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Macroeconomic Effects of Alternative Monetary Policies in Pandemic-Driven Recession Scenarios[1]

The U.S. economy is experiencing the most severe economic downturn since World War II, as the social-distancing measures taken to contain the spread of COVID-19 are generating abrupt and severe disruptions to economic activity and the labor market. In response, the Federal Reserve has taken forceful actions, including promptly cutting the federal funds rate back to its effective lower bound (ELB), issuing new forward guidance (FG), conducting asset purchases on an unprecedented scale to improve market functioning (in so doing, also providing policy accommodation), and launching a broad set of emergency lending facilities. The Congress and the Administration have similarly introduced extraordinary measures, including major spending and lending initiatives, some in collaboration with the Federal Reserve, to support households and businesses.

Notwithstanding these vigorous policy actions, the economic outlook remains exceptionally uncertain. Its course ultimately depends on the success of health care policy, but monetary policy clearly will play a key role, too. Against this background, this memo presents model simulations of additional monetary policy measures that the Committee might undertake in response to the recession caused by the pandemic. These simulations are generated under different settings of monetary policy, including options featuring FG and large-scale asset purchases (LSAPs). In analyzing these options, we take into account the fact that the Committee is already using FG and asset purchases actively, and that it is widely expected to continue to rely on such tools in pursuit of its dual mandate. Our analysis therefore amounts to an effort both to incorporate existing and anticipated policy actions—in order to clarify their likely course—and to consider policy actions that deviate from what the public now anticipates. Because the economic outlook is extremely uncertain, we conduct our simulations under both the April 2020 Tealbook baseline economic projection and the similarly plausible "Second Wave" scenario. In the latter scenario, detailed in the "Risks and Uncertainty" section of the

April Tealbook, the economic downturn is deeper and more prolonged, with the ensuing recovery weaker than in the baseline.[2]

The memo proceeds as follows. We first summarize the staff's policy assumptions that underpin both scenarios and compare those assumptions with market participants' expectations. We then discuss our simulations of further FG and LSAP actions. A key finding is that, under typical model assumptions about the transmission of these actions, policymakers must maintain accommodative financial conditions many years into the future in order to generate significant improvements in unemployment and inflation outcomes. Because some of our model assumptions may not be valid in the current environment, our memo also discusses factors that might alter the potency of policy actions along with a number of considerations for the design of these programs.

The staff's monetary policy assumptions and market expectations

The April Tealbook baseline and "Second Wave" economic projections are constructed under the following monetary policy assumptions.[3]

Federal funds rate

The staff assumes that the FOMC will maintain the federal funds rate at the ELB until slack in the labor market has essentially disappeared—specifically, when the unemployment rate has returned to 4.3 percent. At that point, the policy rate starts to rise slowly, following the prescriptions of the conditional attenuated rule.[4] We see these assumptions as broadly in line with the Committee's actions following the global financial crisis. Notably, when the FOMC initiated normalization of the policy rate in December 2015, the unemployment rate, at 5.0 percent, was only a touch above the median longer-run estimate in the Summary of Economic Projections (SEP) at the time, at 4.9 percent.[5] We also see those assumptions as consistent with the Committee's existing qualitative FG that it expects "to maintain [the current] target range until it is confident that the economy has weathered recent events and is on track to achieve its

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[2] Should the June Tealbook baseline and the "Second Wave" scenario differ materially from what is assumed here, the authors will provide updated simulations results.

[3] All simulations also embed the fiscal assumptions described in the April Tealbook. In particular, the staff assumes that the fiscal measures in response to the pandemic will, by themselves, boost real GDP growth by 4.6 percentage points in 2020 (excluding follow-on multipliers and financial offsets).

[4] The conditional attenuated rule is $R_t = 0.85R_{t-1} + 0.15(r_t^* + \pi_t + 0.5(\pi_t - \pi^{LR}) + 0.2ygap_t)$, where R_t is the federal funds rate, π_t is the four-quarter rate of core PCE price inflation, $ygap_t$ is the output gap, r_t^* is the staff's time-varying intercept, and π^{LR} is the 2 percent longer-run inflation goal.

[5] By contrast, headline and core inflation were both well below 2 percent in December 2015, at 0.4 percent and 1.3 percent, respectively, but the Committee affirmed its expectation that inflation would "rise to 2 percent over the medium term as the transitory effects of declines in energy and import prices dissipate and the labor market strengthens further." In the April Tealbook, projections for core and headline inflation are about 15 basis points below 2 percent at time of departure from the ELB.

maximum employment and price stability goals." This qualitative guidance is, more generally, consistent with a broad range of reasonable policies. Our memo explores some of these policies and the possible benefits arising from adding precision.

The staff's interpretation of the Committee's FG entails the provision of significant monetary stimulus over the next several years of the projection. Under the April Tealbook baseline, the policy rate departs the ELB in 2023:Q2. Furthermore, due to the attenuated coefficient on the output gap in the rule, the policy rate rises only slowly after departure from the ELB.

The resulting policy rate path is within the range of survey- and market-based estimates. In the latest Open Market Desk surveys of market participants and primary dealers, the median respondent saw the policy rate remaining at the ELB through at least the end of 2022 (the final date covered by the survey) as the most likely outcome. A straight read of OIS quotes (that is, assuming zero term premiums) suggests that market participants expected that the federal funds rate will remain at the ELB beyond 2023. Even after an adjustment is made for time-varying term premiums, the OIS quotes do not indicate departure from the ELB before the second half of 2022.

Balance sheet

The Federal Reserve's balance sheet is projected to expand from less than 20 percent of nominal GDP at the start of March 2020 to a peak of 45 percent of GDP in September.[6] This expansion includes $2¼ trillion (11 percent of GDP) in net purchases of Treasury and agency mortgage-backed securities to aid market functioning, along with a $2.7 trillion increase stemming from the Federal Reserve's various emergency lending facilities established under section 13(3) of the Federal Reserve Act. In our simulations, we will hold usage of these lending facilities at their assumed values in the April Tealbook baseline.

The April Tealbook and Second Wave scenarios do not include asset purchases beyond the amounts required to aid market functioning through June. Consistent with past FOMC actions, the staff assumed that reinvestment of principal payments on securities holdings would continue until the federal funds rate reaches 1.25 percent.[7] The balance sheet subsequently grows with nominal GDP once reserves have declined to just above 8¼ percent of GDP ($2 trillion in the April Tealbook baseline, a level met in 2025).

Respondents to the Desk surveys generally expected net purchases of Treasury securities and agency MBS to continue through at least the remainder of this year. In

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[6] In comparison, the Federal Reserve's balance sheet in the wake of the global financial crisis peaked at about 25 percent of GDP.

[7] A reference point is provided by noting that, when the FOMC ceased reinvestments in the fall of 2017, the target range for the federal funds rate was 1 to 1.25 percent.

particular, the median respondent expected that the FOMC would purchase these assets at a monthly pace of $200 billion in June, declining to about $150 billion per month over this summer, and just under $100 billion per month by December. Survey responses do not distinguish between asset purchases conducted for market functioning purposes and those conducted as part of LSAP programs aimed at providing macroeconomic stimulus. That said, under these expectations, the cessation of asset purchases in June, as posited in the staff baseline projection, would in all likelihood lead to broad disappointment in markets and a tightening of financial conditions. Accordingly, the staff's Tealbook projection embeds tighter financial conditions than would be the case under the market expectation of additional purchases.

Even under the staff assumption of no asset purchases beyond June, the expansion of the Federal Reserve's balance sheet in response to the pandemic provides significant monetary policy accommodation. Using our standard multipliers, the reduction in duration risk faced by private investors that stems from purchases of Treasury securities and agency MBS through June leads, all else equal, to declines in the term premium on 10-year Treasury securities of about 80 basis points in the near term and 20 basis points by the end of the decade.[8] These purchases and other balance sheet actions could support the economy through other channels that are not typically captured by models. Notably, such channels include fostering private-sector confidence and market functioning in an unusually fragile economic environment. At the same time, the sharp deterioration in public-sector finances caused by the downturn, along with the forceful provision of fiscal stimulus, will result in exceptionally high issuance of Treasury securities, which would likely put some offsetting upward pressure on term premiums. We shall return to these and other elements affecting the potency of balance sheet actions below.

