Policy Rule Evaluation for the Fed's Strategy Review

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February 4, 2025

Abstract

The Federal Reserve Board started a strategy review at the beginning of 2025 and intends to complete by late summer of 2025. After its only previous review, the Federal Open Market Committee adopted a far-reaching Revised Statement on Longer-Run Goals and Monetary Policy Strategy in August 2020. We analyze and develop policy rules that are either in accord with the original 2012 statement or inspired by the revised 2020 statement and use the rules to evaluate monetary policy using the Federal Reserve Board/United States model. We evaluate policy rules categorized by traditional, shortfalls, Asymmetric Coefficient Inflation Targeting, and Asymmetric Target Inflation Targeting versions of non-inertial and inertial Taylor and balanced approach rules. Economic performance is better with balanced approach rules than with Taylor rules, worse with shortfalls rules than with traditional rules, better with inertial rules than with non-inertial rules, and better with the two asymmetric inflation targeting rules than with traditional rules.

JEL Classification*:* E5; E52; E58

Keywords*:* Policy Rules; Monetary Policy; Federal Reserve Board; Federal Open Market Committee; Federal Reserve Board/United States Model.

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We thank Guillermo Calvo, Hess Chung, John Cochrane, Darrell Duffie, John Taylor, and participants at the International Association for Applied Econometrics and the Federal Reserve Board for helpful comments and discussions

1. Introduction

The Federal Reserve Board is currently conducting a strategy review.[1] After its only previous review, the Federal Open Market Committee (FOMC or Committee) adopted a far-reaching Revised Statement on Longer-Run Goals and Monetary Policy Strategy in August 2020. The framework contains two major changes from the original 2012 statement. First, policy decisions will attempt to mitigate shortfalls, rather than deviations, of employment from its maximum level. Second, the FOMC will implement Flexible Average Inflation Targeting (FAIT) where, "following periods when inflation has been running persistently below 2 percent, appropriate monetary policy will likely aim to achieve inflation moderately above 2 percent for some time."[2]

The 2019 review was heavily influenced by economic performance over the previous decade, including the Effective Lower Bound (ELB) period from December 2008 – December 2015 and the difficulty in raising inflation to the Fed's 2 percent target. While it was reasonable to assume in 2019 that the issues over the previous decade would continue, the 2025 review will be more difficult because, hopefully, the next five years will not involve a repetition of the Covid-19 recession, recovery, inflation, and disinflation.

Another reason why the 2025 review will be more challenging than the 2019 review is that both aspects of the 2020 revised statement, FAIT and shortfalls, were overtaken by unanticipated events. The period where FAIT was applicable was very short as annual core personal consumption expenditure (PCE) inflation increased from 1.5 percent at the March 2021 FOMC meeting to 3.1 percent at the June 2021 SEP meeting, clearly higher than "moderately above" 2 percent. In addition, Papell and Prodan-Boul (2024a) show that, between the September 2020 and March 2021 FOMC meetings, the prescriptions from traditional and FAIT rules are all below the ELB so that FAIT was irrelevant. Unemployment, in contrast, did not fall below 4 percent until March 2022 and the shortfalls played no role in the subsequent rise of the federal funds rate (FFR).

Powell (2024b) discussed the upcoming strategy review. One focus of the discussion was that, while inflation had been low for 20 years prior to the 2019 review, the pandemic hit four months after followed by higher inflation a year later. A second focus was how to think about the

[1] See Powell (2024a)

[2] See Federal Open Market Committee (2020). Clarida (2022) discusses the revised framework

problem of the zero lower bound now that interest rates are substantially higher than at the time of the 2019 review.

We analyze policy rules that are either in accord with the original statement or inspired by the revised statement and use the rules to evaluate monetary policy using the Linearized Version (LINVER) of the Federal Reserve Board/United States (FRB/US) model described in Brayton, Laubach, and Reifschneider (2014) and Brayton and Reifschneider (2022). We use non-inertial versions of the rules where the FFR adjusts immediately to its target and inertial versions of the rules where the FFR adjusts slowly to its target.

Papers conducting policy rule evaluation with the LINVER version of the FRB/US model, including Reifschneider and Williams (2000), Kiley and Roberts (2017), Bernanke, Kiley, and Roberts (2019), Bernanke (2020), Arias et al. (2020), Brayton and Reifschneider (2022), and Kiley (2024) compare traditional Taylor and Balanced Approach rules with rules designed to improve economic performance when the FFR is at the effective lower bound (ELB). Kiley (2024) also analyzes shortfalls rules. We complement this research by comparing traditional and shortfalls rules with rules inspired by the FAIT part of the revised statement. Agents in LINVER can have either forward-looking model consistent (MC) rational expectations or backward-looking vector autoregressive (VAR) expectations. We follow Reifschneider and Williams (2000), Arias et al. (2020), and Kiley (2024) and use the version with MC expectations in financial markets and wage-price setting and VAR expectations in other sectors.[3]

We first consider two inflation targeting (IT) policy rules that are consistent with the original 2012 statement and have been included in the Tealbook since 2004 and the Monetary Policy Report since 2017. The Taylor (1993) rule prescribes that the FFR equal the inflation rate plus 0.5 times the inflation gap, the difference between the inflation rate and the 2 percent inflation target, plus 0.5 times the output gap, the percentage deviation of GDP from potential GDP, plus the neutral real interest rate. The balanced approach rule in Taylor (1999) and Yellen (2012) raises the coefficient on the output gap to 1.0 while maintaining the coefficient of 0.5 on the inflation gap.

We then analyze Taylor and balanced approach (shortfalls) rules, the latter which was introduced in the February 2021 Monetary Policy Report (MPR).[4] These rules are identical to the

[3] The results are robust to specifications where, as in Bernanke, Kiley, and Roberts (2019) and Brayton and Reifschneider (2022), all agents have MC expectations or only asset market participants have MC expectations.
[4] See Federal Reserve Board (2021).

Taylor and balanced approach rules except that they do not prescribe a rise in the FFR when GDP rises above potential GDP or, equivalently, unemployment falls below the rate of unemployment in the longer run. The balanced approach (shortfalls) rule is identical to the Taylor (shortfalls) rule except for having a higher coefficient on the output gap.[5]

When inflation is persistently below 2 percent, a policy that attempts to raise inflation to the 2 percent target can be problematic because the amount of stimulus with the original rules decreases the closer inflation is to achieving its 2 percent target. Arias et al. (2020) analyzed balanced approach Average Inflation Targeting (AIT) and Asymmetric Average Inflation Targeting (AAIT) rules as part of the strategy review. The AIT rule targets the T-year average inflation instead of the current quarter's annualized inflation and the AAIT rule targets the T-year average inflation only when average inflation is below the Fed's 2 percent target. When inflation is below 2 percent and rising, these rules continue to provide stimulus even after inflation increases above 2 percent because average inflation increases slower than current inflation.

Time inconsistency was introduced in the classic papers of Kydland and Prescott (1977) and Calvo (1978). These papers compare policy rules with period-by-period optimal control (discretionary) policy. Economic performance can be improved by following policy rules because, under discretion, rational agents understand that it will be optimal for future governments to modify policies that are optimal from today's perspective. This literature demonstrates the inconsistency of optimal policies. In contrast, we distinguish between time consistent rules where future commitments are credible and time inconsistent rules where future commitments are not credible. Despite sharing the same name, the issues are different because neither time consistent nor time inconsistent rules are optimal.

Duarte et al. (2020) and Jia and Wu (2023) show how average inflation targeting rules are not time consistent. AIT or AAIT rules improve social welfare over IT rules if the FOMC's announcements are believed by the private sector. These policies, however, are not credible. Once annual inflation starting below 2 percent exceeds 2 percent, the FOMC will have the incentive to maximize social welfare by implementing IT and switching from stimulus to restraint even if average inflation is below 2 percent. This will negate the additional stimulus when inflation is below the 2 percent target because the FOMC's announcements will not be believed. Arias et al.

[5] While policy rules are usually written in terms of the output gap, the rules in the MPR use the unemployment gap, the difference between the rate of unemployment in the longer run and the realized unemployment rate. We use the output gap for consistency with most research involving the FRB/US model.

