Monetary Policy Report:
Using Rules for Benchmarking

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March 2018

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 appears to have moderated after growing 2.5 percent in the fourth quarter of 2017. Many forecasters project that fourth quarter growth will be revised

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upward to around 3 percent, but the expectation is for growth of slightly below 2 percent this quarter.

Recently, consumer spending has been weaker than expected, but the lull is expected to be temporary, as economic fundamentals remain strong. The labor market continues to add jobs at a robust pace, both equity and house prices continue to rise, and survey evidence indicates that consumers and firms are very optimistic regarding economic prospects. As was true in mid-2017, the hard and soft data on consumption appear to be diverging somewhat, with the tangible data not fully reflecting the strength found in various surveys.

According to many nowcasts, the U.S. economy has probably been growing below trend in the first quarter of this year, something it tends to do in first quarters. The economy entered the year with significant momentum, and the relative weakness in the current quarter is largely due to a reduction in the pace of consumer spending and a pullback in investment. Despite some recent dollar depreciation and continued improvements in the global outlook, net exports have been a drag as well.

Inflation remains below the Federal Open Market Committee's (FOMC) target, but the most recent data are indicating a slight acceleration in price increases. The economic effects of both the tax cuts and the planned increases in federal government spending could very well add as much as 0.5 percentage point to quarterly growth rates over the next few years. These factors are giving many FOMC members more confidence in the ongoing stability of the expansion, but the persistent shortfall in inflation will remain a concern. Normalization of the balance sheet has proceeded as planned, and the pace of normalization will gradually accelerate this year. To date, the process has gone smoothly.

Providing some foundation for expenditure growth is the continued growth in jobs. After a strong fourth quarter, job growth accelerated further in the first two months of this year, with a net gain of 239,000 jobs in January and 313,000 in February. Strength has been broad based, with relatively strong gains in manufacturing. Over the last 30 years, we have rarely seen such a strong near-term performance in this sector. Labor force participation has risen to 62.9 percent, and the entry of more people into the work force has kept the unemployment rate at 4.1 percent despite the robust job creation. Even though the labor market appears relatively tight, we have not seen much acceleration in wage growth, as measured by either average hourly earnings or by the Atlanta Fed's wage tracker. Anecdotal evidence continues to point to difficulties in filling certain types of job openings, mostly those requiring technical skills.

The labor market also continues to show dynamism. The job openings rate bounced back to 4.1 percent in January, and the hiring rate returned to its highest level since the onset of the recovery.

The healthy labor market is supporting solid income growth, with personal income growing 4.5 percent at an annualized rate over the three months to January.

Over the same period, real consumption grew a disappointing 2.3 percent. Retail sales have been quite weak so far this year, with core sales — excluding autos, gasoline, and sales at building materials and supplies dealers — falling 0.84 percent over the last three months. The weakness in sales has been broad based and has led many analysts to mark down total economic growth in the first quarter.

The housing sector has also weakened of late. New single-family home sales declined for the second straight month, falling 0.6 percent in February after declining 4.75 percent in January. Other measures of housing activity have also had a rather lackluster start to the year, with the index of pending home sales declining 4.7 percent in January. Single-family permits declined as well. However, there was a modest rebound in single-family starts in both January and February, though they remain below their levels of last October and November. While activity in the more important single-family portion of the housing market has shown some positive momentum, the multifamily sector declined noticeably in February, more than reversing January's growth. Commentary has tended to emphasize supply constraints as the driving factor in the latest slowdown, and many analysts are projecting a bounce-back this spring.

Manufacturing survey data indicate continued expansion, with the February headline composite ISM index hitting 60.8, its highest reading of the expansion. Most of the regional surveys are indicating strong growth as well. The latest Philadelphia Fed manufacturing survey, at 22.3, remains solidly in expansion territory. Importantly, there was finally a bit of alignment between the optimistic survey data and the hard numbers. Manufacturing industrial production increased 1.2 percent in February, the first solid number in months. Vehicle assemblies increased sharply, and the production of consumer goods grew at a moderate pace.

