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Further Analysis of Simple Policy Rules in the Current Environment[1]

1. Introduction and Summary

This memo provides additional information on topics discussed in the memo, "An Overview of Simple Policy Rules and their Use in Policymaking in Normal Times and Under Current Conditions." As discussed in that memo, simple rules such as the Taylor (1999) or outcome-based rule seem to characterize Committee behavior fairly well over the quarter century up to the financial crisis. At present, however, the policy rate is at the effective lower bound and the prescriptions of negative rates coming from many simple rules cannot be followed. One possible approach in these circumstances would be to adhere to the rule prescription when that prescription exceeds the bound, while holding the policy rate at the bound otherwise. Doing so, however, may lead to poorer economic performance than other approaches, largely because the effective lower bound creates a range of asymmetries—for both macroeconomic performance and for the contour of the federal funds rate in response to shocks—that could be important for inflation and unemployment as well as the for Committee's communications strategy.

Section 2 discusses the implications of the asymmetries associated with the effective lower bound for the contour of the federal funds rate, economic performance, and risk management strategies. The key results are:

- Strict adherence to rules such as Taylor (1999) and the outcome-based rule to determine the timing and pace of first policy firming would imply a widely-dispersed and fairly flat distribution of firming dates. In light of that dispersion, the mode of this distribution would be a very imperfect summary of the likely date of the first federal funds rate increase. The modal date of policy firming might be very early (for example, this year or early next year) even though both the median date and the date implied by the Tealbook baseline outlook under the rule are as much as six quarters later. The substantial differences in measures of "central tendency" would complicate communication and reflect the importance of the asymmetry imposed by the effective lower bound.
- Strict adherence to rules such as Taylor (1999) and the outcome-based rule not only would lead to a substantial probability of tightening by early next year, these early liftoffs would be associated with a high probability of relatively prompt return to the effective lower bound.
- Risk-management considerations suggest that benefits would accrue from modifying standard rules to delay the first increase in the federal funds rate past the date implied by standard prescriptions, with the extent of the adjustment depending on the perceived likelihood of reverting to the effective lower bound and with greater delays occurring if downside tail risks are larger.
- We explore *ad hoc* adjustments to simple rules that postpone the initial increase in the funds rate. As a simple example, we delay tightening until two quarters after the rules prescribe it. Even such modest adjustments may lead to substantially better performance.

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A principal source of these results is the interaction of shocks with the asymmetry created by the effective lower bound. This asymmetry could be largely eliminated if nonstandard balance sheet policies could entirely make up for the accommodation that might otherwise have been supplied by lowering the federal funds rate below the effective lower bound. Thus, Section 2 presumes some shortfall in accommodation due to, say, costs or other limits on the scope to which balance sheet policies may be deployed.

Section 3 takes up the topic of adjusting the prescriptions of simple rules for the effects of balance sheet policies. We illustrate that the merits of any particular adjustment tend to be quite sensitive to assumptions about which there may be no strong consensus—assumptions regarding the channels of policy, the effectiveness of past actions, and the treatment of policy feedbacks.

2. Illustrating Some Implications of Simple Rules in the Current Situation

Setup of the simulations

We investigate the implications of using three simple policy rules—the outcome-based rule that forms the basis for the Tealbook baseline outlook, the Taylor (1999) rule, and an inertial version of the Taylor (1999) rule—as guides to the timing and contour of the departure of the federal funds rate from the effective lower bound. The methodology we employ is a standard one: We use the same stochastic shocks applied to the same baseline as for the Tealbook fan charts.[2] All the simulations take the June 2012 Tealbook forecast as the baseline outlook.

There are many subtle and practical issues that arise in formulating stochastic simulations for an environment in which forward-looking behavior is relevant. For computational reasons, we use the "VAR-based expectations" version of the FRB/US model. This modeling approach probably downplays the advantages that might flow from adjustments to rules that keep the funds rate at its lower bound for longer because we are not taking account of the possible benefits resulting from expectations of future accommodation.

Result from simulations under uncertainty

Figure 1 shows the distribution of dates of first increase in the federal funds rate as implied by stochastic simulations of the FRB/US model under each of the three simple policy rules considered.[3] In this and all subsequent simulation exercises, we assume that the Committee strictly follows the prescriptions of the policy rule under consideration.

The first observation to be taken from the figure is the wide dispersion of possible firming dates in this stochastic environment. Consistent with the conclusions drawn from Figure 1, because the baseline firming dates are distant in time, there is considerable scope for shocks in the intervening period to shift the departure date by a substantial degree. In addition, the central

[2] The stochastic simulations use 20,000 bootstrapped draws from the shock process implied by the FRB/US model's historical database of shocks. As noted, we use the June Tealbook as our baseline outlook but initiate our stochastic simulations as if policy decisions are implemented beginning with the July-August 2012 FOMC meeting.

[3] For definitions of the three rules, see the accompanying memo, "An Overview of Simple Policy Rules and Their Use in Policymaking in Normal Times and Under Current Conditions."

tendency of the date at which the federal funds rate rises above the lower bound is clearly not simple to characterize, given that the median date is substantially later than the modal date. Indeed, the modal date is a poor summary statistic, as the distribution of the firming date under each rule is very flat, with no individual probability (across any of the rules) much above 20 percent. Moreover, under all three rules the modal date for the initial increase in the funds rate is much earlier than the 2014:Q3 date in the June Tealbook baseline. These early firming results, in part, reflect the fact that, under the baseline assumptions, the unconstrained policy prescription for each of these linear rules is only slightly negative at the outset of the scenario; for that reason, relatively small positive shocks to demand or inflation can cause the funds rate to leave the effective bound. As a result, the probability of the funds rate increasing before 2014:Q1 exceeds 50 percent under the outcome-based rule and the Taylor (1999) rule; the probability of first firming prior to 2014Q1 under the inertial Taylor (1999) rule is one-third (Table 1).

Table 1

Summary statistics on distribution of initial funds rate increase by policy rule

(based on 20,000 stochastic simulations of FRB/US; June TB baseline)

	Baseline	Median	Mode	Probability of first policy firming prior to:	
				2014:Q1	2014:Q4
Outcome-based rule	2014:Q3	2013:Q2	2012:Q4	0.71	0.85
Taylor (1999) rule	2014:Q4	2014:Q1	2012:Q4	0.51	0.68
Inertial Taylor rule	2015:Q2	2014:Q3	2013:Q4	0.33	0.55

Notes: Probabilities in the two right-hand columns of the table are the computed likelihood of the first increase in the federal funds rate from the effective lower bound occurring before the quarter shown. 2014:Q3 is the June 2012 Tealbook firming date; we take 2014:Q4 as a proxy for the "late 2014" FOMC statement firming date. The first column corresponds to the liftoff date associated with each rule under baseline economic assumptions.

Reversal and regret

In this section, we focus on the likelihood of scenarios in which a departure of the funds rate from the effective lower bound is promptly reversed. Such scenarios might involve two sorts of costs. The first, narrower, sort we call "regret;" this concept captures the costs—say, due to communication or credibility problems—that might flow from leaving and then promptly returning to the effective lower bound. In practice, the FOMC has very seldom rapidly reversed a change in its policy stance, and it might be particularly reluctant to do so when reversal involves a return to the effective lower bound. The second sort captures the economic costs that might be associated with exiting and returning to the effective lower bound. We measure these expected costs based on a conventional welfare loss calculation using the loss function used in the optimal policy calculations shown in Tealbook Book B.

Figure 2 shows the probability that the first return to the lower bound occurs within four quarters under the three rules, conditional on commencing funds rate increases at the date given on the horizontal axis. As before, the Committee is assumed to adhere strictly to the rule-based prescriptions regarding both initial firming and any subsequent return to the bound. The figure shows that if the prescription is to raise the funds rate in late 2012, the probability of returning to the bound within a year is about 60 percent under the outcome-based rule or the Taylor rule, and 25 percent under the inertial Taylor rule. The likelihood that a policy firming will have to be reversed in short order falls, more-or-less continuously, as the prescribed tightening date becomes later. This decline in the reversal rate occurs because, as the output gap under the baseline progressively narrows over time, it becomes less likely that subsequent shocks would be sufficient to drive the policy rate back to the lower bound.

Some intuition for the differences in the distribution of the timing of first firming under these three rules is as follows. All else equal, rules written solely in levels of variables, such as Taylor (1999), will tend to be more sensitive to transitory changes in conditions than inertial rules, which effectively base their prescribed policy responses on a weighted moving average of economic conditions. In light of this general feature of inertia, it may seem surprising that the outcome-based rule and inertial Taylor rule show such different behavior—both have about the same coefficient on the lagged funds rate. The difference in behavior is because, unlike the inertial Taylor rule, the outcome-based rule calls for substantial response to the *change* in the output gap. Thus, the outcome-based rule will at times call for a tightening of monetary conditions when growth picks up, even when the level of activity remains well below trend.

Regret and loss under modest adjustments to simple rules

To evaluate the welfare losses that might be associated with an early firming and prompt return to the bound, we must consider the question of losses compared with some plausible alternative. It is common to compare outcomes to the fully optimal policy, but we already know that several of these rules perform very poorly compared with optimal policy. In this memo, we consider some simple, *ad hoc* delay mechanisms to convey the extent to which modest delay affects the likelihood and costs of reversals.

