SPECIAL REPORT
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Monetary Policy Report: Using Rules for Benchmarking

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Introduction

This special report highlights ongoing work to benchmark the stance of monetary policy using a range of policy rules that are widely employed in studies of monetary economics.[1] We perform the exercise with a specific, publicly available model of the macroeconomy developed by researchers at the 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 third quarter grew 3.4 percent after growing at a healthy 4.2 percent in the previous quarter. According to many nowcasts, growth has tapered back toward trend, implying that growth over all of 2018 will likely be around 3.0 percent. The deceleration is largely

[1] The views expressed in this report 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 and Jordan Manes for their assistance.

due to weakening in investment spending, both business fixed and residential. Consumption growth, however, remains solid, and the labor market remains robust. There are, however, a number of risks on the horizon, most notably surrounding policies involving foreign trade. Recently, asset prices have declined worldwide, foreign economic growth has weakened, and the effects of fiscal policy are likely waning.

Real personal consumption expenditures (PCE) continues to grow at a solid pace. It rose at an annual pace of 3.7 percent over the three months to November. Continued strength in consumption has been supported by solid gains in personal income growth and the continued robust growth in jobs. Additionally, over the three months to November, core retail sales have been increasing at a 4.5 percent annualized rate, showing renewed momentum of late. Sales of light vehicles remain robust, growing by 17.4 million units at an annual rate in November and 17.2 million units over the last year. Consumers also continue to be optimistic, as both the mid-December University of Michigan's Consumer Sentiment Index, at 97.5, and the November Conference Board's Consumer Confidence Index, at 135.7, remain in elevated territory. Plans to buy major appliances rose in November, and the labor index, which measures the percentage of respondents who think jobs are plentiful minus the percentage who think jobs are hard to get, rose to 34.4 percent, its highest reading since January 2001.

Underpinning the rebound in consumption growth is the continued strong performance of the labor market. Although November's job growth at 155,000 was somewhat disappointing, job growth has averaged 196,000 over the first two months of the quarter. Particular strength has been seen in the professional and business service sector and in education and health services. The unemployment rate remained at 3.7 percent, which is a historically low level. Additionally, job openings continue to exceed the number of people seeking jobs. Moreover, average hourly earnings continue to firm, growing at 3.1 percent year over year in November. Wage gains have been widespread. We continue to hear more reports of firms increasing wages.

Strength in manufacturing has declined of late, with core factory orders declining in November after being revised up in October and declining over the most recent three months of data. However, the November ISM manufacturing survey increased to 59.3, and details of the report were encouraging. Strength was seen in new orders, employment, and production. Anecdotes from industrial contacts continue to paint a rosy picture. However, the November report on industrial production was discouraging, with manufacturing growing at a 0.4 percent rate over the past three months, following downward revisions to October's growth. The recent trend in industrial production has been fairly solid, and most forecasters are anticipating modest growth going forward. Potential headwinds are present. Trade policy is having a detrimental effect on certain industries, and uncertainty over policy may cause some manufacturers to delay capital expenditure in the near term.

The housing sector appears to be stagnating, with declines in starts, permits, and pending home sales. Housing starts have declined 3.6 percent over the 12 months to November, while permits have increased only 0.4 percent over the same period. Pending home sales have also declined 6.7 percent over the same period and residential construction appears to be a net drag on the economy.

Inflation continues to be close to the FOMC's 2.0 percent target. As of November, year-over-year growth in the headline PCE price index now stands at 1.8 percent, slightly below its targeted rate of 2.0 percent, with a corresponding 1.9 percent rate for the core measure. The headline consumer price index (CPI) was flat in November, pulled down by a decrease of 2.2 percent in the energy CPI. Its 12-month change was 2.2 percent, the same as the core measure. Inflation expectations also seem to be well anchored, and it appears that the Fed has achieved this half of its dual mandate.

It also appears that risks to the economy have increased. Those risks include the possibility of a trade war as tariffs are extended to more goods, with the inevitable likelihood of significant retaliation by our trading partners. Equity prices have become more volatile, and the market has experienced a recent selloff that leaves it down for the year. Additionally, world economic growth has weakened.

