August 30, 2019

How Robust Are the Alternative Strategies to Key Alternative Assumptions?[1]

Under the current policy framework, the Committee may not be able to provide sufficient support for economic activity or prevent persistent undershooting of its inflation objective when the effective lower bound (ELB) of the federal funds rate is binding for a protracted period.[2] As discussed in the companion memo, "Alternative Strategies: How Do They Work? How Might They Help?," better economic outcomes might be achieved by alternative monetary policy strategies that aim to offset, at least in part, past misses of inflation from its objective. These strategies are broadly referred to as "makeup strategies." In this memo, we analyze the robustness of such strategies with particular focus on ways in which the public might form expectations of future economic developments.

Makeup strategies work best when the public understands, believes, and reacts to policymakers' commitment to offset misses in inflation from the 2 percent objective in the future. In particular, makeup strategies are most powerful when policymakers can influence the public's inflation expectations. In doing so, policymakers face a dynamic tension: maintaining long-run inflation expectations around the 2 percent objective while, at the same time, moving shorter-run inflation expectations in response to the new strategy. Given the centrality of these expectations, our memo begins by surveying some empirical evidence. Measures of long-run inflation expectations appear to be well anchored. However, recent evidence from surveys also suggests that long-run inflation expectations respond to persistent changes in realized inflation, and could therefore become unanchored if the current low inflation environment persists. On short-run inflation expectations, a body of research has documented that these expectations seem to react to new information more slowly and to a lesser extent than assumed in most theoretical models.

Informed by these empirical findings, we examine how makeup strategies—with an emphasis on average inflation targeting (AIT), as in the companion memo—perform in variants of the FRB/US macroeconomic model under various assumptions about

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[2] See Caldara and others (2019).

expectations formation. In general, we find that makeup strategies can moderately offset the real effects of adverse economic shocks. This feature holds true even when much of the public is uninformed about the monetary strategy, so long as financial market participants understand and believe policymakers' commitment to the strategy. However, to the extent that the public is uninformed about (or does not believe in or act on) the commitment to a makeup strategy, policymakers will have to respond to an initial period of low inflation with aggressive policy accommodation in order to implement the strategy, potentially leading subsequently to a substantial overheating of the economy and a sustained period of inflation above the 2 percent objective.

We also examine the risk that the adoption of a makeup strategy, which aims to influence short-run inflation expectations, could inadvertently unanchor long-run inflation expectations. In particular, a commitment to (persistently) overshoot the 2 percent inflation objective could lead to an increase in long-run inflation expectations and result in a longer period of inflation above 2 percent than intended. This risk is particularly salient for asymmetric variants of the AIT rule, under which policymakers do not react to average inflation above 2 percent.

Next, we examine the effectiveness of makeup strategies when the public only gradually comes to learn and understand policymakers' strategy by observing their actions. In this case, the timing of the adoption of a makeup strategy matters because the strategy's ability to mitigate undershooting of the inflation objective depends on how long the public has been able to observe policymakers' adherence to the new strategy. Early adoption of the makeup strategy is advantageous when the federal funds rate is likely to be constrained by the ELB, which would limit the public's discernment of changes in policymakers' strategy. It is only when the public has had some opportunity to observe policymakers' commitment to making up for past misses in inflation that this commitment becomes effective in mitigating low inflation.

In the final part of the memo, we briefly discuss the robustness of makeup strategies to other key aspects of the economy beyond expectations. In particular, we examine how makeup strategies perform under different assumptions about the relationship between inflation and economic slack—the slope of the Phillips curve—and in the face of potential misperception of the natural rate of unemployment by policymakers.[3] A steeper Phillips curve (that is, when inflation is more responsive to economic slack) would enhance the power of these strategies, though in such a world conventional inflation targeting would also perform well. If the Phillips curve were instead flatter, meeting the inflation objective would require substantial overheating of the economy, a situation similar to the one that

[3] See Andrea Ajello and others (2019). This memo also considered monetary policy in the context of changes in the slope of the Phillips curve and an uncertain natural rate of interest. Here we focus on the interaction between such factors and makeup strategies.

emerges when the public poorly understands or is poorly informed about policymakers' commitment to a makeup strategy. Uncertainty about the natural rate of unemployment poses less of a challenge for makeup strategies than inflation targeting strategies, as makeup strategies implicitly correct, to some extent, policy errors induced by misperception of slack in the economy.

Empirical Evidence on Expectations and Monetary Policy

The empirical literature on how expectations are formed and respond to new information is vast. Here, we summarize some of its broad conclusions and highlight findings related to inflation expectations that are particularly relevant for the implementation of makeup strategies.

The inflation expectations of a wide variety of economic agents—consumers, firms, professional forecasters, and financial market participants—can be measured either directly through surveys or indirectly from asset prices. A growing body of research has shown that survey measures of inflation expectations can be meaningfully related to households' and firms' economic decisions and co-move in sensible ways with aggregate variables.[4] However, they also behave differently than typically assumed in economic models, in ways that bear on the efficacy of the makeup strategies we consider.

Because the attractiveness of makeup strategies depends both on short-run inflation expectations being responsive to policy and on long-run expectations remaining close to the 2 percent target, we focus on evidence on two main aspects of expectations: (1) the extent to which long-run inflation expectations are currently "anchored," and the possibility that they may become unanchored, and (2) the degree to which short-run inflation expectations respond to news and, particularly, to policy changes.

The anchoring of long-run inflation expectations

It is highly desirable that long-run inflation expectations be anchored to the explicit target set by the central bank. Well-anchored inflation expectations enable the central bank to stabilize the real side of the economy. When long-run inflation expectations are well anchored, economic shocks will have a smaller effect on expected inflation, and ultimately

[4] For example, Malmendier and Nagel (2016) show that households expecting higher inflation tend to enter into fixed-rate rather than floating-rate contracts. Gennaioli, Ma, and Shleifer (2015) show that Chief Financial Officers' expectations are related to firms' investment decisions. Crump et al. (2019) also show that inflation and spending growth expectations data from the Survey of Consumer Expectations (SCE) are mutually consistent through the lens of a consumption Euler equation. Fuhrer (2017) shows that the slow-moving behavior of expectations is better able to account for persistence in aggregate data than other modeling elements typically used to generate slow adjustment.

on actual inflation and economic activity.[5] The anchoring of long-run expectations can also reflect the public's understanding of the central bank's inflation goals and confidence that they will be achieved. Researchers have used various empirical definitions of "well anchored" long-run inflation expectations, including (1) average economic agents' beliefs about inflation remaining within some range of the central bank's inflation target; (2) low cross-sectional dispersion of forecasts around the target; (3) low subjective uncertainty in beliefs (measured from density forecasts) around the target; and (4) small forecast revisions and relatively little response of revisions to news. The evidence generally points toward long-run inflation expectations being better anchored in countries that have adopted an explicit inflation target as well as in recent decades for the United States.[6]

In the United States, the time series of many measures of aggregate inflation expectations (both short- and long-term expectations) fell from very high levels in the 1980s and stabilized in the neighborhood of 2 percent starting in the late 1990s, mirroring a similar fall in realized inflation, as can be seen from both panels in exhibit 1.[7] This behavior is consistent with the first definition of "well anchored" in the preceding paragraph. Some observers have pointed to the slight downward drift in the level of inflation expectations over the past few years as evidence of a potential recent deterioration in the anchoring of inflation expectations. However, cross-sectional evidence from the Survey of Consumer Expectations (SCE) and the Michigan Surveys of Consumers (MSC) suggests that this downward drift stems from changes in the distribution of individual expectations that, according to the second definition of "well anchored" in the preceding paragraph, could be interpreted as better anchoring of expectations around 2 percent. Exhibit 2 shows that the share of individual expectations above 3 percent has been falling, the share between 1 percent and 3 percent has been rising, and the share below 1 percent has remained fairly stable. Thus, the cross-sectional distribution of forecasts has become more symmetric and less dispersed around 2 percent.[8]