Forward guidance

We perform our model simulations of alternative policy measures using the FRB/US model, under the assumptions that the economy is subject to no further economic shocks (beyond those already embedded in each of the two baseline scenarios) and that financial market participants, price setters, and wage setters correctly anticipate how monetary policy will be conducted in the future and are aware of its implications for

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[8] As discussed later in the memo, factoring in the additional asset purchases expected by the median respondent to the Desk surveys leads to a lower term premium, by about an extra 40 basis points in the near term and a bit less than 10 basis points by the end of the decade.

interest rates and the economy.[9] We first explore the effects of explicit FG about the future path of the federal funds rate.

Description of FG specifications

The guidance takes the form of an announcement, which is fully believed by the private sector, that policymakers will keep the federal funds rate at the ELB until some specified improvement in economic conditions has been achieved and, in some specifications, sustained for some period of time. Thereafter, the policy rate rises slowly, as prescribed by the attenuated version of the inertial Taylor (1999) rule.[10] A key feature of such outcome-based FG is that, as long as agents understand the conditional policy commitments and the structure of the economy, the anticipated timing of departure from the ELB should adjust automatically in response to changes in the economic outlook, in a manner that supports achievement of the policy goals.

In our analysis, we first consider specifications of the FG in terms of achieving a specific level of either core inflation or the unemployment rate.[11] In our "core inflation ≥ 2" and "core inflation ≥ 2¼" scenarios, we assume that policymakers keep the policy rate at the ELB at least until core inflation has reached 2 percent and 2¼ percent, respectively.[12] In the "unemployment rate ≤ 3.8" scenario, we assume that policymakers keep the policy rate at the ELB at least until the unemployment rate has fallen to 3.8 percent.[13] This value is ½ percentage point below the 4.3 percent unemployment rate threshold assumed in the April Tealbook baseline and "Second Wave" projections.

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[9] The assumption of full understanding on the part of price and wage setters increases the sensitivity of inflation to FG and other policy measures early in the simulation period compared with a setting in which only financial markets fully understand the implications of the policy. We examine the sensitivity of our FG results to this assumption below and in Appendix A.

[10] For simplicity, in the simulations with macroeconomic thresholds, we hold the term premium effects of the Federal Reserve's balance sheet stance constant at their levels under the baseline.

[11] Alternatively, we could have specified the FG in terms of achieving specific levels of *both* inflation and the unemployment rate, or achieving either a specific level of inflation *or* the unemployment rate (as a form of an escape clause). However, because we simulate the model under perfect foresight and the improvement in goal variables is largely monotonic, it typically suffices to specify the FG in terms of a single variable in our simulations.

[12] We specify our inflation thresholds in terms of core inflation, rather than headline inflation, because the latter measure is subject to more transitory influences. Such influences could develop in a manner that leads to a premature departure from the ELB. The likelihood of premature satisfaction of the criterion might also be reduced by specifying the inflation threshold in terms of an average of inflation outcomes over some period, or by using an inflation projection (as the FOMC did at times in the wake of the global financial crisis).

[13] In the Tealbook projection, and also in the "Second Wave" scenario, periods of intense social distancing are assumed to raise the natural rate of unemployment substantially above its long-run level in the near term and to cause significant scarring effects. In the unemployment rate threshold simulations,

Our implementation of the FG differs in two important ways from the manner in which the FOMC used threshold-based FG between December 2012 and March 2014. First, in our simulations, the satisfaction of our thresholds leads to immediate departures from the ELB (as called for by the conditional attenuated rule), in contrast to the FOMC's emphasis during 2012–2014 that its thresholds should not be interpreted as "triggers" for departure from the ELB. Second, we consider unemployment rate thresholds under which the federal funds rate is to stay at the ELB until slack in the labor market has essentially been eliminated. By contrast, in December 2012, the FOMC's unemployment rate threshold of 6.5 percent was 0.5 to 1.5 percentage points higher than FOMC participants' individual estimates of the unemployment rate in the longer run. By the time the FOMC raised the federal funds rate from the ELB in December 2015, the unemployment rate, at 5 percent, was well below the original threshold value and was near the corresponding median longer-run estimate in the SEP.[14]
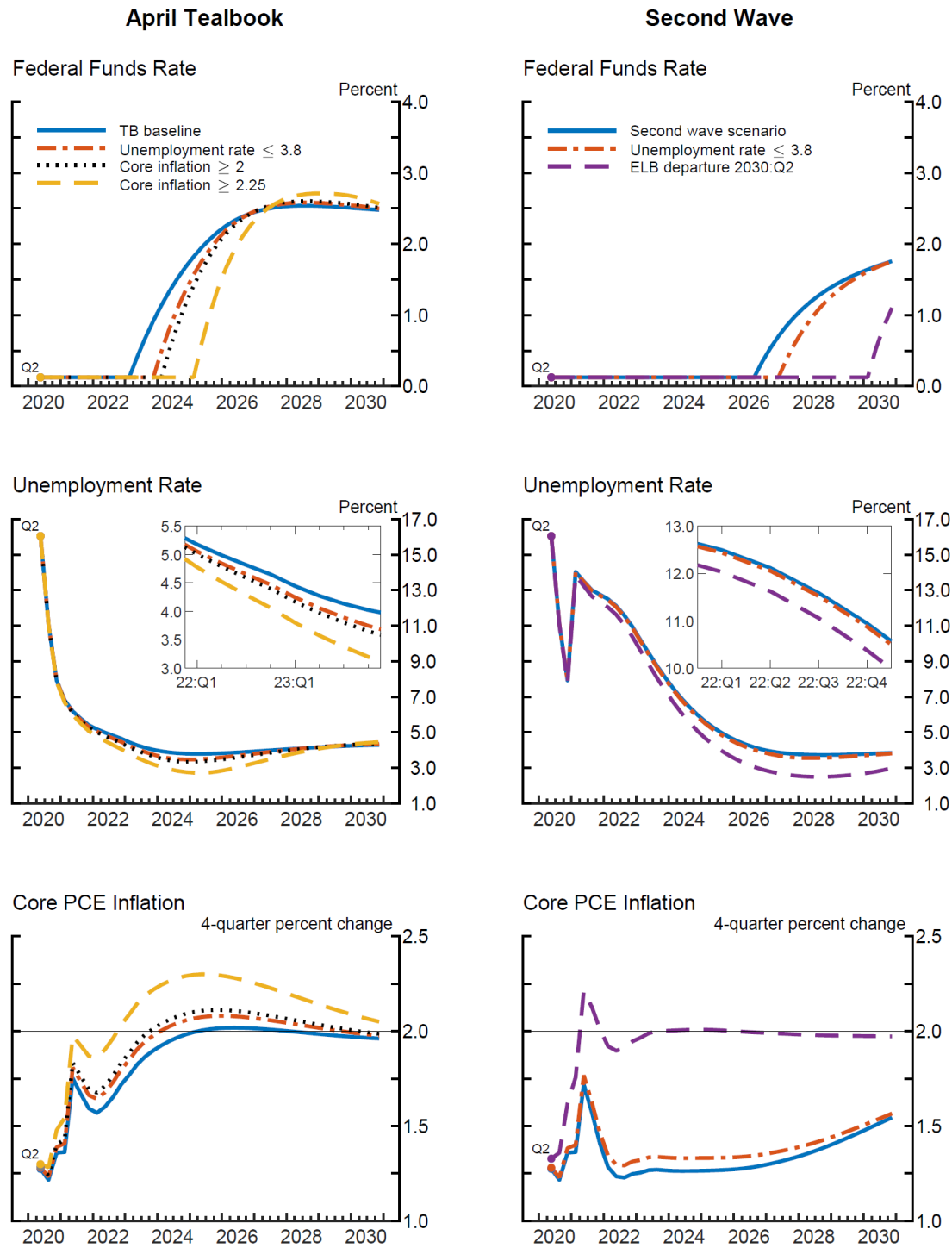
Simulation results

As shown in the left columns of Figures 1a and 1b, under the April Tealbook baseline, an unemployment rate threshold of 3.8 percent and a core inflation threshold of 2 percent prescribe similar departure dates from the ELB and thus yield similar outcomes for longer-term rates and the macroeconomy. Under both thresholds, departure from the ELB is delayed by roughly one year, to early 2024, compared with the Tealbook assumptions. Because the transmission of policy actions to the labor market and real economic activity occurs with long lags in the model, this delay has almost no immediate effect on the unemployment rate. Eventually, however, the more-supportive financial conditions hasten, to a modest degree, the recovery in the labor market, with the unemployment rate falling nearly ½ percentage point below the value in the April Tealbook baseline by 2025. Because of our assumption that price and wage setters are forward-looking, the anticipation of less resource slack over the medium term than in the absence of the thresholds results in upward pressure on prices and nominal wages in the

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therefore, the short-run natural rate of unemployment at the time of departure from the ELB is somewhat above its long-run level of 4.3 percent.