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 while 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	$\boldsymbol{\rho}$	$\boldsymbol{\Psi_\pi}$	$\boldsymbol{\Psi_y}$
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 2018. The forecast begins in the fourth quarter of 2018 and extends through the fourth quarter of 2021. 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 a 2.7 percent annual rate over the next three years.

[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.

- Core PCE inflation reaches 2.0 percent (Q4/Q4) in 2019, rising to 2.3 percent in 2020 and 2.5 percent in 2021.
- The unemployment rate averages 3.4 percent in the fourth quarter of 2019, edging up to 3.5 percent at the end of 2020 and 3.8 percent at the end of 2021.[4]
- The federal funds rate is at 3.0 percent at the end of 2019, 3.6 percent at the end of 2020, and 4.0 percent at the end of 2021.
- Compared with the September forecast, real GDP growth is stronger in 2018 and 2019, inflation is about the same, the unemployment rate path is unchanged over the next two years, and the federal funds rate path is unchanged over the forecast horizon (Figures 5a-d).

The baseline forecast calls for output growth of 3.7 percent in the fourth quarter of 2018, moving down to a 2.6 percent pace by the end of 2019. The model forecast for the fourth quarter of 2018 is stronger than other nowcasts. The Federal Reserve Bank of Atlanta's GDPNow forecast for the fourth quarter of 2018 currently stands at 2.9 percent, while the Federal Reserve Bank of New York's Staff Nowcast is somewhat lower at 2.4 percent. The DSGE model output forecast is made using quarterly data from the third quarter of 2018 and earlier. The incoming data since the end of September 2018 have generally been pointing to a pace of underlying growth for the fourth quarter that is slower than what we saw in the third quarter.

The baseline model shows output growth edging down steadily from about 3.7 percent currently to 2.8 percent at the end of 2021.[5] The unemployment rate averages 3.7 percent in the fourth quarter of 2018 and then moves down to 3.4 percent by the end of 2019. The unemployment rate bottoms out at 3.2 percent in mid-2020 and then rises to 3.8 percent at the end of 2021. Moderately strong growth and anchored long-run inflation expectations lead to an acceleration of core PCE inflation from 1.6 percent in the fourth quarter of 2018 to 2.2 percent by the end of 2019. Core inflation overshoots the FOMC's target of 2.0 percent, reaching 2.5 percent by the end of 2021. 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 2.9 percent at the end of 2019 and then increases at a modest pace to 3.6 percent at the end of 2020 and 4.0 percent at the end of 2021. This is the same path as in the September forecast.

[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 2.0 percent. We then assume that population growth averages 1.0 percent per year over the forecast horizon.

The baseline forecast is stronger than the median projections from the fourth quarter 2018 Survey of Professional Forecasters (SPF) over the forecast horizon. The respondents expected real output growth of 2.7 percent in 2019, 2.1 percent in 2020, and 1.7 percent in 2021. (Note that the SPF reports GDP growth as annual average over annual average.) The SPF's core PCE inflation forecast is 2.1 percent (Q4/Q4) for 2019 and 2.1 percent for 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 3.7 percent in 2019, edging up to 3.8 percent in 2020 and 4.0 percent in 2021.

The December 2018 Summary of Economic Projections (SEP) by FOMC participants shows the median projection for output growth at 2.3 percent in 2019, 2.0 percent in 2020, and 1.8 percent in 2021. The median forecast of the unemployment rate at the end of 2018 is 3.7 percent, edging down to 3.5 percent in 2019 and 3.6 percent in 2020. Core PCE inflation is projected at 1.9 percent in 2018, rising to 2.0 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 December 2018 SEP over the next year but is then higher than the central tendency in 2020 and 2021. The baseline forecast remains above market expectations, which are at about 2.6 percent for the fourth quarter of 2019 and 2.5 percent for the fourth quarter of 2020. 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 moderate 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.

[6] When generating the forecasts under the alternative policy rules, we assume that the state of the economy up to and including the third quarter of 2014 is the same as that implied by the baseline rule calibration of the model. Given the state variable history, we then switch rules and forecast under the alternatives beginning in the fourth quarter of 2014. In this framework, the switch in policy rules is not anticipated by the model agents, and they expect the new rule to be in place for all future periods.

