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. 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 first quarter of 2019 grew at an above-trend 3.1 percent after growing at 2.2 percent in the previous quarter. The current quarter, however, is showing substantial signs of moderating growth, with most projections in the 1.5–2 percent range. Second-quarter growth will...
likely be driven mostly by consumption, which appears to be rebounding from a first-quarter falloff. Growth is supported by strong underlying fundamentals, including solid job growth and firming equity prices. Recent data on retail sales have been firm, and purchases of motor vehicles have been brisk. As well, personal income has been growing at a 3.5 percent annualized rate over the last three months. However, the latest reading on consumer confidence unexpectedly fell to its lowest reading since September 2017, and the decline may be due to May’s rather weak jobs report and increasing concerns over a possible trade war.

Regarding the labor market, the most recent data have been surprisingly weak, but overall most analysts regard it as still providing a strong underpinning to the economy. Although May’s job growth at 75,000 was much weaker than anticipated, job growth has averaged 151,000 over the past three months. The labor market remains dynamic, with hiring rates and job-opening rates at or near record levels, and at 3.6 percent the unemployment rate remained at a roughly 50-year low. There continue to be more job openings than unemployed workers. 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 continuing to use more and varied ways to attract and retain workers, including training and more flexible hours.

Manufacturing has definitely hit a soft spot, with manufacturing industrial production declining by 1.8 percent over the last six months at an annual rate. As well, factory orders declined in April and have contracted noticeably over the last six months. Reflecting weaker hard data, the ISM manufacturing index declined for the second straight month and has generally been trending down since last fall. Further, many of the regional indices nose-dived this month, with our own Manufacturing Business Outlook Survey (MBOS) essentially at zero. A stronger dollar and weakening foreign economies are contributing factors, and most contacts remain guarded in the overall views. Economic uncertainty remains high, with lingering risks of a trade war with China.

The housing sector hasn’t shown much activity, although May’s single-family permits rose for the first time in six months. However, single-family starts declined, and the overall trend has been fairly flat. Also, the gains were confined to the south, with other regions continuing to be listless. The hope is that falling mortgage rates will lead to an increase in activity. The most recent data on existing home sales may be an indication as sales were up by 2.5 percent in May.

Inflation continues to run below the FOMC’s 2 percent target. As of April, year-over-year growth in the headline personal consumption expenditures (PCE) price index was only 1.6 percent, up from 1.5 percent after declining in the previous three months. The latest reading on the consumer price index, however, indicates that there is little inflationary pressure, with May’s reading increasing by a mere 0.1 percent. We are also seeing a deceleration in core consumer price index (CPI) inflation over the last 12 months. Somewhat concerning is the accompanying decline in inflation expectations, with both market and survey measures falling. The Michigan index on consumer
sentiment reported the lowest inflation expectations numbers for the next five years since its inception. The recent behavior of inflation is certainly influencing the policy positions of a number of FOMC participants.

It also appears that risks to the economy are tilted to the downside. Those risks include the continued possibility of a trade war and the weakening global outlook. On a more positive note, equity prices have recovered much of the decline experienced earlier in the 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 while 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 upon 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

\[ R_t = \rho R_{t-1} + (1 - \rho) \left[ \Psi_\pi (\pi_t|_{t-4} - \pi^*) + \Psi_y y gap_t \right] + \varepsilon_t^R, \]

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, \( y gap_t \) is a measure of the output gap, and \( \varepsilon_t^R \) is a monetary policy shock. The parameters \( \rho, \Psi_\pi, \) and \( \Psi_y \) determine how monetary policy reacts to economic conditions. We run forecast simulations under four different versions of the basic rule shown here:

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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.
Table 1

<table>
<thead>
<tr>
<th>Rule</th>
<th>$\rho$</th>
<th>$\Psi_\pi$</th>
<th>$\Psi_\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>0.85</td>
<td>2.62</td>
<td>0.53</td>
</tr>
<tr>
<td>Taylor (1993)</td>
<td>0.0</td>
<td>1.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Taylor (1999)</td>
<td>0.0</td>
<td>1.50</td>
<td>1.0</td>
</tr>
<tr>
<td>Inertial Taylor (1999)</td>
<td>0.85</td>
<td>1.50</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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 first quarter of 2019. The forecast begins in the second 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 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 a 2.7 percent annual rate over the next two and a half years.
- Core PCE inflation reaches 1.8 percent by the end of 2019 and then rises to 2.1 percent (Q4/Q4) in 2020 and 2.3 percent in 2021.
- The unemployment rate averages 4.3 percent in the fourth quarter of 2019, edging up to 4.5 percent at the end of 2020 and 4.6 percent at the end of 2021.
- The federal funds rate is at 2.6 percent at the end of 2019, 3.3 percent at the end of 2020, and 4.1 percent at the end of 2021.
- The comparison with our March forecast shows somewhat stronger GDP growth in 2019 and 2020 and lower inflation over the forecast horizon. The unemployment rate projection

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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.
is largely unchanged vs. March, while the federal funds rate projection calls for a lower path (Figures 5a-d).

The baseline forecast calls for output growth of 2.4 percent in the third quarter, rising to about 2.8 percent in mid-2020. The model forecast for the second quarter of 2019, at 2.1 percent, is a bit stronger than other nowcasts. The Federal Reserve Bank of Atlanta’s GDPNow forecast for the second quarter of 2019 currently stands at 1.9 percent, while the Federal Reserve Bank of New York’s Staff Nowcast is somewhat lower at 1.4 percent. As mentioned above, the NKDSGE model output forecast is made using quarterly data from the first quarter of 2019 and earlier. The incoming data since the end of March 2019 have generally been pointing to a pace of underlying growth for the second quarter that is slower than what we saw in the first quarter.

The baseline model shows output growth running at a pace somewhat above its longer-term trend over the forecast horizon. The unemployment rate averages 4.3 percent in the fourth quarter of 2019 and then edges up gradually to 4.6 percent in 2021Q4. In the model the unemployment rate is now 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 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 1.3 percent in the first quarter of 2019 to 2.2 percent by the end of 2020. Core inflation then continues above the FOMC’s target of 2 percent, reaching 2.3 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 2.6 percent at the end of 2019 and then increases to 3.3 percent at the end of 2020 and 4.1 percent at the end of 2021.

The baseline forecast is stronger than the median projections from the second-quarter 2019 Survey of Professional Forecasters (SPF) over the forecast horizon. The respondents expected real output growth of 2.6 percent in 2019, 2 percent in 2020, and 1.9 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 1.9 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, 3.6 percent in 2020, and 3.7 percent in 2021.

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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.
The June 2019 Summary of Economic Projections (SEP) by FOMC participants shows the median projection for output growth at 2.1 percent in 2019, 2 percent in 2020, and 1.8 percent in 2021. The median forecast of the unemployment rate is 3.6 percent at the end of 2019, edging up to 3.7 percent at the end of 2020 and 3.8 percent at the end of 2021. Core PCE inflation is projected at 1.8 percent in 2019, 1.9 percent in 2020, and 2 percent in 2021. 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 largely above the central tendency of the June 2019 SEP over the forecast horizon. The baseline forecast remains above market expectations, which are at about 1.9 percent for the fourth quarter of 2019 and 1.5 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.\(^5\)

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 the end of 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 0.9 percent and falls gradually to about 0.6 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 4.1 percent at the end of 2021, the alternative rules put the funds rate in a range of 5 to 5.3 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 around 75 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 both show 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 by the end of 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 first quarter of 2019 and does not explicitly account for tax reform, trade policy, or recent movements in equity markets. The model continues to predict 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 three 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 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.