[14] The FOMC's guidance in December 2012 was also conditioned on "inflation between one and two years ahead [being] projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal, and longer-term inflation expectations [continuing] to be well anchored." The Committee further stated that it saw its threshold-based guidance as "consi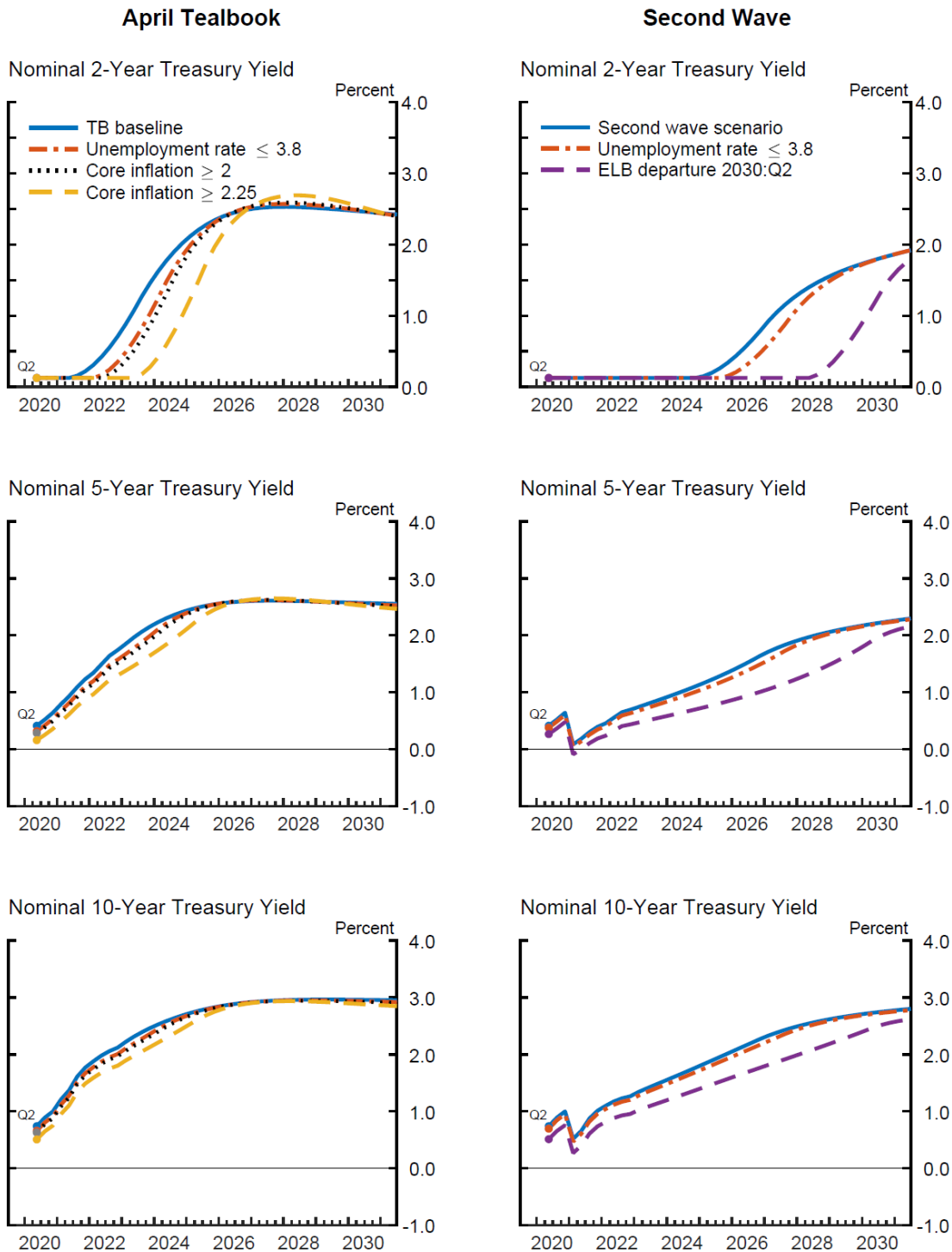stent with its earlier date-based guidance." See https://www.federalreserve.gov/newsevents/pressreleases/monetary20121212a.htm.

Figure 1a: Forward guidance with unemployment rate and inflation thresholds

April Tealbook

Second Wave

Federal Funds Rate

Federal Funds Rate

Unemployment Rate

Unemployment Rate

Core PCE Inflation

Core PCE Inflation

Note: Simulations of FRB/US model conditioned on the April Tealbook baseline and the "Second Wave" alternative scenario.

Source: Staff calculations.

Figure 1b: Forward guidance with unemployment rate and inflation thresholds

April Tealbook

Nominal 2-Year Treasury Yield

Second Wave

Nominal 2-Year Treasury Yield

Nominal 5-Year Treasury Yield

Nominal 5-Year Treasury Yield

Nominal 10-Year Treasury Yield

Nominal 10-Year Treasury Yield

Note: Simulations of FRB/US model conditioned on the April Tealbook baseline and the "Second Wave" alternative scenario. The "nominal 2-year Treasury yield" reflects the expected federal funds rate and a zero term premium. The "nominal 5-year Treasury yield" and "nominal 10-year Treasury yield" include a policy rate expectation component and a term premium.

Source: Staff calculations.

near term. Core inflation is roughly three tenths of a percentage point higher than in the April Tealbook over the next few years, reaching 2 percent in 2023.[15]

A more aggressive core inflation threshold of 2¼ percent delays the departure of the policy rate from the ELB to early 2025—about two years later than in the April Tealbook baseline. Core PCE inflation reaches the 2 percent objective in late 2022, about 2 years earlier than in the baseline, before modestly overshooting policymakers' longer-run objective. As a result, the unemployment rate bottoms out at about 2.7 percent, about 1 percentage point below its trough in the baseline simulation.

The right columns of Figures 1a and 1b show simulations under the "Second Wave" scenario. Under the staff's 4.3 percent unemployment rate threshold and our alternative 3.8 percent unemployment rate threshold, departure from the ELB occurs three and four years later, respectively, than in the Tealbook baseline. These delays illustrate the state-dependent nature of the thresholds, by which the ELB episode lengthens in response to the deterioration in the economic outlook. Even though the unemployment rate falls below the natural rate, inflation does not return to 2 percent over the period shown.[16]

Through the lens of the model, under the "Second Wave" scenario, policymakers would need to keep the federal funds rate at the ELB through 2030 to raise inflation to 2 percent during the 2020s (as shown by the simulation labeled "ELB departure 2030:Q2"). As shown in the right column of Figure 1b, such a policy rate path pushes nominal 10-year Treasury yields to below 50 basis points and the nominal 5-year Treasury yield to mildly negative values for a brief time, an outcome made possible because the corresponding term premium is mildly negative.[17] Because we have assumed that price setters are forward-looking, the long delay in ELB departure raises inflation in earlier years, including in the near term.[18] Of note, policymakers could not

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[15] Core inflation reaches 2 percent in 2023 despite underlying inflation being around 1.9 percent in that year because the unemployment rate is well below the natural rate of unemployment. In the 3.8 percent unemployment rate threshold simulation, for example, the unemployment rate is a little more than 1 percentage point below the natural rate of unemployment when the federal funds rate rises above the ELB.

[16] Under the 3.8 percent unemployment rate threshold, the unemployment rate is around ¾ percentage point below the natural rate of unemployment at the date of departure from the ELB. However, the pace of underlying inflation at that date is only 1.6 percent.

[17] In our model, nothing prevents longer-term nominal Treasury yields falling to negative values. In practice, the behavior of term premiums may mean that nominal rates are subject to an ELB. We defer our discussion of this question to the section on LSAPs, which seek to influence those term premiums.