- The major differences among the forecasts are in near-term output growth and the federal funds rate, not in inflation. The model estimates somewhat persistent inflation measures that respond sluggishly to shocks.
- By the end of 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 3.7 percent in the fourth quarter of 2020, 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 baseline rule puts the funds rate at 2.2 percent in the fourth quarter of 2018. The Taylor (1993) rule calls for the funds rate to be at 2.5 percent, while the Taylor (1999) rule pegs the funds rate at 1.8 percent. The inertial Taylor rule has the funds rate at 2.0 percent in the fourth quarter. At 2.4 percent, the current effective rate lies at the upper end of the range of model rules, but all the rules suggest continued tightening of policy over the next three years. For the fourth quarter of 2019, the funds rate is in a range of 2.9 to 3.1 percent across the rules, suggesting two interest rate hikes in 2019. With ongoing normalization, all the rules suggest that the federal funds rate should be 3.5 percent or higher by the fourth quarter of 2020.

The near-term 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 2.7 percent over 2019. The inertial Taylor (1999) rule, which over the forecast horizon is the most accommodative policy, has real output growth at 3.0 percent in 2019 and 2.5 percent in 2020. Note, though, that the output growth forecasts largely converge by the end 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 2.0 percent (Q4/Q4) in 2019 and shows little dispersion over the forecast horizon across the alternative policies. Core inflation is slightly weaker 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 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 third quarter of 2018 and does not explicitly account for tax reform, trade policy, or recent

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

declines in equity markets. The model continues to predict 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 federal funds rate is within the range of the rules-based recommendations. Under the baseline, though, output is expected to grow at a pace that is somewhat higher than nowcast projections. The alternative policy rules agree that the federal funds rate should rise steadily over the next three years to about 4.0 percent at the end of 2021. 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

