



SPECIAL REPORT

FEDERAL RESERVE BANK OF PHILADELPHIA

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 structural forecasting model based on the New Keynesian dynamic stochastic general equilibrium methodology. 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 fourth quarter of 2018 grew at an above-trend 2.6 percent after growing at a strong 3.4 percent in the previous quarter. For the year as a whole, the economy expanded at a healthy 3.1 percent rate. The current quarter, however, is showing substantial signs of weakness,

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.

with most projections in the 1–2 percent range. Recent data on consumption have been surprisingly weak, especially given that the underlying fundamentals supporting consumption growth are sound. In December, consumption growth declined by 0.6 percent after showing solid strength over much of last year. Additionally, although January core retail sales recovered a portion of December’s large decline, overall the data are pointing to near-term weakness. Most analysts view the drop-off as temporary, as personal income growth has been averaging a healthy 4.6 percent annualized over the three months to January, the labor market has for the most part remained robust, wage growth is accelerating, stock prices are rising quite rapidly, and consumer confidence remains at a high level. Much of the March rebound in confidence was attributable to increased confidence among lower-income households earning less than \$75,000 per year. Additionally, many observers were puzzled by the recent weakness in retail sales, as many retailers reported healthy profits in December, and contacts in the credit card industry saw no comparable declines in usage during that month.

Regarding the labor market, some recent data have been surprisingly weak, but overall most analysts regard it as still providing a strong underpinning to the economy. Although February’s job growth at 20,000 was somewhat of a shock, job growth has averaged 186,000 over the past three months. Weather likely played a key role, with one-third of the deceleration being accounted for in the construction sector. However, manufacturing and private service employment declined significantly as well. Most analysts view February’s weakness as a blip, as other measures are not in accord with a floundering labor market. Year-over-year wage growth accelerated to 3.4 percent, and the participation rate at 63.2 percent continues to defy longer-run demographic factors that will eventually cause its decline. As well, the unemployment rate declined to 3.8 percent, which is quite low by historical standards. Additionally, job openings continue to exceed the number of people seeking jobs. As was true most of last year, we continue to hear reports of supply constraints in the labor market, and many firms report that they are using more and varied ways to attract and retain workers, including training and more flexible hours.

Strength in manufacturing has declined of late. Core factory orders rebounded in January, offsetting December’s decline, implying that orders have been flat over those two months. Confirming a weakening in this sector was the paltry 0.1 percent increase in February’s industrial production after declining by 0.4 percent in January. Thus, first quarter manufacturing activity is off to a disappointing start. An appreciating dollar and weakening foreign economies are certainly contributing to the recent weakness. Additionally, February’s ISM manufacturing index declined to a two-year low of 54.2. Anecdotes from industrial contacts are not painting quite so dire a picture. Their comments lead one to believe that they expect moderate growth over the year, although it will represent a bit of a step back from the experience of last year. Some firms are also indicating that they are turning down projects because of the inability to find additional workers. As well,

uncertainty over policy may cause some manufacturers to delay capital expenditures in the near term.

The housing sector appears to be stagnating as single-family permits continue on their downward trajectory, reaching their lowest level since August 2017. As well, February's single family starts declined by 17 percent, reversing much of January's gain. Part of the large swings we are seeing are likely due to the government shutdown, which affected the quality of the data. Although pending home sales bounced up in January, overall they have been on a downward trend for the past two years. Thus, not many analysts expect any significant near-term economic boost from the housing market. The same is true of January's existing home sales, which also markedly surprised to the upside. If the latest readings persist, then things may gradually turn around for the housing sector, but as of now it is much too early to expect a strong rebound.

Inflation continues to be close to the FOMC's 2 percent target. As of December, year-over-year growth in the headline personal consumption expenditures (PCE) price index of 1.7 percent is once again 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 rose 0.2 percent in February and the 12-month change came in at 1.5 percent as compared with 2.1 percent for the core measure. The weaker headline number is largely attributable to the decline in gasoline prices. Inflation expectations also seem to be well anchored, and it appears that the Fed has substantially achieved this half of its dual mandate.

It also appears that risks to the economy are tilted to the downside. Those risks include the continued possibility of a trade war, but those risks seem to have attenuated recently. Additionally, world economic growth has weakened. On a more positive note, equity prices have recovered much of the decline that was experienced in the latter part of last year.

