SPECIAL REPORT
FEDERAL RESERVE BANK OF PHILADELPHIA

Monetary Policy Report: Using Rules for Benchmarking

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September 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

After a lackluster first quarter in which GDP grew a mere 1.2 percent, the economy rebounded in the second quarter, growing at a healthy 3.1 percent. Additionally, unadjusted for the effects of the recent hurricanes, numerous nowcasts show above-trend third quarter growth. The continued

[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 for her assistance.

economic strength is due to solid consumption activity buttressed by a strong labor market and favorable financial conditions. Further, manufacturing appears to be improving, and investment is contributing more meaningfully to economic activity. The likely drag that Hurricanes Harvey and Irma placed on third quarter activity is expected to be more than offset next quarter.

Economic conditions in developed economies continue to improve, and there is substantial optimism among domestic consumers and firms alike. Inflation remains below the Federal Open Market Committee's target, and the risks to the U.S. economy appear largely balanced. These factors are giving FOMC members more confidence in the ongoing stability of the expansion, and they decided in September to begin normalizing the Fed's balance sheet in October. Stock market swings have been relatively large and may well reflect geopolitical factors such as uncertainty regarding North Korea. Despite international risks, the market continues to make solid gains, and most market indexes are at or near record highs.

Providing some foundation for expenditure growth is the continued growth in jobs, although employment momentum has waned somewhat. Although August's employment report of 156,000 net new jobs was a bit weaker than expected, averaging through the past three months the economy is adding roughly 185,000 jobs on net per month. Weaker job growth caused the unemployment rate to rise one-tenth of a percentage point to 4.4 percent. This rate is still below most economists' views of the natural rate of unemployment. The only disappointment in the labor market is the continued absence of robust wage growth. Over the past 12 months, increases in average 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 Growth Tracker, which corrects for the bias introduced by lower wages paid to newly employed workers, is showing median wage growth of 3.4 percent.

Additionally, the labor market continues to show dynamism. The job openings rate remained at its all-time high in July, and the hiring rate is now as high as its postrecession peak. Quits rates are at healthy levels, and the layoffs rate remains historically low. Contacts in the Philadelphia Fed's region continue to express difficulty in finding workers, especially skilled workers.

The healthy labor market is supporting solid income growth, with personal income growing 3.0 percent over the three months to July and a healthy 0.4 percent in July. Over the same period, real consumption grew 2.8 percent. However, the most recent data on retail sales indicate that personal consumption expenditures are moderating. Core sales declined 0.1 percent in August after a strong July, and June's growth was revised downward into negative territory. The latest report had many forecasters revising downward slightly their outlook for the third quarter. Additionally, motor vehicle sales were lackluster at 16.4 million annualized units, breaking a roughly two-and-a-half year stretch in which sales exceeded 17.0 million units.

The housing sector is lately sending mixed signals but overall since April has been sluggish at best. New home sales fell 3.4 percent in August, but residential construction growth remained solid, averaging 7.8 percent over the past three months. Looking ahead, housing construction starts and homebuilding permits are sending somewhat mixed signals. August starts were down from July's upwardly revised totals, and permits were up 5.7 percent, mostly due to strong growth in the volatile multifamily segment of the market. Multifamily starts, meanwhile, have been weak. Single-family starts and permits, although higher than they were a year ago, remain tepid. Existing house prices appear to be appreciating around 5 to 6 percent. Thus, there is no clear indication of any pickup in residential activity, and we do not anticipate that this sector will contribute strongly to economic growth over the rest of the year.

Survey data indicate continuing expansion in manufacturing activity. The ISM manufacturing survey rose to 58.8 in August, its strongest reading since April 2011. There was also continued strength in the employment, production, and new orders subindexes. Regionally, the latest Philadelphia Fed manufacturing index increased to 23.8, well above its nonrecession average, and all the major subindexes were positive. Hard data appear to confirm continuing growth in this sector. Both core orders and core shipments were revised upward in July's factory orders report to a healthy 1.0 percent and 1.2 percent, respectively. The latest data point to continuing strength in equipment spending. However, as expected, August's industrial production came in negative, falling 0.9 percent, with perhaps most of the decline weather-related. The recent hurricanes are estimated to have contributed 0.75 percentage point of the decline, and unseasonably mild weather led to a large drop in electricity use. So we are downplaying the latest industrial production report.