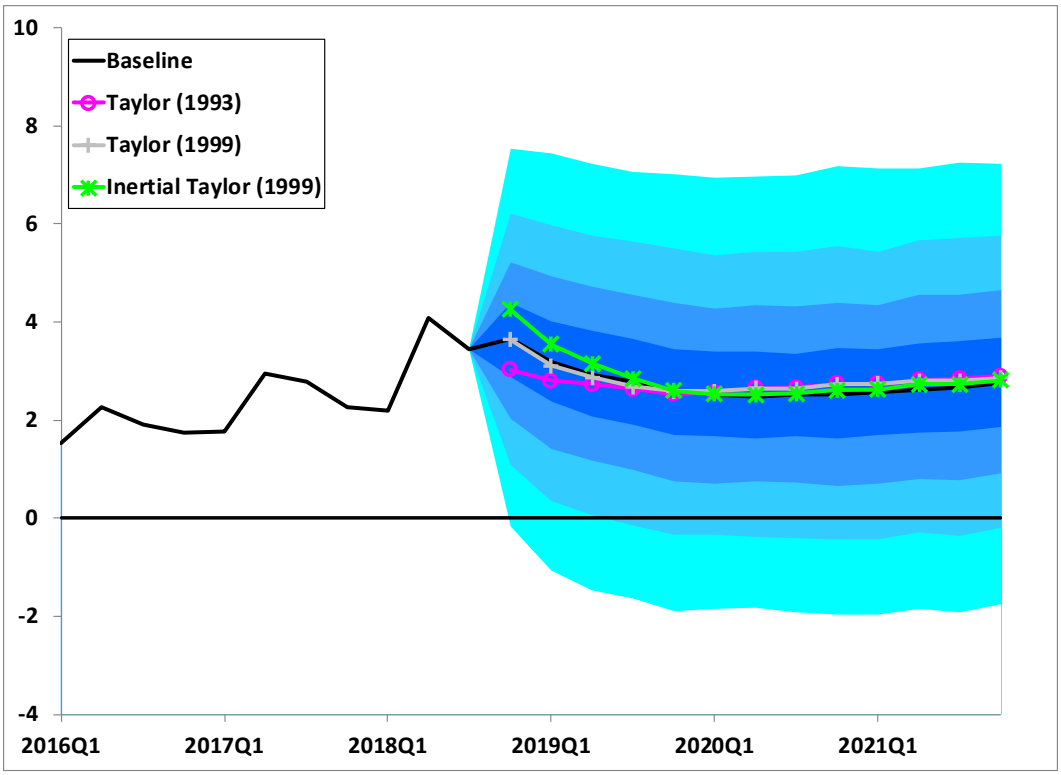

Figure 2: PCE Core Inflation

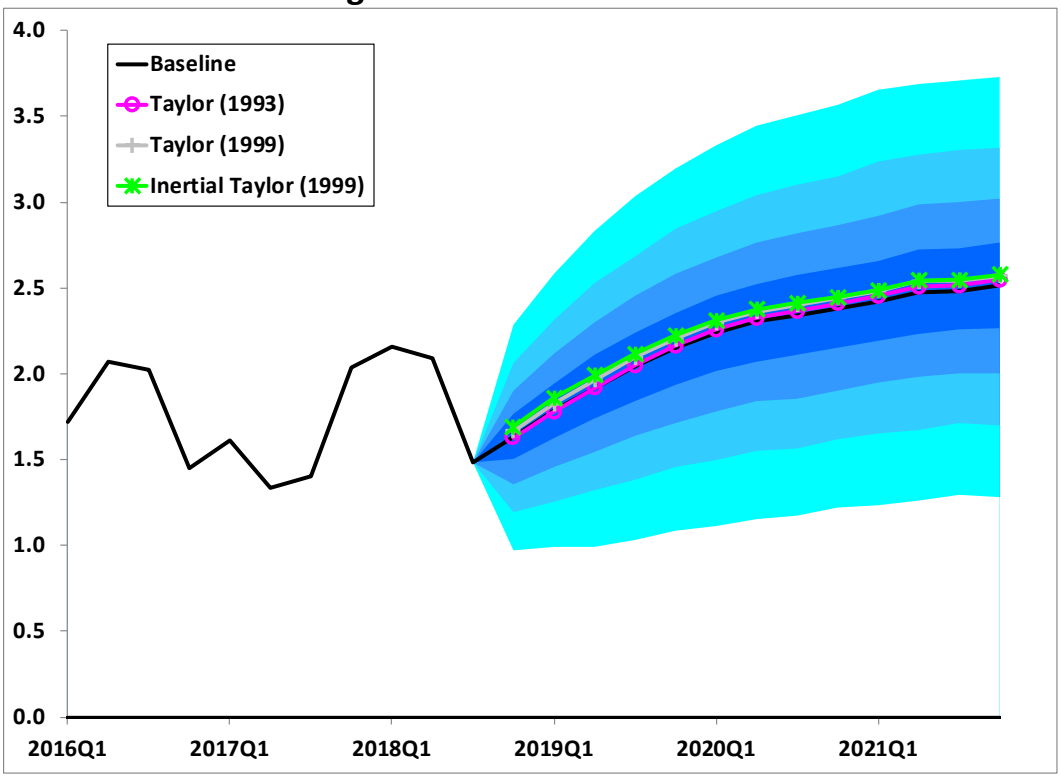

Figure 3: Unemployment Rate