[18] See Appendix A for simulations under the alternative assumption that price and wage setters use only past information to form their expectations (implying that inflation is less responsive to FG early in the simulation period).

achieve this outcome under a 2 percent inflation threshold in which crossing the threshold is taken as triggering an immediate departure from the ELB: If private-sector agents expected policymakers to follow the attenuated rule as soon as core inflation reaches 2 percent, then financial conditions would not be sufficiently accommodative to lift core inflation to 2 percent (either on a sustained basis or more ephemerally).[19] Alternatively, policymakers could commit to raising core inflation to 2 percent on a sustained basis by conditioning the ELB departure on a measure of average inflation rising to 2 percent. In particular, by delaying the ELB departure until the average of inflation calculated from the beginning of the ELB episode reaches 2 percent, policymakers would implement essentially the same policy rate path and achieve the same macroeconomic outcomes as in "ELB departure 2030:Q2."[20]

Further thoughts and caveats on forward guidance

The effects of FG in our simulations are consistent with the prior work presented by the staff on this topic. A broad lesson is that, in a deep recession, extensions of the expected time at the ELB of up to two or three years generate modest, but still appreciable, effects on the paths of the unemployment rate and inflation. However, in a severe scenario like the "Second Wave," a decade at the ELB may be required to get inflation back to 2 percent on a sustained basis. Several caveats apply that might weaken or, in some cases, strengthen these results.

We have maintained the standard parameterization and structure of the FRB/US model, despite a large degree of uncertainty about the monetary policy transmission mechanism in the current economic environment. Interest-sensitive activities, such as "big ticket" purchases, often require in-person interactions. Consequently, they may not respond to monetary policy easing as much as in the past because of both voluntary and involuntary social distancing. In addition, unusually elevated uncertainty about the economic outlook—an element that is not captured by our model—might lead firms and consumers to undertake much less investment and consumption spending even if the terms of credit are more favorable than under the baseline policy assumptions. Furthermore, because of supply-chain disruptions, increased demand might not be fully met by greater production.

While these features of the current economic environment likely weaken the impact of monetary policy on spending, other features, such as a larger-than-usual

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[19] That is, our model would not have a solution. This problem arises because of our assumption that private-sector agents are strongly forward-looking. In our Appendix A, we show that the problem is reduced somewhat when we instead assume that price and wage setters form expectations based solely on past economic outcomes, in which case the front-loaded effects of FG on inflation largely disappear.

[20] For a discussion of such an approach, see Bernanke (2017).

number of credit-constrained households and firms, might, in themselves, amplify the effectiveness of monetary policy as suggested by some heterogeneous agent models.[21] An additional consideration is that the macroeconomic effects of LSAPs or FG might occur more rapidly than suggested by the FRB/US model, which features long lags in the transmission of monetary policy.[22] For example, if these policy measures coordinate private-sector expectations toward a desirable equilibrium or if they boost confidence, the effects could occur earlier than assumed in our model. For similar reasons, our simulations may underestimate the risk of a large and rapid deterioration in the economic outlook if future FOMC actions and communications were to fall short of private-sector expectations.

Because our simulations are conducted under perfect foresight of the future evolution of the economy, they do not capture any insurance-like benefits of threshold-based policies in an economic environment subject to unexpected shocks. To the extent that the public understands how the thresholds affect policymakers' response to various circumstances, threshold-based policies of the type we consider may reassure the public that, if the economy were to worsen, more accommodation would be provided, possibly reducing the severity of negative states of the world. This reassurance, in turn, may lead consumers and businesses to spend more in general—a factor that would lead to a faster economic recovery than is illustrated by our simulations.

Another concern is that longer-term inflation expectations might not prove as resilient as we are assuming—especially if the economy were to recover only slowly. In particular, inflation has generally run modestly below 2 percent in the wake of the global financial crisis. It is therefore conceivable that the prospect of extending the inflation shortfalls for several more years, as under the April Tealbook baseline—or for more than another decade, as in the "Second Wave" scenario—could lead to an erosion of longer-run inflation expectations. Such an erosion would, in turn, call for even more forceful policy measures to achieve the dual mandate.[23]

In our model, FG operates in a large part via the expectations of financial market participants, wage setters, and price setters. Knowledge that policymakers will keep the policy rate low for many years puts downward pressure on the real longer-term interest rates that stimulate economic activity in the model, as does the expectation that inflation will return to, and possibly exceed for a time, the 2 percent goal. However, price and

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[21] See, for example, Feiveson and others (2019), distributed to the Committee last year.

[22] Other macroeconomic models have more frontloaded macroeconomic effects than is the case with the FRB/US model. Often, a key problem regarding results obtained with these models is that the effects of FG on economic outcomes upon announcement are implausibly strong. See, for instance, Carlstrom, Fuerst, and Paustian (2015).

[23] In addition, maintaining highly accommodative policies over extended periods could heighten financial stability risk. See Goldberg and others (2020) for a discussion of the financial stability implications of monetary policy strategies and tools.

wage setters might not be as forward-looking as we have posited, in which case FG would be less effective at raising prices and wages in the near to medium term. Rather, achievement of the 2 percent inflation goal would rely, to a greater degree, on policymakers engineering a prolonged period of tight resource utilization. We explore this possibility in Appendix A by simulating some of our FG measures under the alternative assumption that the expectations of price and wage setters are informed solely by the historical comovement among data indicators. We find that, under the April Tealbook baseline, returning inflation to the 2 percent objective requires keeping the federal funds rate at the ELB for longer than is the case under our baseline assumption about expectations formation.

A related concern is that private-sector agents may not fully understand the data-dependent implications of outcome-based FG, thus reducing its potency. By contrast, the relative simplicity of "calendar-based" FG, under which policymakers delay departure from the ELB at least until some pre-announced future date, may facilitate the formation of private-sector expectations consistent with the guidance. Indeed, the adoption of calendar-based FG in August 2011, when the Committee stated that "economic conditions […] warrant exceptionally low levels of the federal funds rate at least through mid-2013," led to a rapid realignment of policy rate expectations.[24] But whether policymakers pursue outcome-based or calendar-based FG, communications about the likely course of policy many years into the future could inadvertently result in a misunderstanding of policymakers' intentions. For example, a policy announcement might fail to ease financial conditions if, say, private-sector agents receive the policy communication as a signal that the economic outlook is weaker than they had assumed.

In our simulations, policymakers improve economic outcomes over the medium term by promising to maintain low policy rates many years into the future, possibly even beyond when inflation and the unemployment rate have returned to their longer-run levels. Such strategies raise time-inconsistency concerns: Some of the benefits of FG announcements are realized early on, but they require convincing the public that the economy will be allowed to overheat later, at a time when policymakers would appear to

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[24] That said, as discussed in Swanson and Williams (2014), the adoption of calendar-based FG in August 2011 predates the introduction of the "dot plot" in the SEP in January 2012. The dot plot offered another means of communicating FOMC participants' views about the appropriate course of the federal funds rate. In addition, because uncertainty about the evolution of the economy increases with the time horizon, the unconditional nature of calendar-based FG may an important shortcoming if policymakers want to influence policy rate expectations beyond just a couple of years while retaining some ability to respond to unexpected shocks affecting their outlook. See also Campbell and others (2019) for a discussion of the relative merits of outcome-based and calendar-based specifications of the FG.

have no incentive to follow through on their promises.[25] If, however, private-sector agents cannot be fully persuaded that future policymakers will follow through, perhaps in light of such time-inconsistency problems, then the effectiveness of the FG will be attenuated, leading to poorer economic outcomes.[26] To reinforce FG, policymakers could deploy additional tools to provide reassurance to market participants that they intend to maintain accommodative financial conditions. One such tool, described in the next section, consists of LSAPs, a measure that is thought to have reinforced FOMC guidance about the policy rate during the global financial crisis.[27]

Although all outcome-based FG specifications shown in Figures 1a and 1b entail large deviations from maximum employment for several years and relatively smaller, but often persistent, inflation misses from the 2 percent goal, policymakers may see some specifications as more appropriate than others in pursuit of their dual mandate goals. At a normative level, which FG specification is most appropriate depends on the costs that policymakers attach to current and future deviations from their 2 percent inflation goal and from their assessments of the maximum level of employment. Because the economy is dynamic, such normative judgments further depend on policymakers' economic outlook and attendant risks and uncertainty. The "Monetary Policy Strategies" section of Tealbook A provides some benchmarks for optimal policy under the assumption that policymakers' preferences can be captured by simple loss functions.[28] We have reproduced these benchmarks in our Appendix B. In short, when policymakers in the model assign small or no losses to the unemployment rate falling to low levels, the optimal policy features a later departure from the ELB than in the Tealbook baseline, a tighter labor market over the medium term and beyond, as well as a moderate overshoot of the inflation objective. By contrast, when policymakers in the model see a fall in the unemployment rate below the natural rate as costly, the optimal policy generally seeks to contain resource tightness and the accompanying overshoot of the inflation goal.