Not all the data are rosy, as factory goods orders declined in January following an upward revision in December. The trend in this series remains positive, and February's durable goods orders report, in which core orders grew 1.8 percent, indicates that January's weakness is likely to be temporary.

Recently, inflation has accelerated modestly yet remains stubbornly below the FOMC's target of 2.0 percent. Over the three months to January, core PCE inflation rose 2.1 percent at an annual rate compared with its 1.5 percent increase over the preceding 12 months. The acceleration is welcome news to monetary policymakers, but it must be weighed against the fact that inflation has been unexpectedly low for the last six years.

It also appears that risks to the economy have increased. The rising risk is reflected in the heightened volatility in asset markets. 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 March's Summary of Economic Projections (SEP) in which the median projection for growth this year was revised up by 0.2 percentage point to 2.7 percent and for next year by 0.3 percentage point to 2.4 percent. Thus, growth is anticipated to be modestly above potential over the next two years. Further, Committee members' median forecast sees unemployment falling to 3.6 percent over the SEP forecast horizon and inflation returning to target sometime next year. The median projected appropriate funds rate path is for three 25 basis point rate hikes this year and next, with two additional rate hikes in 2020, implying that the funds rate will exceed its long-run neutral value in 2020. While the median view of appropriate policy for 2018 has not changed, the Committee is almost evenly split between those who view three versus four rate hikes as the likely course for policy. Thus, the Committee appears to be more confident in the strength of the economy, 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

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

Model Forecasts Under the Baseline

We first generate forecasts assuming that monetary policy follows the baseline policy rule. The forecast is generated using observed data through the fourth quarter of 2017. The forecast begins in the first 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 3.1 percent (Q4/Q4) in 2018, 2.6 percent in 2019, and 2.6 percent in 2020.

- Core PCE inflation reaches 1.7 percent (Q4/Q4) in 2018, rising to 2.1 percent in 2019 and to 2.3 percent in 2020.

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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.

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

- The unemployment rate averages 3.7 percent in the fourth quarter of 2018, 3.3 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 December forecast, real GDP growth is slightly weaker over the next three years, inflation is slightly stronger over the forecast horizon, the unemployment rate path is lower over the next two years, and the federal funds rate path is slightly steeper over the forecast horizon (Figures 5 a, b).

The baseline forecast calls for output growth of 3.3 percent in the first quarter of 2018, moving down to a 2.6 percent pace by the end of 2019. The model forecast for the first quarter of 2018 is stronger than other nowcasts. The Federal Reserve Bank of Atlanta's GDPNow forecast for the first quarter of 2018 currently stands at 1.8 percent, while the Federal Reserve Bank of New York's Staff Nowcast is at 2.7 percent. The DSGE model output forecast is made using quarterly data from the fourth quarter of 2017 and earlier. The incoming data since January 2018 have generally been pointing to a pace of underlying growth for the first quarter that is somewhat weaker than what we saw in the third fourth.

The baseline model shows output growth steadily declining from about 3.3 percent currently to 2.6 percent at the end of 2019 and then running at about that pace through the end of 2020.[5] The unemployment rate averages 4.1 percent in the first quarter of 2018 and then moves down to 3.7 percent by year-end. The unemployment rate bottoms out at 3.2 percent in the second quarter of 2020 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 1.6 percent in the first quarter of 2018 to 2 percent early in 2019. The inflation path is slightly higher this time compared with the December baseline forecast because of recent improved readings on core PCE inflation. The model views the recent downward pressure on core inflation as transitory. Core inflation overshoots the FOMC's target of 2 percent, reaching 2.3 percent in the second half 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 a somewhat steeper path than was forecast in December.

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[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.

[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.

The baseline forecast is stronger than the median projections from the first quarter 2018 Survey of Professional Forecasters (SPF). Respondents expected real output growth of 2.8 percent in 2018, 2.5 percent in 2019, and 2 percent in 2020. (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 2018 and 2 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 4 percent in 2018, 3.8 percent in 2019, and 3.9 percent in 2020.