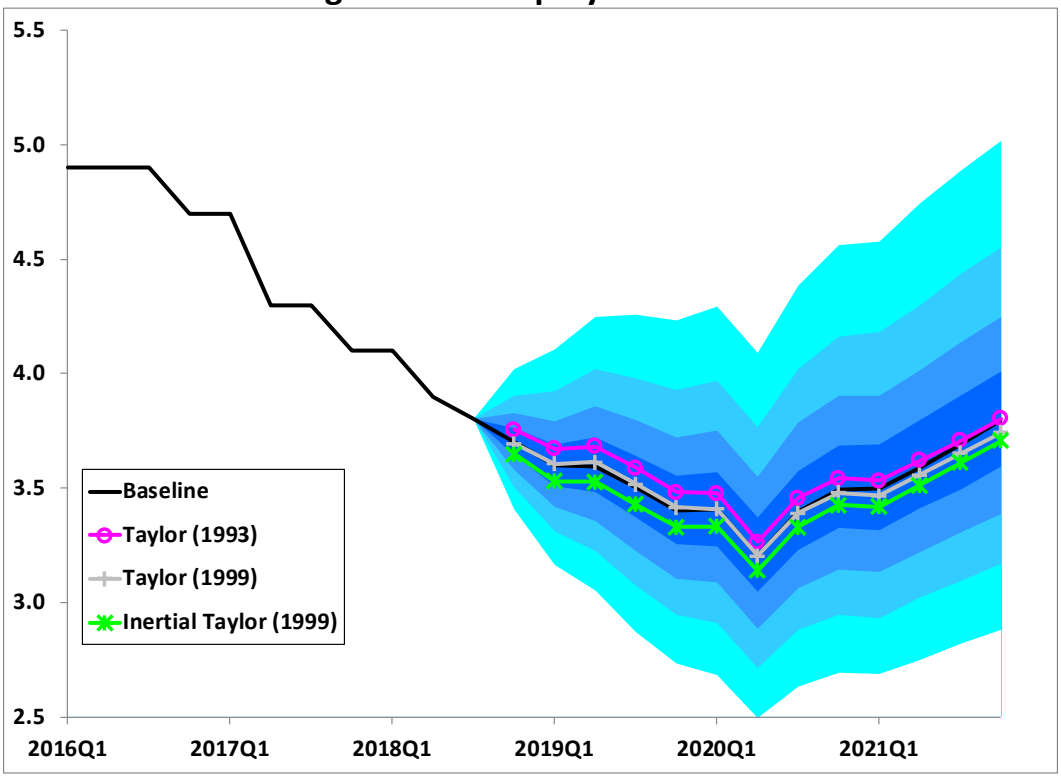

Figure 4: Federal Funds Rate

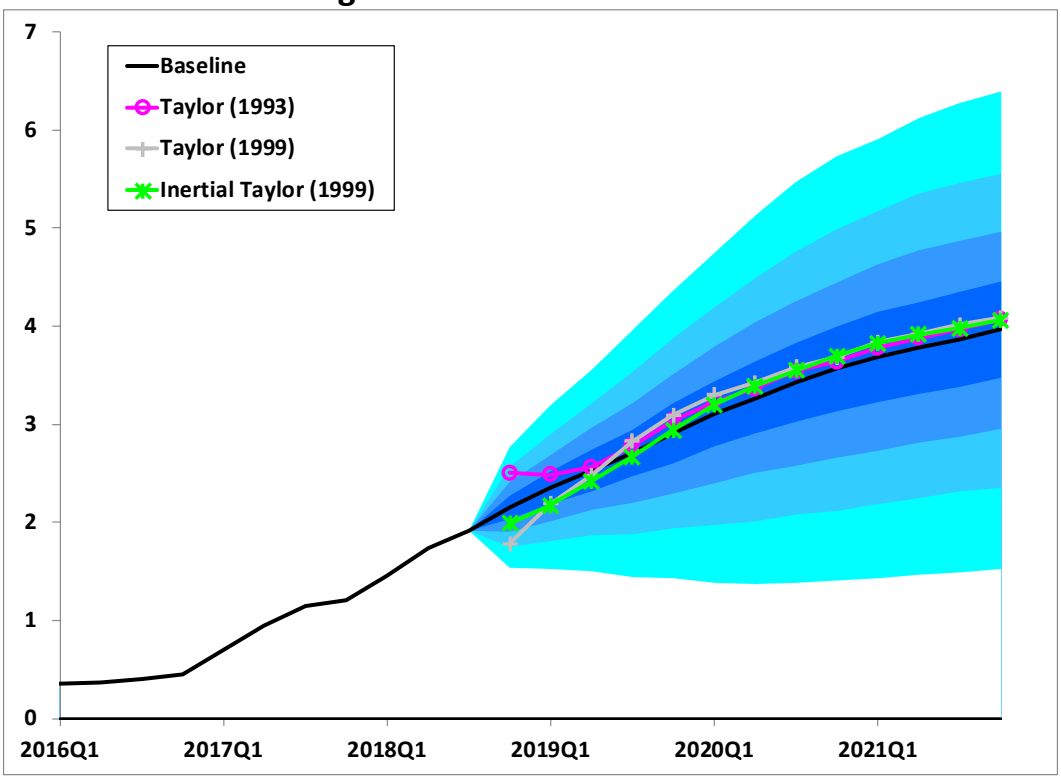

