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Quantitative Analysis of the Macroeconomic Effects of Alternative Strategies for Managing the Federal Reserve's Securities Holdings

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Introduction

As part of its efforts to stimulate economic activity since late 2008, the Federal Open Market Committee (FOMC) has conducted large-scale purchases of longer-term securities. Through its Large-Scale Asset Purchase (LSAP) program, the Federal Reserve has purchased \$300 billion of Treasury securities, roughly \$175 billion of agency debt, and \$1.25 trillion of agency mortgage-backed securities (MBS). The resulting elevated levels of the balance sheet and bank reserves present the need for policymakers to consider the evolution of the Federal Reserve's portfolio as they plan how to adjust the overall stance of monetary policy as the recovery proceeds.

In particular, the FOMC will need to consider as part of its exit strategy whether and how to remove from the Federal Reserve's balance sheet of some of the security holdings acquired under the LSAP program. The Committee has made clear that it intends over time to return the composition of its securities holdings to Treasuries only, implying that the Federal Reserve's holdings of agency debt and mortgage-backed securities will need either to be run off as they prepay or mature, or to be sold. But a reduction in the Federal Reserve's securities holdings is likely to put at least some upward pressure on longer-term interest rates over time and thus restrain aggregate demand. This effect of sales raises the issue of the pace at which these holdings should be unwound to bring the Federal Reserve's balance sheet back toward a more historically normal level and composition. This memorandum provides a quantitative analysis of the possible effects on interest rates, real activity, and inflation of various illustrative options for how the balance sheet could evolve in the next decade. Our main conclusions are as follows:

- Implementing an active program of asset sales would probably raise term premiums on long-term securities and spreads on mortgage rates by a noticeable amount, thereby restraining real activity.
- Nevertheless, the macroeconomic effects of asset sales, if spread out over several years, would likely be modest, particularly if financial market participants expect the FOMC to provide offsetting stimulus through easier conventional monetary policy in the future. Such an offset might entail keeping the federal funds rate near zero for longer or raising it at a more gradual pace.
- Conditioning the initiation and pace of asset sales on economic conditions, and allowing for the possibility of resumed purchases in the event of an unexpectedly weak economic recovery, could prove beneficial in light of the zero lower bound on interest rates.

Alternative Strategies for Managing the Federal Reserve's Securities Holdings

The staff has specified five illustrative options for returning both the size and composition of the Federal Reserve's balance sheet to normal—that is, to a portfolio composed only of Treasury securities (roughly one-third of which would be bills), with an overall size of around 7 percent of GDP. In the case of Option 1, the portfolio adjustment would be accomplished solely through redemptions of agency debt and MBS as well as MBS prepayments, and would not involve any sales. Given the current size and composition of the portfolio, such a strategy of no sales would imply that the Federal Reserve's balance sheet would remain unusually elevated for many years. Moreover, the average maturity of the portfolio under Option 1 would stay unusually long well into the next decade because about \$500 billion in MBS would likely remain on the Federal Reserve's books in 2020. By contrast, under the other options the Federal Reserve is assumed to redeem all maturing Treasury securities and to undertake sales of agency debt and MBS, thereby reducing the size and maturity of the SOMA portfolio more quickly.¹ In particular, Options 2 through 4 would be expected to return asset holdings to normal within five years after the commencement of sales, with the date of initiation and the pace of sales depending on the details of the specific option and (in the case of Options 2 and 3) the state of the economy. Option 5 would schedule sales to achieve an even faster return to a Treasuries-only portfolio, with MBS holdings falling to zero before the end of 2013.²

The extent to which the Federal Reserve's large-scale purchases of Treasury notes and bonds, agency debt, and MBS have boosted its holdings of longer-term securities far beyond historical norms is brought out in the top left panel of figure 1. This panel presents the evolution of SOMA holdings under the various strategies, expressed as a percent of nominal GDP and assuming that the economy evolves as projected by private forecasters in the March 2010 Blue Chip survey. As can be seen, although Option 1 would shrink the portfolio more slowly than the other options, it nonetheless would return the overall size of the balance sheet to about 7 percent of GDP by 2017, the same as under the other options. However, Option 1 would be noticeably less effective at reducing the System's "excess" holdings of longer-term securities—that is, SOMA holdings of assets other than Treasury bills in excess of around 4 percent of GDP, the historical average. As illustrated by the upper right panel, Option 5 would complete the unwinding of excess holdings by early 2013 and Options 2 through 4 by around mid-2015, but Option 1 would entail keeping an unusually high level of long-term securities on the balance sheet through 2020 and beyond.