(2020) and Kiley (2024) analyze the make-up rule in Reifschneider and Williams (2000) which delays liftoff from the ELB until accumulated shortfalls of the FFR from the ELB with the Taylor (1993) rule are eliminated. This rule is also not time consistent because the FFR remains at the ELB after the Taylor rule prescribes liftoff.

Time inconsistency of average inflation targeting and make-up rules is problematic for policy evaluation with the FRB/US model. While agents do not have perfect foresight, they form MC expectations with a full understanding of the implications of future shocks when they hit and, therefore, MC expectations are generated assuming no future shocks. The only way to analyze inconsistent rules is to assume, as in Arias et al. (2020) and Duarte et al. (2020), that some external mechanism exists to make the rules credible. The external mechanisms cited by Duarte et al. (2020), reputation as in Barro and Gordon (1983) and analogies to patent law as in Taylor (1983)), are ways to address time inconsistency of optimal policies and they are not applicable to time inconsistent rules because they are not credible ex ante. We do not analyze time inconsistent rules because it would be tantamount to assuming the issue away.

Flexible Average Inflation Targeting (FAIT) was the centerpiece of the August 2020 Revised Statement. The FAIT solution is to aim to raise inflation moderately above 2 percent for some time when inflation is persistently below 2 percent, with “persistently,” “likely,” “moderately,” and “for some time” undefined. Policy rules involving FAIT have not been included in the MPR, probably because it would involve defining the undefined terms.[6] Clarida (2022) identifies asymmetric and time consistent as two integral aspects of FAIT. We define asymmetric as policy rules with a stronger response of the prescribed FFR to inflation below 2 percent than to inflation above 2 percent and time consistent as policy rules which prescribe raising (lowering) the FFR if inflation is above (below) the FOMC’s 2 percent target.[7]

We proceed to propose and analyze Taylor and balanced approach policy rules that are asymmetric and time consistent in the spirit of FAIT. Asymmetric Coefficient Inflation Targeting (ACIT) rules raise the coefficient on the inflation gap when inflation is below the Fed’s 2 percent

[6] . Papell and Prodan-Boul (2022) consider “consistent” rules which include both FAIT and shortfalls for the period from the end of the Great Recession in 2007:Q4 through 2019:Q4. Papell and Prodan-Boul (2024a, 2024b) consider FAIT, shortfalls, and consistent rules following the Covid-19 recession in 2020:Q2 through 2024:Q3. They make specific assumptions about the undefined terms and do not conduct normative policy evaluation.

[7] Our definition of asymmetric is in accord with Clarida’s, where policy will aim to achieve inflation moderately above 2 percent if it is persistently below 2 percent but will not aim to reduce inflation below 2 percent once conditions to commence policy normalization have begun. His definition of time consistent is specific to the extended period of lower than desired inflation between the Great Recession and the Covid-19 Recession.

target and Asymmetric Target Inflation Targeting (ATIT) rules raise the inflation target when inflation is below the Fed's 2 percent target. The rules provide more stimulus than the original rules when inflation is below 2 percent and revert to the original rules when inflation is above 2 percent. They do not violate time consistency because reverting to the original rules once inflation exceeds 2 percent is part of the rule. The ATIT rule is most closely in accord with FAIT because it "aims" to achieve inflation moderately above 2 percent by temporarily raising the inflation target.

Starting with Taylor (1993), normative policy rule prescriptions, including those in the Monetary Policy Reports, are usually "non-inertial" as the prescribed FFR depends on the realized values of the right-hand-side variables. Following Clarida, Gali, and Gertler (1999), estimated Taylor-type rules are usually "inertial" to incorporate slow adjustment of the actual FFR to changes in the prescribed FFR. The more recent papers cited above using the FRB/US model, however, are both normative and inertial. We therefore analyze both non-inertial and inertial policy rules with the FRB/US model.[8]

We use the LINVER model to evaluate policy rules with loss functions that incorporate either equally weighted squared inflation and output gaps or equally weighted squared inflation gaps, squared output gaps, and the squared change in the FFR. We then evaluate the rules with loss functions that replace the output gap with the unemployment gap. Finally, we evaluate the rules with shortfalls loss functions that place a value of one on the output gap if it is negative and a value of zero if it is positive or, equivalently, a value of one on the unemployment gap if it is positive and a value of zero if it is negative.

We evaluate 32 policy rules categorized by non-inertial (inertial) and Taylor (Balanced Approach) versions of traditional, shortfalls, ACIT with coefficients of 0.75, 1.0, and 1.5 on the inflation gap, and ATIT rules with 2.5, 3, and 4-year inflation targets. The 8 loss functions are categorized by including (not including) the change in the FFR, incorporating output (unemployment) gaps, and using symmetric (shortfalls) versions of the output and unemployment gaps. Multiplying 32 policy rules by 8 loss functions results in 256 policy rule evaluations. We consider versions of the model where the ELB is (is not) imposed for a total of 512 evaluations.

The results when the ELB is imposed can be summarized as follows. Balanced approach rules outperform Taylor rules. For all 128 specifications, the loss with balanced approach rules is

[8] Woodford (2003) analyzes the optimality of inertial rules.

smaller than the loss with Taylor rules.[9] Traditional rules outperform shortfalls rules. For all 32 specifications, the loss with shortfalls rules is larger than the loss with traditional rules. ACIT and ATIT rules outperform traditional rules. For all 192 specifications, the loss with ACIT and ATIT rules is smaller than the loss with traditional rules. Finally, the loss is nearly identical between ACIT and ATIT rules. While the losses when the ELB is not imposed are uniformly smaller than when the ELB is imposed, the comparisons among rules are very similar.

Previous research on policy evaluation using the FRB/US model, including Average Inflation Targeting, Asymmetric Average Inflation Targeting, and make-up rules has found that these rules outperform traditional Taylor and balanced approach rules. These rules, however, are not time consistent and cannot be evaluated by the FRB/US model unless one is willing to make heroic assumptions about how the FOMC will not deviate from these rules even when it is understood ex ante that deviating will be preferable to following the rule. We develop two new policy rules, Asymmetric Coefficient Inflation Targeting and Asymmetric Target Inflation Targeting, that are both time consistent and outperform the traditional rules.

2. Monetary Policy Rules

We start with non-inertial and inertial traditional policy rules which are in accord with the original 2012 statement, the Taylor (1993) rule and the Taylor (1999) and Yellen (2012) balanced approach rule. We then consider shortfalls rules, Asymmetric Coefficient Inflation Targeting (ACIT) rules, and Asymmetric Target Inflation Targeting (ATIT) rules.

2.1 Traditional Rules

The non-inertial Taylor rule where the FFR adjusts immediately to its prescribed value is as follows,

$$R_t = r^* + \pi_t + +0.5(\pi_t - \pi^*) + 0.5y_t \tag{1}$$

where R_t is the level of the short-term federal funds interest rate prescribed by the rule, π_t is the annual inflation rate, π^* is the 2 percent target level of inflation, y_t is the output gap, the percentage

[9] This result does not necessarily generalize to other models. Nikolsko-Rzhevskyy, Papell, and Prodan-Boul (2019) show that non-inertial Taylor rules perform better than non-inertial balance approach rules in the Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2007) models.

deviation of GDP from potential GDP, and $r^*$is the neutral real interest rate that is consistent with inflation equal to the target level of inflation and GDP equal to potential GDP in the longer run. When inflation equals its 2 percent target and GDP equals potential GDP, the federal funds rate equals the neutral real interest rate plus the 2 percent inflation target. The policy rules incorporate the Taylor principle that the nominal interest rate is increased more than point-for-point when inflation rises.

The inertial Taylor rule where the FFR adjusts slowly towards its prescribed value is

$$R_t = 0.85\ R_{t-1} + 0.15[r^* + \pi_t + +0.5(\pi_t - \pi^*) + 0.5y_t] \tag{2}$$

where R_{t-1} equals the rate prescribed by the rule if it is positive and the ELB rate of 0.125 if the prescribed rate is negative, 0.85 is the coefficient on the lagged FFR and 0.15 is the coefficient on the non-inertial Taylor rule prescription. We set the coefficients (0.85, 0.15) as in Bernanke, Kiley, and Roberts (2019), Bernanke (2020), and Fuentes-Albero and Roberts (2021).