The March 2018 SEP by FOMC participants shows the median projection for output growth at 2.7 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 3.8 percent, edging down to 3.6 percent in 2019 and 2020. Core PCE inflation is projected at 1.9 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 March 2018 SEP over the forecast horizon and remains above market expectations, which are at about 2.4 percent for the fourth quarter of 2019. 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.

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.

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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.

- 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 about 2 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 significant differences in near-term levels of the appropriate federal funds rate.[7] The effective federal funds rate is currently at 1.4 percent. The baseline puts the funds rate at 1.4 percent in the first quarter of 2018, the same as the Taylor (1993) rule. However, the Taylor (1999) rule suggests a federal funds rate of about 0.4 in the first quarter — lower than its current level. The inertial Taylor rule suggests a funds rate of 1.1 percent in the first quarter of 2018, about 30 basis points below the actual current target. At 1.4 percent, the current target lies within the range of the model rules, but all of the rules suggest ongoing tightening of policy over the next three years. For the fourth quarter of 2018, the funds rate stands at about 2.1 percent across the rules, suggesting about three 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. Even though the rules call for a low funds rate over the next couple of quarters, 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 2.7 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 4.0 percent in the first quarter of 2018 and 3.6 percent in the second quarter of 2018. Note, though, that the output growth forecasts largely converge by the end 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 1.7 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 December projection, 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