The expected evolution of the SOMA portfolio depends on the economic outlook, partly because the pace of MBS redemptions is sensitive to movements in interest rates and real activity, but mostly because the initiation of sales under Options 2 and 3 is linked to the timing of the decision to begin raising short-term interest rates. The upper panels of figure 2 illustrate this dependency by showing projections of the overall size of the SOMA portfolio and the Federal Reserve's excess holdings of longer-term securities conditional on the staff's March Greenbook projection. A comparison of results across figures 1 and 2 reveals that excess longer-term holdings shrink somewhat more slowly under Greenbook economic conditions than under Blue Chip conditions in the case of Options 2 and 3, primarily because the staff assumes that the

¹ The combination of MBS prepayments and sales varies across the options, as prepayments are partly a function of the long-term interest rate.

² These options are discussed in detail in "Longer-Run Approaches to Redemptions and Asset Sales," Brian Madigan and Bill Nelson (April 21).

federal funds rate will begin to rise in early 2012, more than a year later than projected by private forecasters. Portfolio projections for the other options are less sensitive to economic conditions.

The Link between Excess Securities Holdings and Term Spreads

The different paths for the System's excess holdings of securities outlined in figures 1 and 2 have important implications for the estimated path of long-term interest rates going forward. As discussed in this section, these implications mostly reflect the portfolio balance effects of asset holdings on bond term premiums.

Asset Holdings and Portfolio Balance Effects

Theory suggests that changes in the central bank's holdings of long-term securities are likely to affect long-term interest rates if private investors have a preference for keeping a portion of their portfolios in the form of such securities, as in "preferred habitat" models. According to this view, the private sector is inclined to keep a fraction of its investments in the form of long-term fixed-interest debt such as U.S. government bonds, on the grounds that these assets have characteristics not shared by alternative longer-term investments, such as essentially no default risk and a high degree of marketability. In light of investors' preference for long-term government paper (defined broadly to include securities issued by the GSEs), a reduction in the supply of long-term government debt relative to the supplies of other financial assets, all else equal, leads to a decline in bond yields in order to induce investors to decrease their holdings of such obligations; conversely, higher supplies of long-term government debt boost yields.

In this view, purchases of long-term securities by the Federal Reserve lower government bond yields by reducing the stock of government debt held by the private sector; sales have the opposite effect. In the case of purchases, the private sector finds itself demanding more long-term government debt than is available on the market at the existing configuration of interest rates, and the subsequent bidding needed to clear the market promotes a decline in long-term interest rates. In the event of sales, the increase in supply requires yields to move up to entice more investors to hold these assets. An important aspect of this adjustment process is that long-term interest rates are affected by purchases and sales even if expectations for the future path of short-term interest rates are unchanged because it is the term premium that is sensitive to the volume of long-term debt outstanding.

To quantify these effects, we assume that the term premium on long-term Treasury and GSE securities depends linearly on the discounted sum of current and expected future Federal Reserve holdings of Treasury coupon securities, agency debt, and agency MBS beyond the levels of such securities held prior to the crisis.³ This approach implicitly assumes that the term premium responds symmetrically to asset sales and purchases, thereby allowing us to use empirical estimates of the effect of the LSAP program on yields to help predict the path of bond premiums under the five portfolio strategies discussed above.⁴ For computational convenience, we assume

³ SOMA holdings of longer-term securities prior to the crisis also may have exerted a modest influence on the average historical values of the term premium, but in our analysis we abstract from any such "normal" effect.

⁴ The effect of purchases may in fact not be symmetric, however, because market liquidity conditions during the LSAP program were on average more strained than they are likely to be going forward. If so, the effect of sales on term premiums would be smaller than assumed in our analysis.

that investors currently expect SOMA holdings of longer-term assets to unwind over time following the trajectory specified in Option 1.⁵ We also assume that the total term-premium effect of the LSAP program is about 80 basis points at present, a value near the upper end of the range of econometric estimates and similar to that incorporated in the Greenbook projection.⁶ If we instead used an estimate nearer the bottom end of the estimated range, such as 30 basis points, the results discussed below would be reduced proportionately.