Taylor (1999) and Yellen (2012) analyzed an alternative to the Taylor rule that is called the balanced approach rule, where the coefficient on the inflation gap is 0.5 but the coefficient on the output gap is raised to 1.0. The non-inertial balanced approach rule is

$$R_t = r^* + \pi_t + 0.5(\pi_t - \pi^*) + 1.0y_t \tag{3}$$

and the inertial balanced approach rule is

$$R_t = 0.85\ R_{t-1} + 0.15[r^* + \pi_t + 0.5(\pi_t - \pi^*) + 1.0y_t] \tag{4}$$

The balanced approach rule received considerable attention following the Great Recession because, with the then-conventional neutral real interest rate of two percent, it prescribed a negative FFR and thus provided a justification for quantitative easing and a longer period before exiting the ELB.

The traditional rules are time consistent. When inflation π_t equals the 2 percent inflation target $\pi^*$and the output gap y_t equals zero, the FFR equals the nominal neutral FFF ($r^* + \pi^*$). If inflation π_t increases above the 2 percent inflation target $\pi^*$and the output gap y_t remains equal to zero, the prescribed FFR increases to bring inflation down. The rules are time consistent because the commitment made when inflation is below 2 percent to raise the FFR when inflation exceeds

2 percent is credible. They are symmetric because the FFR is lowered when inflation is below 2 percent by the same amount as it is raised when inflation is above 2 percent.

2.2 Shortfalls Rules

The balanced approach (shortfalls) rule was introduced in the February 2021 MPR. The rule mitigates employment shortfalls instead of deviations by having the FFR only respond to unemployment if it exceeds longer-run unemployment. The non-inertial version with the output gap is,

$$R_t = r^* + \pi_t + 0.5(\pi_t - \pi^*) + 1.0 \min\{0, y_t\} \tag{5}$$

and the inertial version is,

$$R_t = 0.85\, R_{t-1} + 0.15[r^* + \pi_t + 0.5(\pi_t - \pi^*) + 1.0 \min\{0, y_t\}] \tag{6}$$

If the output gap is negative, the FFR prescriptions are the same as with the balanced approach rule. If the output gap is positive, the FOMC will not raise the FFR solely because of low unemployment.[10]

We also analyze Taylor (shortfalls) rules. The non-inertial version is

$$R_t = r^* + \pi_t + 0.5(\pi_t - \pi^*) + 0.5 \min\{0, y_t\} \tag{7}$$

and the inertial version is

$$R_t = 0.85\, R_{t-1} + 0.15[r^* + \pi_t + 0.5(\pi_t - \pi^*) + 0.5 \min\{0, y_t\}] \tag{8}$$

The FFR prescriptions with these rules are the same as with the Taylor rule when the output gap is negative and the same as with the balanced approach (shortfalls) rule when the output gap is positive. The shortfalls rules are time consistent for the same reasons that the traditional rules are time consistent. While they are symmetric with respect to the inflation gap, they are asymmetric with respect to the output gap.

[10] Fuentes-Albero and Roberts (2021) conduct dynamic simulations of an inertial version of the balanced approach (shortfalls) rule that incorporates FOMC forward guidance using the FRB/US model

2.3 Proposed Rules for the 2025 Strategy Review

We propose two new rules that are asymmetric and time consistent. The first is the Asymmetric Coefficient Inflation Targeting (ACIT) rule where the coefficient on the inflation gap is larger when inflation is below 2 percent. The non-inertial Taylor rule version is

$$R_t = \begin{Bmatrix} [r^* + \pi_t + 0.5(\pi_t - \pi^*) + 0.5\, y_t] & \text{if } \pi_t > \pi^* \\ [r^* + \pi_t + \pi^C(\pi_t - \pi^*) + 0.5\, y_t] & \text{if } \pi_t \leq \pi^* \end{Bmatrix} \tag{9}$$

and the inertial Taylor rule version is

$$R_t = \begin{Bmatrix} 0.85R_{t-1} + 0.15[r^* + \pi_t + 0.5(\pi_t - \pi^*) + 0.5\, y_t] & \text{if } \pi_t > \pi^* \\ 0.85R_{t-1} + 0.15[r^* + \pi_t + \pi^C(\pi_t - \pi^*) + 0.5\, y_t] & \text{if } \pi_t \leq \pi^* \end{Bmatrix} \tag{10}$$

We analyze rules where the coefficient π^C on the inflation gap $\pi_t - \pi^*$ when $\pi_t \leq \pi^*$ is 0.75, 1.0, and 1.5. When inflation π_t exceeds the 2 percent inflation target, the rule is identical to the Taylor rule. When inflation π_t is less than the 2 percent inflation target, the rule provides more stimulus than the Taylor rule. The balanced approach rule version is identical to the Taylor rule version except that the coefficient on the output gap is 1.0 instead of 0.5. The ACIT rule provides more stimulus than the traditional rules when inflation is below 2 percent and the same amount of restraint when inflation is above 2 percent. Once inflation exceeds 2 percent, policy acts to reduce inflation to, but not below, the 2 percent target.

The second proposed rule is the Asymmetric Target Inflation Targeting (ATIT) rule where the inflation target π^T is larger than 2 percent when inflation is below 2 percent. The non-inertial Taylor rule version is

$$R_t = \begin{Bmatrix} [r^* + \pi_t + 0.5(\pi_t - \pi^*) + 0.5\, y_t] & \text{if } \pi_t > \pi^* \\ [r^* + \pi_t + 0.5(\pi_t - \pi^T) + 0.5\, y_t] & \text{if } \pi_t \leq \pi^* \end{Bmatrix} \tag{11}$$

and the inertial Taylor rule version is

$$R_t = \begin{Bmatrix} 0.85R_{t-1} + 0.15[r^* + \pi_t + 0.5(\pi_t - \pi^*) + 0.5\, y_t] & \text{if } \pi_t > \pi^* \\ 0.85R_{t-1} + 0.15[r^* + \pi_t + 0.5(\pi_t - \pi^T) + 0.5\, y_t] & \text{if } \pi_t \leq \pi^* \end{Bmatrix} \tag{12}$$

We analyze rules when the inflation target π^T when $\pi_t \leq \pi^*$ is 2.5, 3.0, and 4.0. When inflation π_t exceeds the 2 percent inflation target, the rule is identical to the Taylor rule. When inflation π_t is less than the 2 percent inflation target, the rule provides more stimulus than the Taylor rule. The balanced approach rule version is identical to the Taylor rule version except that the coefficient on the output gap is 1.0 instead of 0.5. The ATIT rule provides more stimulus than the traditional rules when inflation is below 2 percent and the same amount of restraint when inflation is above 2 percent. Once inflation exceeds 2 percent, policy acts to reduce inflation to, but not below, the 2 percent target.

The ACIT and ATIT rules are time consistent. When inflation rises above 2 percent, the coefficient on the inflation gap in the ACIT rule and the inflation target in the ATIT rule immediately revert to their values in the traditional rules. There is no conflict between the FOMC's actions and objectives. The rules are also asymmetric. Once inflation rises above 2 percent and the ACIT and ATIT rules revert to the traditional rules, policy immediately switches from stimulus to restraint. As inflation falls towards the 2 percent target, the amount of restraint becomes smaller with a goal of returning inflation to its 2 percent target, but not below.[11]

One potential advantage of the inertial versions of the ACIT and ATIT rules over the non-inertial versions is that, even though the coefficient on the inflation gap in the ACIT rule and the inflation target in the ATIT rule immediately revert to their values in the traditional rules once the 2 percent inflation target is attained, the amount of stimulus will be reduced more slowly over time with the inertial versions. Combined with the lag between raising the FFR and lowering inflation, the inertial rules are more in accord with the FAIT goal of keeping inflation moderately above 2 percent for some time. The ATIT rule is the closest to the line in the Revised Statement defining FAIT that "appropriate monetary policy will likely aim to achieve inflation moderately above 2 percent for some time" because it "aims" at a higher inflation target when inflation is below 2 percent.[12]

3. Loss Functions

The standard method to evaluate economic performance, as in Taylor (1979) and Woodford (2003), is with a quadratic loss function where the goal of policy is to minimize the sum of squared inflation loss $(\pi_t - \pi^*)^2$ and squared output loss y_t^2 where π_t is inflation, π^* is the inflation target, and y_t is the output gap.

[11] This also satisfies the definition of asymmetry in Clarida (2022).