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

the fourth quarter of 2017, 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 funds rate is at the high end of the rules-based recommendations, while the underlying model has output growing at a pace that is stronger in the near term compared with nowcast projections. However, the model has not anticipated the somewhat weak readings on real activity over the last 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 are consistent with a gradual tightening of policy, according to the various rules we analyze. Accompanying this gradual tightening, the economy remains below full employment and inflation moves up to its longer-run target over the medium term.
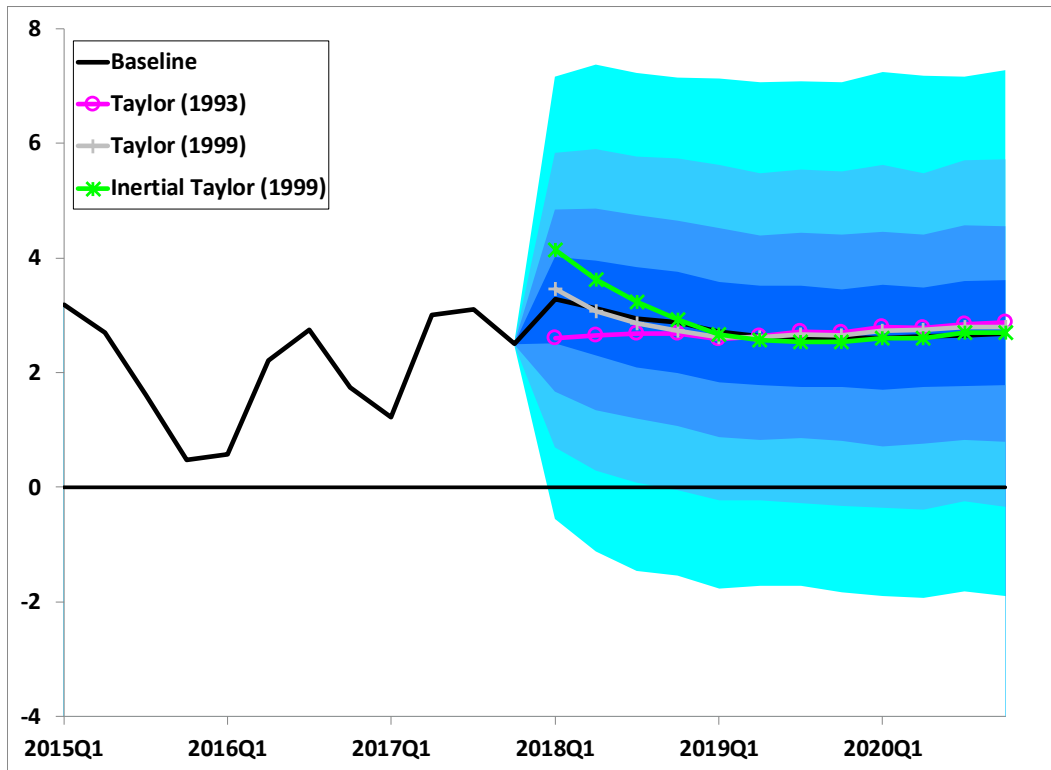
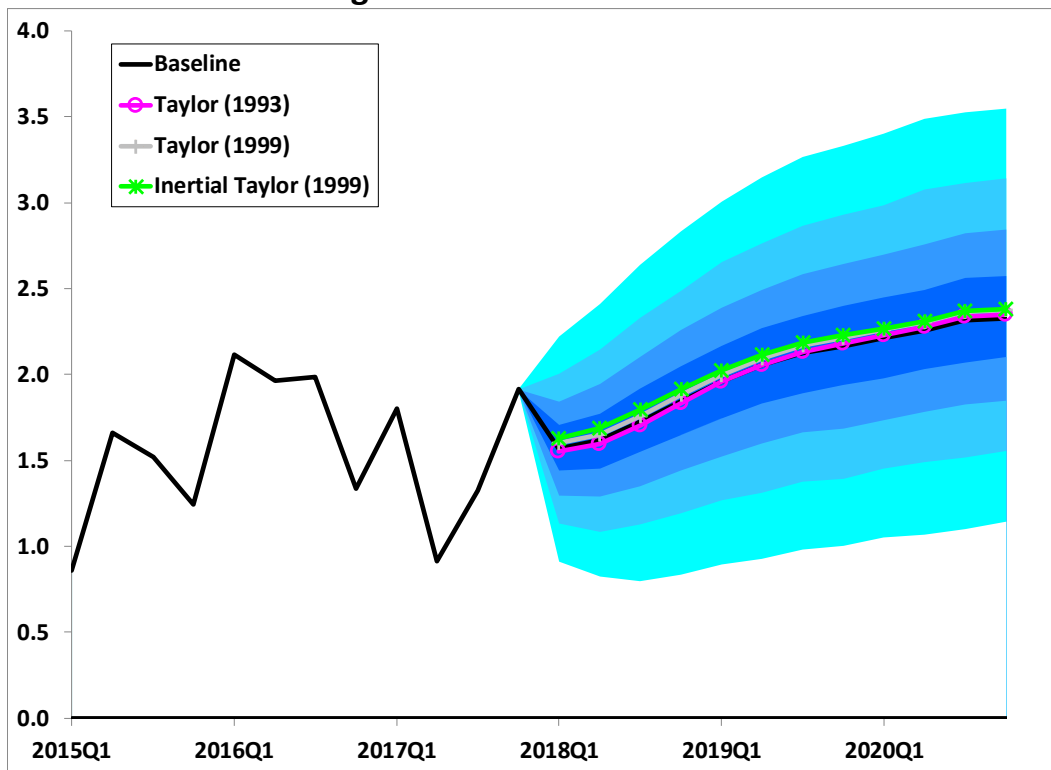## Figure 1: Real GDP Growth

