Monetary Policy Report:
Using Rules for Benchmarking

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December 2017

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

The U.S. economy continues to grow above trend, with third quarter GDP growing at a healthy 3.2 percent and numerous nowcasts indicating that growth will remain above trend in the fourth quarter. The continued economic strength is due to solid consumption buttressed by a strong

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labor market and favorable financial conditions. Additionally, the expansion is broadening, with strong growth in manufacturing and business fixed investment.

Economic conditions in the rest of the world continue to improve, and there is substantial optimism among domestic consumers and firms alike. Inflation remains below the Federal Open Market Committee's (FOMC) target, and the risks to the economy appear largely balanced. The economic effects of federal tax cuts that are to take effect in 2018 are likely to be small. These factors are giving FOMC members more confidence in the ongoing stability of the expansion, and they began normalizing the Fed's balance sheet in October. The stock market continues to make outsize gains, and financial conditions have eased over the year.

Providing some foundation for expenditure growth is the continued growth in jobs. After a hurricane-induced lull in September's employment gains, the labor market came roaring back in October and November, adding 244,000 and 228,000 net new jobs, respectively. All told, it appears that 2017 will be another year of job gains totaling 2 million or more. With the continued strength in job gains, the unemployment rate has moved down to 4.1 percent, measurably lower than most forecasters had expected at the beginning of the year. Importantly, broader measures of unemployment such as U6, which includes marginally attached workers and those working part time for economic reasons, are below their prerecession levels. Additionally, unemployment rates for various demographic groups are also below what they were prior to the recession.

The only disappointment in the labor market is the continued absence of robust wage growth. Over the past 12 months, increases in hourly earnings have averaged 2.5 percent. Other measures of wage growth have been a bit more robust. For instance, the Atlanta Fed's wage tracker, which corrects for the bias introduced by lower wages of newly employed workers, is showing median wage growth of 3.4 percent, though no acceleration. Fairly low labor productivity may be in part responsible, but anecdotal evidence indicates that firms are having difficulty filling skilled occupations.

The labor market continues to show dynamism. The job openings rate ticked down slightly in October from its all-time high in September, and the hiring and quit rates were both at their highest levels since the recovery began.

The healthy labor market is supporting solid income growth, with personal income growing 4.2 percent annualized over the three months to October and a solid 0.4 percent in October. Over the same period, real consumption grew a disappointing 2.3 percent. However, the most recent data on retail sales indicate an acceleration in personal consumption expenditures. Core sales, excluding autos and gasoline, increased by an unexpectedly high 0.8 percent in November, with upward revisions to the two preceding months. The latest report had many forecasters significantly revising up their outlook for the fourth quarter. Motor vehicle sales continued to be

robust at 17.5 million annualized units in November, following two hurricane-recovery-induced blow-out months when sales reached or exceeded 18 million annualized units.

The latest report on housing starts showed further signs of a pickup in housing activity. Starts rose 3.3 percent in November following October's downwardly revised 8.4 percent jump, with the latest increase driven by the single-family segment. Much of October's bounce-back in single-family starts appears to have been due to September's hurricane-related delays in construction activity. Single-family permits also increased, though by less than in October.

Manufacturing survey data indicate continued expansion. The ISM manufacturing survey remained solidly in expansion territory at 58.2 in November, and the employment and new orders subindexes were also strong. Regionally, the Philadelphia Fed manufacturing index increased to 26.2 in December, well above its nonrecession average, and all the major subindexes were positive. Hard data appear to confirm the continuing growth of this sector, with core factory orders growing 0.3 percent in October and core shipments continuing their solid and steady monthly growth of above 1 percent over the past four months. The latest equipment spending data point to continued strength, and manufacturing industrial production increased 0.2 percent in November after a very strong October. Thus, the data also support continued strength in business fixed investment, which should end up growing more than 6 percent over the year.