[12] We have not been able to construct a rule that incorporates "persistently below 2 percent" in the Revised Statement without violating time consistency.

$$L(t) = (\pi_t - \pi^*)^2 + y_t^2 \tag{14}$$

This is a symmetric loss function where, in accord with the FOMC's dual mandate, inflation loss and output loss are equally weighted. Alternatively, the loss function can be specified where the unemployment gap, ($U_t - U^*$), where U_t is the unemployment rate and U^* is unemployment in the longer run, replaces the output gap.

Levin, Wieland, and Williams (1999) show that loss minimizing policy with the loss function in Equation 14 will produce unrealistically high coefficients on the inflation and output gaps and very large fluctuations in interest rates. One solution is to add the squared change in the FFR to penalize large responses when evaluating a policy rule,

$$L(t) = (\pi_t - \pi^*)^2 + y_t^2 + (\Delta\, FFR_t)^2 \tag{15}$$

A similar loss function would replace the output gap with the unemployment gap. Bernanke, Kiley, and Roberts (2019), Brayton and Reifschneider (2022), and Kiley 2024 use the loss function in Equation 14 while Arias et al. (2020) use the loss function in Equation 15.

Starting in July 2016, a shortfalls loss function has also been reported in the Tealbook,[13]

$$L_t = \begin{cases} [(\pi_t - \pi^*)^2 + y_t^2] & \text{if } Y_t < Y^* \\ [(\pi_t - \pi^*)^2] & \text{if } Y_t \geq Y^* \end{cases} \tag{16}$$

where output loss is equal to the squared output gap if GDP is below potential GDP and zero if GDP is above potential GDP. The motivation comes from a "flat" Phillips curve where GDP above potential or unemployment below longer-run unemployment has weak effects on subsequent inflation. The shortfalls loss function both predates and embodies the part of the revised statement replacing deviations with shortfalls from maximum employment. While the shortfalls loss function is used in the Tealbook to analyze optimal policy, it is not used to evaluate policy rules. Shortfalls loss functions with the unemployment gap replacing the output gap and/or adding the squared change in the FFR can be written as described above for the symmetric loss functions. The case of the shortfalls loss function using unemployment gap and deviations in FFR is shown below:

[13] Shortfalls loss functions are reported publicly in the Tealbook through December 2018 in accord with the five-year lag for releasing the reports. The Tealbook uses the term Asymmetric (Shortfalls) loss. We call it shortfalls loss to avoid confusion with asymmetric policy rules.

$$L_t = \begin{cases} [(\pi_t - \pi^*)^2 + (U_t - U^*)^2 + (\Delta FFR_t)^2] & \text{if } U_t > U^* \\ [(\pi_t - \pi^*)^2 + (\Delta FFR_t)^2] & \text{if } U_t \leq U^* \end{cases} \tag{17}$$

4. Evaluating Monetary Policy Rules in LINVER

LINVER is the linearized version of FRB/US, the non-linear macroeconomic model of the United States used by the Federal Reserve. LINVER is written in MATLAB, Octave, and EViews and the code is made available to the public. This paper uses the LINVER package written in MATLAB to study the differential impact of various policy rules on the economy. The MATLAB version requires the use of the add-on package Dynare.

We specify a monetary policy rule for the economy and how agents form expectations. LINVER then uses Dynare to solve the macroeconomic model under these conditions. The solution is composed of matrices that specify the decision rules of agents and the future paths of model variables conditional on the state of the economy in the current quarter. Subsequently, LINVER runs simulations of the economy by drawing a matrix of shocks that can be applied to the behavioral equations in the model. These shocks are drawn from residuals created based on historic US data ranging from 1970 Q1 to 2019 Q4. These simulations result in a distribution for the paths of output, unemployment, inflation, and interest rates. Given a large enough number of simulations, these distributions approximate the population distribution, making the calculated moments the same across various rounds of running the LINVER program. This allows for the comparison of summary statistics for these distributions and evaluation of the performance of various monetary policy rules by only changing the policy rule between different rounds of running the program.

We run 32 rounds of simulations for the policy rules in Section 2. Each round has 5000 simulations, and each simulation has an economy that runs for 200 quarters. Across these rounds, agents in financial markets and wage and price setters have model-consistent expectations while all others have VAR expectations. The effective lower bound (ELB) is imposed by setting the neutral real interest rate r^* equal to 1.0, which is close to the r^* of 0.9 in the September 2024 Summary of Economic Projections. Shocks are drawn by stratified random sampling. The current state of the economy is first determined using a Markov-switching model with three states: normal, mild slump, and severe slump state. Based on this given state of the economy, shocks are then drawn randomly from historical data where the period matches the state of the simulated economy as determined by the Markov model. Model consistent expectations used in the model mean that the agents have a complete understanding of how the effects of past and current shocks will play out in the model over time. Absent any future shocks, the expectations of these agents regarding endogenous variables are the same as the predictions of the model. This is different from perfect foresight where agents know the realizations of future shocks. For agents with VAR expectations, their expectations equal the predictions of a small VAR model based on past data. We modify the LINVER code to implement the ACIT and ATIT rules introduced in this paper. Before comparing the distributions across various rounds, the first 100 quarters are dropped so that differences between the outcomes are not influenced by differences in initial conditions across simulations in the rounds. This is also consistent with how LINVER results are evaluated in literature (Bernanke, Kiley, and Roberts 2019; Brayton and Reifschneider 2022).

Summary statistics from the distribution of the path of the endogenous variables are calculated for the mean and standard deviation of the output gap, unemployment gap, and inflation gap. The average proportion of quarters the economy stays in a recession and at the ELB are also calculated. The output gap in LINVER is defined as the log difference between the actual and potential real GDP times 100. Potential GDP is determined based on the parameters of the equation's models. The unemployment gap is the difference between actual and natural rates of unemployment. The inflation gap is the difference between core PCE inflation and the inflation target.

The above means are calculated as the average in the last 100 quarters across the 5000 simulations. The standard deviations are the standard deviations from the same subset of the results. To compare the performance of policy rules in keeping macroeconomic outcomes close to the target, the eight loss functions in Section 4 are calculated to quantify deviations from targets. The symmetric variant of loss functions that consider inflation gaps, output gaps, and penalize changes in the FFR are calculated from the simulation results as follows.

$$Loss = \frac{1}{5000}\frac{1}{100}\sum_{s=1}^{5000} \sum_{t=101}^{200} \left(\pi_{t,s} - \pi^*\right)^2 + y_{t,s}^2 + (\Delta\, \mathrm{FFR}_{t,s})^{\,2} \tag{18}$$

Loss functions without the FFR can be written by removing $(\Delta\, \mathrm{FFR}_{t,s})^{\,2}$. The variants that use the unemployment gap instead of the output gap replace $y_{t,s}^2$ with $(U_{t,s} - U^*)^2$.

A shortfalls version of the above equation is calculated as follows,

$$Loss = \frac{1}{5000}\frac{1}{100}\sum_{s=1}^{5000} \sum_{t=101}^{200}(\pi_{t,s} - \pi^*)^2 + \mathbb{I}_{\{y_{t,s} < 0\}}\, y_{t,s}^2 + (\Delta\, \text{FFR}_{t,s})^{\,2} \qquad (19)$$

where $\mathbb{I}$ is an indicator function that equals one if there is a negative output gap, $y_{t,s} < 0$, and is zero otherwise. In the variant with unemployment gap, the indicator function equals one if there is a positive unemployment gap, $(U_{t,s} - U^*) > 0$, and is zero otherwise.

The advantage of using the LINVER version of the FRB/US model is the reduction in computational costs while still enabling the implementation of both linear and non-linear rules. Non-linearities are added to the model when implementing the ATIT rules, ACIT rules, and shortfalls rules. ATIT rules have a non-linearity with a sudden change in the inflation target based on the inflation in the economy while ACIT rules bring in non-linearity with the asymmetry in the coefficient on inflation gap based on the inflation level in the economy. Shortfalls rules bring in a non-linearity by considering output gaps in the rule only when the gap is negative. LINVER implements these non-linearities by adding an adjustment term when necessary to the linear solutions of the model so that the rule evaluates to a non-linear rule.

