018 Summary of Economic Projections (SEP) by FOMC participants shows the median projection for output growth at 2.8 percent in 2018, 2.4 percent in 2019, and 2 percent in 2020. The median forecast of the unemployment rate at the end of 2018 is 3.6 percent, edging down to 3.5 percent in 2019 and 2020. Core PCE inflation is projected at 2 percent in 2018, rising to 2.1 percent in 2019 and 2020. Headline inflation is 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) remains within the central tendency of the June 2018 SEP over the forecast horizon and remains above market expectations, which are at about 2.6 percent for the fourth quarter of 2019. The model generally suggests a 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 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 differences among the forecasts are in output growth and the federal funds rate, not in inflation. The model estimates somewhat persistent inflation measures that respond sluggishly to shocks.

- By early 2019, 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 a range of 3.1 to 3.7 percent in 2020Q4, which is well above current market expectations of what the federal funds rate will be at that time.

The alternative policy rules continue to suggest significant differences in near-term levels of the appropriate federal funds rate.[7] The effective federal funds rate is currently at 1.9 percent. The baseline rule puts the funds rate at 1.5 percent in the second quarter of 2018, somewhat higher than the effective funds rate. The Taylor (1993) rule calls for the funds rate to be at 2 percent, while the Taylor (1999) rule pegs the funds rate at 1.2 percent. The inertial Taylor rule has the funds rate at 1.3 percent in the second quarter. At 1.9 percent, the current target lies within the range of the model rules, but all the rules suggest ongoing tightening of policy over the next three years. For the fourth quarter of 2018, the funds rate is in a range of 1.9 to 2.4 percent across 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, suggesting three to four interest rate hikes in 2018. With ongoing normalization, all the rules suggest that the federal funds rate should be 3 percent or higher in the fourth quarter of 2019.

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 averaging 2.3 percent over the next two quarters. The inertial Taylor (1999) rule, which over the forecast horizon is the most accommodative policy, has real output growth at 4.0 percent in the second quarter of 2018 and 3.4 percent in the third quarter of 2018. Note, though, that the output growth forecasts largely converge by the first quarter of 2019. 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 2.1 percent (Q4/Q4) in 2018 and shows little dispersion over the forecast horizon across the alternative policies. Core inflation is slightly higher over the forecast horizon compared with the March projection based largely on recent improved inflation data. 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 2018, and the projection makes no attempt to account for the impact of tax reform or the Bipartisan Budget Agreement on future output growth or inflation. Given those constraints, the model nonetheless 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.