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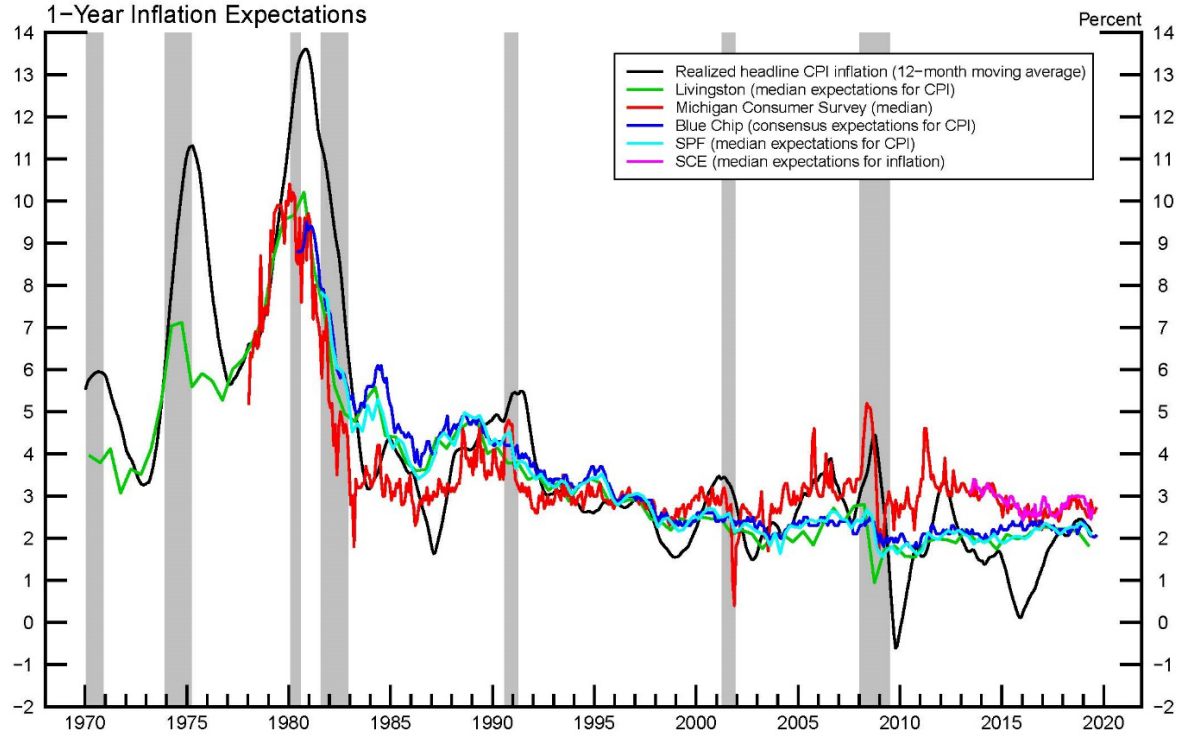
[5] In the simulations, both short- and long-run inflation expectations matter for current inflation through firms' price-setting behavior, but short-run expectations matter relatively more. The relative unimportance of long-run expectations is consistent with the findings in Fuhrer, Olivei, and Tootell (2012) and Fuhrer (2012).

[6] See Williams (2006), Gürkaynak et al. (2010), Fuhrer and Olivei (2010), Ball and Mazumder (2011), Beechey and others (2011), and Davis (2012). Kumar and others (2015) presents some evidence to the contrary among New Zealand firms.

[7] Board staff judges the level of long-term inflation expectations since the late 1990s to have been most consistent with underlying PCE inflation—defined as PCE inflation that would prevail in the absence of slack, idiosyncratic relative price changes, or supply shocks—that has been stable at 1.8 percent, a little below the FOMC's objective.

[8] Note that the expectations elicited in these consumer surveys are for general concepts of inflation, and have historically been above PCE inflation, which defines the current inflation objective.

Exhibit 1: Measures of Aggregate Inflation Expectations



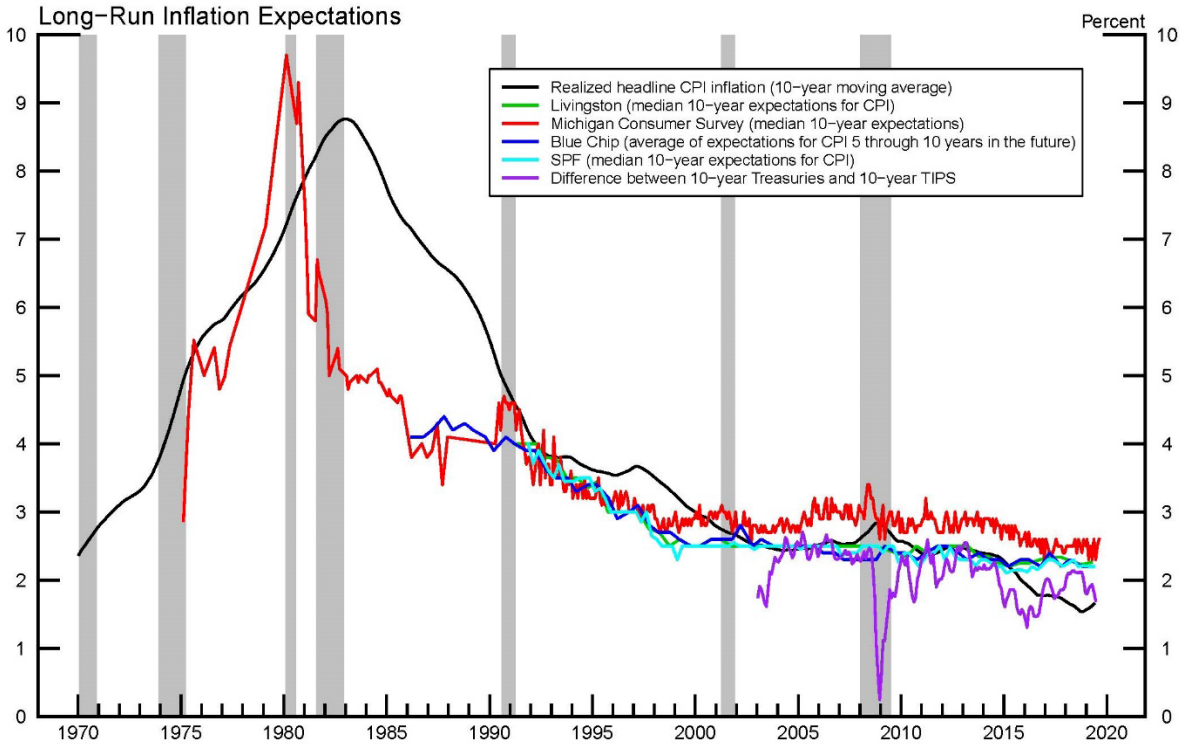
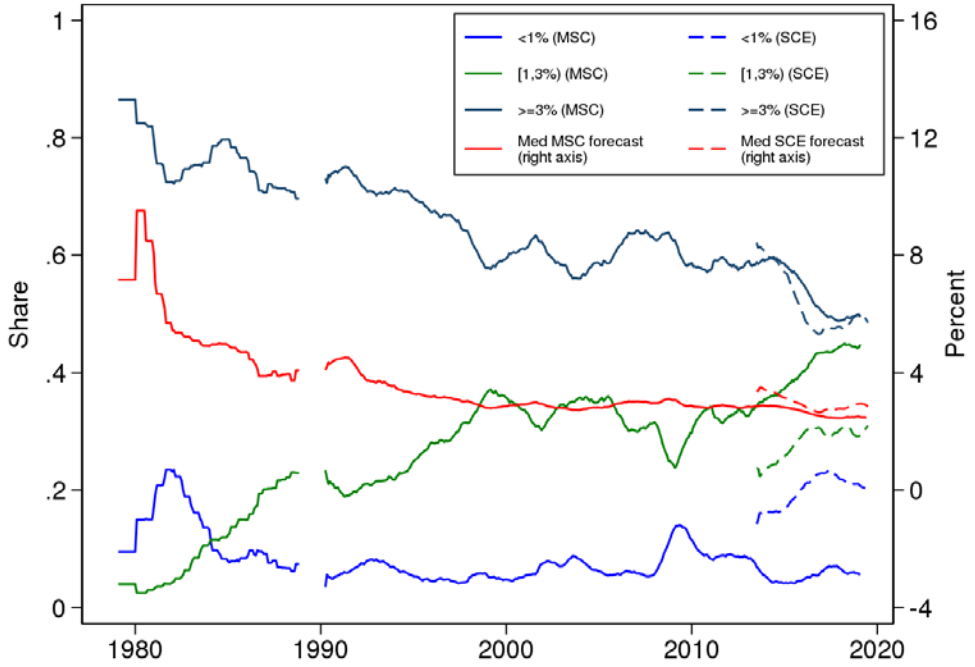


Exhibit 2: Cross-Sectional Evidence on Anchoring of Inflation Expectations



Note: 12-month moving averages for all series.