We consider two different types of intercept adjustments that defer policy firming; in effect, the modified policy rules prescribe "forbearance" on the part of policymakers concerning firming. The first type of adjustment postpones the first federal funds rate increase by two quarters compared with what the outcome-based rule would prescribe; after the two-quarter lapse, policy rates are adjusted as prescribed by the outcome-based rule, provided that the rule still implies tightening. The second type of adjustment holds the federal funds rate at its lower bound until the rate prescribed by the policy rule first reaches or exceeds 75 basis points.[4] These are very

[4] To be precise, in our base-case simulations we deem the funds rate to be above the lower bound when the prescribed policy rate reaches 30 basis points or more for the first time in the simulation at which time firming is prescribed. Under the (time-dependent) two-quarter delay, when the prescribed rate reaches 30 basis points or more, we hold the funds rate at its last sub-30-basis-point level for two quarters and then reassess whether liftoff is called for under the unadjusted rule. Under the (state-dependent) threshold delay, we hold the funds rate near zero until the prescribed rate reaches or exceeds 75 basis points, at which time policymakers return to following the rule's recommendations. Under the latter criterion, there will be occasions on which there is no delay at all.

simple and mechanical adjustments. It is likely that any welfare benefits from forbearance could be greater if forbearance were determined in a more sophisticated manner.

The upper panel of Figure 3 shows how the firming dates change with these forbearance policies under the outcome-based rule. The two-quarter delay results in a distribution (shown by the green line) that is characterized by firming dates later than those in the distribution obtained under the unadjusted outcome-based rule (the blue line, which is the same as in Figure 1). Moreover, the new distribution has a lower peak, because the delayed adjustment means that policy does not react to some shocks that prove transient. As it happens, the rule calling for a delay of 75 basis points (the red line) results in a distribution that looks similar to the one associated with the inertial Taylor rule in Figure 1 (see also Table 2 on the next page). The bottom panel shows the welfare implications of liftoff forbearance, again as measured by the same loss function that is used in the Board staff's optimal control experiments.[5] The panel shows that forbearance in either form yields welfare gains regardless of the prescribed firming date in the baseline. The gains are expressed in percentage terms compared with the outcome-based rule. Greater accommodation than provided by the outcome-based rule is generally a good thing in these simulations. These forbearance policies also markedly reduce the probability that a policy firming will subsequently be reversed (not shown).

Figure 4 replicates the previous exercise for the inertial Taylor (1999) rule and shows that the benefits of forbearance are much less clear for this inertial rule, which is much less sensitive than the outcome-based rule to current conditions. As expected, under either of the forbearance strategies, the distribution of initial firming is markedly delayed when compared with the unadjusted rule. More importantly the bottom panel shows that under the inertial Taylor rule, which has a much lower probability of early firming than the outcome-based rule, additional forbearance is not generally beneficial.

We regard these deviations from simple rules as fairly modest. In particular, the rule that delays policy firming until the prescribed federal funds rate reaches 75 basis points can be interpreted as delaying the first funds rate increase until the output gap has narrowed by ¾ of a percentage point in comparison with the unadjusted rule case (assuming that inflation is close to the 2-percent inflation goal). Thus, relatively minor deviations from the simple rules—especially under the inertial Taylor (1999) rule—yield implications for the distribution of policy firming that seem consistent with the extended period language in the FOMC statement and make costly policy reversals less likely.

[5] As in the Tealbook exercises, policymakers are assumed to place equal weights on keeping headline inflation close to the Committee's 2 percent inflation goal, on keeping the unemployment rate close to the staff's estimate of the effective natural rate of unemployment, and on minimizing changes in the federal funds rate. Formally, the loss function is quadratic in these three arguments and future losses are discounted at one percent per quarter.

Table 2
Summary statistics on distribution of initial funds rate increase by policy rule
(Forbearance to 0.75 in prescribed policy settings; June TB baseline)

	Median	Mode	Probability of first policy firming prior to: 2014:Q1	Probability of first policy firming prior to: 2014:Q4
Outcome-based rule	2014:Q2	2013:Q3	0.37	0.57
Taylor (1999) rule	2014:Q2	2013:Q4	0.39	0.59
Inertial Taylor rule	2016:Q1	2016:Q1	0.03	0.14

Notes: Probabilities in the two right-hand columns of the table are the computed likelihood of the first federal funds rate increase occurring before the quarter shown. 2014:Q3 is the June 2012 Tealbook firming date; we take 2014:Q4 as a proxy for the "late 2014" FOMC statement firming date. The first column corresponds to the liftoff date associated to each rule.

More sophisticated adjustments of simple rules in response to asymmetric risks

Concern over policy reversals is a consideration that is absent from standard Tealbook Book B analysis of outcomes under a modal outlook. If the modal outlook shows only gradual improvement so that the policy prescriptions of the rules remain persistently near the effective lower, modest negative shocks might return the policy rate to the lower bound. In this situation, a high degree of uncertainty about the likelihood that the economy will follow the modal path toward recovery can put downward pressure on real activity and thereby pose a substantial drag on economic recovery that is missing from perfect foresight analysis under the modal outlook.

In response to this asymmetric risk, the Committee might choose to follow some simple rule once the economic recovery was firmly entrenched, but nonetheless remain more accommodative than suggested by the rule for some time while the recovery gains strength, thereby reducing the risk of a return to poor economic performance and the effective lower bound soon after the initial firming. Specifically, it is desirable to follow a more accommodative policy stance than implied by a simple "Taylor-style" linear rule if economic conditions suggest considerable risk that the economy may become constrained by the effective lower bound the medium term.[6] In effect, a policy strategy of remaining "lower for longer" provides insurance against bad outcomes for at least two reasons. First, a more accommodative policy during the early phases of the recovery raises the modal path of activity. Second, by reducing the expected amount of time spent at the bound, such a policy also reduces any special downside risks faced at the bound, such as the risk of a deflationary spiral.

A related research literature has analyzed optimal policy reaction functions under uncertainty. In some cases, these reaction functions are quite complicated nonlinear functions of assumed goal variables, and their exact contours are sensitive to details of model specification. However, one fairly robust result—at least in the context of the stylized models studied in the literature—is that

[6] See, for instance, Orphanides and Wieland (2000), Kato and Nishiyama (2005), and Adam and Billi (2007), and Nakov (2008).

the optimal response to the output gap or inflation rises as economic conditions deteriorate and as the prospect of reaching the effective lower bound correspondingly increases. This is because it is highly desirable to avert the possibility of reaching the effective lower bound. Similarly, on exit, the response to inflation and the output gap remain high in order to raise the likelihood of moving the economy away from the bound. Even so, it should be stressed that the policy strategy we are discussing involves eventual convergence to the “normal times” rule as the economy moves close to full employment.

It is worth emphasizing that the risk management-based motive for delaying firming is distinct from the optimal commitment rationale reflected in Tealbook Book B optimal control simulations. The Tealbook Book B computations assume perfect foresight, and the central bank induces more accommodative conditions at present by committing to deliver future stimulus. In contrast, even a central bank operating purely under discretion would optimally want to manage the asymmetric risks we are discussing, and doing so would require no commitment to overshoot policy goals in later periods.

The upper panel of Figure 5 provides a stylized illustration of how the optimal policy reaction that takes account of uncertainty about the outlook differs from a standard “normal times” rule. In this illustration we assume that inflation is close to the 2 percent while the policy rate is at the effective lower bound. In particular, the solid blue line in the upper panel shows the marginal response to the output gap under the Taylor (1999) rule: hence the response coefficient is simply unity, irrespective of the level of the output gap. By contrast, under the stylized reaction function depicted in the dashed green line, the coefficient is unity in normal times for which the output gap is narrower than minus two percent, but rises monotonically as the output gap falls below minus 2 percent.

There are several factors that bear on the appropriate degree of responsiveness to the output gap in a policy reaction function; these may be interpreted as capturing the “shadow cost” of hitting the lower bound. First, as suggested earlier, greater risk of hitting the lower bound pushes in the direction of a more aggressive policy. This risk clearly increases as economic conditions deteriorate, explaining why the policy response to the output gap rises as the gap turns more negative. Moreover, higher uncertainty (associated with a given output gap) would tend to shift the policy coefficient function upward.

Second, the merits of a precautionary strategy for adjusting the funds rate depend on the perceived efficacy of alternative tools (such as large-scale asset purchases) in achieving policy objectives. A more precautionary rule is desirable if unconventional tools are perceived as relatively poor substitutes for funds rate adjustment, or if there is a high degree of uncertainty about the impact of these alternative tools on the economy, or if there is doubt that such tools will be employed in a timely and reliable fashion.

Third, the optimal amount of insurance depends crucially on the perceived cost. The cost of adopting a more accommodative policy than implied by a linear Taylor rule is that it makes it more likely that the economy, during the recovery, will eventually overshoot its objectives for both inflation and resource utilization. Of course, the costs of overshooting depend on whether such overshooting is transient or more long lasting, and on the policymaker’s objective function.

For instance, policymakers might be more wary of adopting a highly accommodative insurance policy if it were perceived as likely to generate, in due course, a highly persistent rise in inflation and, perhaps, longer-run inflation expectations.