As the SOMA portfolio slowly returns to normal under Option 1, the current portfolio balance effect should gradually decline and eventually fall to zero. Under the other options, active sales imply a more rapid decline in the portfolio balance effect and hence a rise in term premiums. Using the methodology outlined in the appendix to calibrate the speed of decline, we generate paths for the portfolio balance effect conditional on Blue Chip economic conditions under the various options; these results are shown in the bottom left panel of figure 1. The current 80 basis point effect of our excess longer-term asset holdings on the term premium takes many years to unwind under Option 1. Under the other options, by contrast, the portfolio balance effect drops immediately upon announcement of the program and then fades to zero within a few years. Thus, if market participants currently expect the FOMC to implement a policy similar to Option 1, announcement of any of the other strategies should result in an immediate jump in bond premiums (and hence yields), as illustrated in the bottom right panel of figure 1. In the case of Option 5, the initial impact of the announcement on term premiums is calibrated to be about 50 basis points, thereby removing more than half of the current portfolio balance effect; announcing one of the less-aggressive sales programs would generate somewhat smaller effects. Thereafter the effect of any of the sales strategies on bond premiums would decline gradually relative to conditions under Option 1.

The lower panels of figure 2 present portfolio balance effects conditional on the Greenbook forecast. For most of the options, results are little altered by the change in the economic outlook but the same is not necessarily the case under Options 2 and 3. In particular, because these options tie the start of sales to the onset of conventional monetary tightening, their announcement would imply a somewhat smaller rise in term premiums, assuming that market participants share the staff's assumptions for the future path of the federal funds rate. When the latter condition holds (as is assumed in figure 2), premiums initially jump about 30 basis points, 10 basis points less than when investors anticipate Blue Chip conditions. To the degree that current market views are more closely aligned with private forecasts, however, the initial jump would be closer to that predicted under Blue Chip conditions even if the staff forecast is correct. But even in this case, bond premium effects should still converge relatively quickly to the paths

⁵ Financial market participants likely put some odds on active asset sales by the Federal Reserve, and so current bond premiums as well as the baselines used in our analysis are probably not completely consistent with option 1. Thus, adoption of option 1 would likely imply small downward revisions to the baseline projections of long-term interest rates. In addition, the possibility that investors may currently see some chance for sales implies that the estimated increases in bond premiums predicted to occur under options 2 through 5 are somewhat smaller than the effects discussed below. However, the *difference* in effects between Option 1 and the other options is probably independent of current market expectations for sales.

⁶ See Joseph Gagnon, Matthew Raskin, Julie Remache, and Brian Sack, "Large-Scale Asset Purchases by the Federal Reserve: Did They Work?" manuscript, Federal Reserve Bank of New York, March 2010. The latest primary dealer survey suggests that market participants currently view the effects of the LSAP program on long-term yields as well below 80 basis points. However, the dealers' assessment does not decompose the yield effect into movements in term premiums and movements in the average expected future federal funds rate (as is done in this memo), and so may overstate the difference between their views of LSAP effects and our assumptions.

for Options 2 and 3 shown in the lower panels of figure 2 as market participants learn about the true state of the economy.

Other interest rate effects

The response of government bond yields just outlined would be reflected in changes in yields on high-grade corporate bonds (and other similar securities) to the degree that investors view such bonds as substitutes for long-term government debt. Faced with a lower stock of government debt available to the public, investors may attempt to add to their holdings of corporate debt as a replacement. Thus the Federal Reserve's purchase program, combined with investors' substitution between types of debt, likely promoted a bidding-up of prices of both corporate and government bonds. Symmetrically, a reduction in the Federal Reserve's holdings of long-term government assets would probably tend to put upward pressure on corporate bond yields. Since private spending decisions depend on corporate bond yields, these spillover effects of Federal Reserve purchases stimulate aggregate demand, and sales would likely have a restrictive effect.

Other financial spillover effects, especially those concerning the residential mortgage market, may also be important. In part, this reflects the link between the prices of some mortgages and benchmark long-term security yields. In addition, sales of agency MBS and agency debt might have a particularly large effect on the secondary mortgage market, prompting mortgage rates and MBS yields to rise more than comparable-maturity Treasury yields. The simulations discussed in the next section allow for this possibility in the case of Option 5 by incorporating a 15 basis point increase in the MBS-Treasury spread while the Federal Reserve's MBS portfolio is being sold off. Similar but smaller disruption effects are also incorporated into the simulation analysis of Options 2 through 4.⁷

Aside from influencing interest rates, asset sales might also adversely affect equity prices to the extent that the higher level of private yields might lead investors to mark down the earnings outlook of private companies or to discount them at a higher rate. Moreover, higher interest rates would likely lead the foreign exchange value of the dollar to appreciate. Because of the structure of the FRB/US model, these additional financial spillover effects are automatically taken into account in the simulations discussed below.