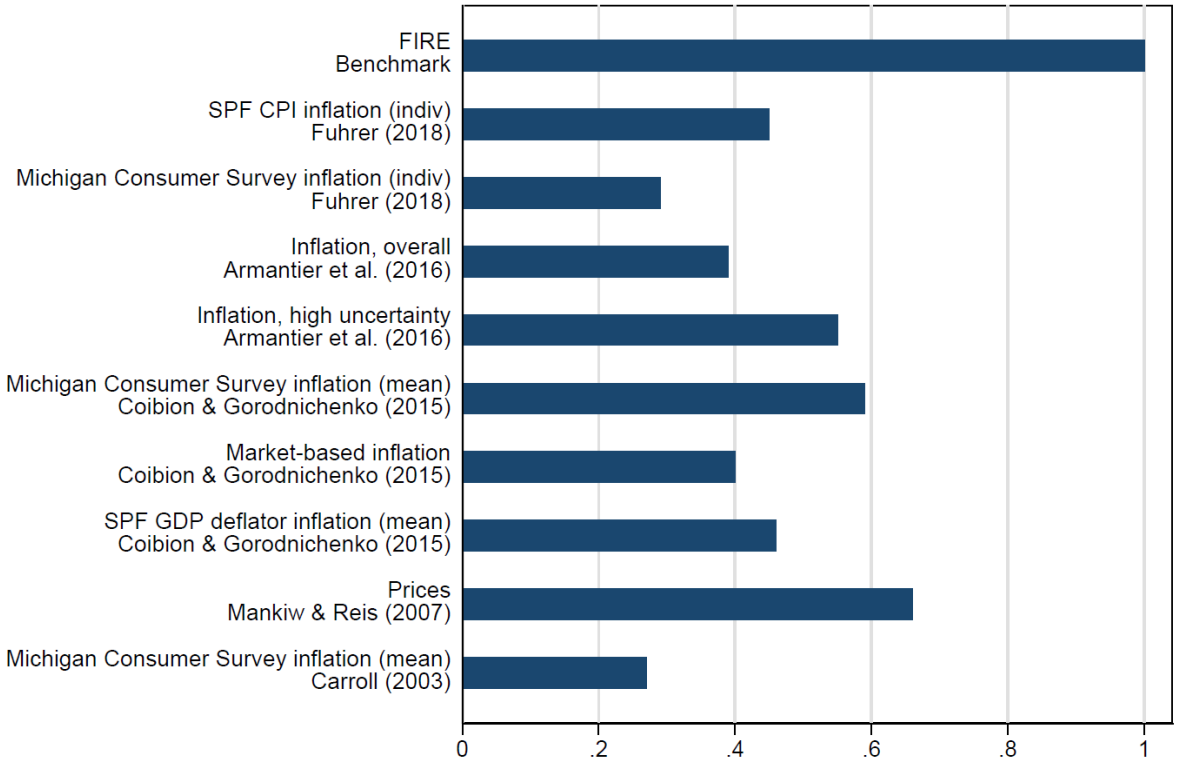
That said, survey evidence also suggests that long-run inflation expectations may respond to prolonged undershooting or overshooting of realized inflation. An experiment recently conducted in the SCE shows that while between one-third and two-fifths of respondents act as if their expectations were perfectly anchored, a majority of respondents do revise their five-year-ahead inflation expectations in response to sustained periods of unusually low or high inflation. Importantly, long-run inflation expectations appear less susceptible to unanchoring following prolonged *positive* inflation shocks.[9] This distinction suggests that the risk that a makeup strategy could inadvertently unanchor long-run expectations on the positive side of the 2 percent target may be limited.

There is some evidence that central bank communications also have the potential to affect long-run inflation expectations. Recent experiences in Norway and Sweden indicate that their central banks' emphasis on financial stability considerations around 2014, which resulted in somewhat tighter monetary policy actions, may have played a role in the observed decline of long-run inflation expectations in both countries.[10]

[9] See Armantier and others (2019) for additional details.

[10] See Williams (2014). For the United States, however, Detmeister and others (2015) find only limited reactions of inflation expectations in response to the FOMC's announcement of the 2 percent longer-run objective for PCE price inflation in January 2012.

Exhibit 3: Evidence of Underreaction of Inflation Expectations to News



Note: Each bar in the exhibit corresponds to a different empirical measure of underreaction of survey-based measures of expectations to news. The measures differ in their methodology and their underlying theory and datasets, but share the common implication that their value implied by theory is one under the assumption of full-information, rational expectations and in the absence of measurement error.

Dynamic properties of short-run inflation expectations

A large body of research shows that shorter-term inflation expectations (typically measured at the one-year-ahead horizon) respond to some degree and in a reasonable manner to new information. Crucially, though, these expectations do not adjust as quickly or as much as standard models adopting the so-called full information, rational expectations (FIRE) paradigm. Exhibit 3 summarizes some key estimates from the literature of the responsiveness of expectations, predominantly about inflation in the short run. While there are some differences, the general conclusion is that expectations adjust to "new information" by a bit less than half the amount typically assumed in standard macroeconomic analysis.[11]

[11] Coibion and Gorodnichenko (2015) present time-series evidence in this direction. Armantier and others (2016), using an information treatment experiment, find that a significant proportion of respondents

There is also evidence that inflation expectations are responsive to policy decisions. In particular, Federal Reserve communications in the wake of the Great Recession, mainly forward guidance (FG), lowered expectations of the future path of the federal funds rate.[12] The effects of FG on growth and inflation expectations are more difficult to assess because they depend on the public's interpretation of the guidance. An unexpected loosening could lower inflation expectations if the public interpreted this action as the Federal Reserve predicting a weak economy in the future.[13] If the public instead saw the change as simply reflecting a more accommodative policy stance, inflation expectations would be expected to rise.[14]

Translation of empirical findings into economic models

Economists have proposed a range of models of expectations formation that are broadly consistent with the empirical evidence discussed earlier. Although there is no consensus on the most suitable expectations framework for macroeconomic modeling, many of the alternatives share common macroeconomic implications, in particular that short-run expectations underreact to news relative to standard models. In studying the implications of the behavior of expectations for the efficacy of alternative policy strategies, we will adopt modeling frameworks that capture this underreaction and also consider the possibility that individuals only slowly learn about the shift to a new policy strategy.

The Efficacy of Makeup Strategies under Alternative Assumptions about Expectations Formation

As noted above, in many macroeconomic models the expectations effect associated with makeup strategies is quite powerful. These models typically assume that the public fully understands the implications of the central bank's strategy for inflation, output, and employment and believes that the central bank will follow through on its commitment to allow a persistent overshooting of inflation. Such assumptions imply that current economic

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(about 40 percent) do not update their expectations following the receipt of new information. Those who do respond do so only partially, adjusting their short-term expectations by 39 basis points for a 1 percentage point gap between their perceptions and the information provided. Fuhrer (2018) also finds evidence of significant underreaction to news using data from the Survey of Professional Forecasters (SPF), the European Central Bank SPF, and the Michigan survey.

[12] See, among others, Del Negro and others (2015) and Swanson (2017). Swanson (2017) also shows that FG reduced uncertainty around both short-run monetary policy and long-term bond yields.

[13] This effect has been referred to as the signaling, or information effect, of policy or as *Delphic* forward guidance in the language of Campbell and others (2012). During the Great Recession, the information effect of FG seemed to be particularly prevalent during the initial periods of qualitative and calendar-based FG beginning in December 2008, in contrast with the later threshold-based FG that was introduced in December 2012 (see Del Negro, Giannoni, and Patterson 2015, Stavrakeva and Tang (2018), and Andrade et al. (2019)).

[14] This topic will be discussed further in a subsequent memo to the Committee.

conditions, in particular inflation, are strongly affected by news about the future, which, as discussed earlier, may overstate the strength of the expectations channel. In this section, we examine the robustness of makeup strategies to alternative assumptions about expectations formation.

A wide range of specific policy rules can be considered makeup strategies. In the simulations in this section, we follow the companion memo and focus attention on average inflation targeting (AIT) strategies. AIT rules are defined by two key features: the size of the makeup window and whether the policy is symmetric—that is, whether policymakers respond to average inflation above and below the 2 percent objective in the same fashion. The length of the window is set to eight years. To give a sense of how the effectiveness of makeup strategies can depend on the interaction between window length and the public's expectations, in the first set of simulations we also consider a price-level targeting (PLT) rule as a reference representing a window length that grows indefinitely. We focus on the symmetric version of the AIT rule. The subsequent simulations all feature prolonged periods of low inflation, so both the symmetric and asymmetric versions of the AIT rule yield similar prescriptions. An exception is the simulation featuring the unanchoring of long-run inflation expectations; in that simulation, we analyze both symmetric and asymmetric AIT.[15]

Alternative assumptions about expectations formation

In the first simulation, we use the FRB/US model to assess the performance of makeup strategies under four alternative assumptions about the expectations formation process. The FRB/US model allows decisionmakers in different sectors of the economy—for example, consumers or financial market participants—to be endowed with either *model-consistent* expectations (MCE) or *VAR-based* expectations. If decisionmakers have model-consistent expectations, they anticipate correctly—absent subsequent shocks—the future evolution of the economy and monetary policy. Conversely, if decisionmakers have VAR-based expectations, they instead form expectations using small-scale statistical (vector autoregressive) models that capture the broad correlations in historical data without imposing specific economic theories. Such expectations proxy a situation in which the public does not understand the full structure of the economy and hence cannot anticipate the implications of policymakers' intention to make up for past deviations of inflation from its objective.[16] By varying the number of decisionmakers (and hence components or blocks) in the FRB/US model who use VAR-based rather than model-consistent expectations, we can adjust the extent to which the public understands policymakers' commitment to a makeup

[15] The appendix contains additional details on the implementation of the various rules in FRB/US.

[16] The VARs are estimated using historical data, thus implicitly embedding expectations and behavioral responses under the current monetary regime. Under such expectations, decisionmakers do not learn; that is, the coefficients of the VAR are not re-estimated in response to new data. A simulation in which the public can learn about the new policy regime is considered subsequently.

strategy and the degree to which aggregate economic variables react to news about the future. To span the range of behavior from complete reaction to complete lack of reaction, we consider four different settings: MCE, where all decisionmakers have model-consistent expectations; MCAPWP, where financial market participants and wage and price setters have model-consistent expectations while everyone else forms VAR-based expectations; MCAP, where only financial market participants have model-consistent expectations; (completely) VAR-based expectations, where everyone has VAR-based expectations.[17]

Exhibit 4 displays the simulated paths for the federal funds rate, unemployment rate, and core PCE inflation rate in response to a large negative shock under both AIT (left column) and PLT (right column). In the recession baseline, the fall in demand causes a large, sustained increase in unemployment and contributes to the initial disinflation. [18] For both AIT and PLT, under the MCE (red lines), MCAPWP (yellow lines), and MCAP (blue lines) settings, the stabilizing features of makeup strategies described in the companion memo are apparent: The initial increase in unemployment is smaller relative to the recession baseline, as enough of the public anticipates the extended period of accommodative policy. Note, the makeup strategy is not a panacea—unemployment still increases substantially and remains elevated for a prolonged period. The moderate beneficial effects stem from expectations about future policy. Under each of these settings for expectations, the anticipated future accommodation translates into higher expected inflation and, hence, higher current inflation and lower real interest rates relative to the baseline. The extent of the boost in inflation (bottom panels) is positively related to the degree to which the public understands the makeup rule.