Figure 5: Baseline Forecast Comparisons

Figure 5a: Real GDP Growth

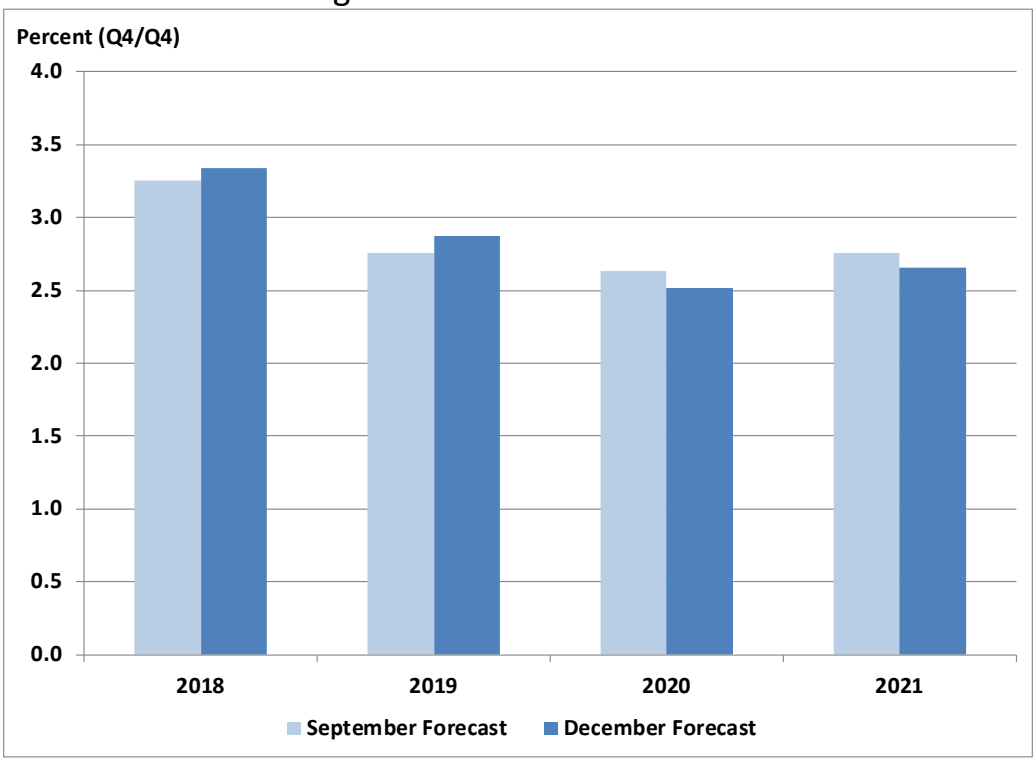

Figure 5b: PCE Inflation Growth