Over the past few months, inflation has failed to move significantly closer to the FOMC's target of 2.0 percent. Many believe the shortfall is largely due to transitory factors, but that story can hold water for only so long. The November consumer price index (CPI) report indicated that the 12-month change in the core CPI, which excludes food and energy prices, is running at 1.7 percent, roughly implying a 1.5 percent increase for the 12-month core PCE. There has been some acceleration over the past three months, and some private forecasters are taking that as a harbinger of a sustained march to target; others are yet to be convinced.

Monetary policymakers' economic forecasts in December's Summary of Economic Projections (SEP) were little changed from September. All in all, their outlook is a bit more robust, with the majority of FOMC members expecting the economy to grow a bit above its projected longer-run trend of 1.8 percent. Members also expect inflation to return to target by the middle of 2019. Notably, there remains a consensus for three rate hikes in 2018, and the federal funds rate is expected to reach almost 2.75 percent by the end of 2019, a touch below the September projection. 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 September and March. Balance sheet normalization appears to be going smoothly, and the FOMC will very gradually increase the pace in 2018.

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 third quarter of 2017. The forecast begins in the fourth quarter of 2017 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 2.6 percent (Q4/Q4) in 2017, 3 percent in 2018, 2.7 percent in 2019, and 2.7 percent in 2020.

- Core PCE inflation reaches 1.3 percent (Q4/Q4) in 2017, rising to 1.7 percent in 2018, 2 percent in 2019, and 2.2 percent in 2020.

- The unemployment rate averages 4.1 percent in the fourth quarter of 2017, falling to 3.9 percent at the end of 2018, holding steady at 3.9 percent at the end of 2019, and then rising to 4.1 percent at the end of 2020.[4]

- The federal funds rate is at 2 percent at the end of 2018, 2.9 percent at the end of 2019, and 3.5 percent at the end of 2020.

- Compared with the September forecast, real GDP growth is slightly stronger over the next three years, inflation is weaker over the forecast horizon, the unemployment rate path is slightly lower over the next two years, and the federal funds rate path is less steep over the forecast horizon (Figures 5 a, b).

The baseline forecast calls for output growth of 3 percent in the fourth quarter of 2017, edging down to 2.8 percent over 2019 and 2020. The model forecast for the fourth quarter of 2017 is in line with other nowcasts. The Federal Reserve Bank of Atlanta's GDPNow forecast for the fourth

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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.

quarter of 2017 currently stands at 3.3 percent, while the Federal Reserve Bank of New York's Staff Nowcast is at 4 percent. The DSGE model output forecast is made using quarterly data from the third quarter of 2017 and earlier. The incoming data since September 2017 have generally been pointing to a pace of underlying growth for the fourth quarter that is somewhat stronger than what we saw in the third quarter.

The baseline model shows output growth steadily declining from about 3 percent currently to 2.7 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 half of 2018 and then edges to down to 3.9 percent in 2019. By the end of 2020, the unemployment rate moves up slightly to 4.1 percent. Moderately strong growth and anchored long-run inflation expectations lead to an acceleration of core PCE inflation from 1.5 percent in the first quarter of 2018 to 2 percent by mid-2019. The inflation path is lower this time compared with the September baseline forecast because of a recent series of low 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 at 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 2.0 percent at the end of 2018 and then increases at a modest pace to 2.9 percent at the end of 2019 and to 3.5 percent at the end of 2020. This is a somewhat shallower path than was forecast in September.

The baseline forecast is stronger than the median projections from the fourth quarter 2017 Survey of Professional Forecasters (SPF). Respondents expected real output growth of 2.2 percent in 2017, 2.5 percent in 2018, 2.1 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 1.4 percent (Q4/Q4) for 2017, 1.8 percent for 2018, and 2 percent for 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 4.1 percent in 2018, falling to 4 percent in 2019, and then rising to 4.1 percent in 2020.

The December 2017 Summary of Economic Projections (SEP) by FOMC participants shows the median projection for output growth at 2.5 percent in 2017, 2.5 percent in 2018, 2.1 percent in 2019, and 2 percent in 2020. The median forecast of the unemployment rate at the end of 2018 is 2.9 percent, holding at 3.9 percent in 2019, and then edging up to 4 percent at the end of 2020. Core PCE inflation is projected at 1.5 percent in 2017, rising to 1.9 percent in 2018 and 2 percent in 2019 and 2020. Headline inflation is projected to run at about the same pace as core inflation

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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.