5. Monetary Policy Rule Evaluation Results

Tables 1 – 6 compare economic loss across various policy rules and loss functions. The policy rules are non-inertial and inertial versions of traditional, shortfalls, Asymmetric Coefficient Inflation Targeting (ACIT) and Asymmetric Target Inflation Targeting (ATIT) Taylor and balanced approach rules. The loss functions are symmetric and shortfalls with and without the change in the FFR using output and unemployment gaps. While we can compare loss between rules with the same loss function, we cannot compare loss between loss functions with the same rule because they will differ by construction.

The LINVER model can be run either with the Effective Lower Bound (ELB) imposed or not imposed. When the ELB is imposed, the FFR is set equal to 0.125 when it would otherwise be lower and even negative. Since the FOMC has never attempted to enact negative nominal interest rates, this is the most straightforward interpretation of Fed policy. The problem with this interpretation, however, is that the FOMC conducts quantitative easing once the ELB is attained to provide additional stimulus. When the ELB is not imposed, the FFR can be interpreted as a "shadow" interest rate that reflects the full extent of the stimulus. The losses when the ELB is not imposed are uniformly smaller than when the ELB is imposed, reflecting the additional stimulus from quantitative easing. Comparison of losses among various rules are very similar whether or not the ELB is imposed.

5.1 Effective Lower Bound Imposed

The results with traditional rules are reported in Table 1. Balanced approach rules outperform Taylor rules. The loss with balanced approach rules is smaller than the loss with Taylor rules for all 16 specifications and the average loss with Taylor rules is 12.60 compared to 10.72 for balanced approach rules. While it is difficult to interpret the average loss across different loss functions, we can gain some insight from the most common specification, symmetric loss with the output gap and no change in the FFR for non-inertial rules. For that case, the average loss is 21.23 for Taylor rules and 17.35 for balanced approach rules, a difference of almost four percentage points. Assuming that the inflation and output gaps are equal, the average of each gap is about 1.4 percentage points.

Inertial rules outperform non-inertial rules. The loss with inertial rules is smaller than the loss with non-inertial rules for all 16 specifications. These include loss functions without the change in the FFF which do not penalize the larger changes in the FFR with non-inertial rules. The magnitudes of the differences are smaller between inertial and non-inertial rules than between Taylor and balanced approach rules, as the average loss with inertial rules is 11.38 compared to 11.95 with non-inertial rules. The percent of quarters at the ELB and the percent of quarters in recession are also reported in Table 1. The percent of quarters at the ELB for traditional rules is 23.33 with non-inertial rules compared with 15.89 for inertial rules. The opposite holds for the percent of quarters in recession, 23.66 with non-inertial rules versus 22.72 with inertial rules, although the differences are smaller. The percent of quarters at the ELB is higher with balanced approach rules, 21.18 percent versus 18.04 percent with Taylor rules, but the percent of quarters in recession is higher with Taylor rules, 23.0 percent versus 21.03 percent with balanced approach rules. Overall, comparison of the percent of quarters at the ELB and the percent of quarters in recession is very different between non-inertial/inertial and Taylor/balanced approach rules.

Results with shortfalls rules are also reported in Table 1. Shortfalls rules underperform traditional rules. The loss with traditional rules is smaller than the loss with shortfalls rules for all 32 specifications, including those with shortfalls loss. The magnitudes of the differences are larger between shortfalls and traditional rules than between Taylor and balanced approach rules, as the average loss with shortfalls rules is 15.16 compared to 11.66 with traditional rules. This accords with the results in Kiley (2024) who shows that shortfalls rules perform worse than traditional rules even when the loss function does not include shortfalls loss.

The results for ACIT rules are reported in Table 2 for coefficients on the inflation gap of 1.0, 1.5, and 2.0 when inflation is less than 2 percent compared with 0.5 for the traditional Taylor and balanced approach rules. The ACIT rules are the same as the Taylor and balanced approach rules when inflation is greater than 2 percent. The loss with ACIT rules is smaller than the loss with traditional rules for all 96 specifications: non-inertial and inertial Taylor and balanced approach rules with three coefficients and eight loss functions. The loss is inversely related to the size of the coefficients with the average loss for the ACIT rules with inflation gap coefficients of 1.0, 1.5, and 2.0 are 10.86, 10.37, and 10.08 while the average loss for the traditional rules with an inflation gap coefficient of 0.5 is 11.66.

Balanced approach rules again outperform Taylor rules. The loss with balanced approach rules is smaller than the loss with Taylor rules for all 48 specifications and the average loss with Taylor rules is 11.26 compared to 9.61 for balanced approach rules. Inertial rules continue to outperform non-inertial rules. The loss with inertial rules is smaller than the loss with non-inertial rules for all 48 specifications, again including loss functions without the change in the FFF which do not penalize the larger changes in the FFR with non-inertial rules. The magnitudes of the differences are again smaller between inertial and non-inertial rules than between Taylor and balanced approach rules, as the average loss with inertial rules is 10.18 compared to 10.69 with non-inertial rules.

The percent of quarters at the ELB and the percent of quarters in recession are also reported in Table 2. The percent of quarters at the ELB for ACIT rules is 25.24 with non-inertial rules compared with 16.51 for inertial rules. The same holds for the percent of quarters in recession, 21.29 with non-inertial rules versus 22.62 with inertial rules. The percent of quarters at the ELB is higher with balanced approach rules, 22.23 percent versus 19.52 percent with Taylor rules. The same holds for the percent of quarters in recession, 21.01 percent with balanced approach rules versus 22.89 percent with Taylor rules. In contrast with the results for traditional rules, comparison of the percent of quarters at the ELB and the percent of quarters in recession for ACIT rules is very different between non-inertial/inertial and Taylor/balanced approach rules.

Table 3 reports results for the ATIT rules with inflation targets of 2.5, 3.0, and 4.0 percent when inflation is less than 2 percent compared with 2.0 for the traditional Taylor and balanced approach rules. The ATIT rules are the same as the Taylor and balanced approach rules when inflation is greater than 2 percent. The loss with ATIT rules is smaller than the loss with traditional rules for all 96 specifications. The loss is inversely related to the magnitude of the targets with the average loss for the ATIT rules with inflation targets of 2.5, 3.0, and 4.0 are 11.07, 10.84, and 10.21 while the average loss for the traditional rules with an inflation target of 0.5 is 11.66.

Balanced approach rules continue to outperform Taylor rules. The loss with balanced approach rules is smaller than the loss with Taylor rules for all 48 specifications and the average loss with Taylor rules is 11.60 compared to 9.91 for balanced approach rules. Inertial rules continue to outperform non-inertial rules as the loss with inertial rules is again smaller than the loss with non-inertial rules for all 48 specifications. The magnitudes of the differences are again smaller between inertial and non-inertial rules than between Taylor and balanced approach rules, as the average loss with inertial rules is 10.47 compared to 11.04 with non-inertial rules. The percent of quarters at the ELB and the percent of quarters in recession are also reported in Table 3. The percent of quarters at the ELB for ATIT rules is 22.59 with non-inertial rules compared with 14.69 for inertial rules. The same holds for the percent of quarters in recession, 21.22 with non-inertial rules versus 22.57 with inertial rules.

The percent of quarters at the ELB is higher with balanced approach rules, 20.21 percent versus 17.01 percent with Taylor rules. The opposite holds for the percent of quarters in recession, 20.93 percent with balanced approach rules versus 22.86 percent with Taylor rules. Comparison of the percent of quarters at the ELB and the percent of quarters in recession between non-inertial/inertial and Taylor/balanced approach rules for ATIT rules is not as similar as for traditional rules and not as different as for ACIT rules.

Comparison of losses between ACIT and ATIT rules is ambiguous because it depends on the choice of inflation gap coefficients for the ACIT rules and the choice of inflation targets for the ATIT rules. Nevertheless, the average loss over all specifications is 10.81 with the ACIT rules and 10.75 with the ATIT rules, providing no reason to choose one over the other.

5.2 Effective Lower Bound Not Imposed

The results with traditional rules are reported in Table 4. Balanced approach rules outperform Taylor rules. The loss with balanced approach rules is smaller than the loss with Taylor rules for all 16 specifications and the average loss with Taylor rules is 9.81 compared to 7.16 for balanced approach rules. While it is difficult to interpret the average loss across different loss functions, we can gain some insight from the most common specification, symmetric loss with the output gap and no change in the FFR for non-inertial rules. For that case, the average loss is 16.09 for Taylor rules and 10.84 for balanced approach rules, a difference of over five percentage points. Assuming that the inflation and output gaps are equal, the average of each gap is about 1.6 percentage points.