The policy alternatives suggest that the actual current level of the funds rate is at the high end of the rules-based recommendations, while the underlying model has output growing at a pace that is weaker in the near term compared with nowcast projections. However, the model has not anticipated the strong readings on real activity over the past few months. The alternative policy rules agree that the federal funds rate should rise steadily over the next three years to about 3.6 percent at the end of 2020. This represents a more aggressive policy normalization compared with financial market expectations or the SEP median policy path. Economic conditions continue to be consistent with a gradual tightening of policy, according to the various rules we analyze. Accompanying this gradual tightening, the economy remains above full employment and inflation moves up above its longer-run target over the medium term.
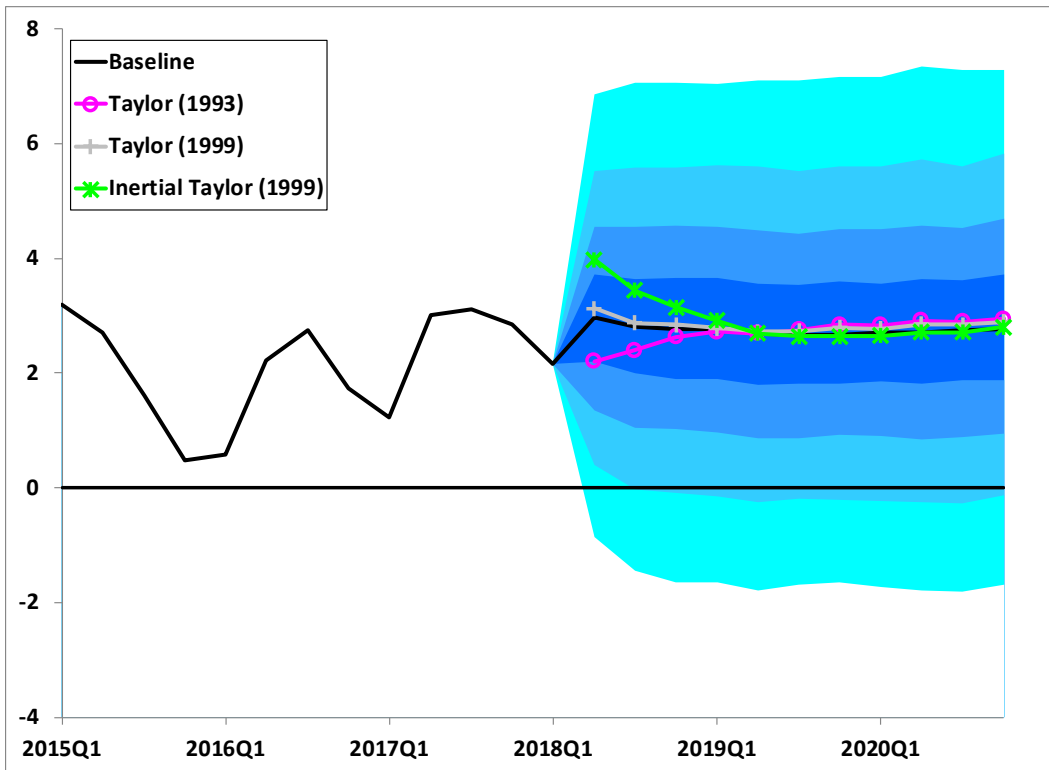
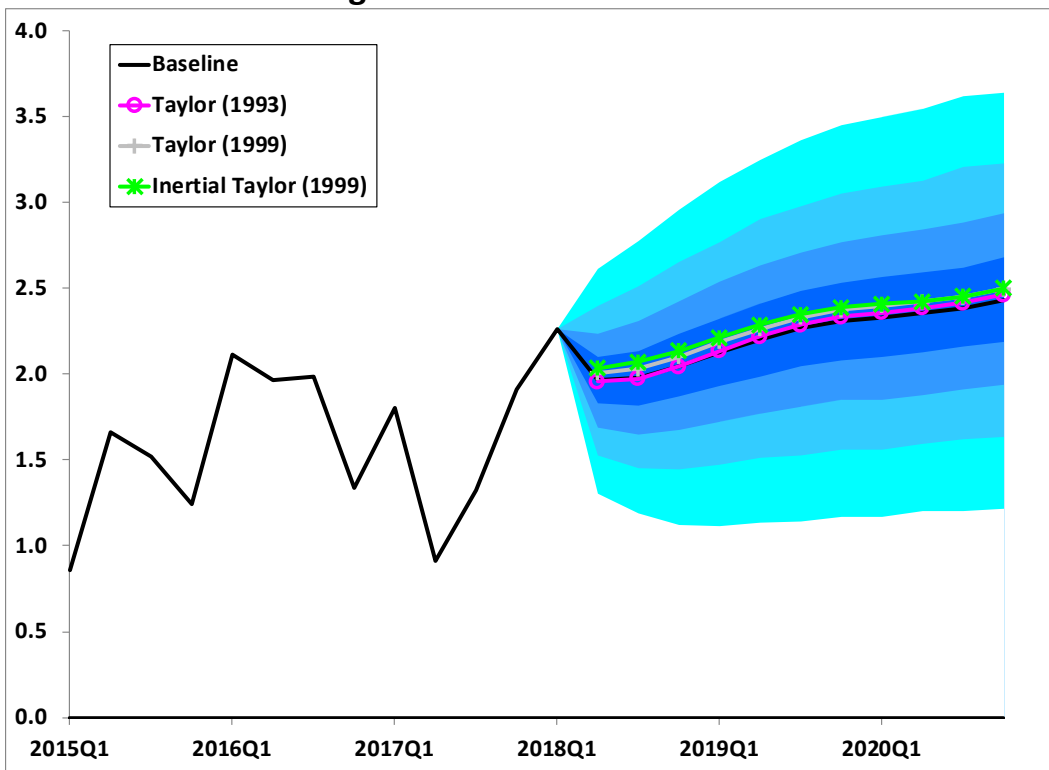## Figure 1: Real GDP Growth