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 2017 SEP over the forecast horizon and remains well above market expectations, which are below 2 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.

- By 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 1.2 percent in the fourth quarter of 2017, the same as the Taylor (1993) rule. However, the Taylor (1999) rule suggests a federal funds rate of about 0.2 in the fourth quarter — lower than its current level. The inertial Taylor rule suggests a funds rate of 0.9 percent in 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.

fourth quarter of 2017, about 50 basis points below the actual current target. At 1.4 percent, the current target lies above 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 percent across the rules, suggesting two to three interest rate hikes between now and then. With ongoing normalization, all the rules suggest that the federal funds rate should be 3 percent or higher in the first quarter of 2020. 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 fourth quarter of 2017 and 3.7 percent in the first 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 lower over the forecast horizon compared with the September projection largely on the weakness of recent 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 third quarter of 2017, and the projection makes no attempt to account for the impact of tax reform on future output growth and inflation. 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.

The policy alternatives suggest that the actual current funds rate is generally higher than the rules-based recommendations, while the underlying model has output growing at about its currently expected pace. However, the model has not anticipated the weak readings on inflation over the past few quarters. The alternative policy rules agree that the federal funds rate should rise steadily over the next three years to about 3.5 percent at the end of 2020. 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 moves up to its longer-run target over the medium term.
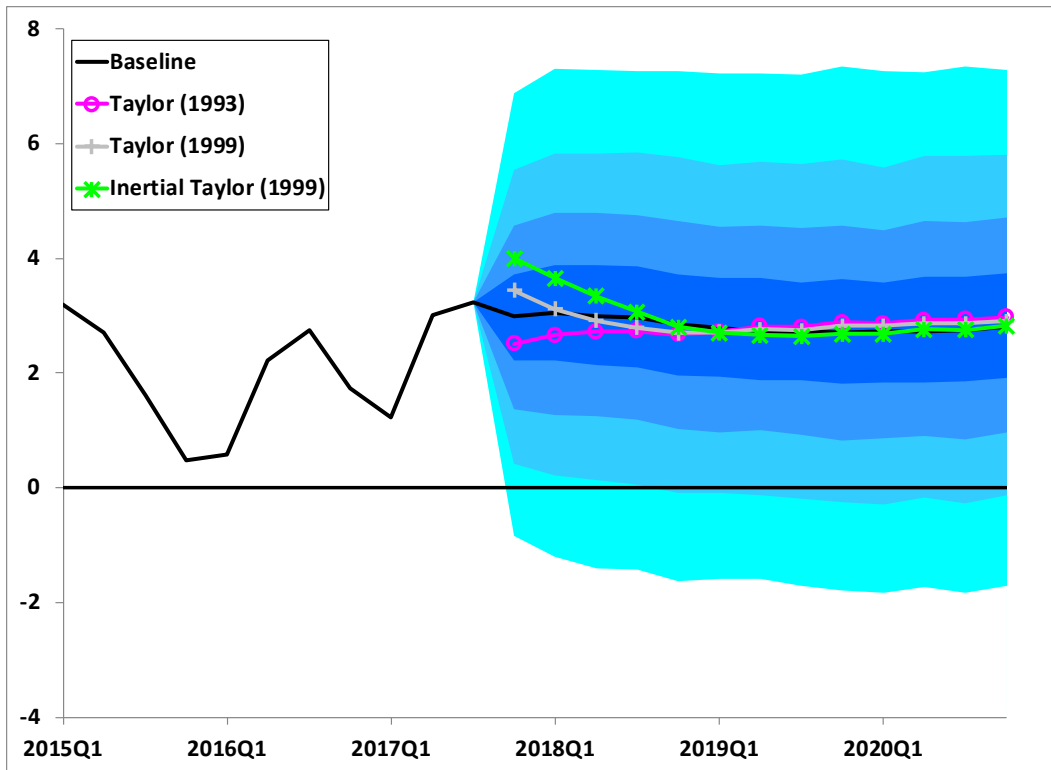
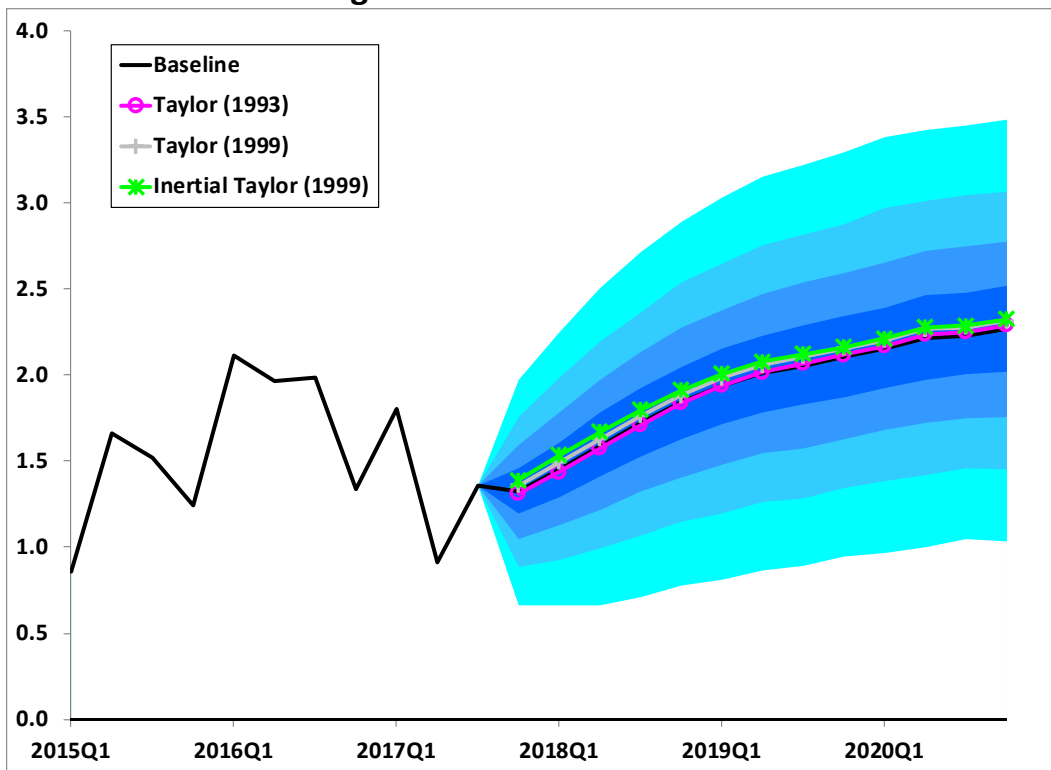## Figure 1: Real GDP Growth