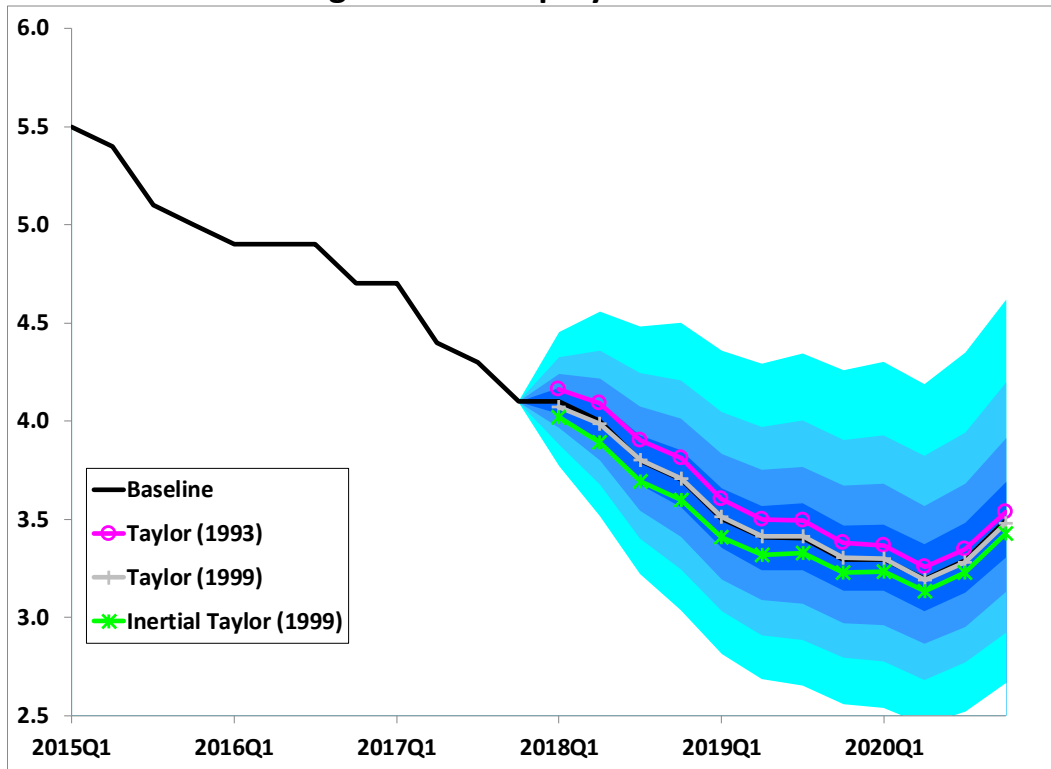## Figure 2: PCE Core Inflation

Figure 3: Unemployment Rate

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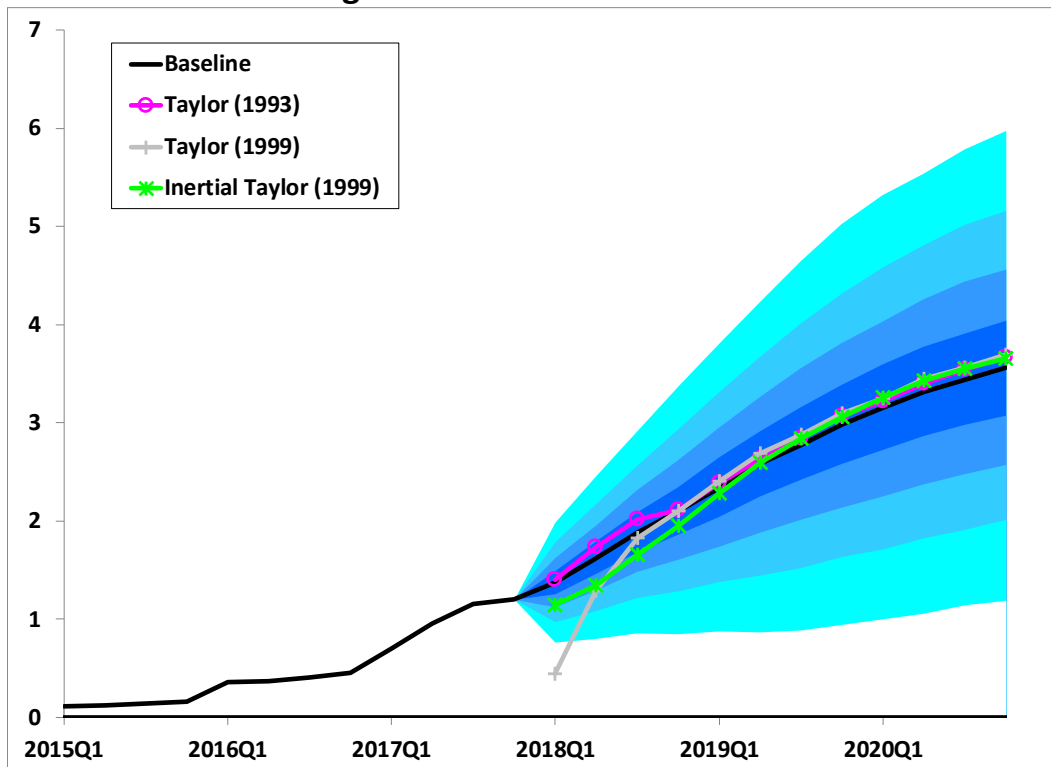
Figure 5: Baseline Forecast Comparisons