The lower panel of Figure 5 plots the implied response of the policy rate under both the Taylor (1999) rule—the solid line—and for the nonlinear rule considered above. In the figure, it is assumed that the natural real rate is 2¼ percent and that inflation is at its target value of 2 percent.[7] Under the unmodified Taylor rule, the nominal interest rate exhibits linear responses—that is, each percentage point change in the output gap elicits a 100 basis points change in the policy rate—irrespective of the absolute size of the output gap. The nonlinear rule clearly implies a more precipitous "desired" response of the policy rate to the output gap as the output gap becomes quite negative. Even though the desired response under the nonlinear rule may be precluded by the effective lower bound, the lower notional rate means that policy rates would typically remain at the effective lower bound during the recovery from a deep recession for some time after the standard Taylor rule would prescribe rising rates. This characteristic of the nonlinear rule helps insulate the policy rate from reacting to transient shocks that boost activity temporarily, or that raise inflation. For example, if the output gap equaled minus 3¾ percent—the level at which rates are poised to increase according to the linear Taylor rule—the Taylor rule would prescribe that policy rates rise 150 basis points in response to a shock that boosted inflation by 1 percentage point; by contrast, modified rules would keep rates unchanged and allow the inflation shock to simply pass through. The figure also makes clear that in a recovery as the output gap begins to close, policy rates begin their rise later, but ultimately rise more sharply under the nonlinear rule.

3. Considerations Involved with LSAP Adjustment of Interest Rate Rules

Currently, the FOMC is putting downward pressure on long-term interest rates and so providing stimulus through two tools—holding the nominal funds rate near zero and signaling that it anticipates doing so through at least late 2014, and increasing the overall size and maturity of the Federal Reserve's security holdings. The funds rate prescriptions from simple rules regularly presented in Tealbook Book B do not, however, make any explicit adjustment for the stimulus provided by the second tool. Consequently, guidance from simple rules that fail to take proper account of the systematic application of nonstandard tools to judge pace of conventional policy firming are arguably flawed.

As noted in work previously distributed to the Committee and reviewed below, under some simplifying assumptions, one can derive LSAP rule adjustments that aim to correct for this flaw. As we will show below, however, these adjustments may not deliver "appropriate" guidance if the Committee's portfolio actions have not completely made up for past shortfalls in conventional policy created by the lower bound on interest rates; in such a situation, better guidance could be given by unadjusted policy prescriptions. In addition, LSAP adjustments raise other issues related to model uncertainty, the desirability of making other adjustments to simple rules, and the need to take account of feedback effects to real activity and inflation.

[7] For simplicity, in this exercise we assume that inflation is consistent with its target level.

LSAP adjustments within a simple model

To date, work in this area has focused on modifying the prescriptions of simple rules by an amount intended to approximate the “funds rate equivalent” of the stimulus provided by the Federal Reserve’s balance sheet actions. In particular, the general approach has been to estimate the effect of balance sheet policy on the term premium embedded in longer-term rates, and then to translate the latter into a reduction in the funds rate that would provide roughly the same amount of easing. In two recent studies reported to the Committee, staff at the Board and at the Federal Reserve Bank of Minneapolis have carried out this sort of analysis using the following simple illustrative model of the economy:[8]

$$gap_t = 0.1\, E_t gap_{t+1} + 0.85\, gap_{t-1} - 0.1\,[rl_t - E_t \pi l_t - 3] + z_t \qquad (1)$$

$$\pi_t = 0.9\, E_t\pi_{t+1} + 0.1\, \pi_{t-1} + 0.01\, gap_t \qquad (2)$$

$$rl_t = \phi_t + (1-\theta)\, \Sigma_{j=0}^{\infty}\, \theta^j\, E_t R_{t+j} \qquad (3)$$

$$\pi l_t = (1-\theta)\, \Sigma_{j=0}^{\infty}\, \theta^j\, \pi_{t+j} \qquad (4)$$

In the model, the output gap (*gap*) depends on the real long-term interest rate, defined as the nominal bond rate (*rl*) minus expected average inflation over the life of the bond ($E_t\, \pi l$); resource utilization is also affected by exogenous shocks to aggregate demand, *z*. Current inflation (π) depends on expected inflation, lagged inflation, and the output gap. The nominal long-term rate (*rl*) is a function of expected future values of the short-term rate *R* plus a term premium ϕ that depends on the Federal Reserve’s asset holdings.[9] Finally, long-term inflation expectations are defined in a manner analogous to that used to define the long-term interest rate.

To close the model, a rule for the federal funds rate is required, and the adjustment issue turns on the question of whether the specified rule should include a term that explicitly recognizes the presence of LSAPs. To answer this question, both reports assumed that the policymaker wishes to replicate the outcomes for real activity and inflation that would have occurred if the effective lower bound had not existed and policy had been free to follow the unconstrained prescriptions of a particular simple funds rate rule—say, Taylor (1999)—without engaging in balance-sheet operations. In the context of the illustrative model and under some additional assumptions, the Minneapolis staff showed that the appropriate LSAP-adjusted rule is:

$$R_t^{ADJ} = r^* + \pi_t + 0.5(\pi_t - \pi^*) + 1.0 gap_t - (1-\theta)^{-1}(\phi_t^* - \theta E_t(\phi_{t+1}^*)) \qquad (5)$$

This equation is simply the Taylor (1999) rule, augmented by an expression involving the effect of the Federal Reserve’s balance sheet on term premiums (ϕ^*) in the current quarter and the next quarter.

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[8] See E. Nelson and J. Roberts, “Interpreting Interest Rate Policy Rule Prescriptions in the Presence of LSAPs,” memo sent to the Committee on March 2, 2012, and J. Heathcote and M. Yogo, “LSAP Adjustments to Interest Rate Policy Rules,” Federal Reserve Bank of Minneapolis, memo of April 10, 2012 (available on SDS).

[9] The discount factor θ is set at a value that makes the effective duration of the long-term interest rate the same as that of a ten-year Treasury note; accordingly, we refer to this yield as the “10-year bond rate” in Figures 7 and 8.

Effects of the LSAP adjustment within the illustrative model

Figure 6 illustrates the effect of LSAP adjustment in the illustrative model by presenting simulated outcomes under four scenarios. In all scenarios, a large persistent negative shock to aggregate demand occurs in the initial period. In what we will call the baseline scenario, denoted by the black lines, policymakers follow the unadjusted Taylor rule without being constrained by the effective lower bound or engaging in asset purchases; among the policies under consideration, the baseline scenario with no constraint on reducing the funds rate delivers the best performance. For the purposes of comparison, the blue lines report the less favorable outcomes that occur when nominal interest rates cannot fall below the effective lower bound and no LSAP program is undertaken. In the remaining two scenarios, policymakers engage in asset purchases and either follow the prescriptions of the unadjusted Taylor rule (red lines) or the adjusted Taylor rule (green lines). As can be seen, the LSAP program is assumed to be large enough to make up for most of the past shortfalls in conventional monetary policy. In particular, outcomes for real activity and inflation under either form of the Taylor rule are only modestly worse than those in the baseline case. That said, in this instance, the adjusted form of the Taylor rule, by tightening sooner than the unadjusted rule, does somewhat worse than the latter in replicating results under the baseline scenario.

The reason the unadjusted Taylor rule outperforms the adjusted rule in these scenarios is that the asset-purchase program fails to satisfy a key assumption underlying the derivation of the LSAP adjustment—the program does not put enough downward pressure on term premiums during the first few periods to make up fully for past shortfalls in conventional monetary policy forced by the effective lower bound.[10] As a result, the unadjusted rule does better than the adjusted rule because it makes up for some of the past shortfalls in the funds rate by staying lower for longer. The situation is reversed, however, if policymakers were to respond to the adverse shock with an even larger LSAP program. This situation is illustrated in Figure 8. Now the LSAP program is sufficient to push the yield on the 10-year bond a bit below the ideal baseline case, resulting in somewhat higher real activity and inflation compared with the results reported in Figure 7. With unconventional monetary policy now essentially "filling in the hole" created by the effective lower bound, the conditions underlying the LSAP adjustment are satisfied, and the adjusted Taylor rule does a better job than the unadjusted rule in replicating the baseline outcomes for real activity and (especially) inflation. Alternatively put, under these conditions the guidance provided by the adjusted rule concerning the timing and pace of conventional tightening provides the more accurate guide to determining the appropriate stance of policy over time, at least as judged by a policymaker who prefers the outcomes that are hypothetically attainable under the unconstrained Taylor (1999) rule.

These results suggest that the reliability of the LSAP-adjusted rule as a guide to policy depends on whether or not the FOMC's portfolio actions have made up for past shortfalls in conventional policy. If not, then policymakers might be better off forgoing LSAP adjustments to policy rules unless they are accompanied by other adjustments intended to compensate for being constrained by the effective lower bound in the past, perhaps along the lines suggested by Reifschneider and Williams (2000).

[10] As a result, the key condition $r^* + \pi_t + \alpha(\pi_t - \pi^*) + \beta gap_t - (1-\theta)^{-1}(\phi_t^* - \theta E_t(\phi_{t+1}^*)) \geq 0$ does not hold.

More broadly, these results raise questions about the benefits of using the unconstrained Taylor rule without asset purchases as the metric for judging the appropriateness of any LSAP adjustment. Even under the very large LSAP program, the unadjusted rule delivers both less slack and inflation closer to 2 percent than the baseline case, and so would presumably be preferred by policymakers. Moreover, the unadjusted rule always delivers a narrower output gap and inflation closer to 2 percent than the adjusted rule.