Inertial rules outperform non-inertial rules. The loss with inertial rules is smaller than the loss with non-inertial rules for 13 out of 16 specifications. These include loss functions without the change in the FFF which do not penalize the larger changes in the FFR with non-inertial rules. The magnitudes of the differences are smaller between inertial and non-inertial rules than between Taylor and balanced approach rules, as the average loss with inertial rules is 8.49 compared with 8.70 for non-inertial rules. The percent of quarters in recession is 19.76 with non-inertial rules compared with 21.79 for inertial rules and 19.56 with balanced approach rules compared with 21.92 for Taylor rules.

Results with shortfalls rules are also reported in Table 4. Shortfalls rules underperform traditional rules. The loss with traditional rules is smaller than the loss with shortfalls rules for all 32 specifications, including those with shortfalls loss. The magnitudes of the differences are larger between shortfalls and traditional rules than between Taylor and balanced approach rules, as the average loss with shortfalls rules is 11.63 compared to 8.60 with traditional rules.

The results for ACIT rules are reported in Table 5 for coefficients on the inflation gap of 1.0, 1.5, and 2.0 when inflation is less than 2 percent compared with 0.5 for the traditional Taylor and balanced approach rules. The ACIT rules are the same as the Taylor and balanced approach rules when inflation is greater than 2 percent. The loss with ACIT rules is smaller than the loss with traditional rules for all 96 specifications: non-inertial and inertial Taylor and balanced approach rules with three coefficients and eight loss functions. The loss is inversely related to the size of the coefficients with the average loss for the ACIT rules with inflation gap coefficients of 1.0, 1.5, and 2.0 are 7.89, 7.60, and 7.48 while the average loss for the traditional rules with an inflation gap coefficient of 0.5 is 8.60.

Balanced approach rules again outperform Taylor rules. The loss with balanced approach rules is smaller than the loss with Taylor rules for all 48 specifications and the average loss with Taylor rules is 8.66 compared to 6.65 for balanced approach rules. Inertial rules continue to outperform non-inertial rules. The loss with inertial rules is smaller than the loss with non-inertial rules for all 48 specifications, again including loss functions without the change in the FFF which do not penalize the larger changes in the FFR with non-inertial rules. The magnitudes of the differences are larger between inertial and non-inertial rules than between Taylor and balanced approach rules, as the average loss with inertial rules is 7.44 compared to 7.87 with non-inertial rules. The percent of quarters in recession is 20.10 with non-inertial rules versus 21.89 with inertial rules and 19.89 percent with balanced approach rules versus 22.10 percent with Taylor rules.

Table 6 reports results for the ATIT rules with inflation targets of 2.5, 3.0, and 4.0 percent when inflation is less than 2 percent compared with 2.0 for the traditional Taylor and balanced approach rules. The ATIT rules are the same as the Taylor and balanced approach rules when inflation is greater than 2 percent. The loss with ATIT rules is smaller than the loss with traditional rules for all 96 specifications. The loss is inversely related to the magnitude of the targets with the average loss for the ATIT rules with inflation targets of 2.5, 3.0, and 4.0 are 7.77, 7.20, and 7.13 while the average loss for the traditional rules with an inflation target of 0.5 is 8.60.

Balanced approach rules continue to outperform Taylor rules. The loss with balanced approach rules is smaller than the loss with Taylor rules for all 48 specifications and the average loss with Taylor rules is 8.52 compared to 6.54 for balanced approach rules. Inertial rules continue to outperform non-inertial rules as the loss with inertial rules is again smaller than the loss with non-inertial rules for all 48 specifications. The magnitudes of the differences are again smaller between inertial and non-inertial rules than between Taylor and balanced approach rules, as the average loss with inertial rules is 6.93 compared to 8.15 with non-inertial rules and 19.69 with balanced approach rules versus 21.91 with Taylor rules.

The percent of quarters in recession is 19.83 with non-inertial rules 21.77 with inertial rules. Comparison of losses between ACIT and ATIT rules is again ambiguous because it depends on the choice of inflation gap coefficients for the ACIT rules and the choice of inflation targets for the ATIT rules. The average loss over all specifications is 7.60 with the ACIT rules and 7.53 with the ATIT rules, again providing no reason to choose one over the other.

6. Counterfactuals for Monetary Policy Rules

We compare FFR prescriptions from Taylor and balanced approach versions of traditional rules with prescriptions from our proposed Asymmetric Coefficient Inflation Targeting (ACIT) and Asymmetric Target Inflation Targeting (ATIT) rules. Since the prescriptions are identical when inflation is greater than or equal to 2 percent, we focus on the period following the Great Recession when inflation was lower than 2 percent. These are counterfactuals and not simulations. The data for the rules are historical and do not account for how adoption of different rules might have changed the inflation and unemployment gap outcomes.

Inflation fell below 2.0 percent in 2008:Q4 and stayed equal or below 2.0 percent through 2019:Q4. The Federal Reserve has included prescriptions from monetary policy rules, including the Taylor and balanced approach rules, in the semi-annual Monetary Policy Report (MPR) since July 2017. We consider what prescriptions from the ACIT and ATIT rules would have been if they were included in the MPR. The rules in the MPR are non-inertial with the unemployment gap replacing the output gap. The Taylor rule is

$$R_t = r_t^* + \pi_t + 0.5(\pi_t - \pi^*) + (U_t^* - U_t), \tag{13}$$

where R_t is the level of the short-term federal funds interest rate prescribed by the rule, πt is the inflation rate, π^* is the 2 percent target level of inflation, U_t^* is the time-varying rate of unemployment in the longer run, U_t is the current unemployment rate, and r_t^* is the time-varying neutral real interest rate that is consistent with inflation equal to the target level of inflation and unemployment equal to the rate of unemployment in the longer run. The neutral real interest rate and the rate of unemployment in the longer run are time-varying and trend downward during the period. The coefficient of 1.0 on the unemployment gap is equivalent to a coefficient of 0.5 on the output gap with an Okun's Law coefficient of 2.0. The balanced approach rule is identical to the Taylor rule with a coefficient of 2.0 on the unemployment gap. The ACIT and ATIT rules are from Equation 9 and Equation 11 with the variables described above.[14]

Figure 1 depicts the prescriptions from the traditional Taylor and balanced approach rules from 2009:Q1 – 2019:Q4. They do not impose the Effective Lower Bound (ELB) and are identical to the prescriptions in the figures from the MPR's.[15] The initial negative prescriptions from the balanced approach rules are larger and longer-lasting than those from the Taylor rules, with a prescribed exit from the ELB of 2014:Q2 with the balanced approach rule and 2011:Q4 with the Taylor rule. Both of these are faster than the actual 2015:Q4 exit.

[14] Prescriptions from the make-up rule in Reifschneider and Williams (2000) have been included in the MPR since July 2017 under the name "Taylor (1993) rule, adjusted". We do not include this rule because of time inconsistency issues. Prescriptions from the balanced approach (shortfalls) rule have been included since February 2021. We do not include this rule because we do not extend it.

[15] Prescriptions from these rules are compared with prescriptions from different alternative rules in Papell and Prodan-Boul (2022). We splice data from various MPRs because none of the individual reports contain the full span of data. This is not a problem because the MPR's use real-time data.

The prescriptions from the ACIT and ATIT rules with a coefficient of 1.0 on the inflation gap for the ACIT rules and an inflation target of 3.0 for the ATIT rules are also illustrated in Figure 1. The prescribed liftoff from the ELB is one or two quarters after the traditional rules. While the increased length of time at the ELB reflects the additional stimulus with the ACIT and ATIT rules than with the traditional rules, the actual length of time depends on the choice of the coefficient for the ACIT rules and the target for the ATIT rules. Larger coefficients and targets would increase the time at the ELB while smaller coefficients and targets would do the opposite. Comparison between ACIT rules and ATIT rules is similarly arbitrary.