Figure 5a: Real GDP Growth

Percent (Q4/Q4)
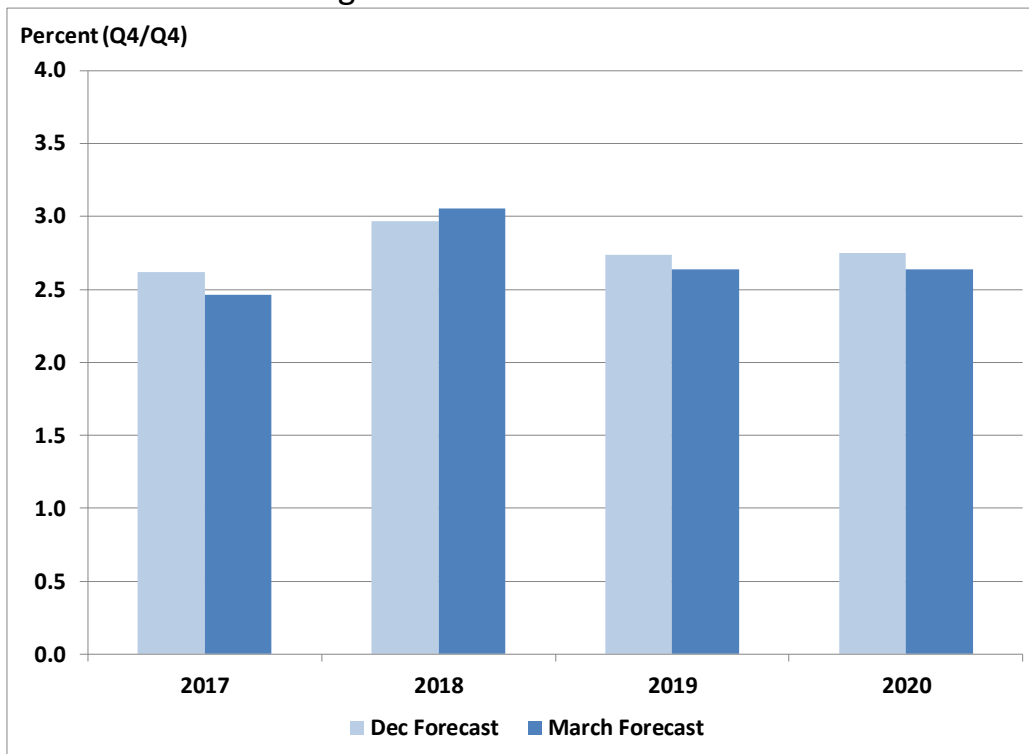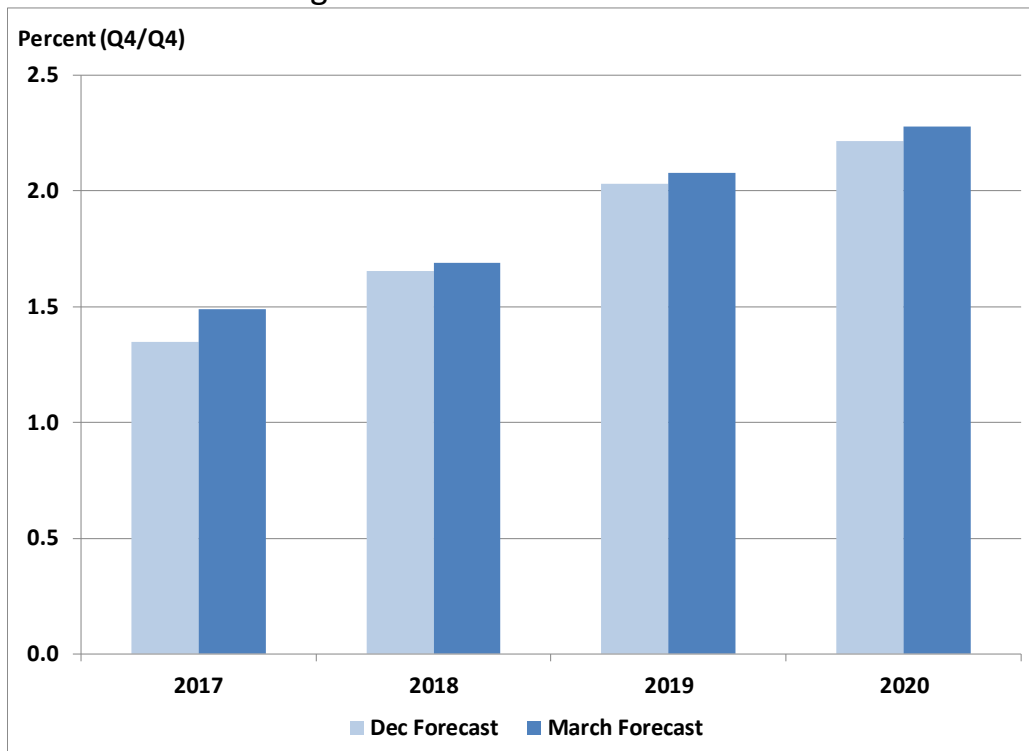