Counterfactual simulations of the LSAP-adjusted rule using the FRB/US model

The LSAP-adjusted rule discussed above was derived from a simple illustrative model of the economy; in addition, the simulation results were based on a stylized shock and a stylized LSAP program. We now consider the economic performance implied by the adjusted Taylor rule when applied to the FRB/US model. The black line in Figure 8 presents results from a historical counterfactual simulation in which the federal funds rate after 2008 follows the unconstrained prescriptions of the Taylor (1999) rule and the FOMC undertakes no LSAP programs or MEP; accordingly, this simulation is similar in spirit to the baseline scenario considered in Figures 6 and 7. Compared with a world in which the policy rate is constrained by the effective lower bound and no portfolio actions are undertaken (the blue lines), the baseline case features a noticeably lower path for the unemployment rate and inflation closer to 2 percent.[11] Finally, the red and green lines report simulation results under the unadjusted Taylor rule and the adjusted Taylor rule, respectively, conditional on implementing the two LSAP programs and the (recently extended) MEP.[12] On the criterion of replicating outcomes under the unconstrained Taylor rule and no portfolio actions, neither version of the constrained Taylor rule clearly outperforms the other. That said, the unadjusted Taylor rule delivers somewhat lower unemployment and inflation closer to 2 percent—outcomes more in line with the FOMC's dual mandate.

Static versus dynamic calculations of adjusted policy rule prescriptions

In Figure 8, the paths of the federal funds rate under the unadjusted and adjusted Taylor rules—that is, the red and green lines—are relatively similar. This similarity may seem surprising, since calculations of the LSAP adjustment based on staff estimates of LSAP/MEP term premium effects suggest that the wedge between the two series should be on the order of 150 basis points currently and 125 basis points in late 2014 (upper panel of Figure 9). And as shown in the lower panel of Figure 9, the adjusted Taylor (1999) rule would call for tightening to begin this year, conditional on the June Tealbook paths for the output gap and inflation and making no allowance

[11] The results reported in Figure 8 may appear to understate the macroeconomic benefits from the FOMC's portfolio actions because the results implicitly assume that policymakers partially offset the stimulus provided through their unconventional policy actions by bringing forward the date when the federal funds rate begins to rise. In contrast, Chung, Laforte, Reifschneider and Williams (2012) assume that policymakers did not advance the (projected) date for the start of policy firming or otherwise alter the path of the federal funds rate for four years into the future; only past this point was conventional monetary policy assumed to return to the path prescribed by a simple policy rule. Under these assumptions, the estimated macroeconomic benefits of the FOMC's portfolio actions are noticeably larger.

[12] The projected path for the term premium effect incorporated into these two simulations is the same as that reported in Tealbook Book B for June 2012. Term premium effects for the period from 2009:Q1 through 2012:Q2 are staff estimates and match those discussed in Yellen (2012).

for feedback effects; in contrast, the unadjusted rule would delay the departure of the funds rate from its lower bound until late 2014. Computed on this static basis, the adjusted rule would also prescribe a persistently higher level of the funds rate well beyond 2014.

Such static estimates of policy rule prescriptions can be misleading, however, because they fail to take account of the response over time of output and inflation to current and projected movements in the funds rate. Once allowance is made for these endogenous responses—in particular, to the weaker real activity and lower inflation that would result from the persistent upward shift in the Taylor rule implied by the adjustment—the projected differences the prescriptions of the adjusted and unadjusted rules diminish appreciably. Figure 10 illustrates this phenomenon by using the FRB/US model to simulate the outlook for real activity, inflation, and interest rates under the two versions of the Taylor (1999) rule, conditional on the June Tealbook forecast but allowing for endogenous responses to any changes from baseline in monetary policy. As can be seen, monetary policy under the adjusted Taylor rule reverses course in early 2013 and returns to the effective lower bound, where it remains until mid-2014.

Further observations

As noted above, LSAP-adjusted policy rules may yield less "appropriate" guidance about the timing and pace of tightening than unadjusted rules if the FOMC's balance-sheet operations have not fully compensated for past shortfalls in conventional monetary policy occasioned by the effective lower bound—a likely condition, given that the FOMC's willingness to exploit this tool is limited by its various costs and risks. Unadjusted rules may also be preferable if outcomes under the hypothetical unconstrained policy are not particularly satisfactory from the standpoint of the Committee's objectives under the dual mandate. Aside from these considerations, there are two other caveats about LSAP adjustment worth noting:

- The appropriate LSAP adjustment is sensitive to one's assumptions about the dynamics of the economy. The adjustment discussed above is based on a simple model in which transmission from monetary policy tools (both the funds rate and LSAPs) to spending is via a single long-term interest rate. While this assumption is a rough approximation of the more complicated dynamics of the FRB/US model, in the real world interest rates across the maturity spectrum matter importantly for consumption and investment.[13] This model-specific nature of LSAP adjustment runs against one of the arguments for simple policy rules, namely, that they should not be wedded to the precise specification of a model.

- The proposal to adjust funds rate prescriptions for LSAP effects should be viewed in conjunction with other adjustments that could be appropriate under present conditions. In principle, adjustments to rule prescriptions might be made to reflect special factors arising under current conditions from private sector and fiscal policy behavior. Some of the adjustments that might be contemplated—such as a setting of the intercept at a lower level to reflect persistently low values of the equilibrium real interest rate—would go in the opposite direction of an LSAP adjustment to the funds rate prescription. Moreover, the discussion

[13] Another model-specific aspect of LSAP adjustment is that the term premium effects of the Federal Reserve's balance-sheet operations are partly a function of funds rate policy, as the onset of policy rate firming is assumed to trigger the start of balance-sheet renormalization.

elsewhere in this memo and in the companion memo[14] has stressed that risk-management considerations prevailing at the effective lower bound generally point to deviating from simple rules in the direction of easier policy—the opposite of the direction suggested by LSAP adjustment. Therefore, an LSAP adjustment, taken by itself without adjustments to reflect other factors, might not even move the prescribed funds rate setting in the right direction, let alone by the appropriate amount.

[14] See the memo to the FOMC, "An Overview of Simple Policy Rules and Their Use in Policymaking in Normal Times and Under Current Conditions," by C. Erceg, J. Faust, M. Kiley, J.-P. Laforte, D. López-Salido, S. Meyer, E. Nelson, D. Reifschneider and R. Tetlow.

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Figure 1
Distribution of First Liftoff from ELB
(selected policy rules)

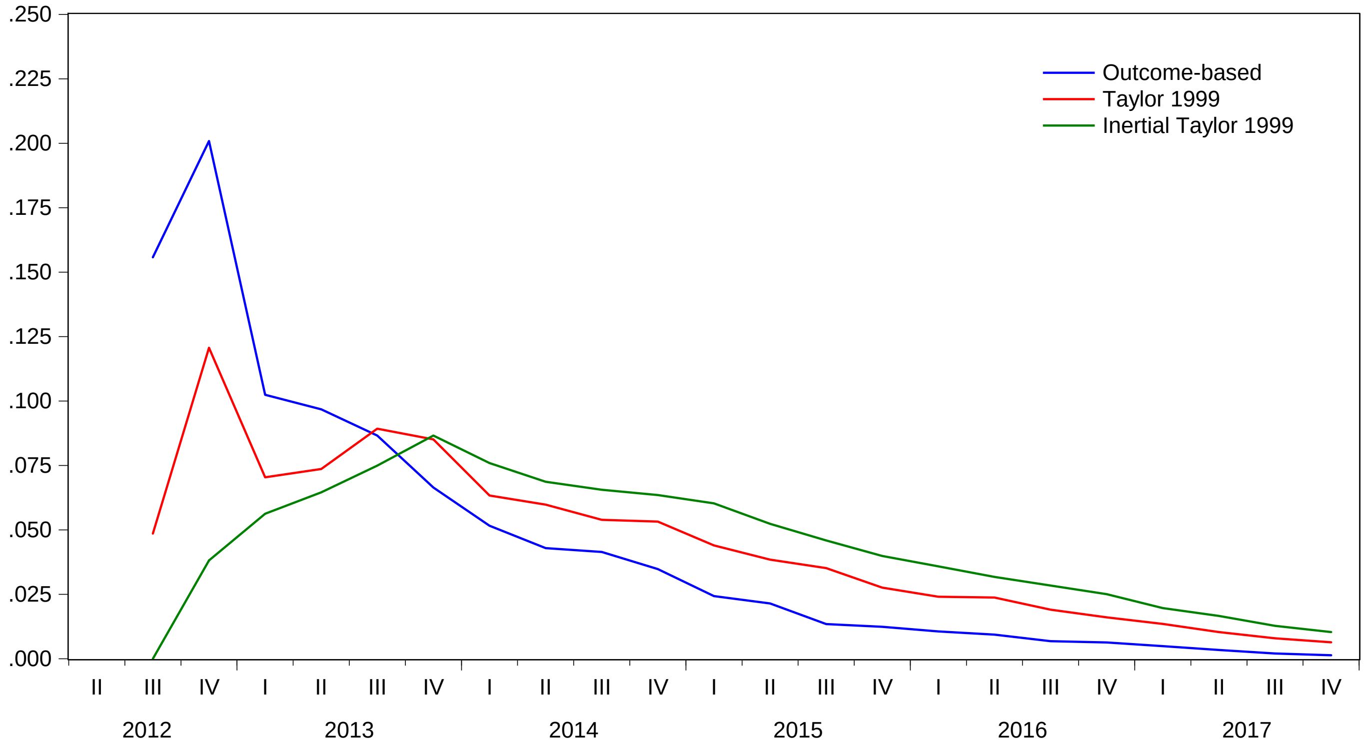


Figure 2
Probability of first return to the ELB, indexed by prescribed liftoff date
(Return within four quarters for selected policy rules)