Over that past few months, inflation has moved further from the FOMC's desired target of 2.0 percent. As of July, the 12-month gain in the core personal consumption expenditures (PCE) price index was only 1.4 percent, its lowest value since December 2015. However, August's consumer price index (CPI) showed the first signs of some firming in prices since April, coming in at 1.9 percent over the past 12 months. The core index remains soft, rising 1.7 percent in each of the previous four months. Although the latest data on consumer prices show there may be a glimmer of hope that inflation will gradually return to target, it is still only one month of data, and it would be premature to read too much into the most recent price report.

Turning to monetary policymakers' views, the economic forecasts in September's Summary of Economic Projections (SEP) were little changed from June and indicate that the majority of FOMC members expect the economy to grow a bit above its projected longer-run trend of 1.8 percent. Members also expect inflation to return to target 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 2.9 percent by the end of 2019. That would leave the funds rate very close to the median projection for the

long-run neutral funds rate, which is similar to what members had thought in March. Of note, the FOMC signaled that balance sheet normalization will begin in October.

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	$\boldsymbol{\rho}$	$\boldsymbol{\Psi_\pi}$	$\boldsymbol{\Psi_y}$
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

[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 second quarter of 2017. The forecast begins in the third quarter of 2017 and extends through the fourth quarter of 2020. We do not explicitly incorporate the effects of the hurricanes in the forecast. Most forecasters are calling for a weaker third quarter followed by a fourth quarter rebound. Over the medium term, although the storms took a severe toll on large portions of the populations of Houston, Florida, and Puerto Rico, the net effect on the national economy is small. The forecasts under the baseline and the alternative policy rules are shown in Figures 1 through 4. The baseline forecast is represented by the dark solid line. The colored bands around the baseline forecast represent 10 percent confidence intervals of the predictive distribution around the median of the baseline forecast.[3]

The key features of the baseline forecast are as follows:

- Real output is forecast to grow at about 2.7 percent (Q4/Q4) in 2017, 2.9 percent in 2018, 2.6 percent in 2019, and 2.7 percent in 2020.
- Core PCE inflation reaches 1.3 percent (Q4/Q4) in 2017, rising to 1.8 percent in 2018, 2.1 percent in 2019, and 2.2 percent in 2020.
- The unemployment rate falls to 4.2 percent in the fourth quarter of 2017, to 4 percent at the end of 2018, and to 3.8 percent at the end of 2019, and then rises to 4.1 percent at the end of 2020. [4]
- The federal funds rate is at 1.2 percent at the end of 2017, 2.2 percent at the end of 2018, 3 percent at the end of 2019, and 3.5 percent at the end of 2020.
- Compared with the June forecast, real GDP growth is slightly stronger in 2018, inflation is weaker over the forecast horizon, the unemployment rate path is lower, and the federal funds rate path is less steep over the forecast horizon (Figures 5 a, b).

[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 baseline forecast calls for output growth of slightly above 3 percent, on average, over the next few quarters. The model forecast for the third quarter of 2017 is considerably stronger than suggested by the incoming data, since the model does not incorporate the effects of the recent storms. The Federal Reserve Bank of Atlanta's GDPNow forecast for the third quarter of 2017 currently stands at 2.2 percent, while the Federal Reserve Bank of New York's Staff Nowcast is at 1.6 percent. The DSGE model output forecast is made using quarterly data from the second quarter of 2017 and earlier. The incoming data since June 2017 have generally been pointing to a pace of underlying growth for the third quarter that is similar to what we saw in the second quarter (but, again, absent hurricane effects).

The baseline model shows output growth steadily declining from about 3 percent in the first quarter of 2018 to about 2.6 percent in mid-2019. The unemployment rate falls to 4.2 percent by the first quarter of 2018 and then hits a low of 3.8 percent in mid-2019 before edging up to 4.1 percent at the end of 2020.[5] 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 by the first quarter of 2019. The inflation path is lower this time compared with the June 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 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 2.2 percent at the end of 2018 and then increases at a modest pace to 3 percent at the end of 2019 and 3.5 percent at the end of 2020.

The baseline forecast is stronger than the median projections from the third quarter 2017 Survey of Professional Forecasters (SPF). Respondents expected real output growth of 2.1 percent in 2017, 2.4 percent in 2018, 2.2 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 1.5 percent (Q4/Q4) for 2017, 1.9 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 4.2 percent in 2018, and 4.3 percent in 2019 and 2020.