For the MCE and MCAPWP simulations, this boost is relatively large; consistent with the earlier makeup of inflation misses, under both AIT and PLT the federal funds rate rises away from the ELB the earliest under these two expectations settings. The initial increase in inflation is attenuated under MCAP for both the AIT and PLT rules, but, as asset prices—in particular long-term interest rates—still react to the prolonged period of accommodation under the makeup strategies, real activity follows essentially the same trajectory as under MCE and MCAPWP early in the simulation.

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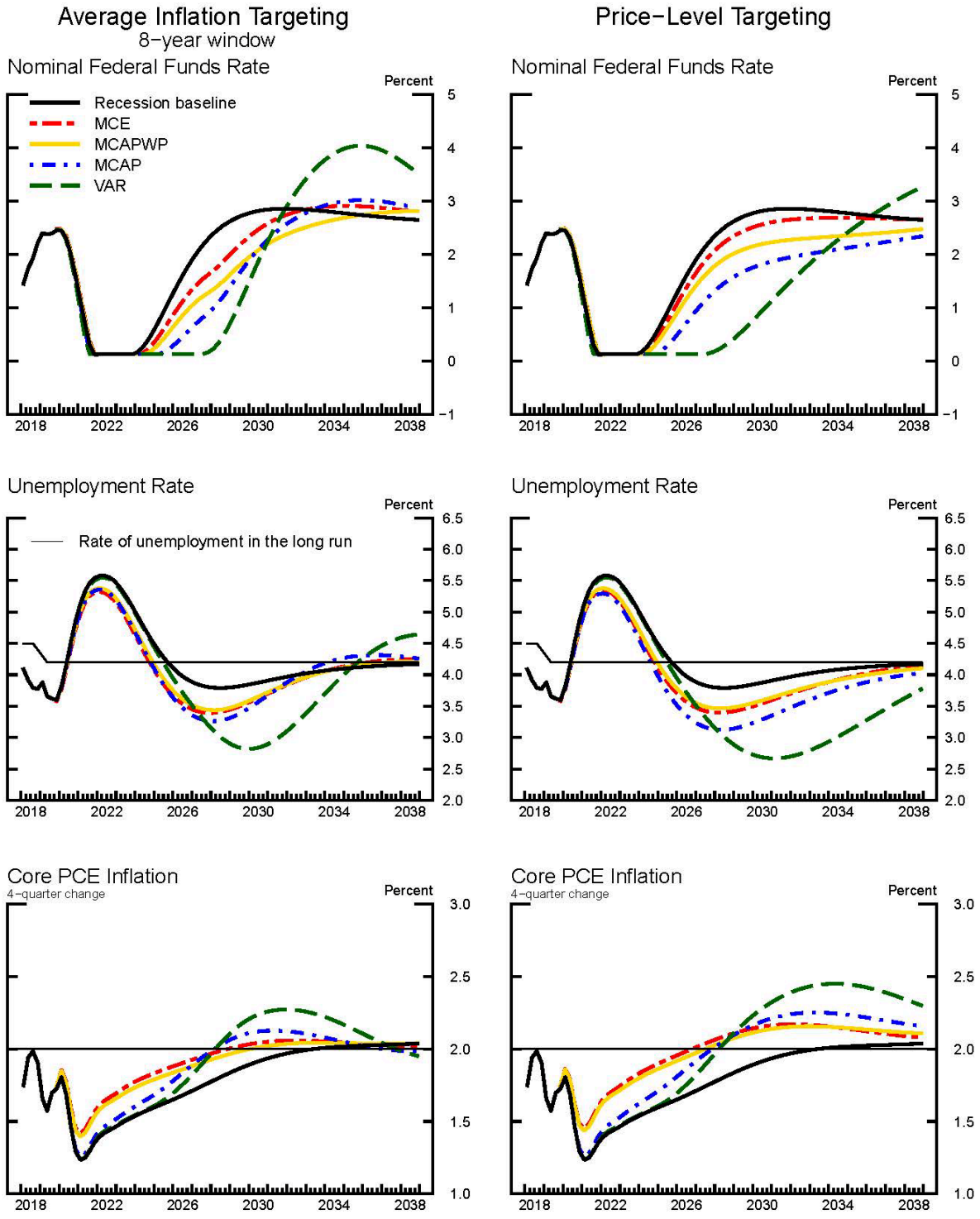
[17] The dichotomous nature of expectations settings in FRB/US makes it somewhat difficult to relate them back to the empirical evidence discussed above, but we can make a rough comparison using the movements in inflation expectations (after one year) in response to news about monetary policy two years in the future. Relative to the response under MCE—the FRB/US counterpart of FIRE—inflation expectations move approximately zero, 40, and 80 percent under VAR, MCAP, and MCAPWP, respectively.

[18] The recession baseline is identical to the mild recession scenario of the companion memo, and is constructed using both demand shocks and shocks to the FRB/US equation for core inflation. In this recession baseline, policymakers follow the inertial Taylor (1999) rule regularly featured in the Tealbook.

Exhibit 4: Alternative Assumptions on Expectation Formation



Under completely VAR-based expectations (green lines)—where the public lacks any understanding of policymakers' commitment to making up past misses in inflation—the paths of inflation and unemployment are essentially identical to the recession baseline early in the simulation. That is, the makeup strategies do not offset the contractionary effects of the demand shock at all relative to standard inflation targeting. With impaired transmission of policy through expectations, downside misses of the inflation target persist for longer, resulting in aggressively accommodative policy prescriptions under both the AIT and PLT rules; this in turn leads to a substantial overheating of the economy. In the FRB/US model, this overheating is represented by the unemployment rate being driven well below historical lows, but, in reality, overheating might also take the form of financial market imbalances and other kinds of macroeconomic vulnerability. Note, though, that because inflation misses eventually drop out of the AIT rule, the required overshooting of inflation is much smaller than under the PLT rule, which prescribes offsetting the history of below-target inflation since the beginning of the recession. Under the PLT rule, such a commitment keeps the federal funds rate at the ELB several years longer than under the other three expectations settings. Thus, the "limiting case" of the PLT highlights an important point about window length in AIT rules: The longer the window length, the less AIT enjoys a "safety valve" if policymakers cannot engineer movements in the public's expectations, and the more sensitive outcomes are to the public's understanding of the rule.

Taken together, these results suggest that makeup strategies do not require that the public completely understand them in order to provide most of their benefits. In FRB/US, it is only necessary for financial market participants to understand policymakers' commitment to a makeup strategy. However, we stress that in terms of real outcomes, the benefits of such strategies are modest—even if the public completely understands policymakers' commitment to the makeup strategy.

The anchoring of long-run inflation expectations

While the previous set of simulations has focused on the general behavior of expectations and their interaction with makeup strategies, in this simulation we focus exclusively on the behavior of long-run inflation expectations. When the slope of the Phillips curve is very flat, inflation expectations—and beliefs about future conditions more generally—rather than current economic slack, play the predominant role in determining current inflation.

Here, we consider the possibility that long-run inflation expectations can become unanchored. To model this situation, we modify the structure of long-run inflation expectations in FRB/US in the following way. Beginning from the MCAP expectations settings where only financial market participants have model-consistent expectations, we modify the long-run inflation expectations to be more responsive to current and lagged inflation and, thus, to potentially drift far away from the Committee's 2 percent inflation objective. This simulation is meant to speak to the concern that long-run inflation