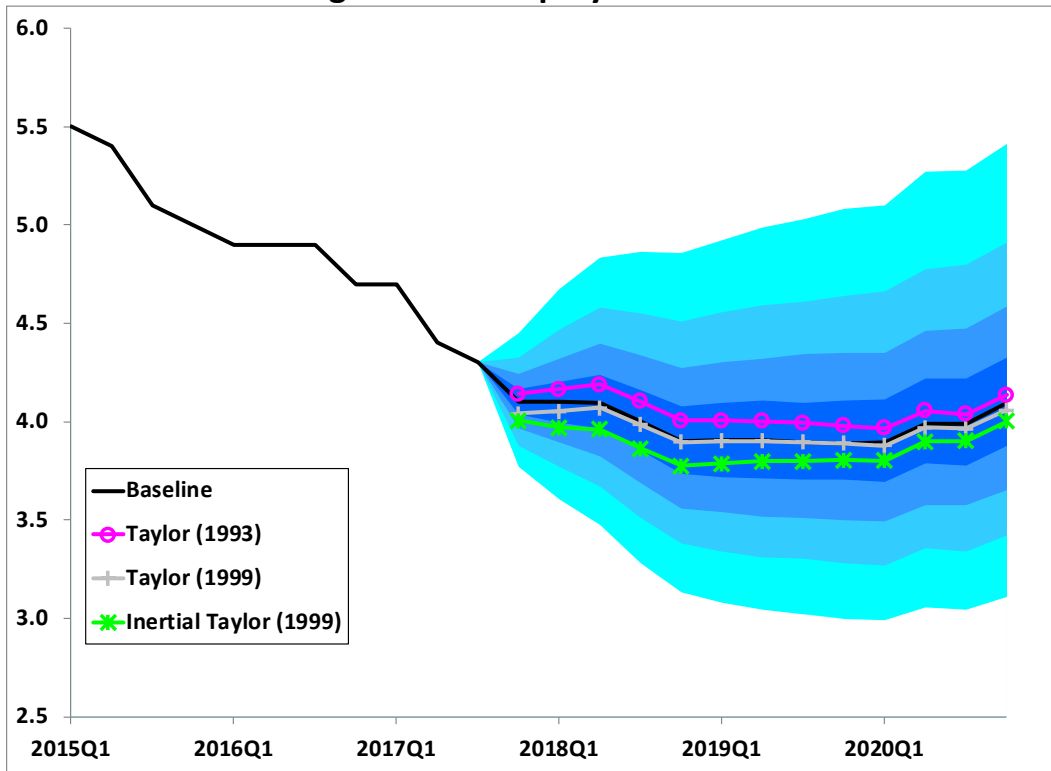## Figure 2: PCE Core Inflation

Figure 3: Unemployment Rate

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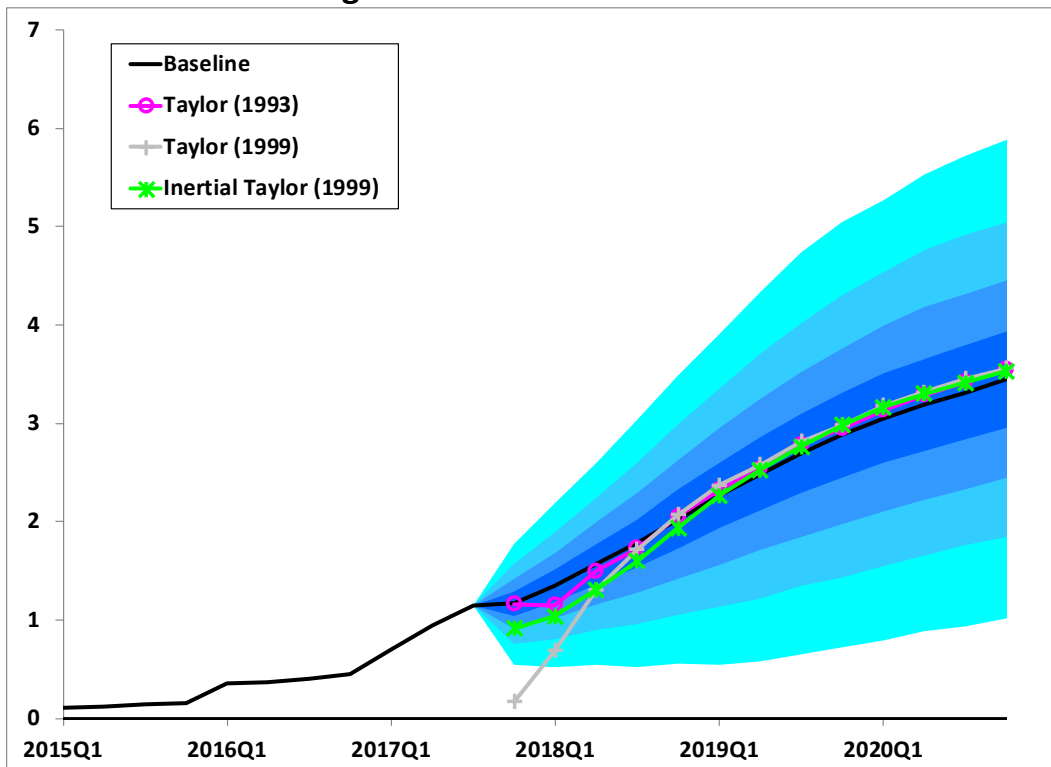
Figure 5: Baseline Forecast Comparisons