Caveats

Certain caveats apply to the analysis of this section. First, neither in our exercise nor in the analysis by Gagnon, Raskin, Remache, and Sack (2010) is there a clear distinction between Federal Reserve holdings of Treasury securities, agency MBS, and agency debt. But it is conceivable that holdings of the latter two types of assets might exert a smaller impact on the ten-year Treasury term premium than would the same amount of Treasury holdings. If this were the case, an analysis that distinguished between Treasury, agency MBS, and agency debt holdings might imply effects on the term premium for Treasury securities smaller than those used here. Second, our analysis is based on dollar amounts of purchases and sales. Because the duration of Federal Reserve MBS holdings tends to be lower than that of its long-term Treasury holdings, a similar analysis using duration-adjusted amounts might alter our estimates of the

⁷ It is also possible that the direct effect of asset sales on market interest rates more generally could be magnified somewhat, at least temporarily, by convexity-related hedging strategies and other market dynamics.

effects of asset sales on Treasury term premiums going forward. More generally, a high degree of uncertainty surrounds the magnitude of the interest rate effects just described. In order to bring out some of the major sources of uncertainty and their macroeconomic implications, the discussion below will consider simulation results incorporating smaller portfolio balance effects, larger market disruption effects, and market misperceptions regarding the interaction of sales and the setting of the federal funds rate.

Macroeconomic Effects of the Portfolio Options—FRB/US Simulations

The analysis presented so far suggests that taking a more aggressive approach to normalizing the SOMA portfolio could have noticeable effects on financial conditions. To explore the macroeconomic consequences of such effects, we now use the FRB/US model to simulate the response of real activity and inflation to changes in term premiums on fixed-income instruments and in mortgage rate spreads of the sort discussed in the previous section. In doing so, we make the simplifying assumption that baseline conditions are consistent with implementation of Option 1. Accordingly, all the simulation results presented below illustrate the macroeconomic effects of announcing strategies requiring active sales and full Treasury redemptions *relative* to macroeconomic conditions under a gradualist approach involving only redemptions of non-Treasury securities and prepayments.

For our analysis, we consider two different baseline scenarios for the evolution of the economy and the associated timing and pace of conventional monetary tightening. The first baseline is the March Greenbook projection, in which short-term interest rates (following a simple policy rule) do not begin to rise until early 2012 despite ongoing recovery because inflation remains subdued and slack remains elevated. The other baseline is one consistent with the March Blue Chip consensus forecast, in which short-term interest rates begin to rise steadily starting late this year despite a recovery in real activity that is more sluggish than in the Greenbook. We view this earlier and more pronounced tightening as indicating that private forecasters are less optimistic than the staff about the level and growth rate of potential output—an interpretation consistent with the Blue Chip projection of a gradual rise in inflation over the next few years.⁸

Basic macroeconomic effects of asset sales

We begin by comparing macroeconomic effects under the baseline strategy that eschews asset sales and Treasury redemptions (Option 1) with effects under the most aggressive sales strategy for normalizing the balance sheet (Option 5), assuming that macroeconomic conditions will be similar to that anticipated by private forecasters—that is, the Blue Chip consensus forecast. The black lines in the panels of figure 3 show the baseline paths for interest rates, real activity and inflation under Option 1. The blue lines show conditions under Option 5 when the federal funds rate follows the prescriptions of the simple policy rule and financial market participants fully

⁸ For both baselines, we assume that the federal funds rate (R) follows the prescriptions of a simple policy rule of the form $R = 2.5 + \pi - 0.5gap + 0.5(\pi - 2)$, subject to an effective lower bound of 12½ basis points. In this expression, π denotes the four-quarter rate of core PCE inflation, and gap is an estimate of the output gap. For the Greenbook baseline, the gap is measured using the unemployment rate and the staff estimate of the effective NAIRU, together with an appropriate adjustment to the gap coefficient. For the Blue Chip baseline, the projected gap (and hence potential output) is inferred from the consensus forecast of short-term interest rates, inflation, and real GDP. The same policy rule is used to set the federal funds rate in all the simulations except where noted.

understand the implications of Option 5 for the pace of asset sales and the effects of these sales on bond premiums, interest rates, and economic conditions more broadly—a strong assumption.

In response to the faster pace of asset sales under Option 5, the yield on 10-year Treasury securities jumps 35 basis points relative to the baseline and mortgage rates jump about 50 basis points—movements that are smaller than the rise in term premiums because of expectational effects discussed below. These changes in long-term interest rates, together with the model's prediction for the accompanying decline in equity prices and increase in the exchange rate, lead to weaker real activity: Real GDP growth is about half a percentage point lower over 2011 and 2012, and the unemployment rate is about four tenths of a percentage point higher in 2013. Under the simple policy rule, the weaker level of real activity and the lower inflation rate imply a more gradual increase in the federal funds rate. By assumption, investors understand the contractionary effects of asset sales and anticipate a downward revision to the path of future short-term rates that, in turn, is priced immediately into bond yields. This expectational effect damps the initial jump in long-term interest rates, which would otherwise be closer to 50 basis points—the impact effect on term premiums of announcing Option 5 discussed in the previous section. Without the offset coming from policy expectations, the macroeconomic consequences of rapid asset sales would be roughly half again as great.