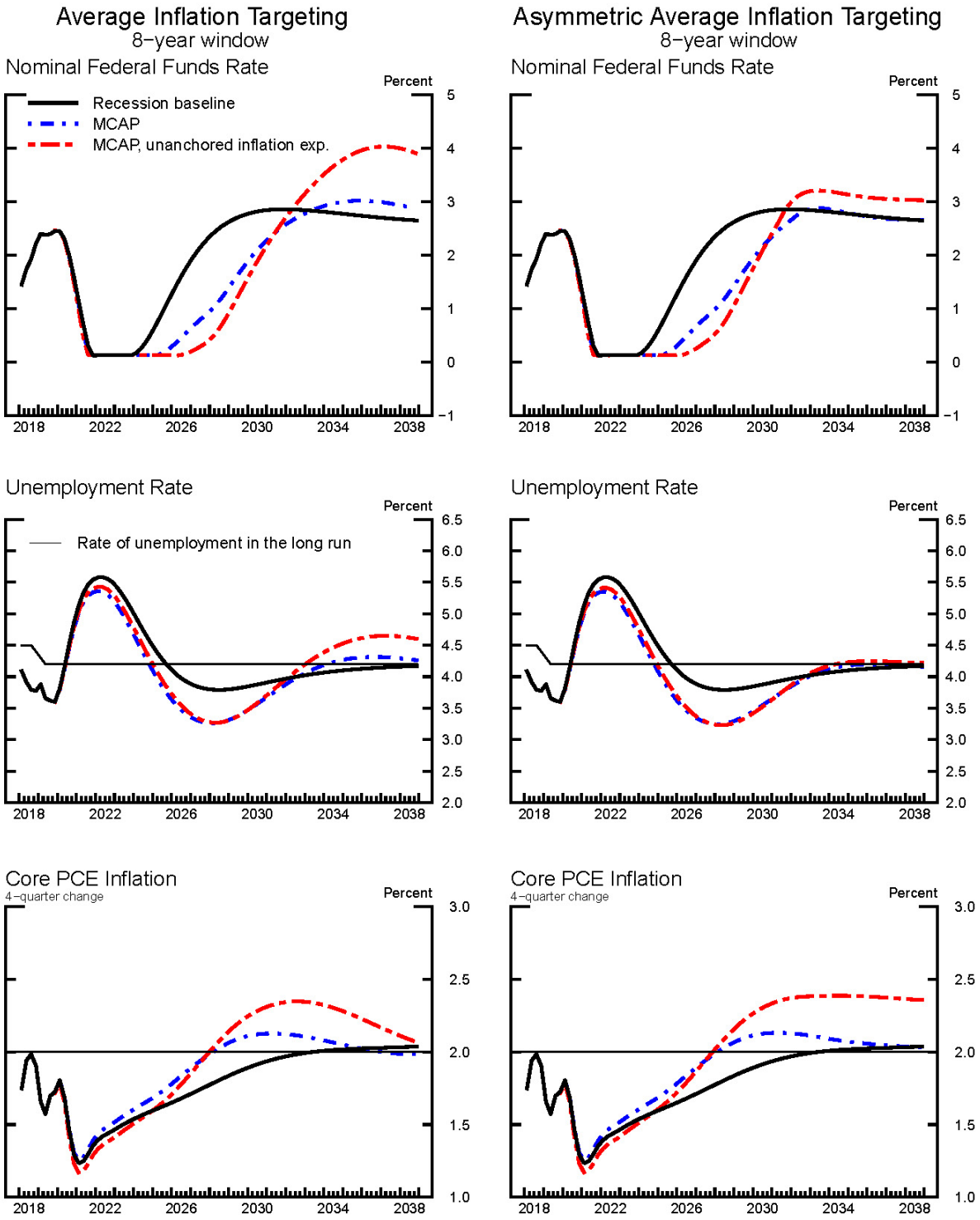
expectations could be influenced by prolonged periods of inflation above or below 2 percent.[19]

We use the recession baseline considered in the previous simulation. Exhibit 5 reproduces the baseline paths and the trajectories of economic variables under MCAP from the earlier exhibit. In addition, the lines corresponding to the "MCAP, unanchored inflation exp." label show the evolution of the economy when long-run inflation expectations are more responsive to current inflation. If long-run inflation expectations become unanchored, the initial undershoot of inflation drags long-run expectations down, putting further downward pressure on inflation. Initially, this shortfall triggers aggressively accommodative policy prescriptions under the makeup strategy, inducing a sustained overshoot of inflation, which in turn causes long-run expectations to eventually drift above the 2 percent objective. This unanchoring puts upward pressure on inflation during the recovery, thus requiring a substantially more aggressive liftoff path for policy (the red line) than otherwise (the blue line). Under an asymmetric AIT strategy for which policymakers seek to make up persistent shortfalls, but not overshoots, in inflation, the overshoot of inflation during the recovery falls outside the scope of the makeup commitment and therefore is allowed to persist.

These simulations highlight a dynamic tension faced by policymakers using a makeup strategy: It is desirable for shorter-run inflation expectations to be responsive to changes in the monetary policy stance, but it is also desirable to maintain longer-run inflation expectations anchored near the 2 percent objective. Given the uncertainty surrounding the expectations process and the imprecise nature of the communications process, it may be difficult to achieve this balance. Policymakers may instead find that the adoption of a makeup strategy affects longer-run inflation expectations in an undesirable way, thus requiring more aggressive interest rate stabilization policy. That said, longer-run inflation expectations have been roughly stable, even over a prolonged period of low inflation. Moreover, the experimental evidence from the SCE described in the empirical section suggests that the risk of unanchoring long-run inflation expectations following prolonged positive inflation shocks may be limited.

[19] In the *MCAP* setting for expectations in FRB/US, short-run inflation expectations are influenced by long-run inflation expectations. This direct link is a shorthand way of capturing the fact that expectations at all horizons can be driven by common factors, such as the public's perceptions of the level and credibility of the central bank's inflation objective. To emphasize the tradeoff faced by policymakers in this simulation, we further assume that long-run inflation expectations react more to changes in inflation caused by the stance of monetary policy than they react to the recessionary shocks underlying the baseline.

Exhibit 5: Unanchored Inflation Expectations



Gradual learning of makeup strategies

In this subsection, we consider that it may take time for the public to learn the policy strategy pursued by policymakers. After the adoption of a makeup strategy, the public begins to understand the strategy only after observing the new policy rule in action. During this learning period, potential misperceptions of the strategy by the public can negatively affect economic outcomes. In this case, the timing of the strategy's adoption matters for its effectiveness. It is advantageous to commit to a makeup strategy prior to adverse conditions—that is, even if inflation is not persistently undershooting the 2 percent objective or the federal funds rate is not constrained by the ELB. A proactive switch gives the public more time to learn about policymakers' commitment to the new strategy.

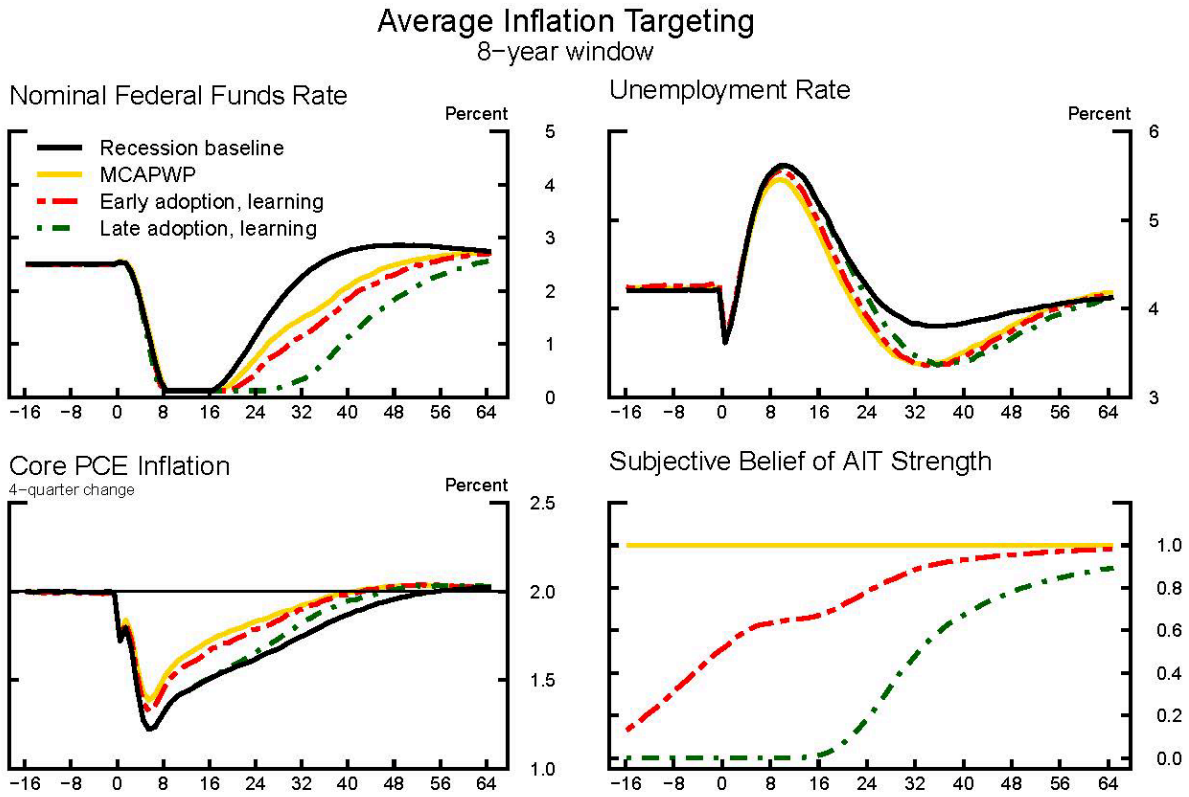
For this analysis, we consider policymakers switching from an inflation-targeting regime—specifically, the inertial Taylor (1999) rule—to the AIT rule described earlier in the context of a large negative shock. When policymakers switch to the AIT rule, it takes time for the public to learn this new strategy through observing the joint behavior of the federal funds rate, inflation, and economic slack.[20] In this learning framework, the most effective form of communication policymakers can use is to put the policy and its principles into practice.

Exhibit 6 shows outcomes under the recession baseline (black lines)—generated using the inertial Taylor (1999) rule—and under the AIT rule for three different specifications for the learning of the strategy. The first of these specifications is a benchmark one in which the public immediately understands—to the greatest extent possible—the policymakers' strategy ("MCAPWP," yellow lines). These outcomes are essentially identical to those under AIT with MCAPWP expectations settings shown in the previous simulations.[21]

[20] We use a framework of learning about policy strategies developed by Bodenstein, Hebden, and Winkler (forthcoming) adapted to small FRB/US, a simplified version of the FRB/US model. Agents form beliefs about the parameters of a policy rule that nests both the inertial Taylor (1999) rule and the AIT rule and update these beliefs through estimation of a small statistical model of the policy rule. The estimated parameters eventually converge to the true rule parameters.