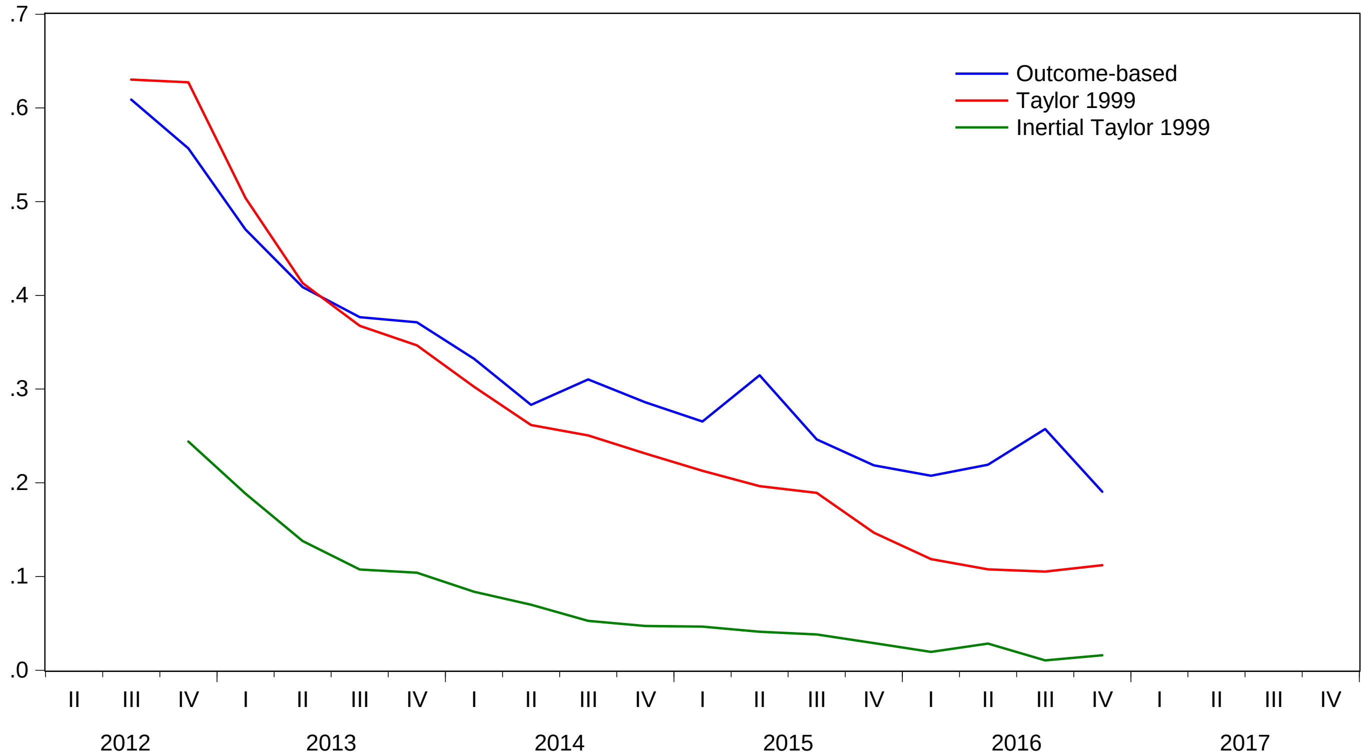
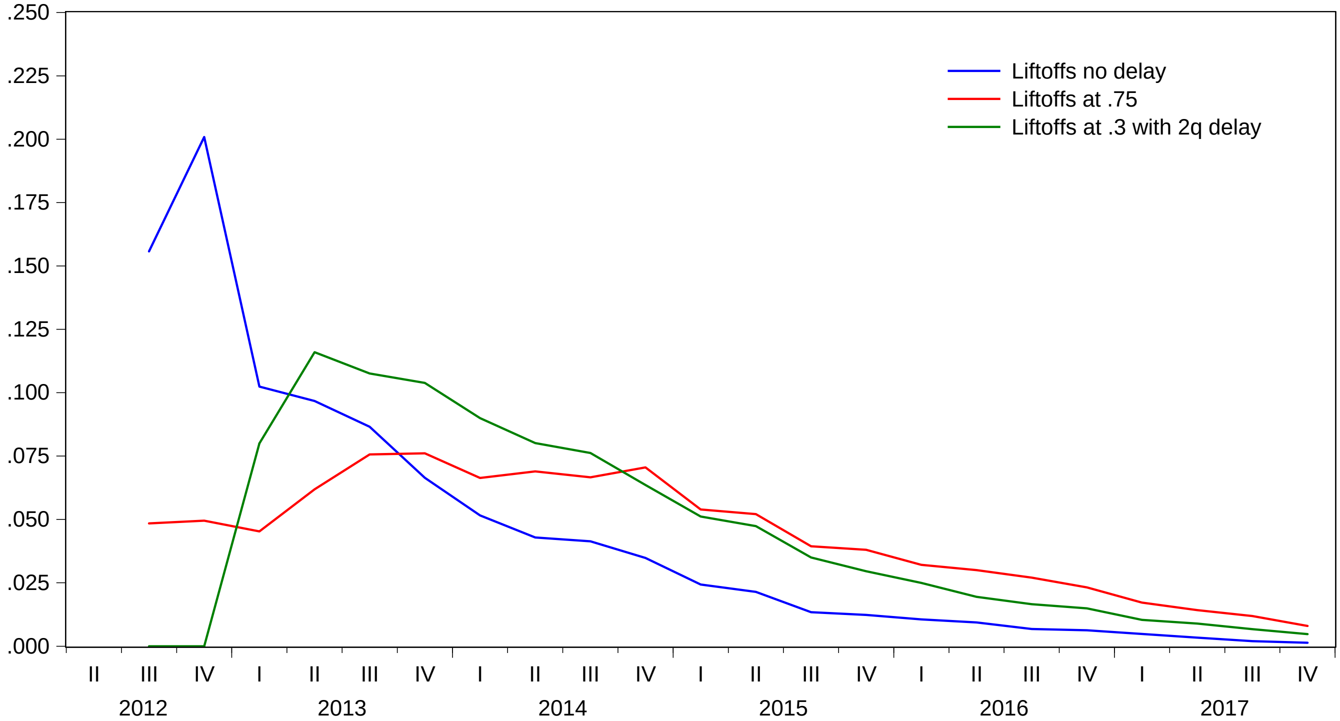


Figure 3
Distribution of First Liftoff from ELB and percentage difference in losses
(Outcome-based rule)



Welfare gain from delay strategies
(percent of baseline policy welfare)

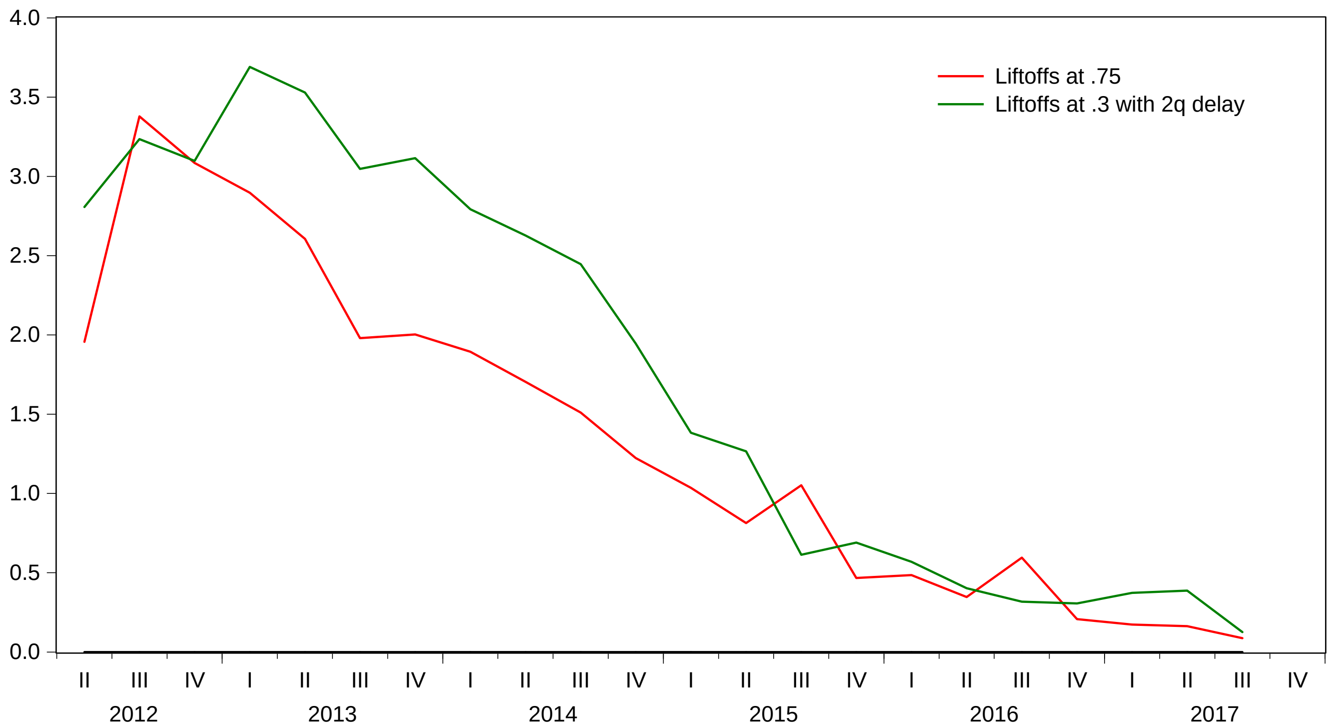
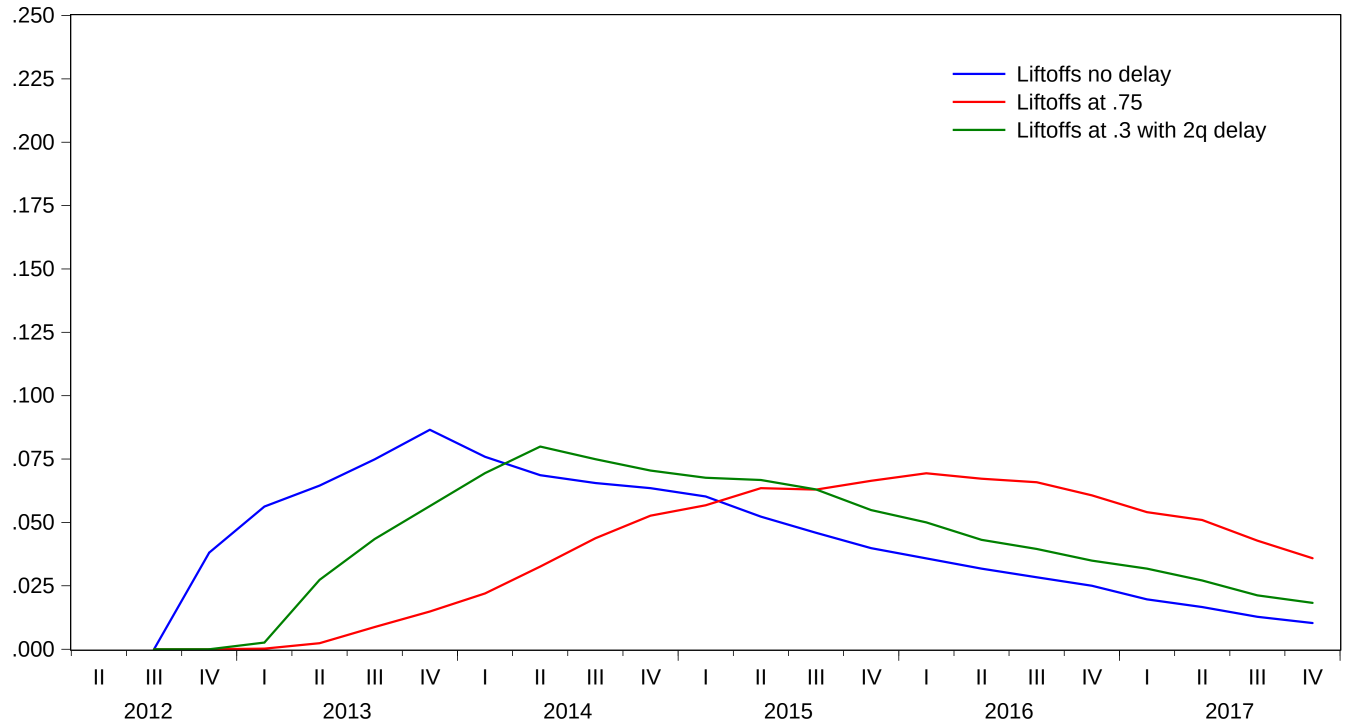