7. Conclusions

The Federal Reserve started a comprehensive Review of Monetary Policy, Tools, and Communications in 2019 which resulted in the 2020 Revised Statement on Longer-Run Goals and Monetary Policy Strategy. As the Fed conducts another review, it is worth thinking about how our results might relate to that process.

We use the LINVER version of the FRB/US model to evaluate the performance of a variety of policy rules. These include non-inertial and inertial versions of two rules that are consistent with the 2012 Statement, the Taylor (1993) rule and the Yellen (2012) balanced approach rule. They also include shortfalls rules that are in accord with parts of the 2020 Revised Statement. We show that economic performance is better with balanced approach rules than with Taylor rules, worse with shortfalls rules than with traditional rules, and better with inertial rules than non-inertial rules.

Background papers on policy evaluation using the FRB/US model prepared for the 2019 Review, including Average Inflation Targeting, Asymmetric Average Inflation Targeting, and make-up rules showed that the rules outperformed traditional Taylor and balanced approach rules. These rules, however, are not time consistent and were not included in the Revised Statement in favor of the ambiguous Flexible Average Inflation Targeting framework. We develop two new policy rules, Asymmetric Coefficient Inflation Targeting and Asymmetric Target Inflation Targeting that are both time consistent and outperform the traditional rules. Powell (2024b) suggested that the base case for the 2025 Review should, in contrast to the make-up strategies that were the focus of the 2019 Review, be more like a traditional reaction function where you don't promise an overshoot of inflation. Our proposed ACIT and ATIT policy rules are both in accord with this suggestion and an improvement over traditional rules. We believe that they would make good candidates for inclusion in the 2025 Review.

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Table 1: Traditional and Shortfalls Rules With ELB Imposed

Rule	Taylor		Balanced Approach	
	Traditional	**Shortfalls**	**Traditional**	**Shortfalls**
		Non-Inertial		
Loss with Output Gap				
Symmetric Loss	21.23	27.77	17.35	26.43
Symmetric Loss with ΔFFR	21.77	28.26	18.08	26.96
Shortfalls Loss	15.70	16.56	13.96	15.30
Shortfalls Loss with ΔFFR	16.23	17.05	14.68	15.83
Loss with Unemployment Gap				
Symmetric Loss	8.07	10.21	6.85	9.89
Symmetric Loss with ΔFFR	8.61	10.7	7.57	10.41
Shortfalls Loss	5.39	7.57	4.48	7.54
Shortfalls Loss with ΔFFR	5.93	8.06	5.20	8.07
Quarters				
% of Quarters at ELB	21.77	21.94	24.89	24.65
% of Quarters in Recession	22.42	25.22	20.20	24.48
		Inertial		
Loss with Output Gap				
Symmetric Loss	20.92	27.58	17.02	26.13
Symmetric Loss with ΔFFR	20.99	27.64	17.11	26.2
Shortfalls Loss	15.27	16.14	13.5	14.69
Shortfalls Loss with ΔFFR	15.35	16.20	13.59	14.76
Loss with Unemployment Gap				
Symmetric Loss	7.80	9.94	6.61	9.60
Symmetric Loss with ΔFFR	7.88	10.00	6.71	9.67
Shortfalls Loss	5.17	7.34	4.37	7.35
Shortfalls Loss with ΔFFR	5.25	7.41	4.41	7.42
Quarters				
% of Quarters at ELB	14.31	14.59	17.46	17.33
% of Quarters in Recession	23.58	25.79	21.85	25.17

Table 2: Asymmetric Coefficient Inflation Targeting Rules With ELB Imposed

	Taylor			Balanced Approach		
ACIT Coefficient	**1.0**	**1.5**	**2.0**	**1.0**	**1.5**	**2.0**
			Non-Inertial			
Loss with Output Gap						
Symmetric Loss	19.75	18.94	18.48	16.23	15.44	14.96
Symmetric Loss with ΔFFR	20.37	19.64	19.26	17.04	16.33	15.93
Shortfalls Loss	14.07	13.18	12.65	12.72	11.84	11.28
Shortfalls Loss with ΔFFR	14.69	13.88	13.42	13.52	12.73	12.25
Loss with Unemployment Gap						
Symmetric Loss	7.47	7.16	6.97	6.40	6.08	5.89
Symmetric Loss with ΔFFR	8.09	7.86	7.75	7.20	6.97	6.86
Shortfalls Loss	5.11	4.97	4.89	4.26	4.12	4.04
Shortfalls loss with ΔFFR	5.73	5.67	5.67	5.07	5.01	5.01
Quarters						
% of Quarters at ELB	22.73	23.91	25.16	25.59	26.50	27.53
% of Quarters in Recession	22.34	22.33	22.38	20.18	20.22	20.28
			Inertial			
Loss with Output Gap						
Symmetric Loss	19.62	18.93	18.54	16.05	15.37	14.96
Symmetric Loss with ΔFFR	19.70	19.02	18.64	16.15	15.49	15.09
Shortfalls Loss	13.80	12.94	12.41	12.37	11.55	11.01
Shortfalls loss with ΔFFR	13.89	13.04	12.52	12.48	11.67	11.14
Loss with Unemployment Gap						
Symmetric Loss	7.25	6.97	6.81	6.21	5.92	5.76
Symmetric Loss with ΔFFR	7.34	7.07	6.92	6.31	6.04	5.89
Shortfalls Loss	4.91	4.80	4.75	4.12	4.00	3.94
Shortfalls Loss with ΔFFR	4.99	4.89	4.86	4.22	4.11	4.06
Quarters						
% of Quarters at ELB	14.53	15.02	15.75	17.55	17.86	18.34
% of Quarters in Recession	23.48	23.43	23.45	21.77	21.76	21.81

Table 3: Asymmetric Target Inflation Targeting Rules With ELB Imposed

	Taylor			Balanced Approach		
ATIT Targets	**2.5**	**3**	**4**	**2.5**	**3**	**4**
			Non-Inertial			
Loss with Output Gap						
Symmetric Loss	20.49	19.80	18.68	16.76	16.24	15.27
Symmetric Loss with ΔFFR	21.07	20.43	19.43	17.53	17.05	16.2
Shortfalls Loss	14.85	14.09	12.86	13.30	12.71	11.63
Shortfalls Loss with ΔFFR	15.43	14.72	13.61	14.06	13.52	12.56
Loss with Unemployment Gap						
Symmetric Loss	7.76	7.49	7.06	6.61	6.39	6.02
Symmetric Loss with ΔFFR	8.34	8.12	7.81	7.37	7.2	6.94
Shortfalls Loss	5.25	5.12	4.94	4.36	4.26	4.09
Shortfalls Loss with ΔFFR	5.82	5.75	5.69	5.12	5.07	5.02
Quarters						
% of Quarters at ELB	21.24	20.91	20.99	24.42	24.11	23.86
% of Quarters in Recession	22.36	22.30	22.26	20.18	20.12	20.09
			Inertial			
Loss with Output Gap						
Symmetric Loss	20.21	19.59	18.59	16.45	15.94	15.13
Symmetric Loss with ΔFFR	20.29	19.68	18.68	16.55	16.05	15.24
Shortfalls Loss	14.47	13.76	12.58	12.85	12.26	11.30
Shortfalls Loss With ΔFFR	14.55	13.84	12.67	12.95	12.37	11.41
Loss with Unemployment Gap						
Symmetric Loss	7.50	7.25	6.86	6.38	6.17	5.84
Symmetric Loss with ΔFFR	7.58	7.34	6.95	6.48	6.27	5.96
Shortfalls Loss	5.03	4.92	4.76	4.20	4.11	3.97
Shortfalls Loss with ΔFFR	5.11	5.00	4.85	4.30	4.21	4.08
Quarters						
% of Quarters at ELB	13.70	13.14	12.43	16.87	16.35	15.66
% of Quarters in Recession	23.48	23.42	23.33	21.79	21.72	21.67