Figure 5a: Real GDP Growth

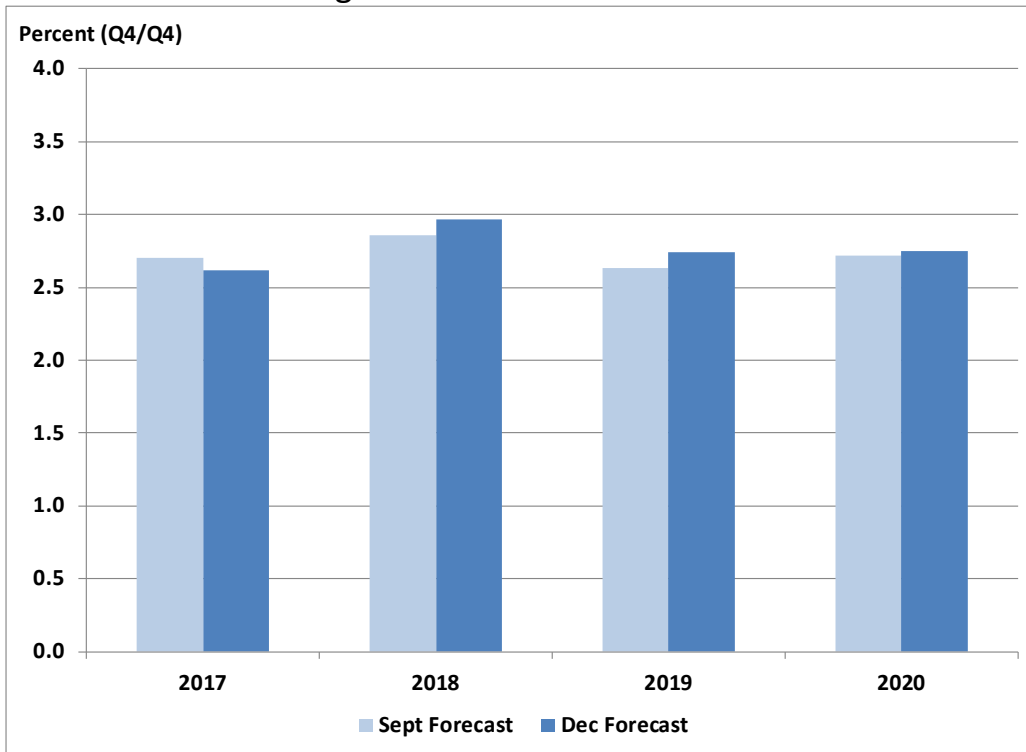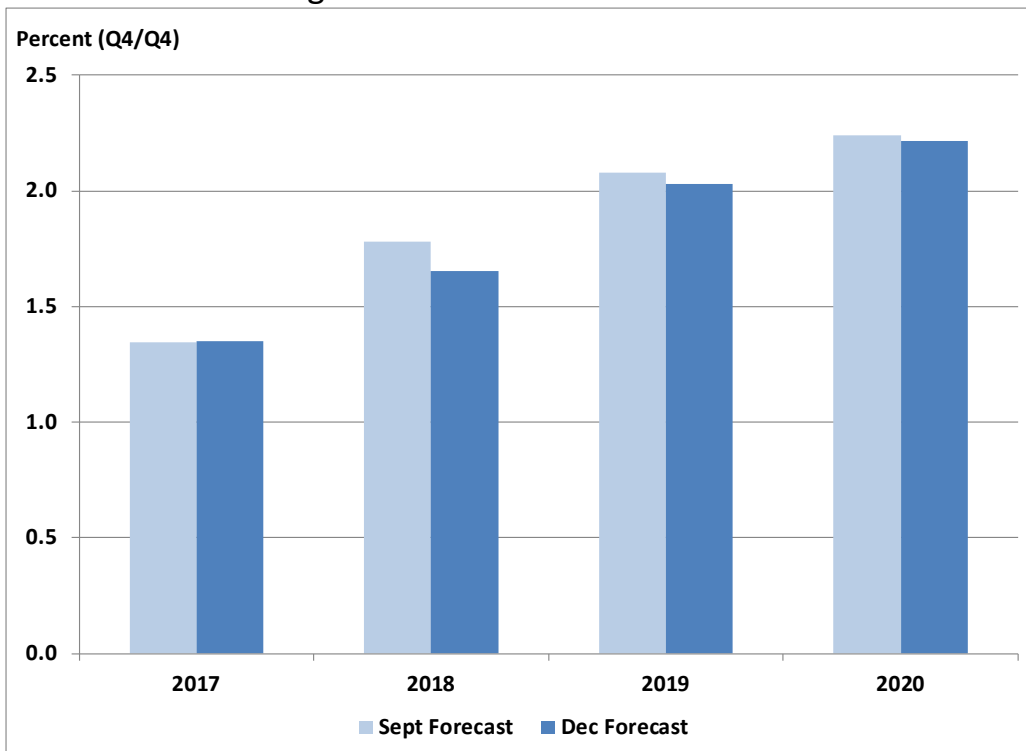Figure 5a: Real GDP Growth — bar chart, Percent (Q4/Q4), years 2017–2020, comparing Sept Forecast and Dec Forecast.