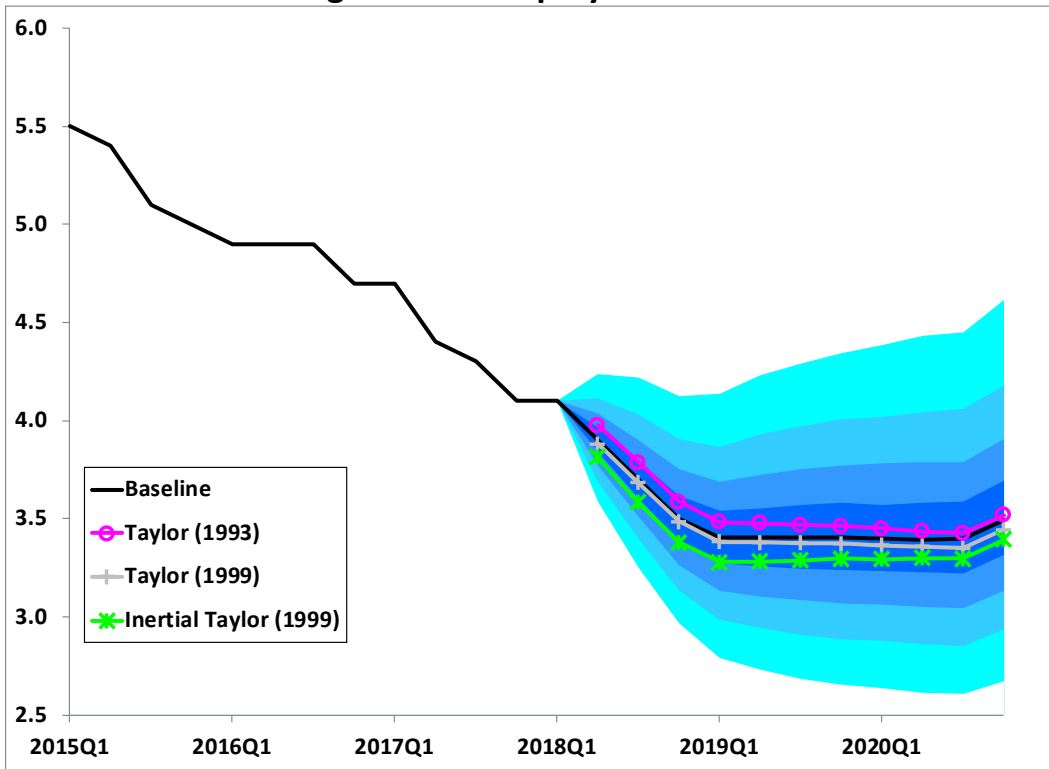## Figure 2: PCE Core Inflation

Figure 3: Unemployment Rate

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