The September 2017 Summary of Economic Projections (SEP) by FOMC participants shows the median projection for output growth at 2.4 percent in 2017, 2.1 percent in 2018, 2 percent in 2019, and 1.8 percent in 2020. The median forecast of the unemployment rate in the fourth quarter of 2017 is 4.3 percent, edging down to 4.1 percent in 2018 and 2019 and to 4.2 percent in

[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.

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 over the forecast horizon. The forecast model's baseline forecast for the federal funds rate (Figure 4) remains at the top of the central tendency of the September 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 difference between the forecasts is in output growth and not in inflation. The model estimates somewhat persistent inflation measures that respond sluggishly to shocks.
- By mid-2018, the forecasts for output, inflation, and the federal funds rate have largely converged across the policy alternatives. The entire future path of the interest rate — rather than the current rate — is key for the dynamics of the economy.
- The federal funds rate under the policy rules reaches about 2 percent by the third quarter of 2018, 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 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

[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.

federal funds rate of 0.7 percent in the fourth quarter — lower than its current level. The inertial Taylor rule suggests a funds rate of 0.9 percent in the fourth quarter of 2017, about 20 basis points below the actual current target. At 1.1 percent, the current target lies within the range of the model rules, but all of the rules suggest gradual and ongoing tightening of policy over the next three years. For the fourth quarter of 2018, the funds rate stands at about 2.3 percent across the rules, suggesting four to five 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 by the end of 2019. Even though the inertial Taylor and Taylor (1999) rules call for a lower 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 2.8 percent over the next few quarters. The inertial Taylor (1999) rule, which over the forecast horizon is the most accommodative policy, has real output growth at 4.4 percent in the third quarter of 2017 and 3.8 percent in the fourth quarter. 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 1.3 percent (Q4/Q4) in 2017 and shows little dispersion over the forecast horizon across the alternative policies. Core inflation is lower over the forecast horizon compared with the June 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 second quarter of 2017, and the projection makes no attempt to account for the impact of recent hurricanes. 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 level of the funds rate is generally near the the rules-based recommendations, although the underlying model has output growing somewhat faster than currently expected. The inertial Taylor rule suggests the funds rate should be about 40 basis points lower than its current setting, while the Taylor (1993) rule suggests the funds rate is on target. 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