The Benchmark Model

To create our forecasts and to carry out our monetary policy benchmarking exercises, we use a structural forecasting model based on the New Keynesian dynamic stochastic general equilibrium (NKDSGE) methodology, which is at the forefront of macroeconomic modeling and forecasting. Our model features households and firms that are forward-looking and that make decisions facing resource constraints. The model includes a labor market where firms and households engage in search and matching behavior — allowing us to model the unemployment rate in a meaningful way. The model features a rich menu of shocks as well as adjustment costs that make wages and prices less than fully flexible in responding to changes in economic conditions. Detailed documentation on the model structure is available from the authors on request. We generate forecasts from the 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, $ygap_t$ is a measure of the output gap, and ε_t^R is a monetary policy shock.² The parameters ρ , Ψ_π , and Ψ_y determine how monetary policy reacts to economic conditions. We run forecast simulations under four different versions of the basic rule shown here:

Table 1

Rule	ρ	Ψ_π	Ψ_y
Baseline	0.85	2.62	0.53
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 NKDSGE 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 2018. The forecast begins in the first quarter of 2019 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

² The model calibration implies that the long-run equilibrium value of the federal funds rate is 3.75 percent. The output gap is calculated using the flexible-price version of the model. The gap is then measured as the log difference of realized output from its flexible-price counterpart. For the baseline rule, the output gap is a growth gap — the deviation of realized output growth from its longer-run trend.

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 2.6 percent annual rate over the next three years.
- Core PCE inflation reaches 2.1 percent (Q4/Q4) in 2019, rising to 2.4 percent in 2020 and to 2.4 percent in 2021.
- The unemployment rate averages 4.5 percent in the fourth quarter of 2019, edging up to 4.6 percent at the end of 2020 and staying there through the end of 2021.
- The federal funds rate is at 3.1 percent at the end of 2019, 4.1 percent at the end of 2020, and 4.6 percent at the end of 2021.
- The comparison with our December forecast is less meaningful this time as we are using a different structural model. That said, under the new model, real GDP growth is somewhat weaker in 2019 and somewhat stronger in 2020. Inflation is generally stronger in the new model forecast, and the unemployment rate is markedly higher over the next three years. The federal funds rate path is higher in the new model over the forecast horizon (Figures 5a-d).

The baseline forecast calls for output growth of 2.6 percent in the first quarter, maintaining about that pace of growth over the next three years. The model forecast for the first quarter of 2019 is stronger than other nowcasts. The Federal Reserve Bank of Atlanta's GDPNow forecast for the first quarter of 2019 currently stands at 1.2 percent, while the Federal Reserve Bank of New York's Staff Nowcast is slightly higher at 1.3 percent. As mentioned above, the NKDSGE model output forecast is made using quarterly data from the fourth quarter of 2018 and earlier. The incoming data since the end of December 2018 have generally been pointing to a pace of underlying growth for the first quarter that is slower than what we saw in the fourth quarter.

The baseline model shows output growth running at a pace somewhat above its longer-term trend over the forecast horizon.⁴ The unemployment rate averages 4.3 percent in the second quarter of 2019 and then edges up gradually to 4.6 percent in 2021Q4. In the new model the unemployment rate is an outcome variable, whereas previously we inputted our own subjective view about the unemployment rate path into the forecast. This change in methodology led to a large upward revision in the unemployment rate path compared with December — the structural model

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 model estimates long-run real per capita output growth of about 1.6 percent. We then assume that population growth averages 0.8 percent per year over the forecast horizon.

anticipates a much quicker return of the unemployment rate to its longer-term value compared with December's subjective expectation.

Moderately strong growth and anchored long-run inflation expectations lead to an acceleration of core PCE inflation, from 1.7 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 percent, reaching 2.4 percent by the end of 2021. Under the baseline policy parameterization, the output growth and inflation outcomes correspond to a rising federal funds rate over the next three years. The model predicts that the federal funds rate rises to 3.1 percent at the end of 2019 and then increases to 4.1 percent at the end of 2020 and to 4.6 percent at the end of 2021.

The baseline forecast is stronger than the median projections from the first quarter 2019 Survey of Professional Forecasters (SPF) over the forecast horizon. The respondents expected real output growth of 2.4 percent in 2019, 2 percent in 2020, and 1.8 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 percent (Q4/Q4) for 2019 and 2.1 percent for 2020. The forecasters' path for the unemployment rate is lower than in the baseline model: The median SPF forecast for the unemployment rate averages 3.7 percent in 2019 and 2020, edging up to 4 percent in 2021.