The adverse effects of rapid asset sales could be mitigated further if, under Option 5, market participants also expected the FOMC to hold the federal funds rate below the prescriptions of the simple policy rule for a significant period, and the FOMC ratified this expectation. The red lines in figure 3 show the results of a more accommodative policy that holds the funds rate 100 basis points below the policy rule (to the extent possible, given the effective lower bound) for five years and then gradually returns to the rule-based funds path after eight quarters. This scenario assumes that the Committee provides credible forward guidance to financial market participants regarding this additional policy accommodation. Under this policy, the path of the unemployment rate is nearly identical to that in the baseline. This exercise gives a sense of the magnitude of asset sales expressed in terms of conventional monetary action, in that it requires a sizable deviation of short-term interest rates from the baseline path for a prolonged period to offset the contractionary effect of sales.

Figure 4 replicates the results in figure 3 but takes as the baseline the March Greenbook projection, which is shown as the black lines in the panels. As before, these scenarios assume model-consistent expectations on the part of financial market participants. In the baseline, the funds rate begins to rise in the second quarter of 2012 while under Option 5 tightening is delayed by one quarter and is more gradual to partially offset the economic restraint from the asset sales (blue lines). Overall, the effects of more rapid asset sales are similar to those under Blue Chip conditions. The red lines show the effects of holding the funds rate below the prescriptions of the simple policy rule as described above. Despite the fact that conventional monetary policy is constrained by the zero lower bound for over a year longer than under Blue Chip conditions, the policy of promising (and delivering) a lower funds rate for an extended time in the future is again successful in offsetting the macroeconomic effects of asset sales.

The projections shown in figures 3 and 4 assume that financial market participants perfectly anticipate the macroeconomic effects of the different portfolio strategies. Given that the public has only a limited experience with large-scale shifts in the Federal Reserve's holdings of longer-term assets, figure 5 relaxes that assumption in favor of more gradual learning by market

participants. The black lines repeat the Greenbook baseline from figure 4. The blue lines show the effects of Option 5 when market participants have a limited understanding of the policy implications of asset sales. In particular, they are assumed initially not to understand that the funds rate will be lower than in the baseline as a result of the sales, leading to a larger initial jump in long-term interest rates than occurs under rational expectations.⁹ In this case, the unemployment rate is 0.5 percentage point higher under Option 5 than under Option 1 in 2013, slightly more than occurs when investors fully understand the implications of asset sales. The more accommodative monetary policy described above, shown by the red lines, is not able to reverse the adverse effects of asset sales on real variables in this case because market participants do not initially anticipate the lower path for the funds rate: Long-term bond yields are the same under the more accommodative policy until mid-2012, when the funds rate fails to rise as it would have under the simple policy rule and market participants start to learn about the change in policy.

Table 1 summarizes the macroeconomic effects of all the strategies involving sales, expressed relative to baseline—that is, relative to effects under Option 1—under different assumptions for economic conditions and expectations formation. As can be seen, effects on real activity, the unemployment rate, and core PCE inflation are modest and fairly similar under all the options and assumptions, reflecting the broadly similar implications of all four sales strategies for the average magnitude of the portfolio balance effect over the next several years. As forward-looking variables, however, long-term interest rates at any point in time are more sensitive to the future implications of portfolio strategy, economic conditions, and expectational assumptions.

One might worry that the contractionary effects of asset sales on long-term interest rates assumed so far are too small because the estimates understate the possible effects on interest rates and thus real activity of temporary market disruptions. In view of this concern, we considered the possible effects of additional disruption in the mortgage market as a result of MBS sales by raising the size of these effects on MBS yields from the baseline Option 5 assumption of 15 points to 40 basis points. However, incorporating the larger disruption effects into the analysis boosted the macroeconomic effects of rapid sales only marginally, reflecting both the limited size of the additional increase in mortgage rates and the small share of housing in the overall economy. We also considered the possibility that market participants might temporarily misread the announcement of asset sales as signaling earlier and more pronounced increases in the federal funds rate than had been anticipated. To illustrate this possibility, we incorporated into the analysis an additional 50 basis point rise in long-term yields upon announcement of Option 5, with that announcement effect fading away over the next four quarters as the public comes to understand that the FOMC's intentions concerning conventional monetary policy had not in fact changed. Again, adding this misperception effect to the analysis did not significantly alter the simulated response of real activity and inflation to asset sales.¹⁰

⁹ Expectations are formed using a simple VAR model of the economy involving the output gap, the federal funds rate, core PCE inflation, and long-run expectations of the funds rate and inflation. The estimated coefficients of this simple forecasting model are based on a long historical sample, and so VAR-based expectations implicitly assume that real activity, inflation, and interest rates will evolve in response to shocks in a manner consistent with average historical experience. Under this characterization of expectations formation, the changes in bond premiums that result from Federal Reserve asset sales manifest themselves as unexpected disturbances that have noticeable but ultimately transitory effects on the expected future path of the economy.