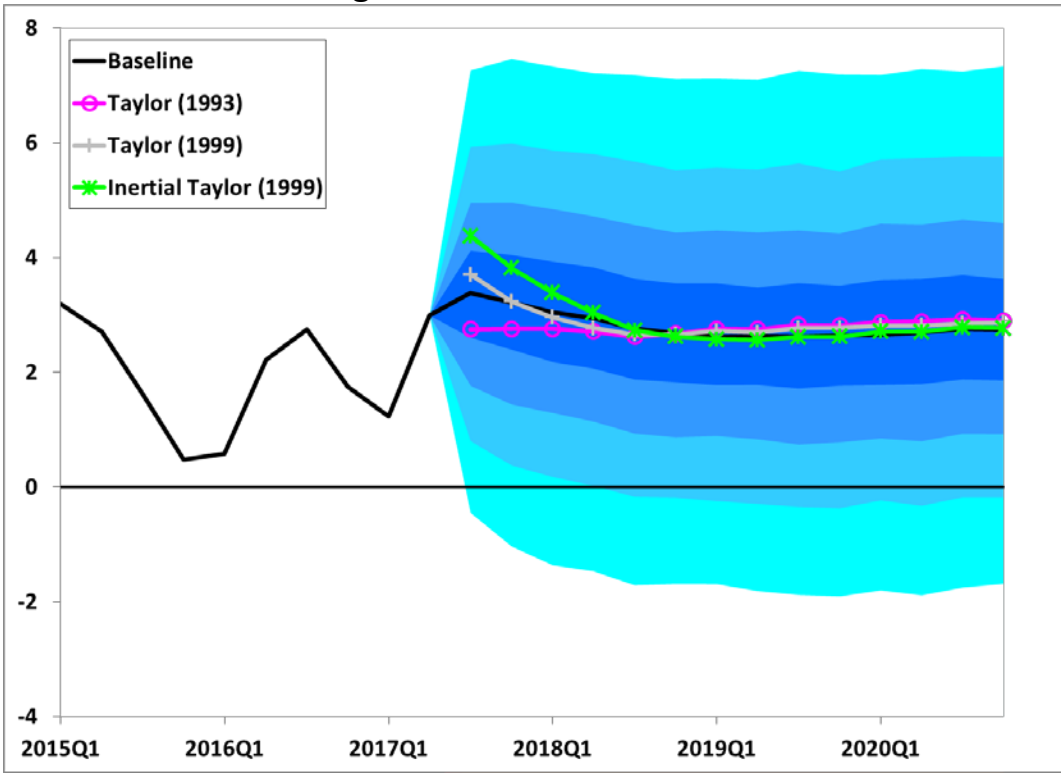

Figure 2: PCE Core Inflation

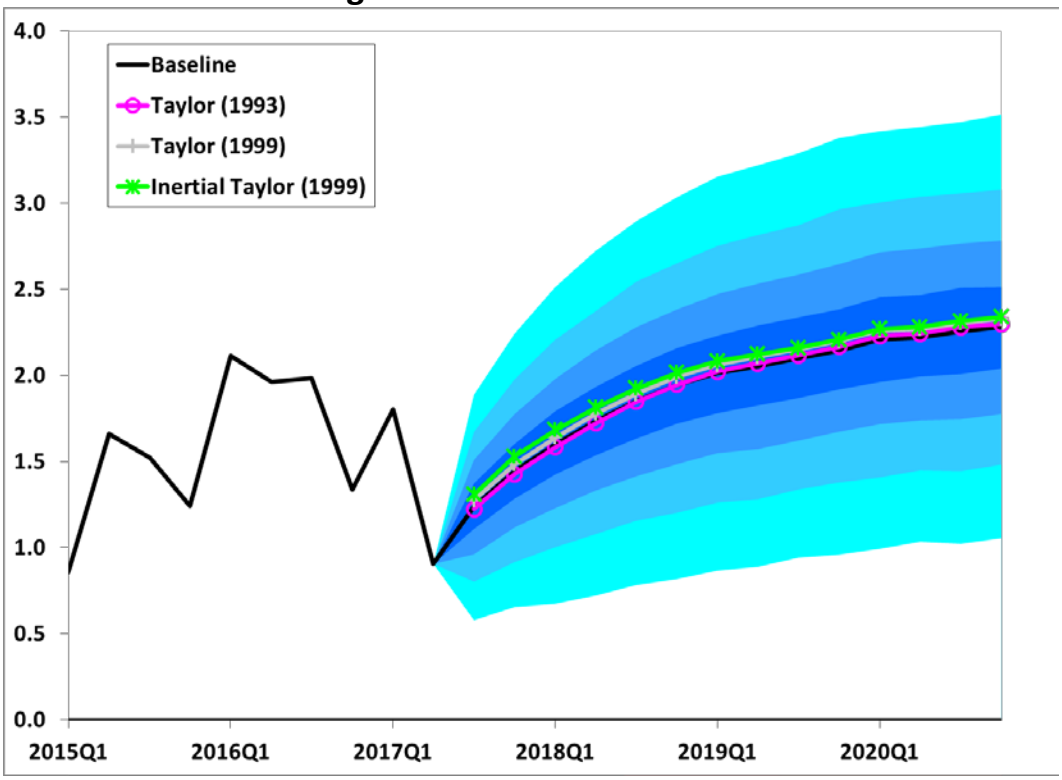

Figure 3: Unemployment Rate