The March 2019 Summary of Economic Projections (SEP) by FOMC participants shows the median projection for output growth at 2.1 percent in 2019, 1.9 percent in 2020, and 1.8 percent in 2021. The median forecast of the unemployment rate is 3.7 percent at the end of 2019, edging up to 3.8 percent at the end of 2020 and 3.9 percent at the end of 2021. Core PCE inflation is projected at 2 percent in each of the next three years. 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) is now above the central tendency of the March 2019 SEP over the forecast horizon. The baseline forecast remains above market expectations, which are at about 2.3 percent for the fourth quarter of 2019 and 2.1 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 1.⁵

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 the baseline rule or the 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 near-term output growth and inflation (as well as in the near-term federal funds rate). The new model generates very persistent inflation and interest rate outcomes.
- By the end of 2019, the forecasts for output have largely converged. However, the outcomes for inflation, interest rates, and the unemployment rate all show significant deviations from the baseline path through the forecast horizon. An important difference across the baseline and alternative rules is how the output gap is measured. The baseline rule uses a growth gap — the deviation of output growth from its longer-run trend. The alternative Taylor rules use a level gap — the deviation of the level of output from the flexible-price alternative.
- The federal funds rate under the alternative policy rules reaches 4 percent or a bit above by mid-2020, which is well above current market expectations of what the federal funds rate will be at that time.

The alternative policy rules show significant differences in the paths for inflation and interest rates compared with the baseline forecast. The primary reason that the alternative Taylor rules show higher interest rates, lower near-term inflation, and lower near-term output growth is that the rules use a different output gap compared with the baseline rule. The model estimates that the output gap in levels is currently about positive 1 percent and falls gradually to about 0.5 percent at the end of 2021. In NKDSGE models, the level of output depends on the future path of interest rates — hence, higher future interest rates are needed to bring the level of output down to the

⁵ When generating the forecasts under the alternative policy rules, we assume that the state of the economy up to and including the fourth quarter of 2018 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 first quarter of 2019. 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.

natural rate. This mechanism is somewhat attenuated in the inertial Taylor rule, since the lagged interest rate helps pin down the current interest rate. The Taylor 1993 and Taylor 1999 rules do not incorporate a lagged interest rate term and so are free to respond more strongly to changes in the output gap and inflation gap.

The alternative policy rules suggest a stronger path of interest rates over the forecast horizon to close the output gap. While the baseline rule expects the funds rate to be 4.6 percent at the end of 2021, the alternative rules put the funds rate in a range of 5.3 to 5.7 percent. All of the model-based rules are significantly higher than expectations from financial markets. In the near term, the Taylor 1993 and Taylor 1999 rules indicate the funds rate should be about 100 basis points higher — again in part because these rules do not include a lagged interest rate term to smooth interest rate changes.

The near-term path of output growth and the unemployment rate shows a somewhat weaker economy under the Taylor 1993 and Taylor 1999 rules, consistent with their higher predictions for the federal funds rate. The most dramatic difference across the forecasts is in the path for inflation. The higher path for interest rates under the Taylor 1993 and Taylor 1999 rules leads to significantly lower near-term inflation as the monetary policymaker tries to close the output gap. Under these rules, inflation would drop to near 1 percent over the near term and then accelerate quickly to 2 percent and higher in 2020. Under the inertial Taylor rule, the economy stays stronger in the near term since the interest rate cannot adjust as quickly to eliminate the output gap. Consequently, the path for inflation is higher over the next two years compared with the other Taylor rules and the baseline rule. By the end of 2021, inflation, unemployment, and interest rates have largely converged across the alternative rules — though at higher levels compared with the baseline rule. As time unfolds, the economy settles down to be the same across all the rules, but given the estimated persistence in the model, it takes a very long time for this to occur.

Summary

The baseline NKDSGE model uses historical correlations in the data to generate its forecasts and does not incorporate judgmental adjustment. The NKDSGE model also does not take account of data after the fourth quarter of 2018 and does not explicitly account for tax reform, trade policy, or recent movements in equity markets. The model predicts healthy output growth over the next three years and inflation rising modestly above the FOMC's 2 percent target. The unemployment rate is expected to move up this year to its longer-run natural-rate level. To keep inflation forces in check, the federal funds rate rises at a fairly strong pace over the next 3 years — significantly more strongly than anticipated by financial markets.