Figure 5b: PCE Inflation Growth

Figure 5b: PCE Inflation Growth — bar chart, Percent (Q4/Q4), years 2017–2020, comparing Sept Forecast and Dec Forecast.
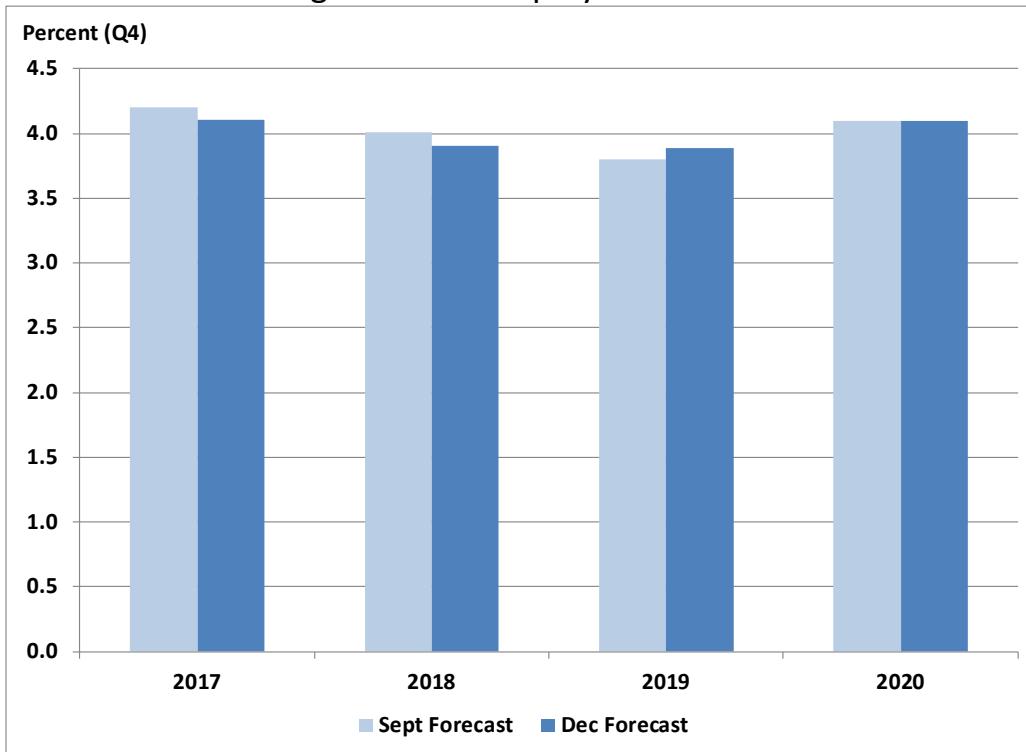
Figure 5c: Unemployment Rate

Percent (Q4)

Figure 5d: Federal Funds Rate

Percent (Q4)