¹⁰ The FRB/US simulations would understate the macroeconomic effects of asset sales if the economy is more sensitive to contractionary shocks than the model predicts, perhaps reflecting the current impaired state of the

Table 1
 Macroeconomic Effects of Implementing Various Asset Sale Options
 Instead of Pursuing a No-Sales Strategy
 (results reported as deviations from baseline conditional on Option 1)

	Option 2	Option 3	Option 4	Option 5
<i>Real GDP (average Q4/Q4 percent change, 2010-2013)</i>				
Blue Chip conditions, full-information expectations ¹	-0.22	-0.22	-0.19	-0.25
Greenbook conditions, full-information expectations ¹	-0.19	-0.20	-0.21	-0.27
Greenbook conditions, limited-information expectations ²	-0.21	-0.21	-0.23	-0.28
<i>Unemployment rate (average, 2013)</i>				
Blue Chip conditions, full-information expectations ¹	0.34	0.34	0.30	0.40
Greenbook conditions, full-information expectations ¹	0.28	0.29	0.31	0.41
Greenbook conditions, limited-information expectations ²	0.31	0.32	0.34	0.44
<i>Core PCE prices (Q4/Q4 percent change, 2013)</i>				
Blue Chip conditions, full-information expectations ¹	-0.07	-0.07	-0.06	-0.08
Greenbook conditions, full-information expectations ¹	-0.05	-0.06	-0.06	-0.08
Greenbook conditions, limited-information expectations ²	-0.06	-0.06	-0.06	-0.08
<i>Federal funds rate (average, 2010-2013)</i>				
Blue Chip conditions, full-information expectations ¹	-0.29	-0.29	-0.26	-0.35
Greenbook conditions, full-information expectations ¹	-0.17	-0.18	-0.19	-0.25
Greenbook conditions, limited-information expectations ²	-0.19	-0.20	-0.21	-0.27
<i>Addendum: Initial 2010:Q3 response of 10-year Treasury yields to the announcement of an asset sales program</i>				
Blue Chip conditions, full-information expectations ¹	0.26	0.27	0.23	0.35
Greenbook conditions, full-information expectations ¹	0.22	0.23	0.25	0.38
Greenbook conditions, limited-information expectations ²	0.31	0.32	0.34	0.49

1. Under full-information expectations, financial market participants fully and immediately understand the implications of asset sales for the future path of the federal funds rate and the economy more broadly.
2. Under limited-information expectations, participants learn only gradually about these implications.

Conversely, the interest-rate effects of sales incorporated into the simulations may be too large. As was discussed earlier, estimates of the downward pressure on current bond premiums from portfolio balance effects range from roughly 30 to 80 basis points. Because the movement in bond premiums incorporated into the simulations of Option 5 is calibrated using the upper bound of this range, the simulations may overstate the economic effects of a rapid program of asset sales by more than a factor of two.

balance sheets of financial institutions, many households, and some firms. An offsetting consideration, however, is that conventional monetary policy should also be unusually stimulative under such conditions (at least when free of the zero lower bound). If so, this factor would at least partially counteract any understatement of the sensitivity of real activity to higher bond yields.

Potential benefits of conditionality

Thus far, we have focused on Option 5, the most aggressive strategy for normalizing the balance sheet, relative to the effects of Option 1. As shown in table 1, this focus partly reflects the similarity of Option 5's macroeconomic effects to those generated by Options 2 through 4 under both Blue Chip and Greenbook economic conditions. This similarity across the various sales options does not necessarily hold under all economic conditions, however. Because Options 4 and 5 entail a more or less pre-set schedule of sales, whereas Options 2 and 3 explicitly condition sales on the state of the economy, noticeable differences in macroeconomic performance can arise under more extreme conditions.