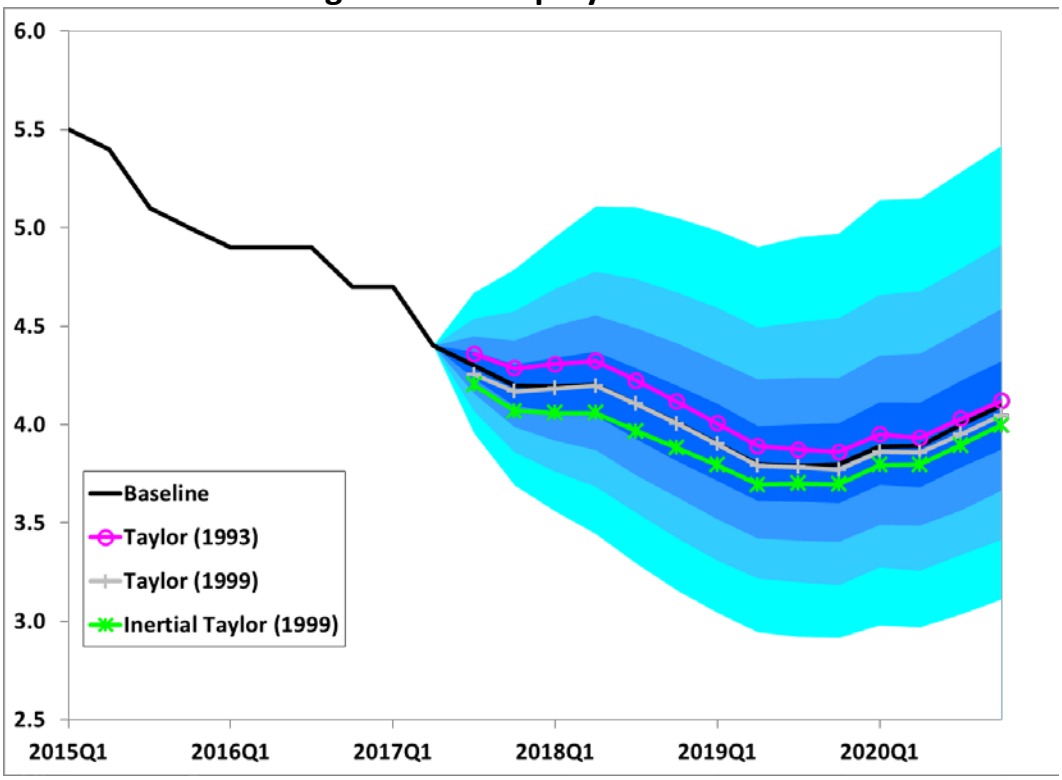

Figure 4: Federal Funds Rate

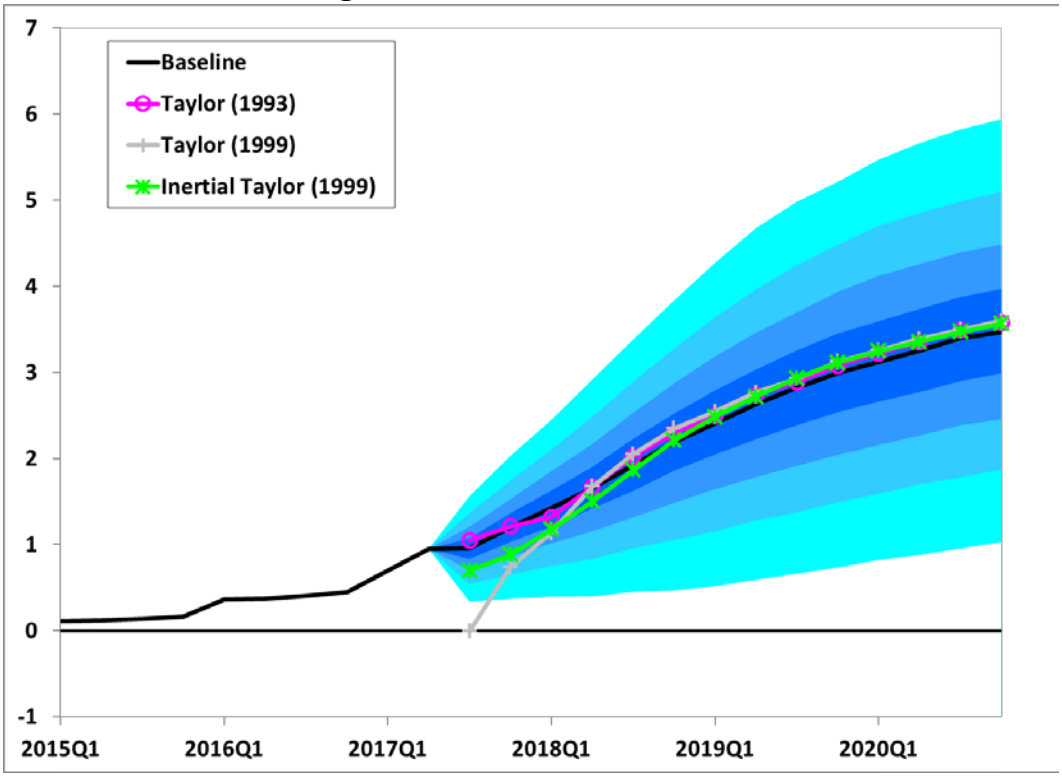