Figure 4
Distribution of First Liftoff from ELB and percentage difference in losses
(Inertial Taylor 1999)



Welfare gain from delay strategies
(percent of baseline policy welfare)

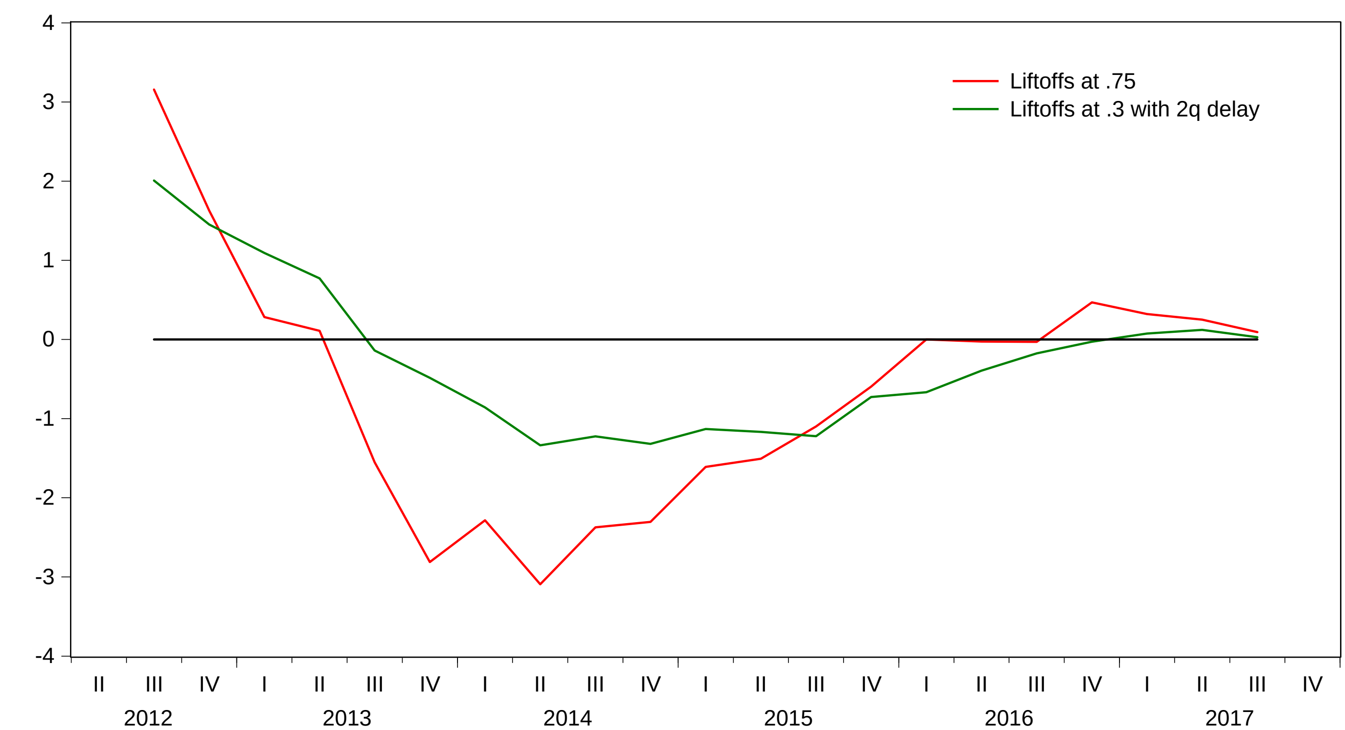


Figure 5a: Coefficient on Output Gap as Function of Output Gap

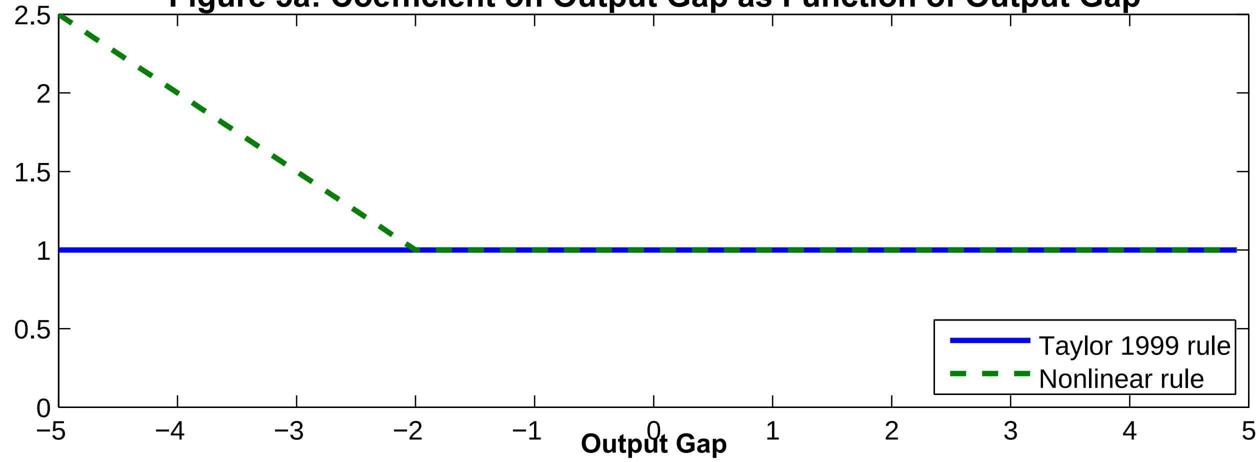


Figure 5b: Policy Rate as Function of Output Gap

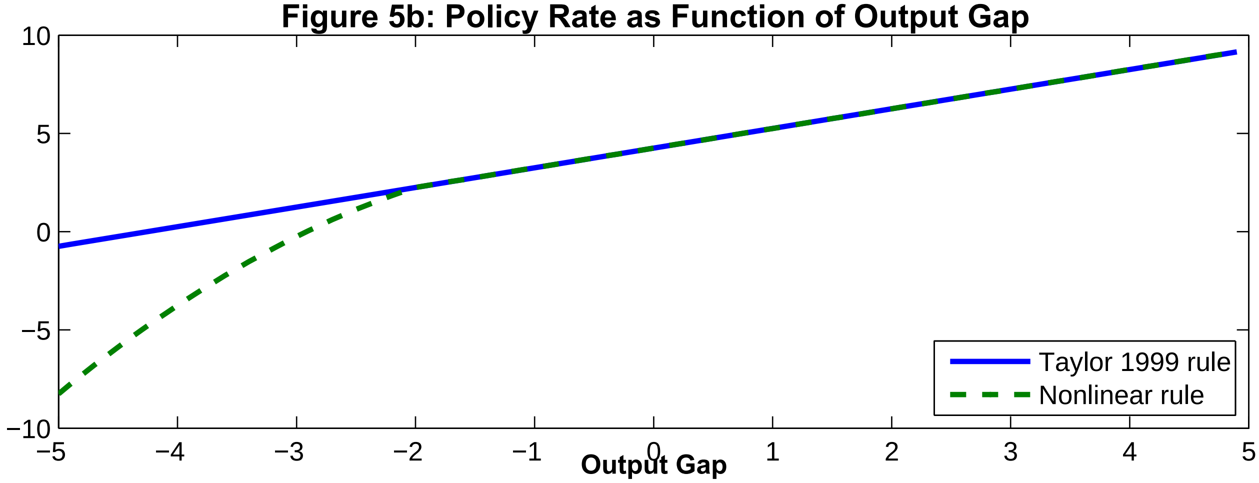


Figure 6
Effects of a Large Persistent Adverse Shock Under the Taylor 1999 Rule in the Simple Model, With and Without the Lower-Bound Constraint, a Large LSAP Program, and Rule Adjustments