Finally, as our simulations of the "Second Wave" scenario illustrate, if price and wage setters are as forward-looking as we assume, then satisfying a specified macroeconomic threshold may require additional commitments regarding the path of the

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[25] As discussed in a memo to the FOMC last year (Duarte and others, 2019), maintaining a reputation might provide the missing incentive to follow through with the initial commitment.

[26] For a discussion of the time-inconsistent challenges associated with FG and policy strategies more generally, see Duarte and others (2019).

[27] Controlling interest rates at various maturities through yield caps or targets would be another way to reinforce the FG. Staff will discuss the Federal Reserve and foreign experience with this alternative tool in a separate memo being prepared for the June 2020 FOMC meeting.

[28] The concept of optimal control employed in Tealbook A is one in which current policymakers are able to commit future policymakers to their plans and both policymakers and the public have perfect foresight.

federal funds rate after departure from the ELB.[29] For a threshold to shape expectations appropriately, it may therefore be important that policymakers credibly communicate their policy intentions regarding the period after reaching the threshold—and also that these intentions be supportive of the economic outcomes that they seek to achieve.

LSAP programs

Next, we simulate the provision of further policy accommodation through open-market purchases of Treasury securities and agency MBS. To this end, we solve jointly the FRB/US model and a detailed model of the Federal Reserve's balance sheet and its effects on financial conditions. Our simulations embed the assumption that price setters, wage setters, and financial market participants know the size and composition of asset purchases from the outset, along with their macroeconomic implications. Through asset purchases, policymakers in the model reduce, for any given path of Treasury securities and MBS supply, the total duration risk faced by private investors—a reduction that, in turn, puts downward pressure on term premiums and longer-term borrowing rates, thereby supporting economic activity and a return of inflation to 2 percent.[30]

Description of LSAP programs

We consider two illustrative LSAP programs in which the Federal Reserve would announce the purchase of Treasury securities and agency MBS. These illustrative programs are assumed to start in the middle of this year.

- In "LSAP program 1," we assume that policymakers purchase securities at a pace of $110 billion per month for 12 months.[31] As a result, the Federal Reserve's Treasury and agency MBS holdings expand about $1.3 trillion (6.2 percent of GDP) more than assumed in the April Tealbook.

- Under "LSAP program 2," policymakers purchase securities at a pace of $150 billion per month for 18 months. The Federal Reserve's Treasury and agency MBS holdings increase about $2.7 trillion (12.8 percent of

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[29] Experience with simulations under thresholds suggests that such constraints arise quite commonly, even in not especially extreme or otherwise unusual scenarios.

[30] The combined model does not incorporate possible effects from modest purchases of agency CMBS and usage of the lending facilities.

[31] Because of growth in nominal GDP, purchases at a monthly rate of $110 billion have, all else equal, roughly the same term premium effects in our model as purchases at the monthly rate of $85 billion during the Federal Reserve's third LSAP program undertaken in 2012–2014.

GDP) more than assumed in the April Tealbook—roughly twice as much as under our "LSAP program 1."[32]

The assumed composition of purchases—roughly 60 percent in Treasury securities and 40 percent in agency MBS—is similar to the composition of asset purchases over the course of 2020 expected by the median respondent to the latest Desk surveys. Additionally, the assumed residual maturity composition is similar to that during the Federal Reserve's third LSAP program undertaken in 2012–2014, with purchases of Treasury securities being concentrated in securities with remaining maturities of no less than four years and having an average weighted duration of about 10 years.[33] As in the Tealbook baseline, we posit that maturing Treasury securities will be rolled over at auction; that principal payments received on agency MBS will be fully reinvested in agency MBS until the federal funds rate reaches 1.25 percent; and that reinvestment of principal payments ceases from this point until reserve balances have fallen to near 8¼ percent of nominal GDP. For now, we assume that the LSAP programs are deployed alongside FG in which the Committee states that the policy rate will remain at the ELB until the unemployment rate has fallen to 4.3 percent, and then will follow the prescriptions of the conditional attenuated rule. (Below we also consider inflation thresholds.)

Broadly speaking, we think of the staff's balance sheet assumptions in the April baseline, our first LSAP program, and our second LSAP program as capturing cumulative asset purchases that would, respectively, fall short of, roughly match, and exceed the expectations of market participants. Of course, market participants hold a wide range of views regarding future asset purchases by the Federal Reserve, and these views are evolving over time. Consequently, the comparisons just given should not be interpreted too literally. Below we discuss simulations that are conditional on the April Tealbook baseline only. Arguably, were the economic outlook to be as weak as it is in the "Second Wave" scenario, then even more forceful balance sheet measures than those described above might need to be explored.

Simulation results

The upper-right and middle-right panels of Figure 2 show the total assets held by the Federal Reserve and the total term premium effects (TTPEs) on the 10-year Treasury yield, respectively, for the two LSAP programs and the April Tealbook baseline. Under

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[32] Our "LSAP program 1" and "LSAP program 2" are smaller and larger, respectively, as a share of GDP than the 2012–2014 LSAP program, at 9.6 percent of 2013 GDP.

[33] By comparison, for the market functioning asset purchases conducted since March, the Desk has bought Treasury securities across a broader range of residual maturities. The weighted average duration of these purchases is about 6 years.