Dec Forecast   March Forecast

Figure 5b: PCE Inflation Growth

Percent (Q4/Q4)

Dec Forecast   March Forecast

Figure 5c: Unemployment Rate
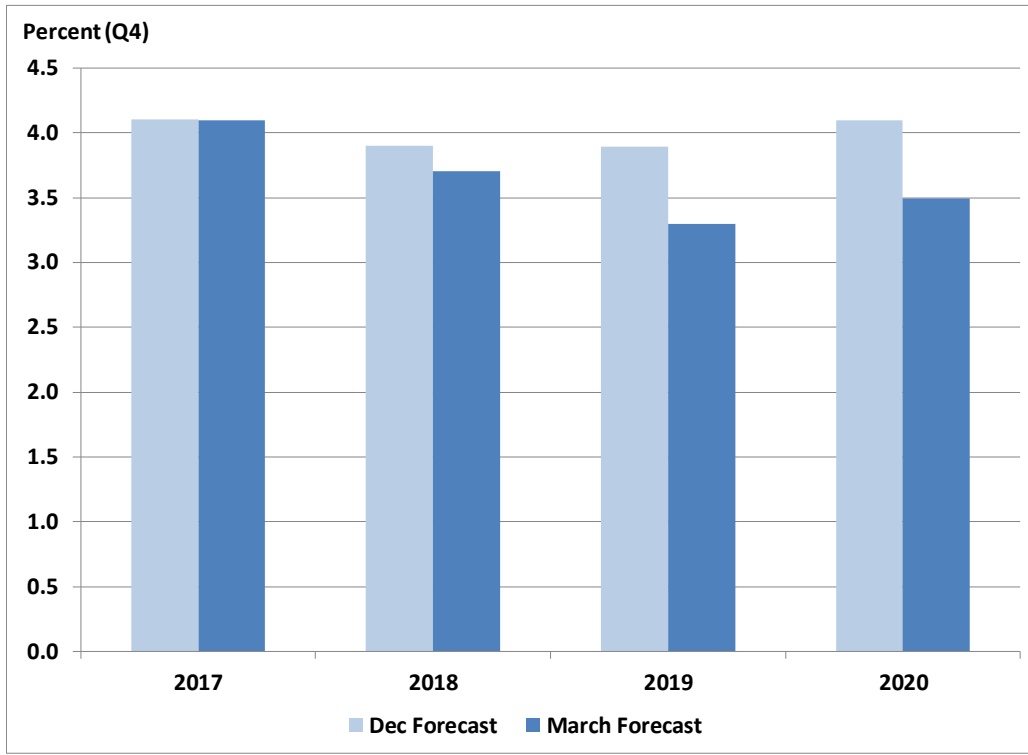
Percent (Q4)

	Dec Forecast	March Forecast

Figure 5d: Federal Funds Rate

Percent (Q4)

	Dec Forecast	March Forecast