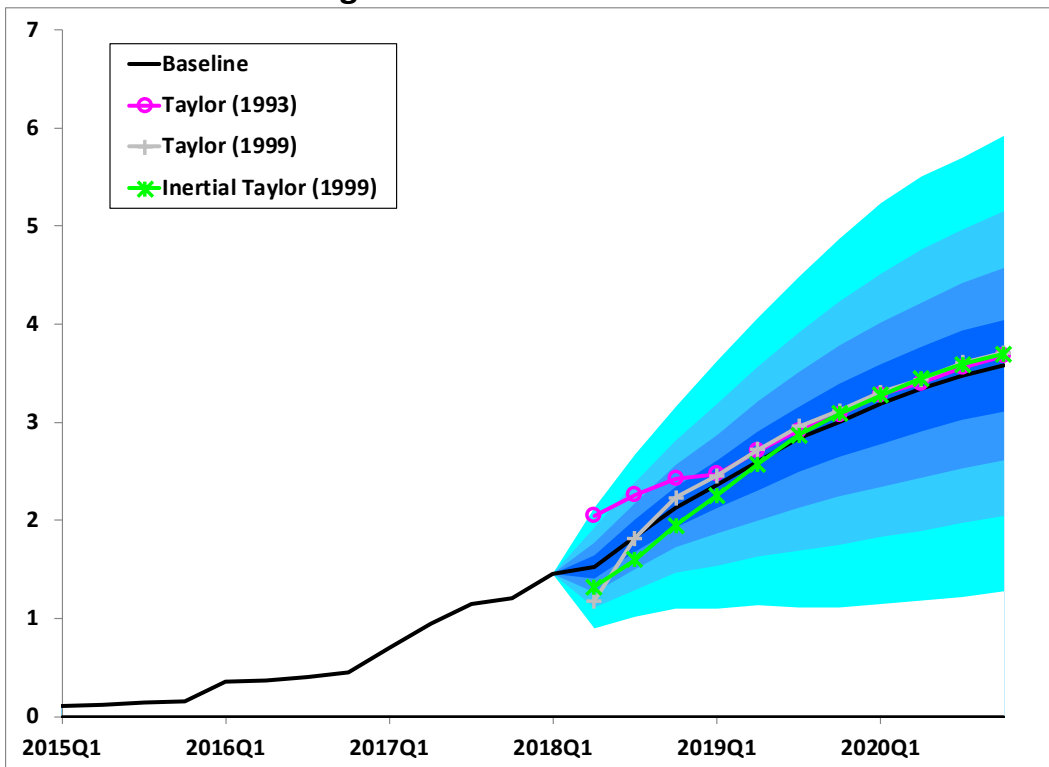
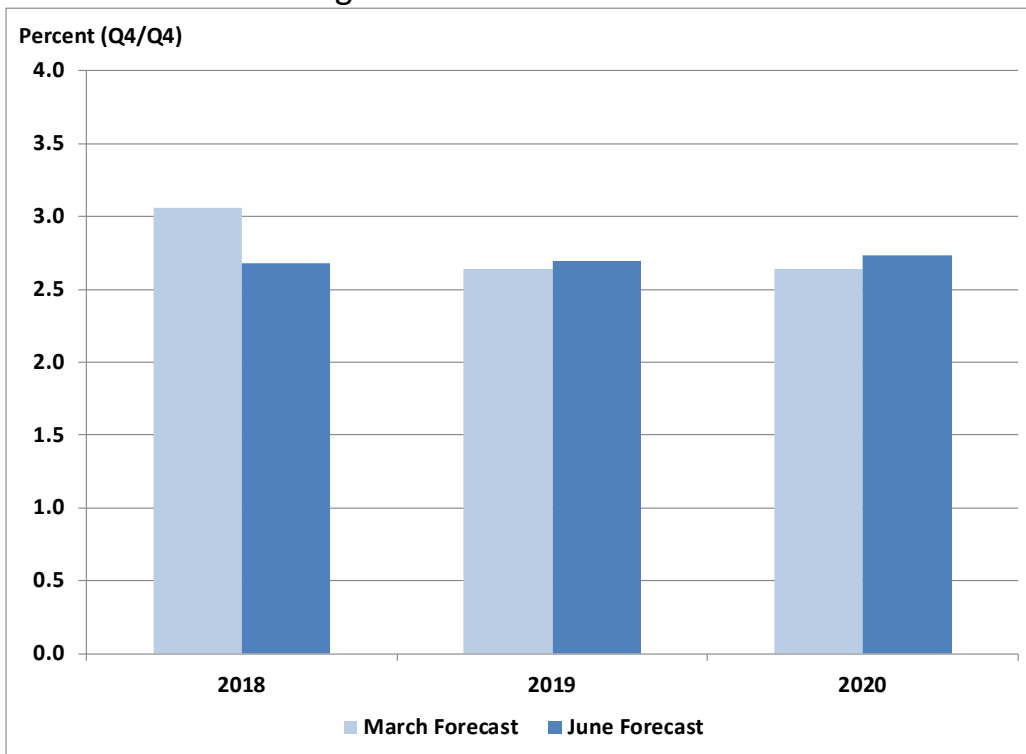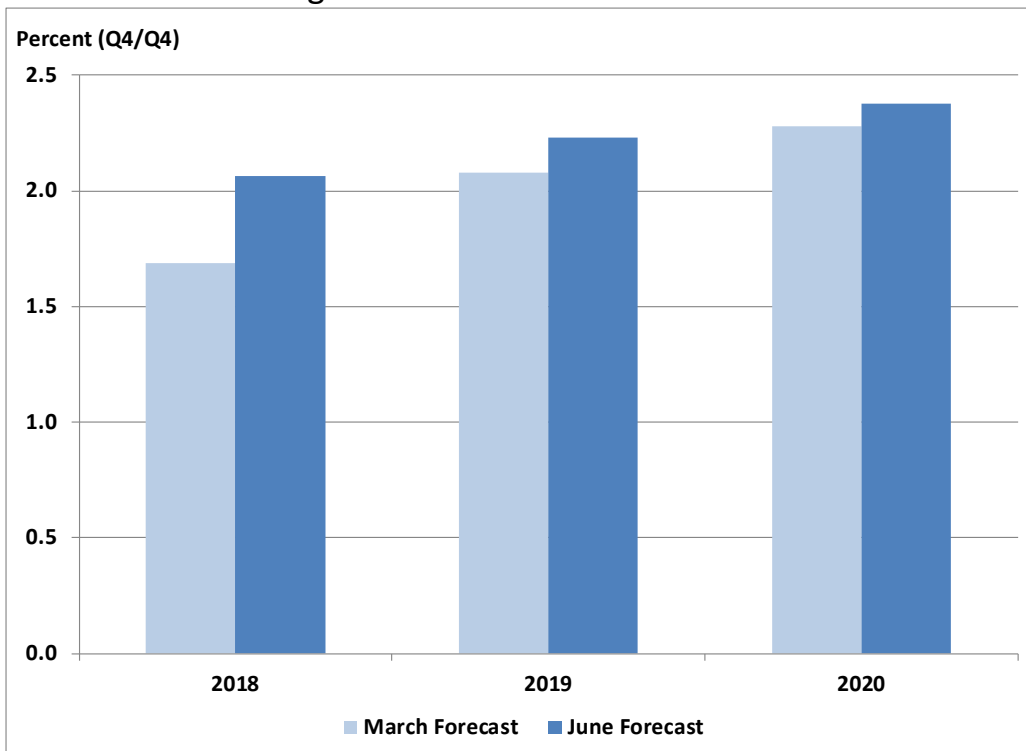# Figure 5: Baseline Forecast Comparisons