"LSAP program 1," the extra asset purchases exert notable downward pressure on term premiums in the model: The 10-year TTPE is about 30 basis points more negative, on average over the next three years, than under the April Tealbook baseline. These purchases result in more accommodative financial conditions than in the staff baseline projection.[34] Consequently, the unemployment rate (shown in the middle-left panel) declines a bit faster over the medium term than under the Tealbook baseline, hastening the departure of the federal funds rate from the ELB. In addition, core inflation (shown in the lower-left panel) is almost 15 basis points higher than under the Tealbook baseline over the medium term.
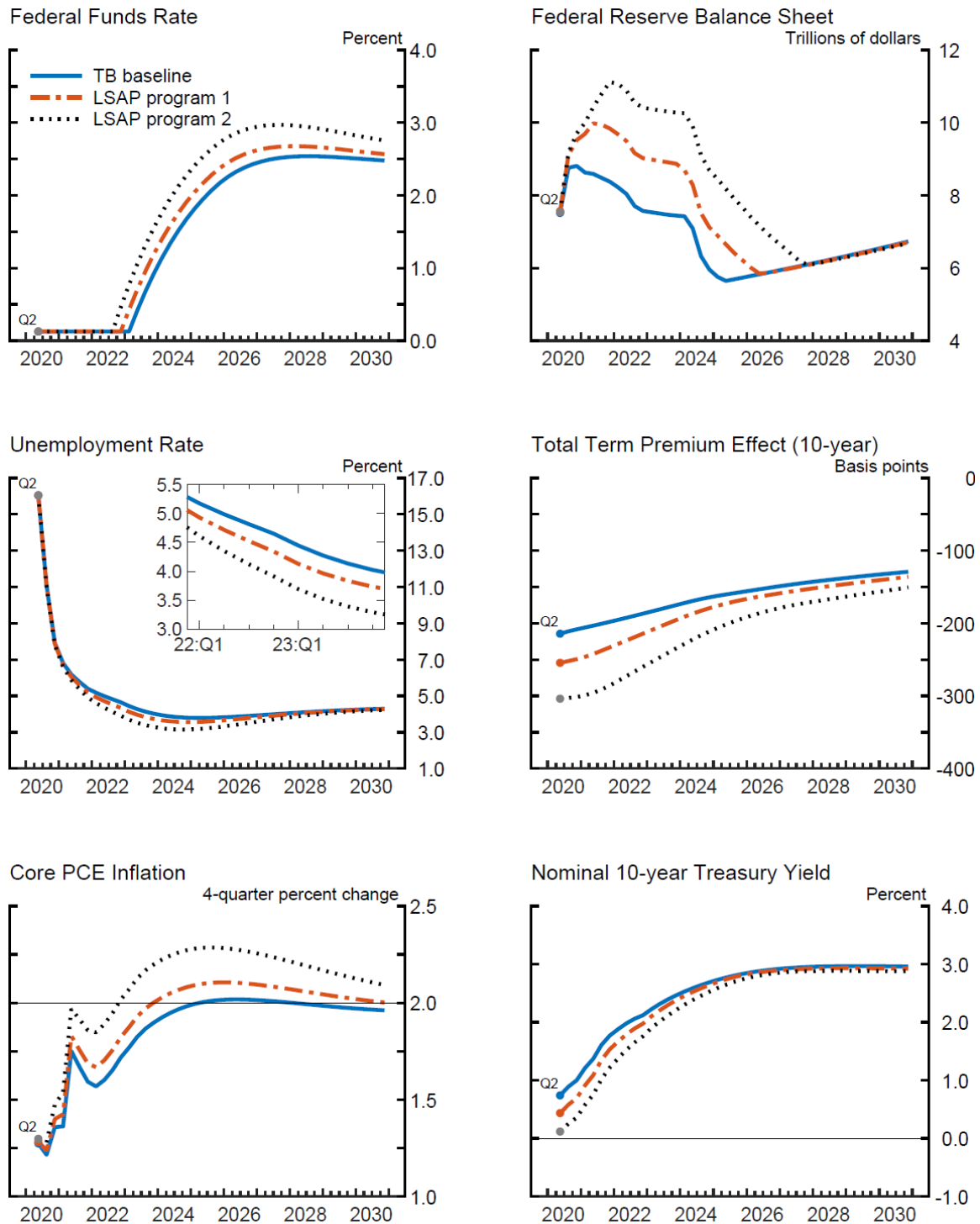
Under "LSAP program 2," the additional asset purchases make the path of the TTPE on the 10-year Treasury yield about 35 and 65 basis points lower in the medium term than the corresponding paths under "LSAP program 1" and under the April Tealbook baseline, respectively. Because of the more aggressive LSAP policy, the unemployment rate declines a touch more than under "LSAP program 1" over the next several years, while inflation runs about 15 basis points higher, peaking at 2¼ percent in 2025. Consistent with this stronger economic outlook, the federal funds rate departs from the ELB half a year sooner than under the April Tealbook baseline.

In Figure 3, we report simulations of our "LSAP program 2" but replace the criterion for departure from the ELB with either a 2 percent or a 2¼ percent core inflation threshold. Under a 2 percent threshold, we obtain essentially the same policy rate path and macroeconomic outcomes as those under the unemployment rate threshold of 4.3 percent (the "LSAP program 2" simulation shown in Figure 2). This similarity is in contrast to the FG simulations shown in Figure 1a, in which the use of a 2 percent core inflation threshold materially delayed departure from the ELB compared with the 4.3 percent unemployment rate threshold in the April Tealbook baseline. The reason for this similarity is that forward-looking price and wage setters anticipate the extra monetary accommodation stemming from asset purchases. This anticipation hastens the return of inflation to 2 percent, a development that would otherwise lag the closing of the unemployment rate gap.[35] Under a 2¼ percent inflation threshold, departure from the ELB is a few quarters later than under the 2 percent inflation threshold—a difference in policy accommodation that leads to a modestly lower path of the unemployment rate and a slightly higher inflation path.

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[34] However, we emphasize that the effect on actual financial conditions of an announcement of a measure like "LSAP program 1" would be uncertain. As noted earlier, respondents to the Desk surveys widely expect the Federal Reserve to continue to purchase assets beyond June, which suggests that financial quotes already embed the anticipation of further asset purchases. However, these expectations are quite dispersed and evolving.

[35] Expectations of higher inflation also help overall: the higher path for inflation helps lower the real longer-term rates that are key drivers of economic activity in the model.
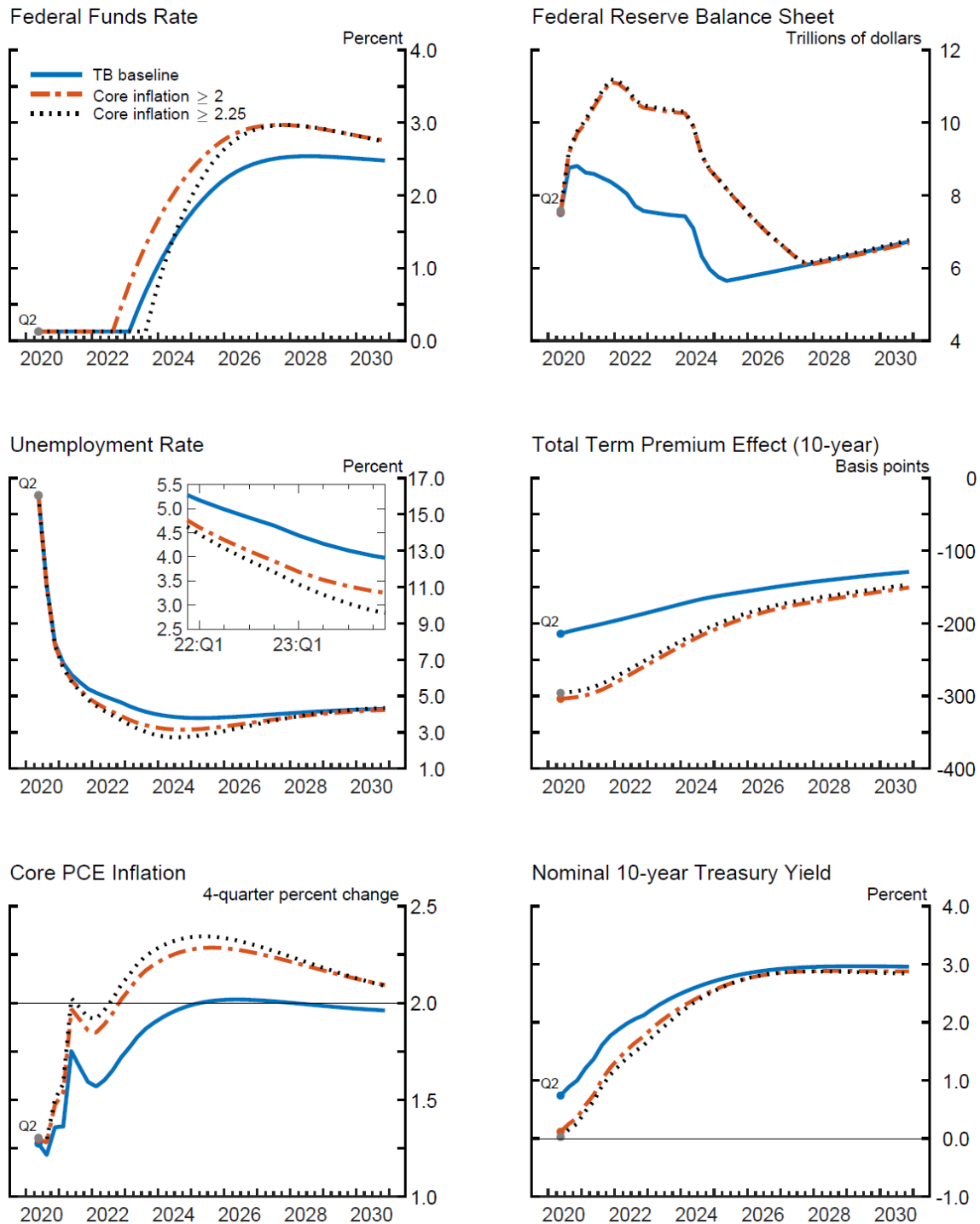
Figure 2: Large-scale asset purchases

Federal Funds Rate

Percent

- TB baseline
- LSAP program 1
- LSAP program 2

Federal Reserve Balance Sheet

Trillions of dollars

Unemployment Rate

Percent

Total Term Premium Effect (10-year)

Basis points

Core PCE Inflation

4-quarter percent change

Nominal 10-year Treasury Yield

Percent

Note: Simulations of FRB/US model conditioned on the April Tealbook.
Source: Staff calculations.