Both Options 2 and 3 indicate the Committee's willingness to postpone selling assets in the event the economic recovery is slower to take hold than in the Greenbook baseline, primarily by linking the initiation of sales to the decision to raise the target funds rate. Moreover, Option 3 implies that, once started, sales could later be slowed or suspended and purchases even resumed if economic conditions subsequently deteriorated. Such conditionality could prove beneficial in the event the recovery unexpectedly stalls or inflation continues to drift down, leaving short-term interest rates constrained at the effective lower bound for a longer period of time than envisioned in the Greenbook projection. Under such stressful conditions, Options 2 and 3 might deliver superior macroeconomic performance relative to what would occur under the pre-set schedule of asset sales embodied in Options 4 and 5, because the latter strategies would be putting upward pressure on term premiums at a time when the FOMC would be seeking to provide further monetary stimulus.

Figure 6 explores these considerations by comparing the effects of alternative strategies in a situation where, unexpectedly, economic growth remains anemic for the next several years and inflation continues to drift down. Under Option 1 and the simple policy rule, these conditions cause the federal funds rate to remain close to zero through 2013 and to rise only slowly thereafter (black lines). Macroeconomic performance is even worse under Option 5 (red lines). By selling assets rapidly and raising term premiums, the FOMC ends up persistently tightening financial conditions at a time when economic developments call for a further easing that conventional monetary policy, with the funds rate pinned at the effective lower bound, cannot supply. As a result, unemployment runs higher than under Option 1 and disinflationary pressures are more intense.

Conditions are somewhat better under Option 2 than under Option 5 because MBS sales do not begin until 2014 (blue lines). Nevertheless, because redemptions of Treasury securities and MBS pre-payments begin this year under this option and proceed largely independent of economic conditions, Option 2 entails a degree of tightening even under extremely weak economic conditions. In addition, because financial market participants initially share the outlook embodied in the Blue Chip baseline, and only gradually learn that the economic situation is in fact much bleaker, bond premiums jump upon the FOMC's announcement of Option 2. These two factors taken together mean that the FOMC tightens at a time when, in hindsight, it would have preferred to ease. But as time passes and the public comes to understand that the federal funds rate will remain low and that sales will be delayed for many years, bond premiums partially reverse their initial jump and financial conditions ease somewhat relative to the situation where the FOMC sells its MBS holdings on a fixed schedule.

Under circumstances as weak as those envisioned in figure 6, the Committee might even wish to resume asset purchases, as is possible under Option 3. To illustrate such a state-contingent policy, we employ a simple rule for asset purchases and sales that is similar in spirit to the rule used to determine the federal funds rate. In particular, this rule prescribes boosting SOMA holdings of longer-term assets relative to those that would prevail under Option 1 if the output gap increases relative to baseline and if inflation falls relative to the Blue Chip baseline. Under this strategy, the FOMC would roughly maintain the current level of longer-term assets in the portfolio through 2015 and thereafter gradually sell off assets to bring the size of the portfolio back to normal. As a result, long-term interest rates move lower than they would under Option 1 by next year and stay there into 2015, providing additional support to real activity and mitigating the downward pressure on prices.¹¹

Strategic considerations related to the risk of higher inflation

Of course, inflation and interest rates could turn out to be unexpectedly high several years from now for reasons unrelated to SOMA holdings. As discussed in an accompanying memo, such a development could have important implications for both the Federal Reserve's portfolio income and realized capital losses under the various portfolio options.¹² Aside from those concerns, however, there is the risk that the FOMC's management of its balance sheet might itself potentially trigger rising inflation and nominal interest rates. To illustrate this risk, the blue lines in figure 7 show the results of a simulation in which long-run inflation expectations rise under Option 1, reflecting concerns triggered by the Federal Reserve's elevated asset holdings.¹³ Inflation in this simulation starts to rise rapidly by the middle of next year, prompting a faster rise in both short- and long-term interest rates. Real activity remains close to the baseline until 2013 when the effects of a higher real federal funds rate start to bite. In contrast, overall macroeconomic conditions by the middle of the decade are more benign under Option 5 because the FOMC's program of asset sales is assumed to keep inflation expectations well-anchored.

¹¹ In practice, there would be significant communications challenges associated with introducing such a rule for asset purchases and sales.

¹² This risk is discussed in more detail in "Projections of the Federal Reserve's Balance Sheet and Income," Seth Carpenter, Jane Ihrig, Beth Klee, and Josh Loria (April 21, 2010).

¹³ An alternative would be to have inflation expectations depend on the quantity of reserve balances. In that case, some of the increase in inflation expectations could be offset through the use of short-term reserve draining tools.