[21] The recession baseline in exhibit 6 is constructed such that as of quarter 0, there is a downward revision in the outlook that matches the recession baseline of the earlier exhibits. Neither policymakers nor the public have advance knowledge (before quarter 0) of the recession in this simulation—consistent with the empirical reality that recessions are difficult to predict. Note that the exhibit reports median outcomes from sets of 2000 stochastic simulations. Although the median outcomes for the federal funds rate, inflation, and economic slack are stable before the onset of the recession, in any individual stochastic simulation these variables' outcomes will deviate from the reported medians because of economic shocks, such that the public can discern policymakers' strategy even before the onset of the recession.

Exhibit 6: Gradual Learning of Policy Strategies



Note: X-axes denote quarters since the start of the sequence of adverse demand shocks. The bottom right panel shows the public's statistical estimate of the coefficient in the policy rule on average inflation within an 8-year rolling window. The true coefficient is one for the AIT rule and zero for the inertial Taylor (1999) rule. All lines are median outcomes from stochastic simulations of the small FRB/US model.

The final two specifications both feature significant learning, with the only difference being the timing of the adoption of the AIT rule. In the first of these ("early adoption, learning," red lines), policymakers start following the prescriptions of the AIT rule 40 quarters before the recession. In the second ("late adoption, learning," green lines), policymakers adopt the prescriptions of the AIT rule only at the onset of the recession.

The stabilization benefits under the early adoption of the AIT rule are almost as large as in the benchmark MCAPWP simulation. At the onset of the recession, the public has had sufficient time to observe policymakers following the prescriptions of the AIT rule as opposed to those of the inertial Taylor (1999) rule. The public's subjective belief about the strength of policymakers' response to the average level of inflation is shown in the bottom-right panel of exhibit 6. Even though these beliefs do not yet fully reflect the true strength of the response to average inflation at the onset of the recession, this partial understanding of the makeup strategy suffices for its stabilization benefits to materialize.

Under the late adoption of the AIT rule, however, the switch to the new strategy does not confer any immediate benefit: Output and inflation initially fall just as much as under

the inertial Taylor (1999) rule. The public does not initially understand this switch in the policy rule, as the prescriptions of the inertial Taylor (1999) rule and the AIT rule are identical because the policy rate is constrained by the ELB. Indeed, the public's belief about the strength of the response to average inflation remains near zero for nearly 5 years after the adoption of the AIT rule. It is only once the AIT rule keeps the policy rate at the ELB for longer than the inertial Taylor (1999) rule that the public becomes convinced that a switch in the policy strategy has happened. The resulting adjustment in expectations leads to a gradual increase in inflation toward the paths of the other AIT simulations.

Overall, these simulations indicate that there are advantages to adopting a makeup strategy well before adverse economic conditions materialize or the policy rate reaches the ELB. Doing so gives policymakers time to show their commitment to the new strategy through their actions so that the strategy can reach its full effectiveness before its benefits are needed most. Waiting until adverse economic conditions materialize can lead to worse outcomes if the public does not initially understand or believe policymakers' commitment to the new strategy.[22]

Robustness of Makeup Strategies to Other Economic Assumptions

While the previous section focused on the robustness of makeup strategies with respect to the expectations formation process, there is also considerable uncertainty about other key factors determining the transmission of monetary policy. In this section, we discuss the sensitivity of makeup strategies to the slope of the Phillips curve and to mismeasurement of the natural rate of unemployment, u^*.[23]

The slope of the Phillips curve—the strength of the relationship between inflation and economic slack—has diminished in recent decades. Moreover, the persistence of inflation has dropped considerably, consistent with the anchoring of inflation near 2 percent in recent years. Although those shifts are apparent in the data, their causes are not as well understood. Given this uncertainty, it seems possible that the dynamics of inflation could change yet again. A steeper Phillips curve helps policymakers achieve their goal of stabilizing the price level, as it makes inflation more responsive to resource utilization. If the Phillips curve were instead to flatten further, meeting the inflation objective would require substantial overheating of the economy, a situation similar to the one that emerges when the public poorly understands or is uninformed about policymakers' commitment to a makeup strategy. Despite poor tradeoffs when the Phillips curve is flatter, in these

[22] This caveat also applies to temporary or asymmetric makeup strategies. Even if formally announced before a recession, the prescriptions of these strategies are identical to inflation-targeting strategies until adverse economic conditions materialize. It is conceivable that the full stabilization benefits of those strategies only materialize once the public has had the opportunity to see their characteristics in action—that is, once policymakers have followed through at least once on their promise to make up for past misses in inflation..

[23] Detailed simulation results for these two simulations can be found in the appendix.

circumstances an AIT strategy may still hold relative appeal over traditional inflation targeting, or even over other makeup strategies. In particular, if a flatter Phillips curve inhibits making up past inflation misses, those misses will nevertheless eventually become bygones under an AIT rule, whereas under a PLT rule there is no such safety valve when inflation misses are harder to make up, and exceptionally tight resource utilization results.

The natural rate of unemployment—an unobserved variable—is inherently challenging to measure. Research has emphasized the potential mismeasurement of resource utilization by policymakers as one cause of the rise in inflation during the 1970s.[24] In this simulation, we consider how the performance of makeup strategies interacts with errors in estimating the level of u^*. When policymakers overestimate u^*, conventional inflation targeting rules typically call for increases in the federal funds rate, relative to a situation in which there is no mismeasurement, in order to offset the tight utilization perceived by policymakers. But because the unemployment rate associated with this outcome is higher than the true natural rate of unemployment in the economy, inflation falls and remains low for a sustained period of time. Under makeup strategies, the same errors in estimating the level of u^* engender smaller deviations of inflation from its target level as under typical inflation targeting rules. Makeup strategies also initially call for increases in the federal funds rate, as they also react to the deviation of resource utilization from its estimated natural level. However, the makeup strategies will eventually respond to the resulting persistent shortfall of inflation from 2 percent with looser monetary policy conditions relative to an inflation targeting rule. Thus, makeup strategies seem to be somewhat more robust to misperceptions of u^* than inflation targeting strategies, as makeup strategies implicitly correct for these misperceptions by reacting to the cumulative deviations of inflation from 2 percent that they cause.

Conclusion

Makeup strategies work best when the public understands, believes, and reacts to policymakers' commitment to offset misses in inflation from the 2 percent objective in the future. The model simulations in this memo indicate that such policies are likely to perform well even if some decisionmakers in the economy form expectations in a way that implies only a limited understanding of the monetary policy framework. However, the less expectations behave as desired, the more policymakers will have to provide aggressive policy accommodation and deliver a substantial overshoot of inflation to credibly implement the strategy.

Our conclusions ought to be tempered by technical and practical considerations. First, FRB/US is only one model of the economy, and conclusions may differ somewhat across models. Second, the specific dimensions of robustness analyzed do not capture all

[24] See Staiger, Stock, and Watson (1997), Orphanides (2003), and Romer and Romer (2002).

the potential situations that policymakers may face. The persistent negative demand shock featured in this memo is of course only one among many adverse scenarios. For example, makeup strategies can all, to varying degrees, be inflexible in the face of temporary disruptions.[25] In practice, the implementation of makeup strategies would have to be accompanied by safety valves for these kinds of scenarios, which could complicate communication of the policy.

[25] For example, when a value-added tax was introduced in Australia in 2000, it caused a one-time increase in the price level. The inflation-targeting regime allowed the Reserve Bank of Australia to "look through" this temporarily high inflation rate while, which, under some makeup strategies, would have required either a permanent or temporary shift in a target value that could have proven challenging to effectively communicate, or a different policy response. See, for example, Debelle (2018).

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Appendix

This appendix first provides expressions for the policy rules used in this memo. It then reports the results of simulations referenced in the section "Robustness of Makeup Strategies to Other Economic Assumptions." The appendix concludes with tabulations of the simulation results for key variables shown in Exhibits 4 through 6.

Parameterization of policy rules

Table A.1 gives expressions for the four policy rules used in the simulations in this memo: the inertial Taylor (1999) rule, an average inflation targeting (AIT) rule, an asymmetric average inflation targeting (AAIT) rule, and a price-level targeting (PLT) rule.