Table 4: Traditional and Shortfalls Rules Without ELB imposed

Rule	Taylor		Balanced Approach	
	Traditional	**Shortfalls**	**Traditional**	**Shortfalls**
		Non-Inertial		
Loss with output gap				
Symmetric Loss	16.09	21.95	10.84	18.75
Symmetric Loss with ΔFFR	16.82	22.63	11.92	19.61
Shortfalls Loss	10.91	11.69	7.68	8.76
Shortfalls loss with ΔFFR	11.64	12.37	8.76	9.61
Loss with Unemployment Gap				
Symmetric Loss	6.63	8.58	4.92	7.66
Symmetric Loss with ΔFFR	7.36	9.26	6.00	8.51
Shortfalls Loss	4.95	6.94	3.89	6.68
Shortfalls loss with ΔFFR	5.68	7.62	4.96	7.54
Quarters				
% of Quarters in Recession	21.15	23.80	18.37	22.36
		Inertial		
Loss with output gap				
Symmetric Loss	16.30	22.42	11.14	19.33
Symmetric Loss with ΔFFR	16.39	22.50	11.27	19.43
Shortfalls Loss	10.95	11.70	7.80	8.80
Shortfalls loss with ΔFFR	11.04	11.78	7.93	8.90
Loss with Unemployment Gap				
Symmetric Loss	6.43	8.43	4.81	7.58
Symmetric Loss with ΔFFR	6.25	8.51	4.94	7.68
Shortfalls Loss	4.67	6.72	3.70	6.54
Shortfalls loss with ΔFFR	4.77	6.80	3.83	6.64
Quarters				
% of Quarters in Recession	22.69	24.78	20.75	23.8

Table 5: Asymmetric Coefficient Inflation Targeting Rules Without ELB imposed

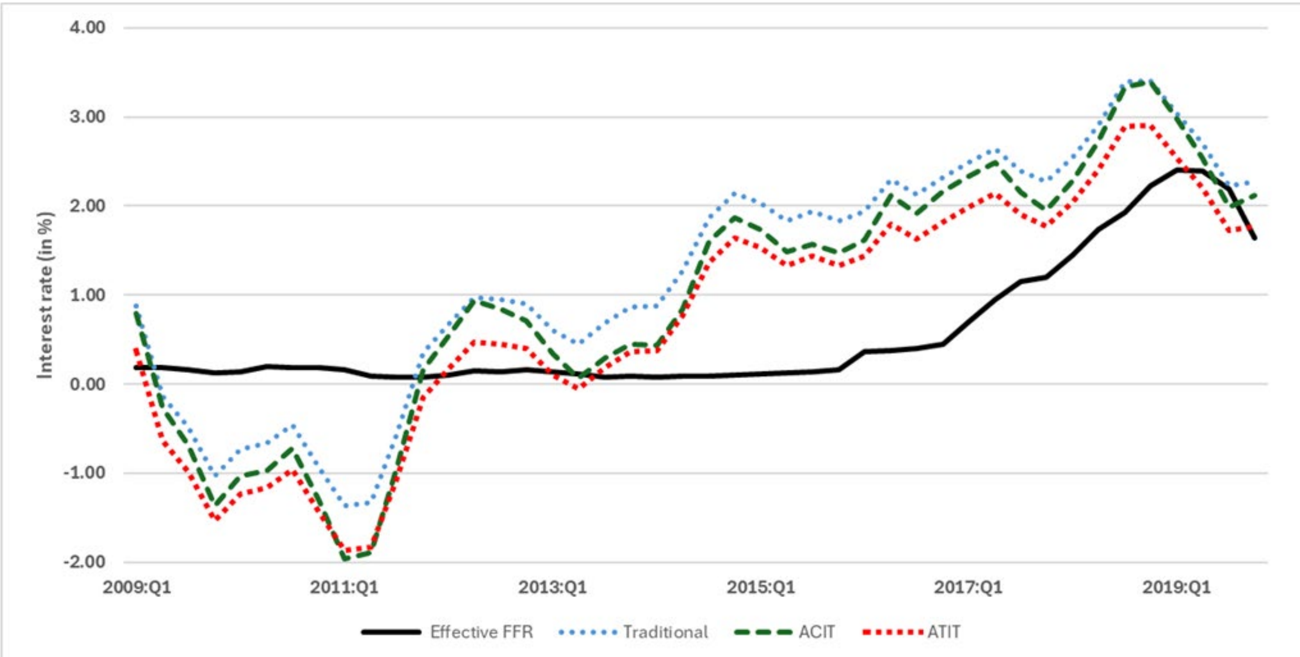
	Taylor			Balanced Approach		
ACIT Coefficient	**1.0**	**1.5**	**2.0**	**1.0**	**1.5**	**2.0**
			Non-Inertial			
Loss with output gap						
Symmetric Loss	14.71	14.00	13.61	10.22	9.87	9.66
Symmetric Loss with ΔFFR	15.64	15.16	15.04	11.49	11.38	11.45
Shortfalls Loss	9.38	8.54	8.03	6.94	6.47	6.16
Shortfalls loss with ΔFFR	10.31	9.70	9.46	8.21	7.98	7.94
Loss with Unemployment Gap						
Symmetric Loss	6.00	5.68	5.52	4.61	4.44	4.34
Symmetric Loss with ΔFFR	6.93	6.85	6.95	5.89	5.95	6.13
Shortfalls Loss	4.61	4.46	4.39	3.72	3.63	3.59
Shortfalls loss with ΔFFR	5.54	5.62	5.82	4.99	5.14	5.38
Quarters						
% of Quarters in Recession	21.22	21.38	21.59	18.56	18.81	19.06
			Inertial			
Loss with output gap						
Symmetric Loss	15.16	14.61	14.32	10.65	10.39	10.26
Symmetric Loss with ΔFFR	15.27	14.74	14.48	10.8	10.56	10.46
Shortfalls Loss	9.59	8.83	8.34	7.13	6.71	6.41
Shortfalls loss with ΔFFR	9.70	8.96	8.50	7.28	6.88	6.61
Loss with Unemployment Gap						
Symmetric Loss	5.9	5.65	5.52	4.55	4.42	4.34
Symmetric Loss with ΔFFR	6.01	5.78	5.67	4.70	4.59	4.54
Shortfalls Loss	4.41	4.31	4.28	3.57	3.52	3.50
Shortfalls loss with ΔFFR	4.52	4.45	4.44	3.72	3.69	3.70
Quarters						
% of Quarters in Recession	22.71	22.79	22.9	20.85	20.96	21.10

Table 6: Asymmetric Target Inflation Targeting Rules Without ELB imposed

	Taylor			Balanced Approach		
ATIT Targets	**2.5**	**3**	**4**	**2.5**	**3**	**4**
			Non-Inertial			
Loss with output gap						
Symmetric Loss	15.55	15.08	14.32	10.58	10.35	9.98
Symmetric Loss with ΔFFR	16.32	15.9	15.29	11.69	11.52	11.31
Shortfalls Loss	10.27	9.72	8.83	7.35	7.05	6.57
Shortfalls loss with ΔFFR	11.05	10.54	9.80	8.46	8.23	7.90
Loss with Unemployment Gap						
Symmetric Loss	6.36	6.14	5.80	4.78	4.66	4.47
Symmetric Loss with ΔFFR	7.14	6.97	6.78	5.90	5.83	5.80
Shortfalls Loss	4.80	4.68	4.51	3.80	3.73	3.63
Shortfalls loss with ΔFFR	5.58	5.51	5.48	4.92	4.91	4.96
Quarters						
% of Quarters in recession	21.15	21.17	21.19	18.42	18.46	18.60
			Inertial			
Loss with output gap						
Symmetric Loss	14.57	14.38	14.1	10.34	10.25	10.14
Symmetric Loss with ΔFFR	14.69	14.50	14.24	10.49	10.41	10.32
Shortfalls Loss	8.74	8.46	8.03	6.60	6.45	6.20
Shortfalls loss with ΔFFR	8.85	8.59	8.17	6.76	6.61	6.37
Loss with Unemployment Gap						
Symmetric Loss	5.63	5.55	5.44	4.38	4.34	4.29
Symmetric Loss with ΔFFR	5.75	5.68	5.58	4.54	4.50	4.46
Shortfalls Loss	4.30	4.28	4.26	3.49	3.48	3.47
Shortfalls loss with ΔFFR	4.42	4.4	4.39	3.65	3.64	3.65
Quarters						
% of Quarters in recession	22.64	22.64	22.69	20.83	20.87	20.96

Figure 1: Effective Federal Funds Rate and Policy Rule Prescriptions for 2009:Q1 – 2019:Q4

Panel (a): Non-Inertial Taylor Rule



Panel (b): Non-Inertial Balanced Approach Rule