Figure 5a: Real GDP Growth

Percent (Q4/Q4)

March Forecast   June Forecast

Figure 5b: PCE Inflation Growth

Percent (Q4/Q4)

March Forecast   June Forecast

Figure 5c: Unemployment Rate

Percent (Q4)

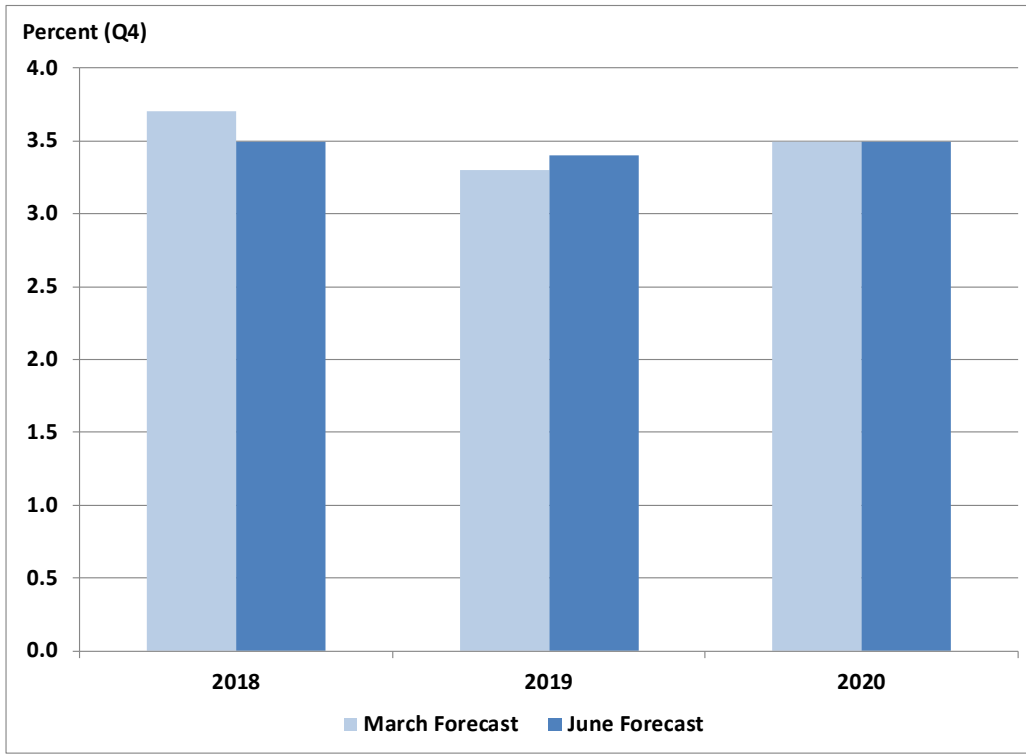Bar chart comparing March Forecast and June Forecast for years 2018, 2019, 2020.

Legend: March Forecast, June Forecast

Figure 5d: Federal Funds Rate

Percent (Q4)

Bar chart comparing March Forecast and June Forecast for years 2018, 2019, 2020.

Legend: March Forecast, June Forecast