Figure 5: Baseline Forecast Comparisons

Figure 5a: Real GDP Growth

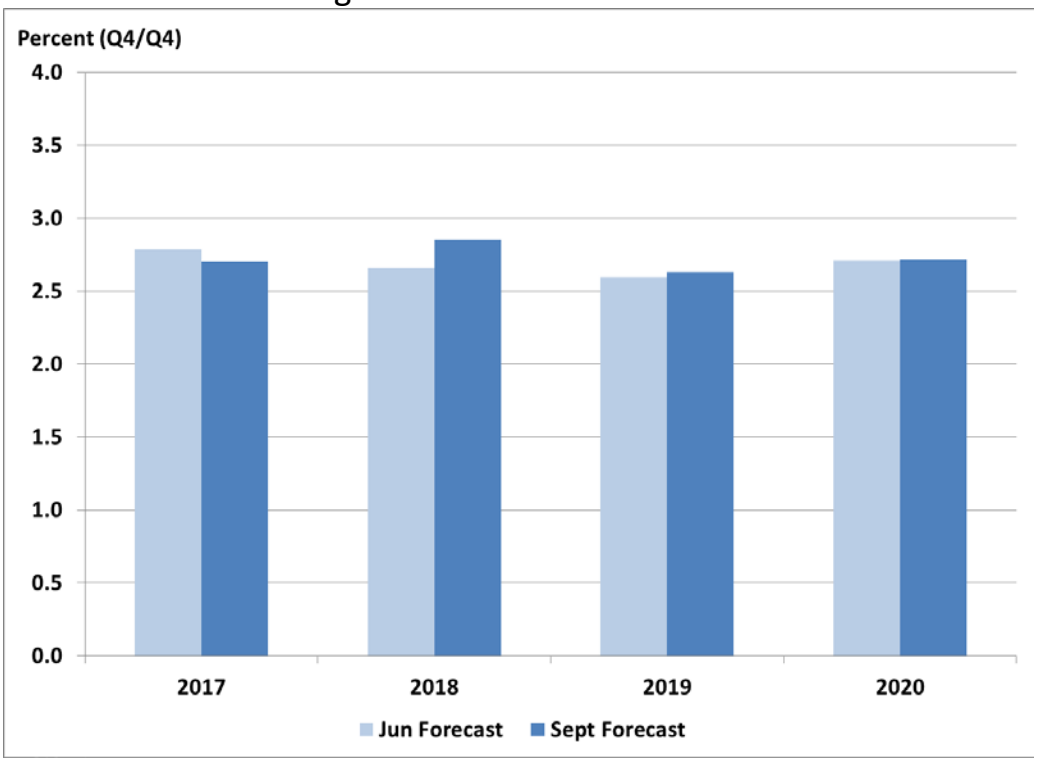

Figure 5b: PCE Inflation Growth