The alternative policy rules suggest that the future path of the federal funds rate would be even higher than that predicted by the baseline model. This is fundamentally driven by the significant

positive output gap that the policy reaction function works to close. Both the estimated and alternative policy rules indicate that inflation will be higher than in recent experience and that the federal funds rate will need to move up much more rapidly than currently anticipated by financial markets as well as by FOMC participants as indicated in their SEP forecasts.

Figure 1: Real GDP Growth

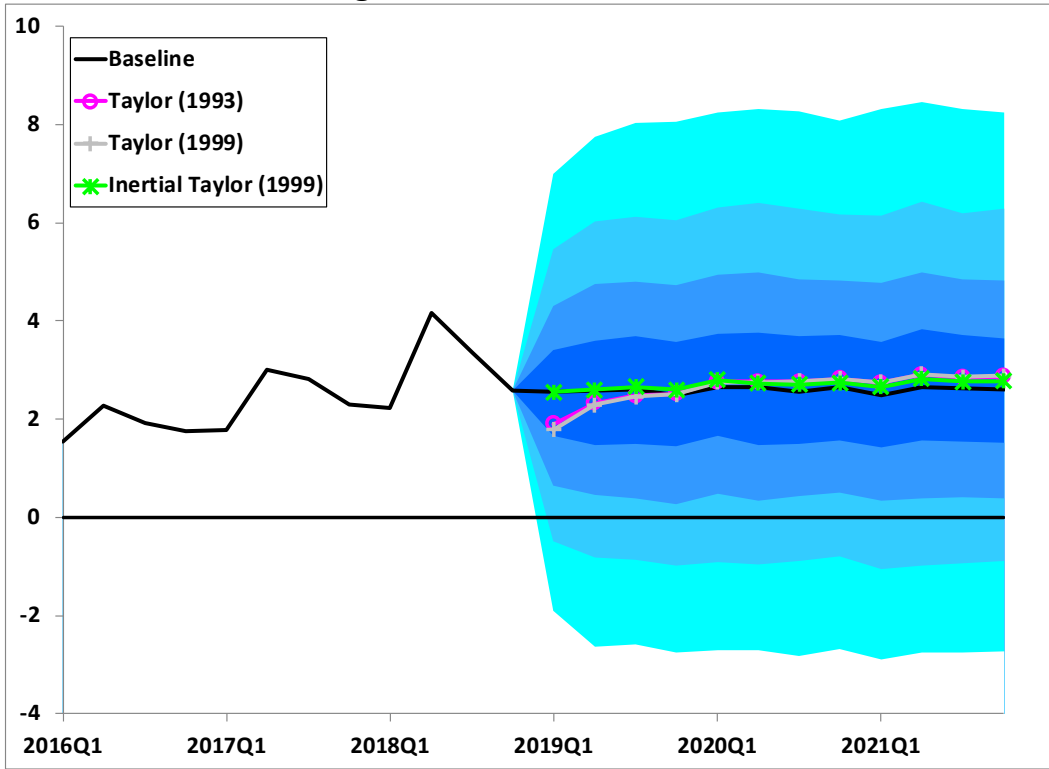


Figure 2: Core PCE Inflation

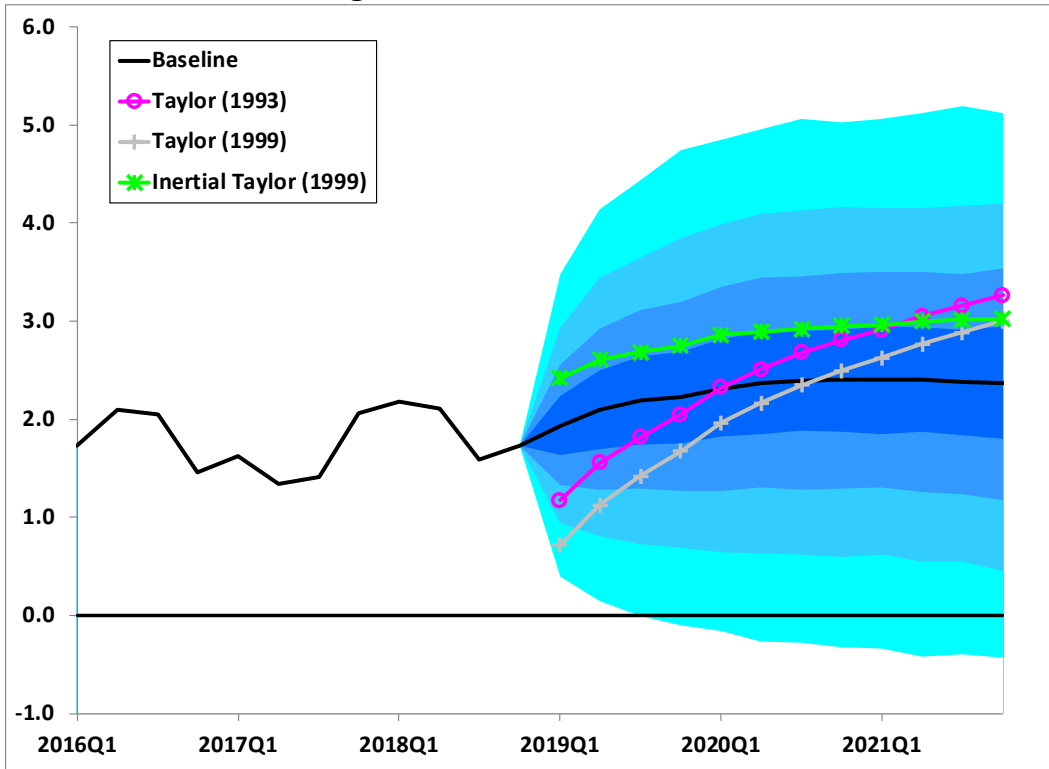


Figure 3: Unemployment Rate