Table A.1: Policy Rules

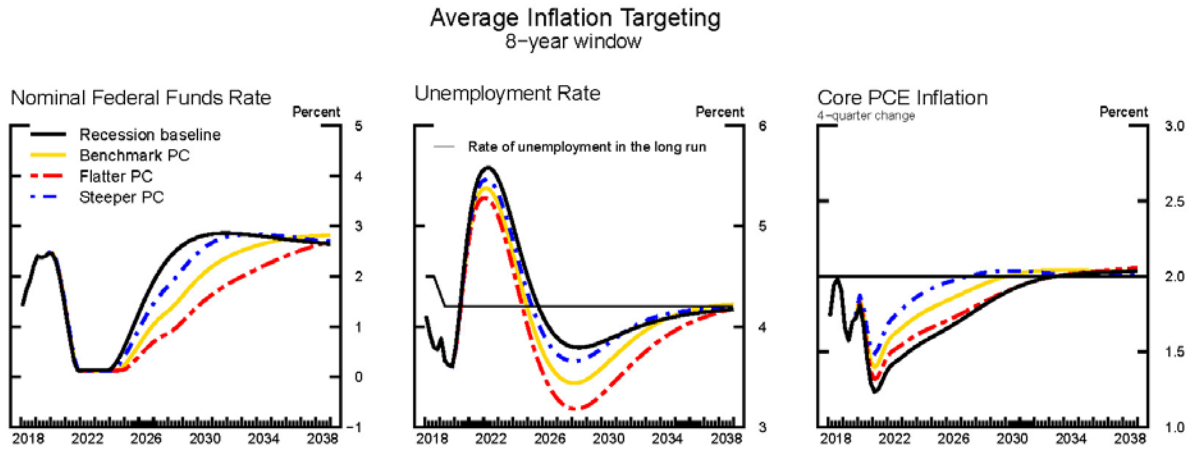
Inertial Taylor (1999) rule	$R_t^{iT99} = 0.85R_{t-1} + 0.15\left(r^* + \pi_t + ygap_t + 0.5(\pi_t - \pi^{LR})\right)$
Average inflation targeting rule	$R_t^{AIT} = 0.85R_{t-1} + 0.15\left(r^* + \pi_t + ygap_t + T\left(\bar{\pi}_t^{(T)} - \pi^{LR}\right)\right)$
Asymmetric average inflation targeting rule	$R_t^{AAIT} = \begin{cases} R_t^{AIT}, & \text{if } \bar{\pi}_t^{(T)} < \pi^{LR} \\ R_t^{iT99}, & \text{otherwise} \end{cases}$
Price-level targeting rule	$R_t^{PLT} = 0.85R_{t-1} + 0.15\left(r^{LR} + \pi_t + ygap_t + (p_t - p_t^*)\right)$

Here, R_t denotes the nominal federal funds rate prescribed by a strategy for quarter *t*, $ygap_t$ the output gap for quarter t, and π_t the trailing four-quarter core PCE price inflation for quarter *t*. The variable r^* is the level of the neutral real federal funds rate in the longer run that, on average, is expected to be consistent with sustaining maximum employment and inflation at the FOMC's 2 percent longer-run objective. The parameter T represents the length in years of a rolling window of cumulative past deviations of inflation from 2 percent that the policymaker will seek to make up, and $\bar{\pi}_t^{(T)}$ represents average core PCE price inflation within the current rolling window. We set $T = 8$ and the inflation gap at the start of the simulations to zero. Finally, $p_t - p_t^*$ represents the gap between the actual price level and a target path that grows at a 2 percent annual rate. The price-level gap is set to zero at the start of the simulations.

Makeup strategies with a steeper Phillips curve

Exhibit A.1 displays how outcomes under an AIT rule depend on assumptions about the slope of the Phillips curve.[26] The trajectories associated with a steeper Phillips curve are shown in the blue lines. A steeper Phillips curve advances policymakers' goal of stabilizing the price level, as it makes inflation more responsive to resource utilization. Inflation does not fall as much as under the baseline Phillips curve during the recession. The federal funds rate path is lower and the unemployment rate is slightly higher than under the baseline Phillips curve. By contrast, the simulations also show that makeup strategies are not a panacea for the challenges posed by a flatter Phillips curve, which makes it more difficult to stabilize price-level fluctuations. Under a flatter Phillips curve (the red lines), the federal funds rate path is lower and levels of resource utilization are higher than under the baseline Phillips curve, as the AIT rule has to generate more accommodative policy conditions in order to undo the shortfall of inflation in the recession baseline, similar to when the public is relatively uniformed about the makeup strategy.

Exhibit A.1: Varying the Slope of the Phillips Curve



Makeup strategies under misperception about u*

Exhibit A.2 displays the simulated paths of the federal funds rate, the unemployment rate, and core PCE inflation for three different paths of the perceived natural rate of unemployment u^*.[27] We assume that policymakers follow either the prescription of the

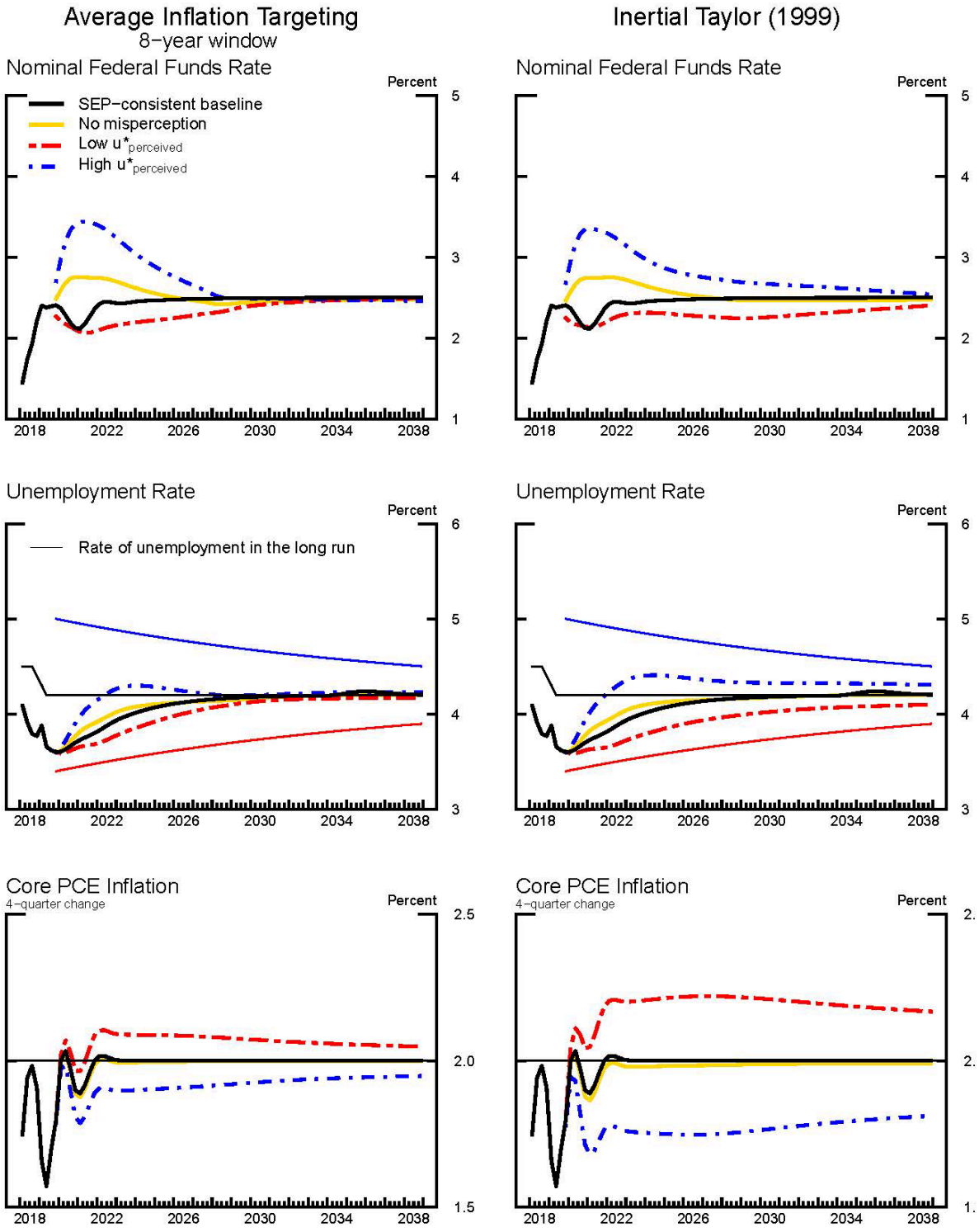
[26] This simulation is implemented in a slightly different way than the other FRB/US simulations. In these simulations, the recession baseline is fixed across changes in the slope of the Phillips curve. Fixing the baseline abstracts from changes in the slope of the Phillips curve altering the deflationary effects of the recession itself.

[27] In the simulations labeled "low perceived u^*" and "high perceived u^*," the misperceived natural rate is initially 80 basis points below and above the true natural rate, respectively. Each year thereafter,

inertial Taylor (1999) rule (right panel) or those of the AIT rule (left panel). Under the inertial Taylor (1999) rule, errors in estimating the level of u^* lead to persistent deviations of inflation from its target level of 2 percent. When policymakers overestimate u^*, the inertial Taylor (1999) rule calls for raising the federal funds rate in order to reduce levels of resource utilization. But because the unemployment rate associated with this outcome is higher than the true natural rate of unemployment in the economy, inflation falls below 2 percent for a sustained period of time. Under the AIT rule, the same errors in estimating the level of u^* engender smaller deviations of inflation from its target level than under the inertial Taylor (1999) rule. When policymakers overestimate u^*, the AIT rule also initially calls for raising the federal funds rate, as it reacts to the deviation of resource utilization from its estimated natural level. But the AIT rule responds to the resulting persistent shortfall of inflation from 2 percent with looser monetary policy conditions, relative to the inertial Taylor (1999) rule, later in the simulation.

policymakers close 5 percent of the remaining gap between their estimate and the true natural rate. The policy rules featured in this memo key off the output gap, and the misperceived natural rate feeds into a misperceived output gap through a form of Okun's law.