Figure 3: LSAP program 2 with FG in the form of core inflation thresholds

Federal Funds Rate

Federal Reserve Balance Sheet

Unemployment Rate

Total Term Premium Effect (10-year)

Core PCE Inflation

Nominal 10-year Treasury Yield

Note: Simulations of FRB/US model conditioned on the April Tealbook and "LSAP program 2."
Source: Staff calculations.

Further thoughts and caveats on LSAPs

In contrast to our FG simulations, in which the amount of policy stimulus depended explicitly on economic outcomes, we have considered LSAP programs of predetermined sizes, in a manner reminiscent of the Federal Reserve's first and second LSAP programs and its maturity extension program, which were implemented in response to the global financial crisis and slow subsequent economic recovery. Alternatively, policymakers could make their asset purchases conditional on achieving specific economic outcomes—for example, by announcing that they will purchase securities at a specified monthly rate until they have achieved some measures of progress on the employment and inflation fronts (a "flow-based" or "open-ended" purchase program).[36] In our perfect-foresight simulations, the distinction between fixed-size and flow-based LSAP programs is largely immaterial because the two approaches can be designed to achieve essentially the same macroeconomic outcomes. In practice, however, the announcement of outcome-based policy measures may be an advantage or a disadvantage, depending on public understanding. As was the case with threshold-based FG, if the public understands the data-dependent nature of policymakers' purchase decisions, then the policy measure acquires an important automatic-stabilizer property. That said, the conditionality of policy commitments in unprecedented economic conditions may not be clear, and so the effectiveness of the announced policy may be reduced.[37] In addition, policy actions predicated on outcomes several years into the future may be seen as less likely to be fully realized—especially if achievement of these outcomes entails some degree of judgment—than announcements of fixed-size programs. As the Federal Reserve's experience suggests, households and businesses may come to expect that policymakers will follow a data-dependent approach even if policymakers announce a fixed-size program—so that, say, a deterioration in the economic outlook would generate expectations of further policy actions.

In generating our simulations, we have assumed the standard financial and macroeconomic effects of balance sheet policies. However, many of the factors noted in our discussion of FG that might reduce the sensitivity of aggregate spending to movements in interest rates during a pandemic also apply here. For example, activities sensitive to longer-term interest rates, such as automobile and home purchases, might be difficult to influence, at least over the next few quarters, because of mandatory social distancing and a general reluctance to engage in face-to-face interactions. A

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[36] For example, when the FOMC launched its third LSAP program in September 2012, the Committee stated that it "[if] the outlook for the labor market does not improve substantially, [it would] continue its purchases of agency mortgage-backed securities, undertake additional asset purchases, and employ its other policy tools as appropriate until such improvement is achieved in a context of price stability." See https://www.federalreserve.gov/newsevents/pressreleases/monetary20120913a.htm.

[37] For a thorough discussion of the benefits and costs of flow-based and fixed-size purchase programs, see Carlson and others (2019).

consideration with opposite implications is that our balance sheet model abstracts from transmission channels that may boost the potency of asset purchases. Most notably, because the course of the pandemic and economy are exceptionally uncertain, vigorous deployment of balance sheet measures may help private actors rule out some of the most catastrophic contingencies from their risk assessments, in turn mitigating financial stresses and providing reassurance to households and businesses. Indeed, it is plausible that the balance sheet measures already undertaken have had unusually large effects through such channels. As financial stresses wane and confidence stabilizes, however, future rounds of asset purchases may have financial and macroeconomic effects that, at the margin, resemble those observed during the aftermath of the global financial crisis and which inform the estimates of balance-sheet policy effects used in our simulations.[38] We also note that purchases of agency MBS reduce the convexity risk faced by private-sector investors—in which case there may be further downward pressure on term premiums, in a manner not captured by our model.

       Another key consideration is that longer-term interest rates were at or near historical lows going into the pandemic. For example, on the eve the pandemic, the 10-year nominal Treasury yield had been running somewhat below 2 percent for more than a year. The low level of longer-term interest rates has been traced back to a secular decline in the neutral real interest rate (a development that, all else equal, reduces nominal yields at all maturities) and to historically depressed terms premiums (which affect the level of the medium- to longer-term yields that policymakers seek to influence through LSAPs). In particular, the staff's estimate of the longer-run real neutral interest rate, at 50 basis points, has declined over 150 basis points in the past decade. The staff's current estimate of the term premium on 10-year Treasury securities, at roughly negative 80 basis points, is well below its assumed longer-run level, at positive 50 basis points. In such a low-interest-rate context, arbitrage opportunities available to portfolio holders may mean that longer-term nominal interest rates are subject to an ELB—a factor possibly limiting the ability of monetary policy to add downward pressure to nominal longer-term interest rates through LSAPs.[39] Although medium- to longer-term nominal yields stay positive in our simulations (with a handful of modest and short-lived exceptions), it bears emphasis that these rates could trend much lower if term premiums failed to rise back to their

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[38] A similar reasoning applies with regard to asset purchases in response to the global financial crisis. Estimates of the financial and macroeconomic effects of the Federal Reserve's first LSAP program in 2008–2009 tend to be larger than for subsequent programs. See Caldara and others (2019) for a discussion.

[39] Gagnon and Jeanne (2020) argue that the ELB on short-term rates also provides a lower bound on longer-term nominal rates, even when central banks have recourse to LSAPs. See also Marcel Priebsch (2020), "Does Central Bank Policy Imply a Lower Bound on Longer-Term Yields?," memorandum, Federal Reserve Board, March 31.

assumed longer-run value, or if the neutral real interest rate turned out to be lower than assumed by the staff (as some estimates are suggesting).

Finally, we note that the expansion of the Federal Reserve's balance sheet is taking place amid unusually high federal debt issuance because of the sharp cyclical deterioration in public-sector finances and the sizable fiscal stimulus measures taken to lessen the damage inflicted by the pandemic on the U.S. economy. The staff projects that the federal debt held by the public will reach 106 percent of GDP in fiscal year 2022— that is, 27 percentage points higher than in fiscal year 2019—and that greater Treasury debt issuance could put upward pressure on term premiums.[40] Under the staff's rules of thumb, the projected increase in the debt-to-GDP ratio lifts term premiums roughly 65 basis points. Compared with the staff's balance sheet assumptions on the eve of the pandemic, the expansion of the balance sheet assumed in the April Tealbook is estimated to depress term premiums in the near term by about 80 basis points and 20 basis points by the end of the decade. The projected effect of high public debt on term premiums is another reason why staff expects the 10-year nominal Treasury yield, which currently stands near 60 basis points, to remain positive in the Tealbook projection. That said, we note that elevated public debt has not prevented longer-term nominal yields on government debt securities from falling to near, or even below, zero percent in Japan and a number of European economies.

Conclusion

The pandemic has caused large departures from the FOMC's mandated goals of maximum employment and price stability, and these departures are likely to persist to some degree regardless of the Committee's policy actions. That said, the Federal Reserve's issuance of FG, asset purchases, and other policy measures have already helped support economic activity during the most intense phase of the crisis, and further policy actions could hasten improvement in labor market conditions and the return of inflation to 2 percent during the recovery. Regardless of the tools employed, achieving significant impacts on economic conditions necessitates commitments to accommodative monetary policy several years into the future. Indeed, in light of the severity of the economic downturn, the fragility of household and business confidence, the extreme economic uncertainty, and the historically low-interest-rate environment in which the

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[40] Treasury security issuance could put additional upward pressure on term premiums if concentrated at relatively long maturities. The average duration of Treasury security issuance during the 2008-2009 and early-1980s recessions was somewhat higher than for other, less severe past economic downturns. For a discussion, see the box "Measuring the Combined Effects of the Federal Reserve's Asset Purchase Programs and Treasury's Debt Management" in the Balance Sheet Projections section of the September 2019 Tealbook B.

FOMC operates, multiyear policy commitments are arguably central to the achievement of the dual mandate at the current juncture.