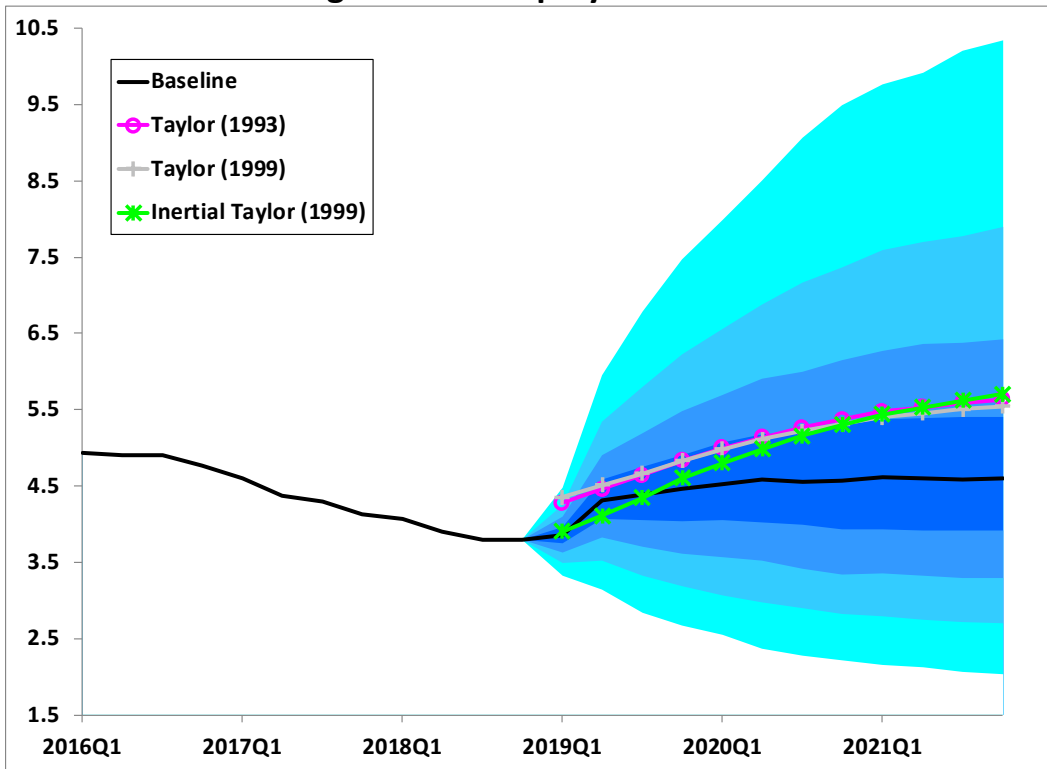


Figure 4: Federal Funds Rate

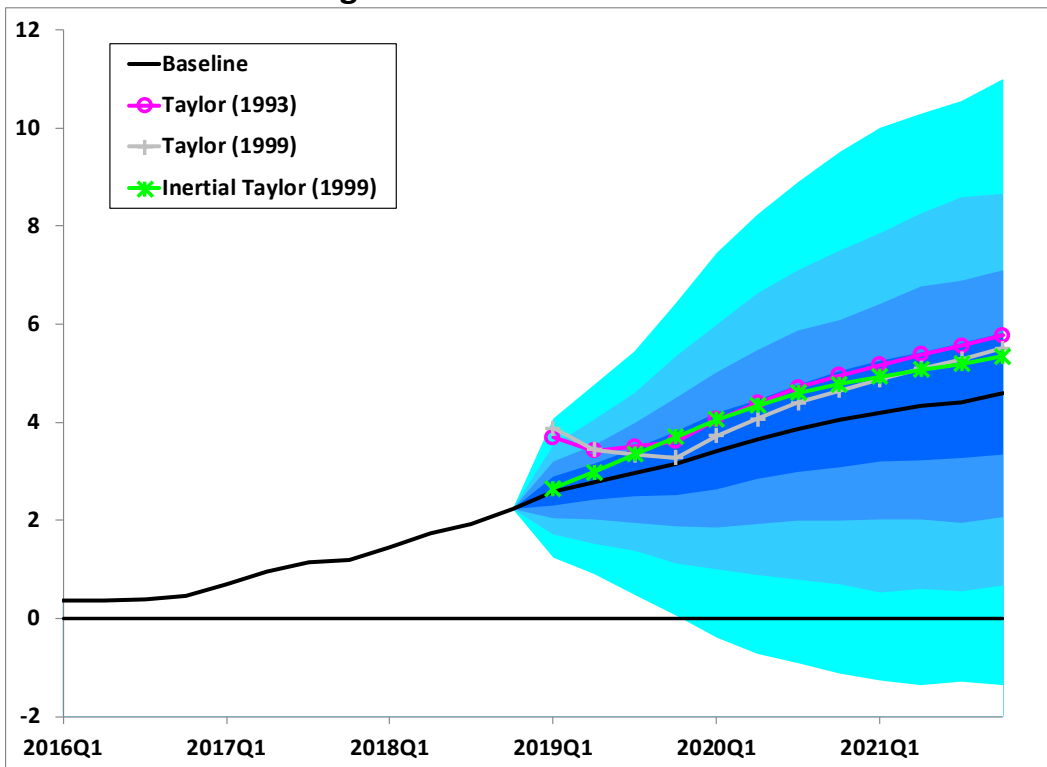


Figure 5: Baseline Forecast Comparisons

Figure 5a: Real GDP Growth

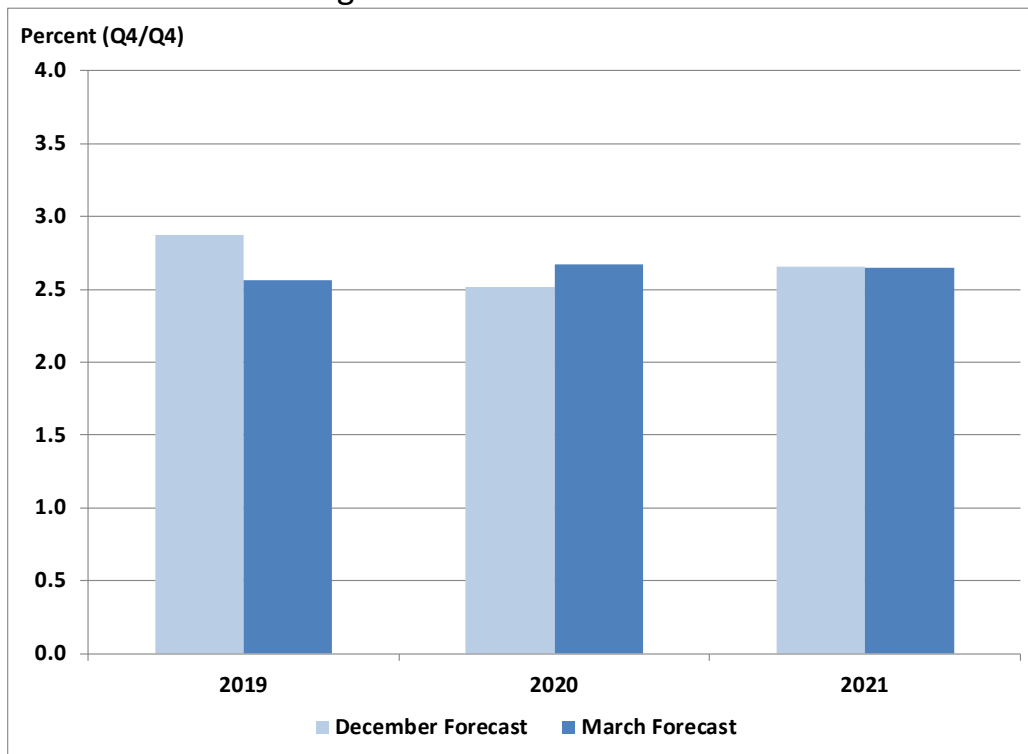


Figure 5b: Core PCE Inflation Growth