Exhibit A.2: Misperception of the Natural Rate of Unemployment



Tables

The tables below show the simulation results for key variables under the policy rules shown in exhibits 4 through 6.

Table A.2: Alternative Assumptions about Expectations Formation
Average Inflation Targeting Rule

(Percent change, annual rate, except as noted)

Outcome and strategy	2020	2021	2022	2024	2027	2030	2034	2038
Nominal federal funds rate[1]								
Recession baseline	1.6	.1	.1	.5	2.3	2.8	2.8	2.6
MCE	1.7	.1	.1	.3	1.6	2.6	2.9	2.8
MCAPWP	1.6	.1	.1	.2	1.3	2.2	2.7	2.8
MCAP	1.5	.1	.1	.1	.9	2.2	3.0	2.9
VAR	1.5	.1	.1	.1	.2	2.2	4.0	3.5
Real GDP								
Recession baseline	-1.1	.1	2.1	3.0	2.2	1.9	2.0	1.9
MCE	-.9	.3	2.3	3.2	2.2	1.8	1.8	1.9
MCAPWP	-.9	.3	2.2	3.2	2.2	1.8	1.9	1.9
MCAP	-.9	.3	2.3	3.2	2.3	1.7	1.8	1.9
VAR	-1.1	.1	2.1	3.1	2.8	2.1	1.4	1.7
Unemployment rate[1]								
Recession baseline	4.9	5.5	5.5	4.6	3.8	3.9	4.1	4.2
MCE	4.7	5.3	5.2	4.1	3.4	3.7	4.1	4.3
MCAPWP	4.8	5.4	5.3	4.2	3.4	3.7	4.1	4.2
MCAP	4.8	5.3	5.2	4.2	3.3	3.6	4.3	4.3
VAR	4.9	5.5	5.5	4.5	3.2	2.9	4.0	4.6
Core PCE prices								
Recession baseline	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.0
MCE	1.5	1.6	1.7	1.8	2.0	2.0	2.0	2.0
MCAPWP	1.4	1.5	1.6	1.8	1.9	2.0	2.0	2.0
MCAP	1.3	1.4	1.5	1.7	2.0	2.1	2.1	2.0
VAR	1.3	1.4	1.5	1.6	1.9	2.3	2.2	2.0

1. Percent, average for the final quarter of the period.

Table A.3: Alternative Assumptions about Expectations Formation
Price-Level Targeting Rule

(Percent change, annual rate, except as noted)

Outcome and strategy	2020	2021	2022	2024	2027	2030	2034	2038
Nominal federal funds rate[1]								
Recession baseline	1.6	.1	.1	.5	2.3	2.8	2.8	2.6
MCE	1.7	.1	.1	.4	2.0	2.6	2.7	2.7
MCAPWP	1.7	.1	.1	.3	1.7	2.2	2.4	2.5
MCAP	1.6	.1	.1	.1	1.3	1.9	2.1	2.3
VAR	1.5	.1	.1	.1	.2	1.1	2.4	3.3
Real GDP								
Recession baseline	-1.1	.1	2.1	3.0	2.2	1.9	2.0	1.9
MCE	-.9	.3	2.2	3.2	2.2	1.9	1.9	1.9
MCAPWP	-.9	.3	2.2	3.1	2.2	1.9	1.9	1.9
MCAP	-.8	.4	2.3	3.3	2.4	1.9	1.9	1.8
VAR	-1.1	.1	2.1	3.1	2.8	2.4	1.9	1.6
Unemployment rate[1]								
Recession baseline	4.9	5.5	5.5	4.6	3.8	3.9	4.1	4.2
MCE	4.7	5.3	5.2	4.2	3.4	3.6	4.0	4.2
MCAPWP	4.8	5.4	5.3	4.2	3.5	3.6	3.9	4.1
MCAP	4.7	5.3	5.2	4.1	3.1	3.3	3.8	4.0
VAR	4.9	5.5	5.5	4.5	3.2	2.7	3.1	3.8
Core PCE prices								
Recession baseline	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.0
MCE	1.5	1.6	1.7	1.9	2.1	2.2	2.1	2.1
MCAPWP	1.5	1.6	1.7	1.9	2.0	2.1	2.1	2.1
MCAP	1.3	1.4	1.5	1.7	2.0	2.2	2.2	2.2
VAR	1.3	1.4	1.5	1.6	1.9	2.3	2.4	2.3

1. Percent, average for the final quarter of the period.

Table A.4: Unanchored Inflation Expectations
Average Inflation Targeting Rule

(Percent change, annual rate, except as noted)

Outcome and strategy	2020	2021	2022	2024	2027	2030	2034	2038
Nominal federal funds rate[1]								
Recession baseline	1.6	.1	.1	.5	2.3	2.8	2.8	2.6
MCAP	1.5	.1	.1	.1	.9	2.2	3.0	2.9
MCAP, unanchored inflation exp.	1.5	.1	.1	.1	.4	2.1	3.8	3.9
Real GDP								
Recession baseline	-1.1	.1	2.1	3.0	2.2	1.9	2.0	1.9
MCAP	-.9	.3	2.3	3.2	2.3	1.7	1.8	1.9
MCAP, unanchored inflation exp.	-.9	.2	2.2	3.2	2.4	1.6	1.7	1.9
Unemployment rate[1]								
Recession baseline	4.9	5.5	5.5	4.6	3.8	3.9	4.1	4.2
MCAP	4.8	5.3	5.2	4.2	3.3	3.6	4.3	4.3
MCAP, unanchored inflation exp.	4.8	5.4	5.3	4.3	3.3	3.7	4.5	4.6
Core PCE prices								
Recession baseline	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.0
MCAP	1.3	1.4	1.5	1.7	2.0	2.1	2.1	2.0
MCAP, unanchored inflation exp.	1.2	1.3	1.4	1.6	2.0	2.3	2.3	2.1

1. Percent, average for the final quarter of the period.

Asymmetric Average Inflation Targeting Rule

(Percent change, annual rate, except as noted)

Outcome and strategy	2020	2021	2022	2024	2027	2030	2034	2038
Nominal federal funds rate[1]								
Recession baseline	1.6	.1	.1	.5	2.3	2.8	2.8	2.6
MCAP	1.6	.1	.1	.1	.9	2.3	2.8	2.7
MCAP, unanchored inflation exp.	1.5	.1	.1	.1	.5	2.3	3.1	3.0
Real GDP								
Recession baseline	-1.1	.1	2.1	3.0	2.2	1.9	2.0	1.9
MCAP	-.9	.3	2.3	3.2	2.3	1.7	1.9	1.9
MCAP, unanchored inflation exp.	-.9	.3	2.2	3.2	2.4	1.7	1.9	1.9
Unemployment rate[1]								
Recession baseline	4.9	5.5	5.5	4.6	3.8	3.9	4.1	4.2
MCAP	4.8	5.3	5.2	4.2	3.3	3.6	4.2	4.2
MCAP, unanchored inflation exp.	4.8	5.4	5.3	4.2	3.2	3.6	4.2	4.2
Core PCE prices								
Recession baseline	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.0
MCAP	1.3	1.4	1.5	1.7	2.0	2.1	2.1	2.0
MCAP, unanchored inflation exp.	1.2	1.3	1.4	1.6	2.0	2.3	2.4	2.4

1. Percent, average for the final quarter of the period.

Table A.5: Gradual Learning of Makeup Strategies
Average Inflation Targeting Rule

(Percent change, annual rate, except as noted)

Outcome and strategy	4 q.	8 q.	12 q.	20 q.	32 q.	44 q.	60 q.	76 q.
Nominal federal funds rate[1]								
Recession baseline	1.6	.1	.1	.6	2.3	2.8	2.8	2.7
MCAPWP	1.7	.1	.1	.3	1.5	2.3	2.7	2.7
Early adoption, learning	1.6	.1	.1	.2	1.2	2.1	2.7	2.7
Late adoption, learning	1.5	.1	.1	.1	.4	1.6	2.5	2.7
Real GDP								
Recession baseline	-1.2	-.0	2.1	3.0	2.1	1.9	1.9	1.9
MCAPWP	-1.0	.2	2.3	3.2	2.2	1.7	1.9	2.0
Early adoption, learning	-1.1	.2	2.2	3.2	2.3	1.7	1.9	2.1
Late adoption, learning	-1.2	-.0	2.1	3.0	2.4	1.8	1.9	2.0
Unemployment rate[1]								
Recession baseline	4.9	5.6	5.5	4.6	3.8	3.9	4.1	4.2
MCAPWP	4.8	5.4	5.3	4.2	3.4	3.7	4.1	4.3
Early adoption, learning	4.9	5.5	5.4	4.3	3.4	3.6	4.1	4.3
Late adoption, learning	4.9	5.5	5.5	4.6	3.5	3.6	4.0	4.3
Core PCE prices								
Recession baseline	1.3	1.3	1.4	1.6	1.8	1.9	2.0	2.0
MCAPWP	1.4	1.5	1.7	1.8	1.9	2.0	2.0	2.0
Early adoption, learning	1.4	1.5	1.6	1.7	1.9	2.0	2.0	2.0
Late adoption, learning	1.3	1.3	1.4	1.6	1.8	2.0	2.0	2.0

1. Percent, average for the final quarter of the period.