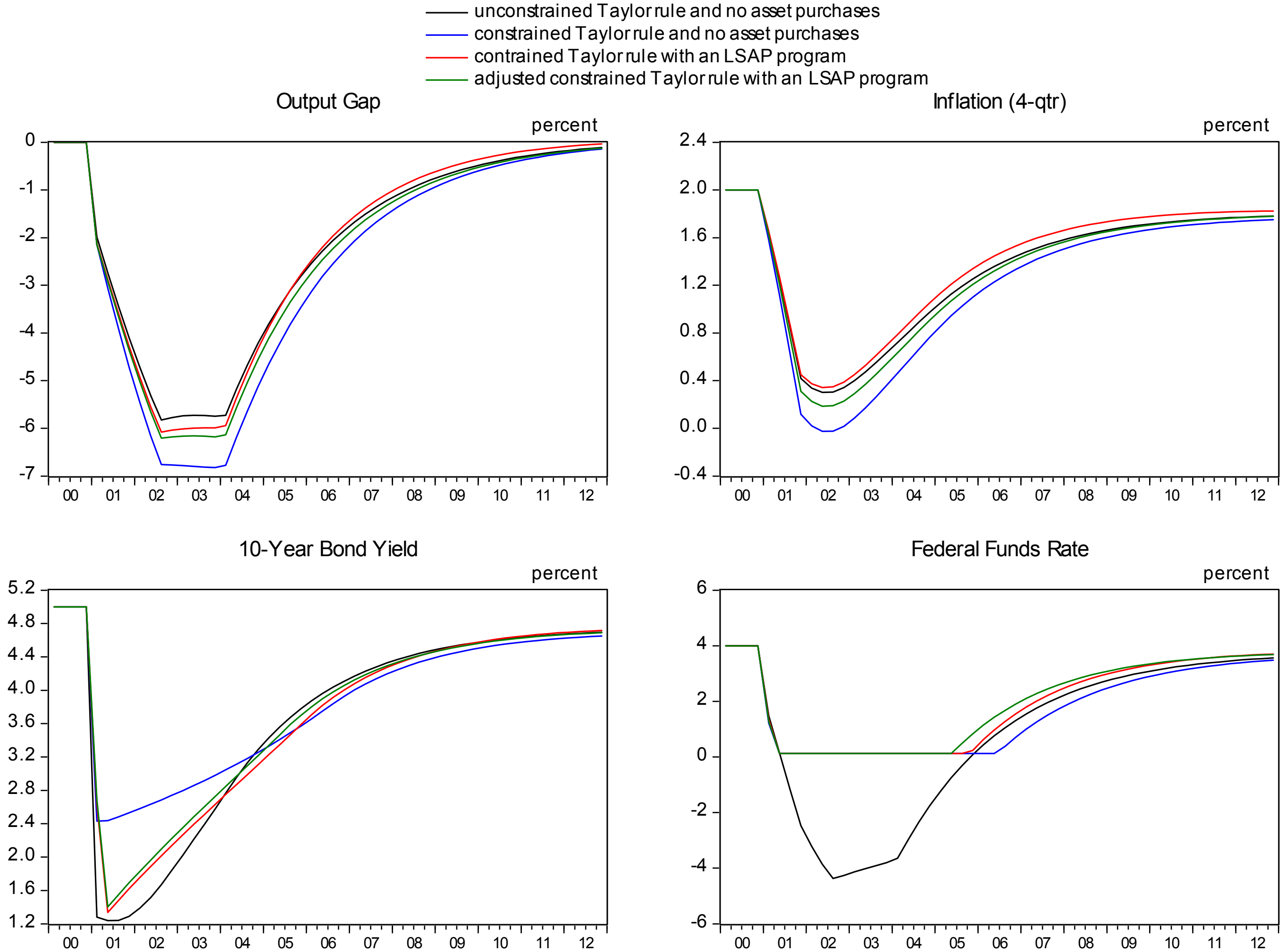


Figure 7
Effects of a Large Persistent Adverse Shock Under the Taylor 1999 Rule in the Simple Model, With and Without the Lower-Bound Constraint, a Very Large LSAP Program, and Rule Adjustments

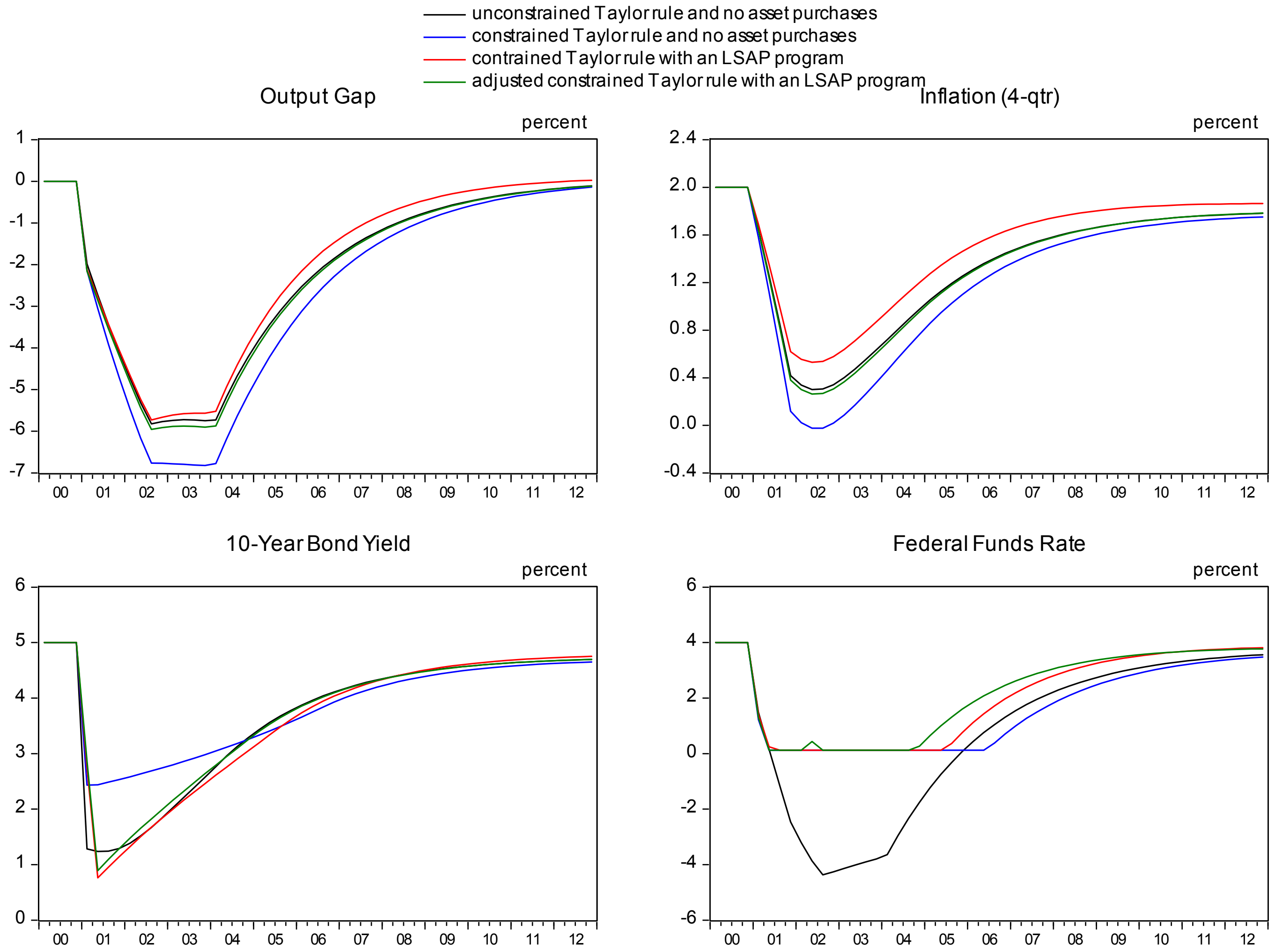


Figure 8
FRB/US Counterfactual Simulations of Post-2009 Conditions Under the Taylor 1999 Rule,
With and Without the Lower-Bound Constraint, the FOMC's Portfolio Actions, and Rule Adjustments