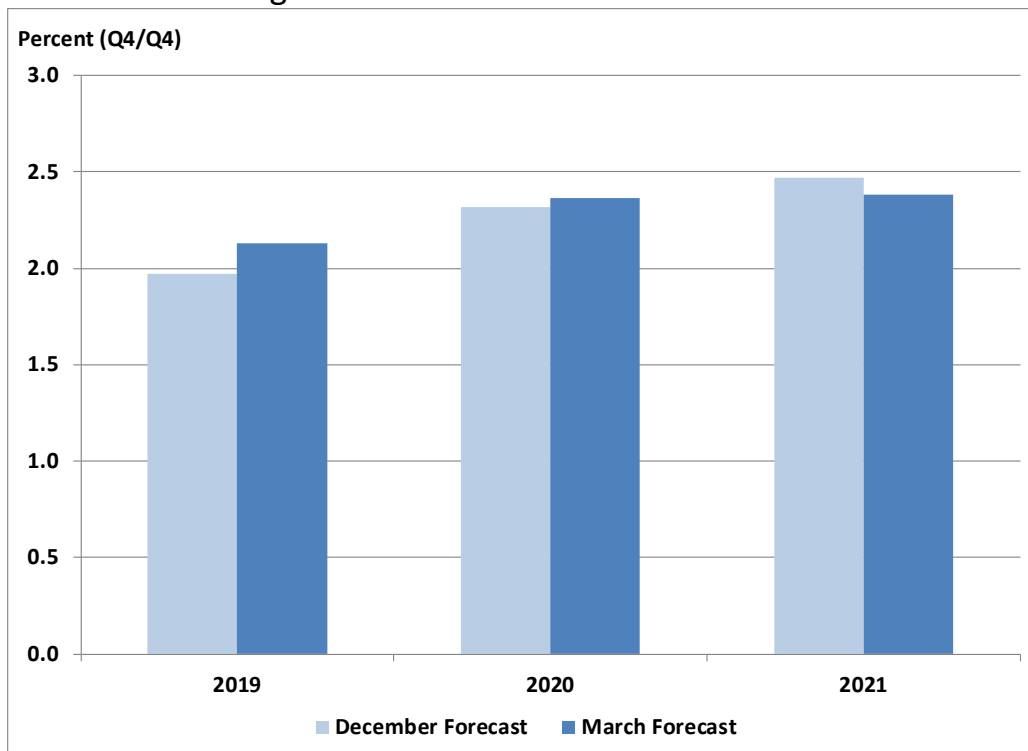


Figure 5c: Unemployment Rate

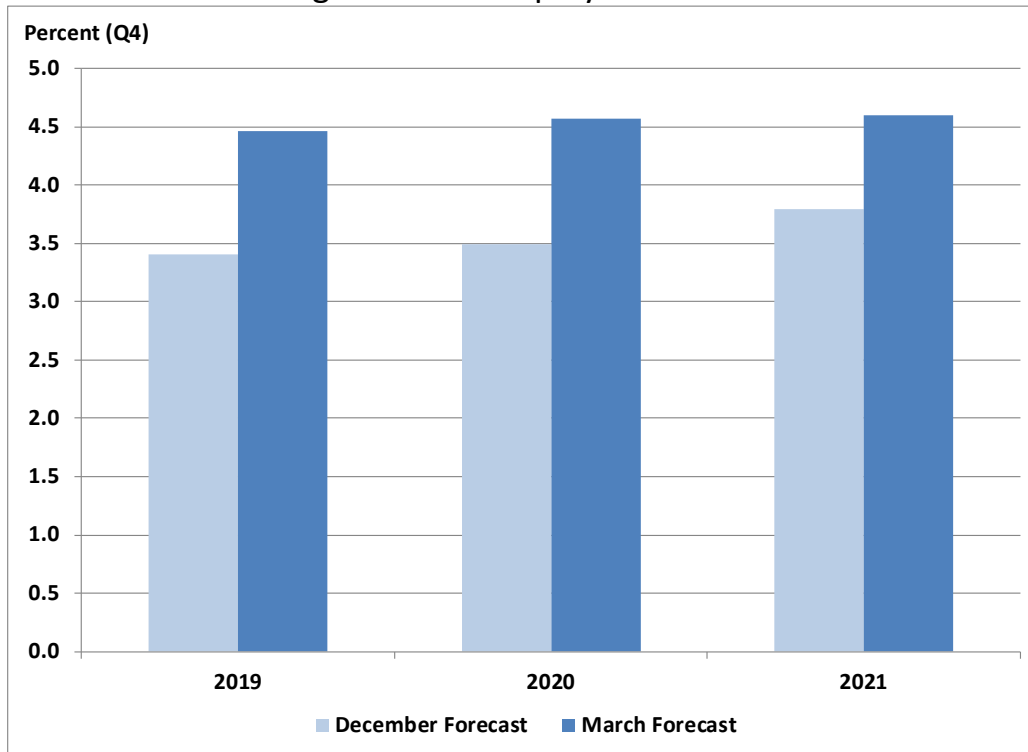
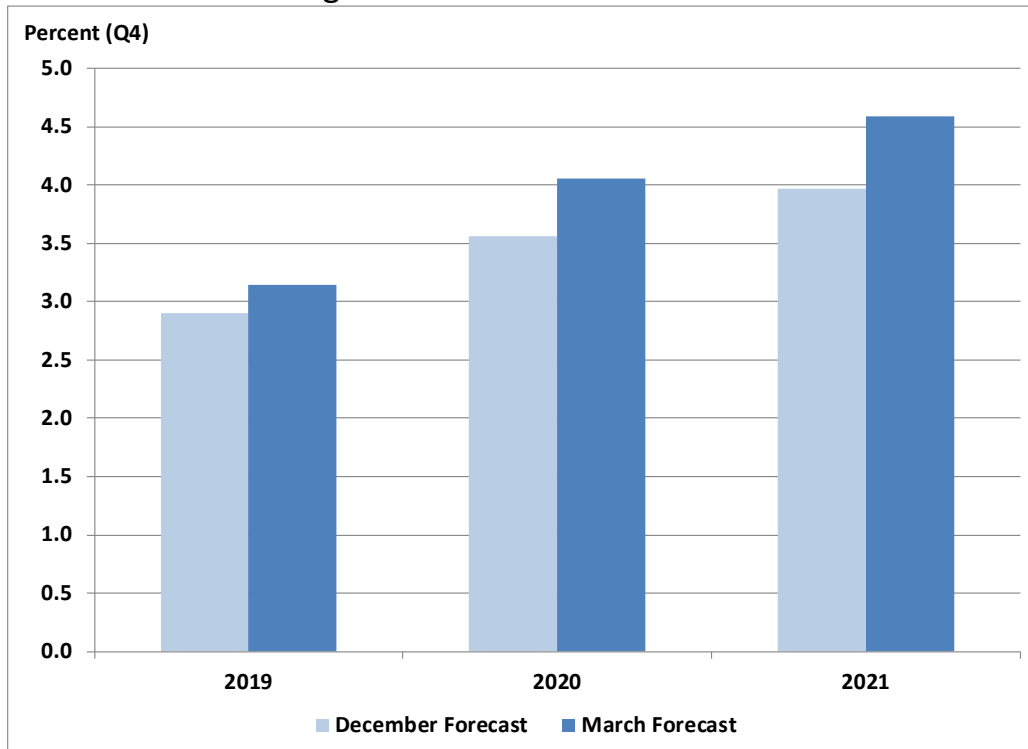


Figure 5d: Federal Funds Rate



Note: Historical data have been retrieved from Haver Analytics.