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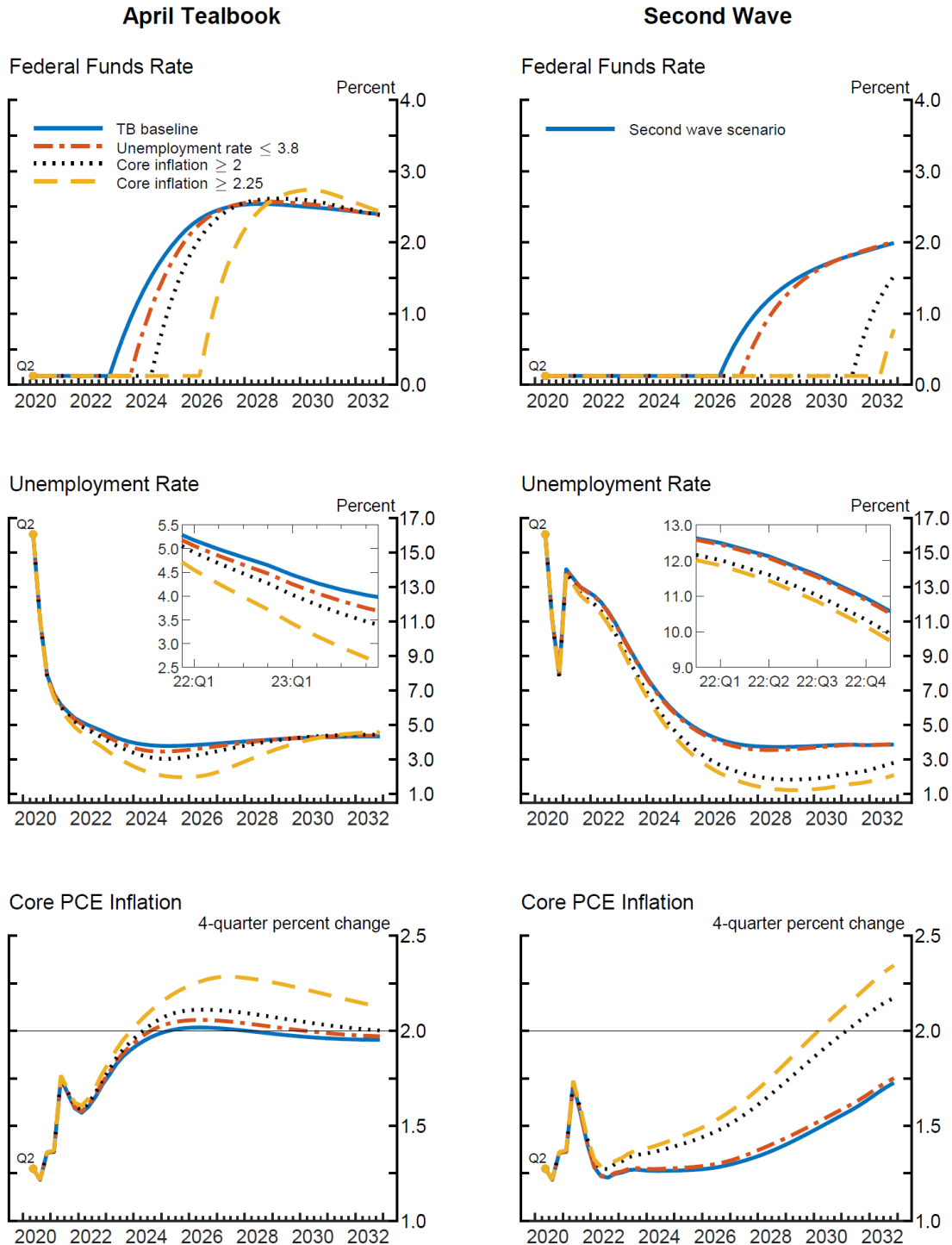
Appendix A: Outcome-based forward guidance under VAR-based expectations

This appendix explores the robustness of our main outcome-based FG simulations to assumptions about expectations formation by price and wage setters. In our main simulations, these decision makers have model-consistent expectations that are formed with knowledge of the structure of the economy and conduct of monetary policy. In this appendix, these decision makers' expectations are informed solely by the historical comovement among data indicators, as captured by small-scale vector autoregressions (VARs). That is, price and wages setters do not respond to FG beyond its effects on current and past economic conditions. We continue to assume that financial market participants are forward-looking.

Figure A1 shows the result associated with inflation thresholds of 2 percent and 2¼ percent. A key finding is that the assumption of VAR-based expectations slows the return of inflation to 2 percent because price and wage pressures build only gradually as realized resource slack diminishes. As a result, departure from the ELB under the inflation thresholds is delayed compared with the simulations shown in Figure 1 for forward-looking price and wage setters.

The rise in core inflation to the threshold levels occurs in a large part through increasingly tight resource utilization, with the unemployment rate falling to as low as 2 percent under a core inflation threshold of 2¼ percent. Once the inflation thresholds are met, the economic momentum is sufficient to keep core inflation rising for a time.

Figure A1: Forward guidance with selected inflation and unemployment rate thresholds when price and wage setters have VAR-based expectations

April Tealbook

Federal Funds Rate

Unemployment Rate

Core PCE Inflation

Second Wave

Federal Funds Rate

Unemployment Rate

Core PCE Inflation

Note: Simulations of FRB/US model conditioned on the April Tealbook baseline and the "Second Wave" alternative scenario.

Source: Staff calculations.

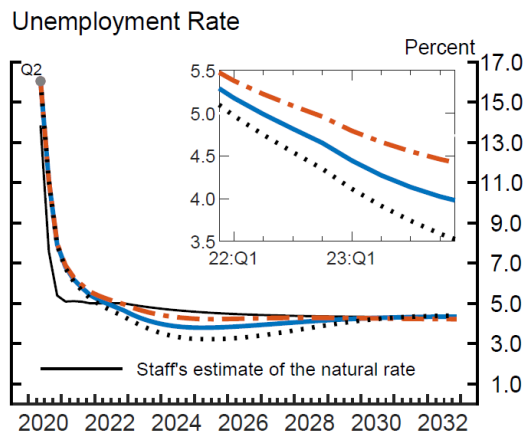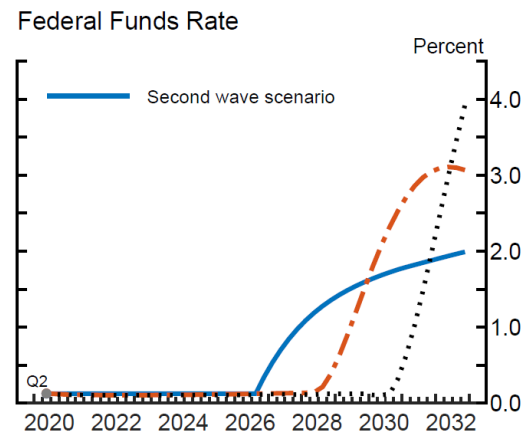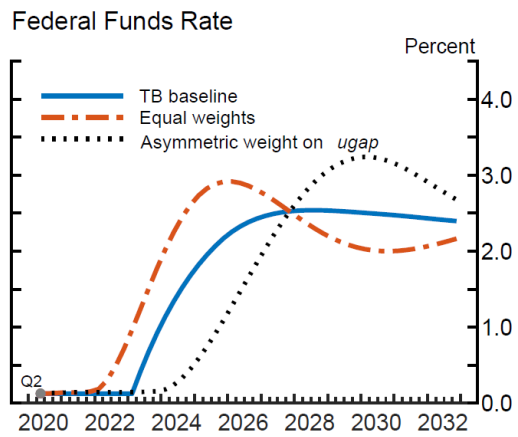## Appendix B: Optimal control simulations

This appendix displays optimal control simulations under two specifications of a simple loss function. These simulations differ on whether unemployment rates below the natural rate are viewed as costly by policymakers (as they are under "equal weights") or are not seen as costly (as in the "asymmetric weight on *ugap*" case).[41] In the "Second Wave" scenario, an "equal weights" accommodative policy is maintained and leads eventually to a persistent decline in the unemployment rate below its natural rate, though not to the extreme extent that prevails under asymmetric preferences.

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[41] A description of the loss functions and their motivation can be found in the appendix of the "Monetary Policy Strategies" section of Tealbook A.

Figure A2: Optimal control simulations

April Tealbook

Second Wave

Note: Simulations of FRB/US model conditioned on the April Tealbook baseline and the "Second Wave" alternative scenario.

Source: Staff calculations.