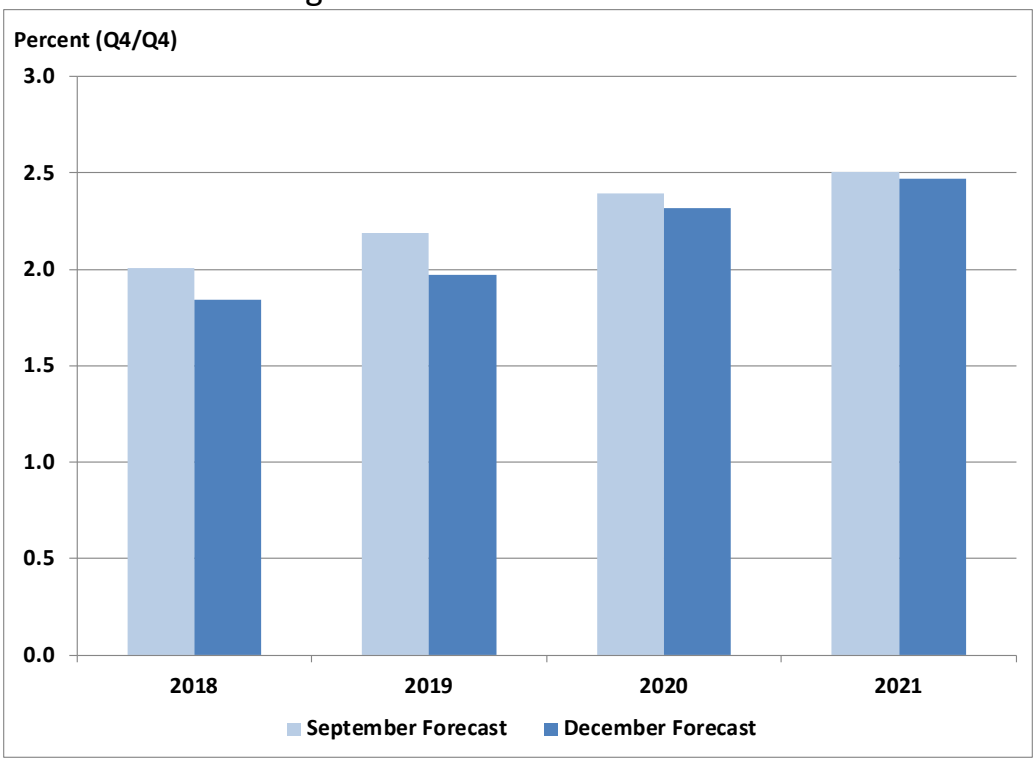

Figure 5c: Unemployment Rate

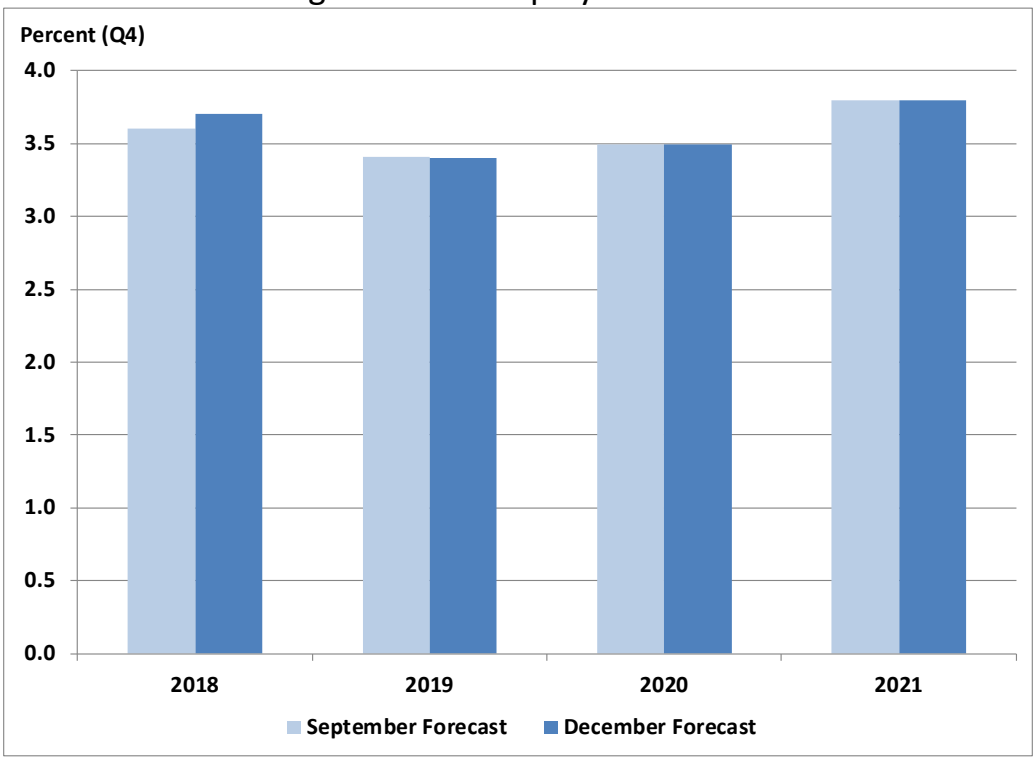

Figure 5d: Federal Funds Rate