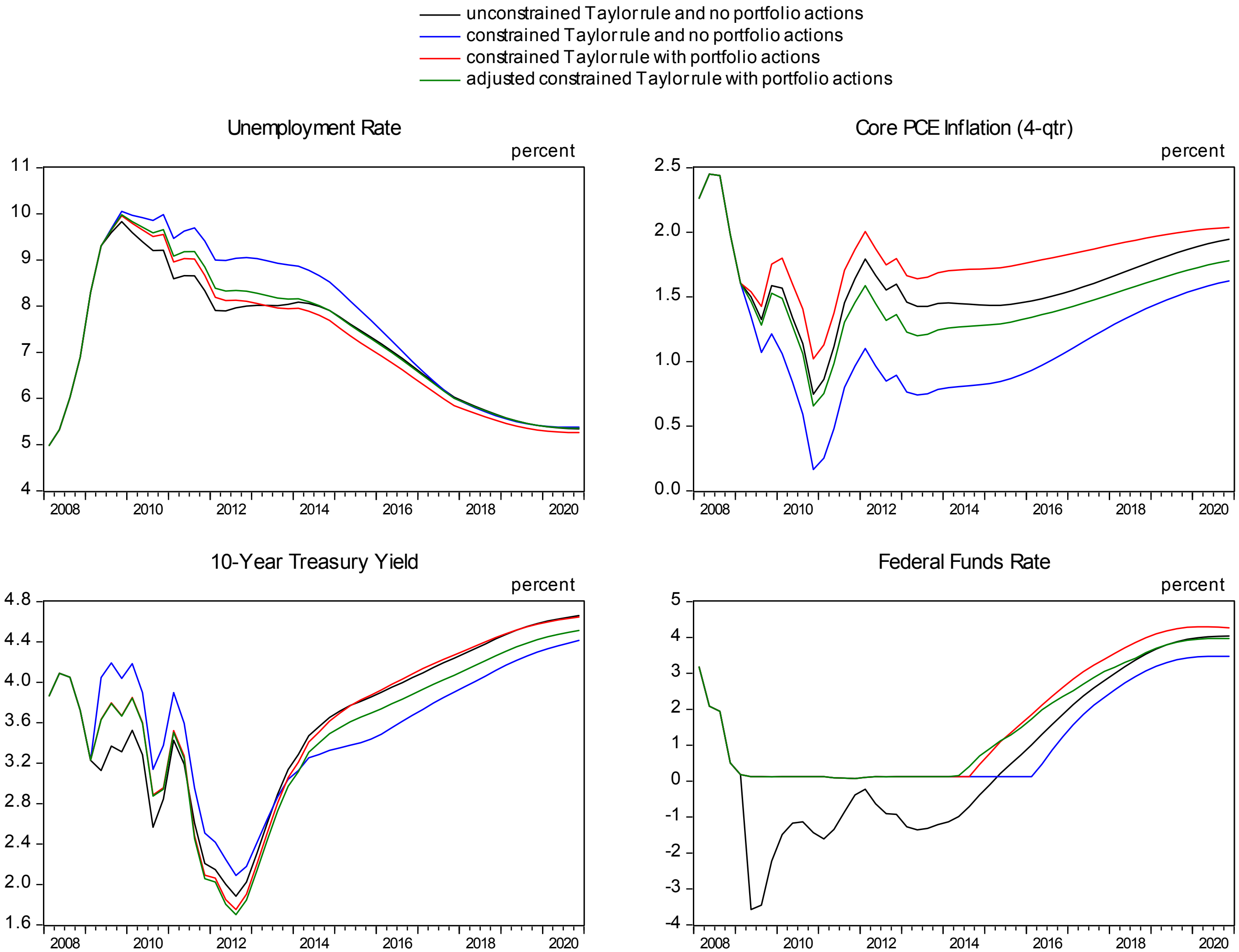
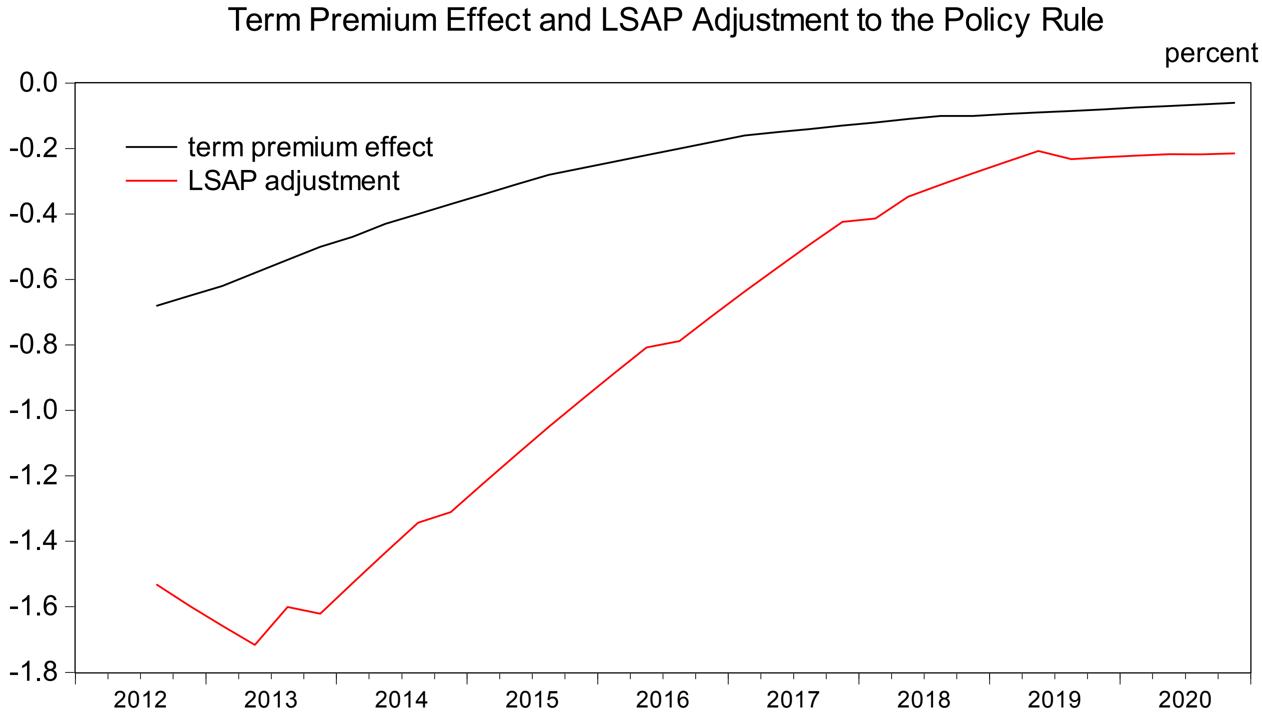


Figure 9
Term Premium Effects and Taylor Rule Prescriptions Conditioned on June Tealbook Forecast Without Feedback



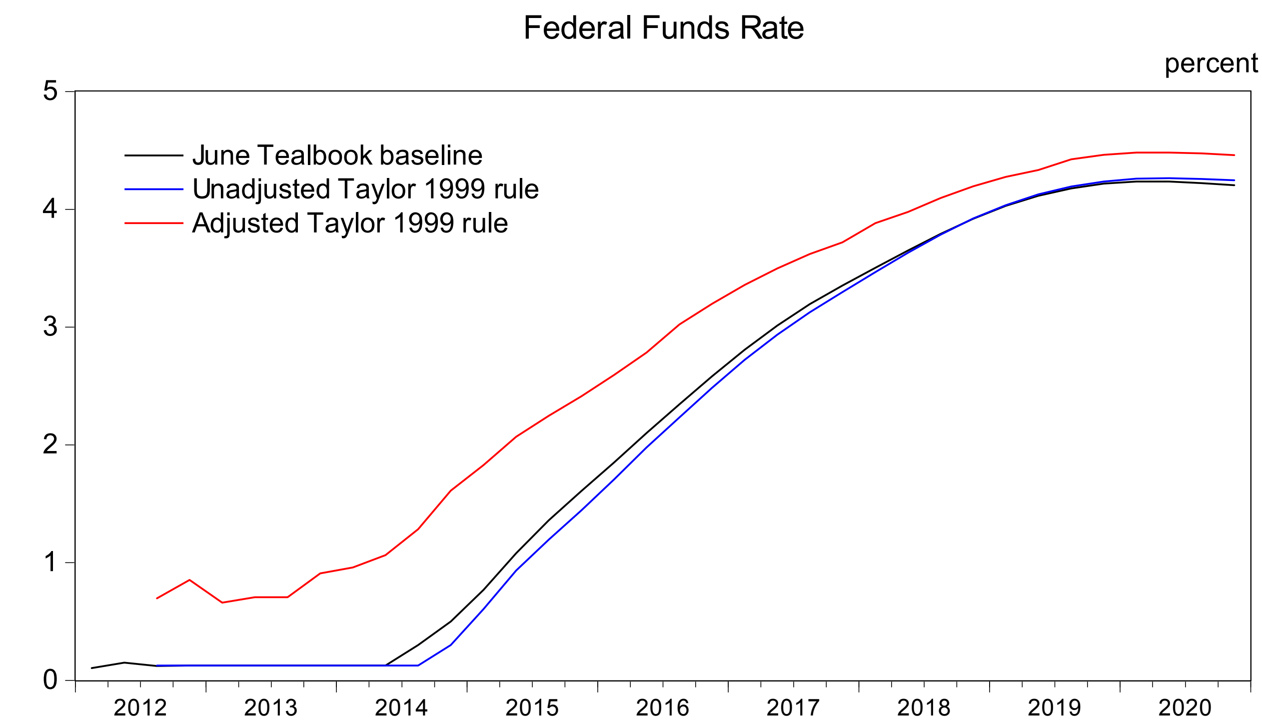


Figure 10
MacroEconomic Outlook Under the Taylor 1999 Rule with Feedback,
With and Without LSAP Adjustments