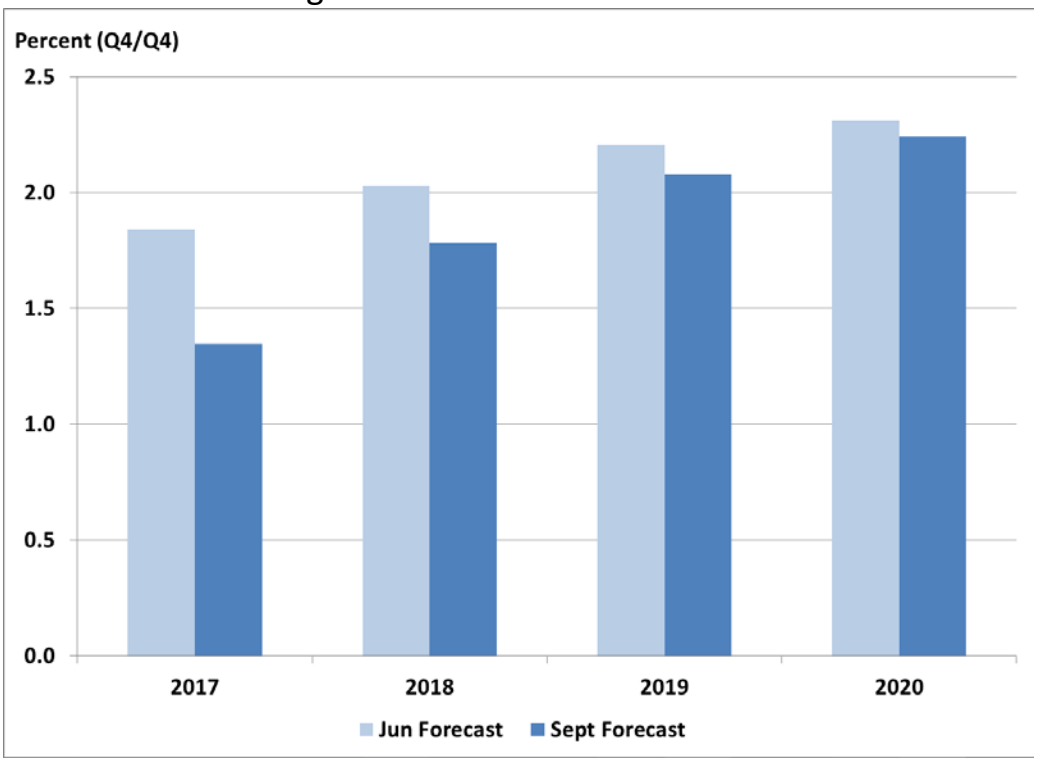

Figure 5c: Unemployment Rate

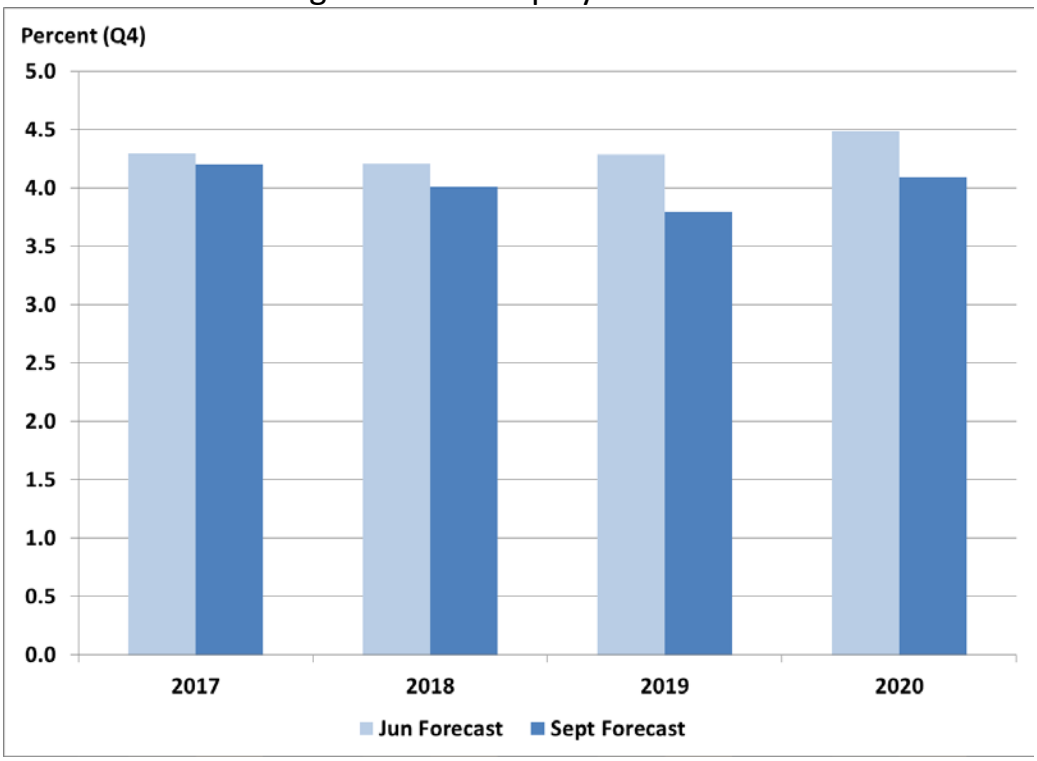

Figure 5d: Federal Funds Rate