Appendix

Methodology for Quantifying the Term Premium Effects of Alternative Strategies for Managing the SOMA Portfolio

To quantify the effects on long-term interest rates of alternative approaches to managing the SOMA portfolio, we first need to specify how movements in the Federal Reserve's holdings of longer-term securities over time influence term premiums via the portfolio balance effect. Specifying the nature of this relationship with any certainty is impossible given the lack of experience with asset sales. Still, last year's experience with asset purchases provides at least some guidance. In particular, the response of long-term interest rates to major announcements concerning the LSAP program suggests that expectations play an important role in the portfolio balance effect, in that yields moved significantly in advance of the actual purchases. Based on this evidence of forward-looking behavior, we assume that the magnitude of the downward pressure on term premiums at any point in time depends not only on the Federal Reserve's current holdings of longer-term assets (relative to the amount it would normally hold), but also on market participants' expectations for the future path of such holdings. Under this approach, the effect on term premiums of announcing a particular strategy for managing the portfolio depends on what that strategy implies for the discounted sum of future excess holdings, relative to the expected holdings path already priced into bond yields.

To formalize this approach, let x_t denote the expected volume at time t of SOMA holdings other than Treasury bills, expressed as a ratio to nominal GDP, with x_0 denoting the Federal Reserve's current holdings. In addition, let \bar{x} denote the volume of longer-term SOMA holdings under normal conditions (roughly 4 percent of GDP). By assumption, all the options considered in the memo eventually cause x_t to return to normal, so that $x_T = \bar{x}$ for a sufficiently large T . Option 1 is the slowest strategy for returning the portfolio to normal, and so defines T . Although this option, as described in the main text, eschews asset sales altogether, for convenience we assume that the FOMC would in fact start selling MBS at a modest pace beginning in 2021 in order to normalize the SOMA portfolio within five years after the initiation of sales. Thus, T equals the fourth quarter of 2025 in the calibration exercise outlined below.

The various options for reducing the Federal Reserve's excess holdings of long-term assets (relative to GDP) are associated with corresponding trajectories x_{it} . For each alternative $i = 1$ to 5, we define the series $\{x_{it}\}$ for $t = 0$ to T , where we require the initial (x_{i0}) and the terminal (x_{iT}) values of the series to be the same across the different policies. Following the discussion above, we assume that the term premium at any point in time depends on the discounted sum of future SOMA excess holdings of longer-term assets expected under each strategy, as follows:

$$PBE_{it} = -\gamma \sum_{t=s}^T \beta^{t-s} [x_{it} - \bar{x}], \text{ with } x_{iT} = \bar{x}. \quad (1.1)$$

In this expression, PBE_{it} (the portfolio balance effect) denotes, for sales strategy i , the difference between the actual long-term bond premium and the value that it would have taken in period t if the Federal Reserve had never undertaken any large-scale asset purchases. This formula implies that the announcement in period $t = 1$ of a portfolio sales strategy covering the period from $t = 1$ to T has a portfolio balance effect on the term premium in period 1 that reflects changes in holdings through period T , with the caveat that a discount factor is applied to changes in holdings beyond period $t = 1$. Thus, as one shifts (for example) from period 1 to period 2, the period 2 holdings have a more sizable effect on the spread than they did in period 1 because they are no longer discounted. Notice that PBE_{it} will converge to zero by time T under all five options, and

considerably earlier under Options 2 through 5 because these all involve asset sales that start relatively soon.

To use the formula for PBE to calibrate the effects of the various options on bond premiums, we need to specify values for the β and γ . We assume that the discount factor, β , equals .99, which is equivalent to a discount rate of 4 percent per year. To calibrate γ , the parameter that defines the average scale of the portfolio balance effect, we rely on a study by Gagnon, Raskin, Remache, and Sack (2010) that reports estimates of the effects of the LSAP program. Based on their empirical results, the Federal Reserve's asset purchases—by boosting x from \bar{x} to x_0 —lowered bond premiums between 30 and 80 basis points. Using the upper-bound estimate from this study, and assuming that market participants currently expect future excess SOMA holdings to evolve as envisioned under Option 1 ($x_{1,t}$), the value of PBE currently associated with the no-sales strategy (and priced into bond yields) equals 80 basis points. Accordingly, the discounting formula shown above implies that:

$$\gamma = -80 / \left[\sum_{t=0}^T \beta^t (x_{1,t} - \bar{x}) \right].$$

Having obtained an estimate of the coefficient γ , and given projected paths for all the various options, we are thus able to quantify the reaction of term premiums over time associated with each of the five portfolio strategies using equation 1.1.

Figure 1
 Implications of Various Asset Sale Strategies for SOMA Holdings,
 the Portfolio Balance Effect, and Bond Premiums under Blue Chip Conditions

— option 1 — option 2
 — option 3 — option 4
 — option 5

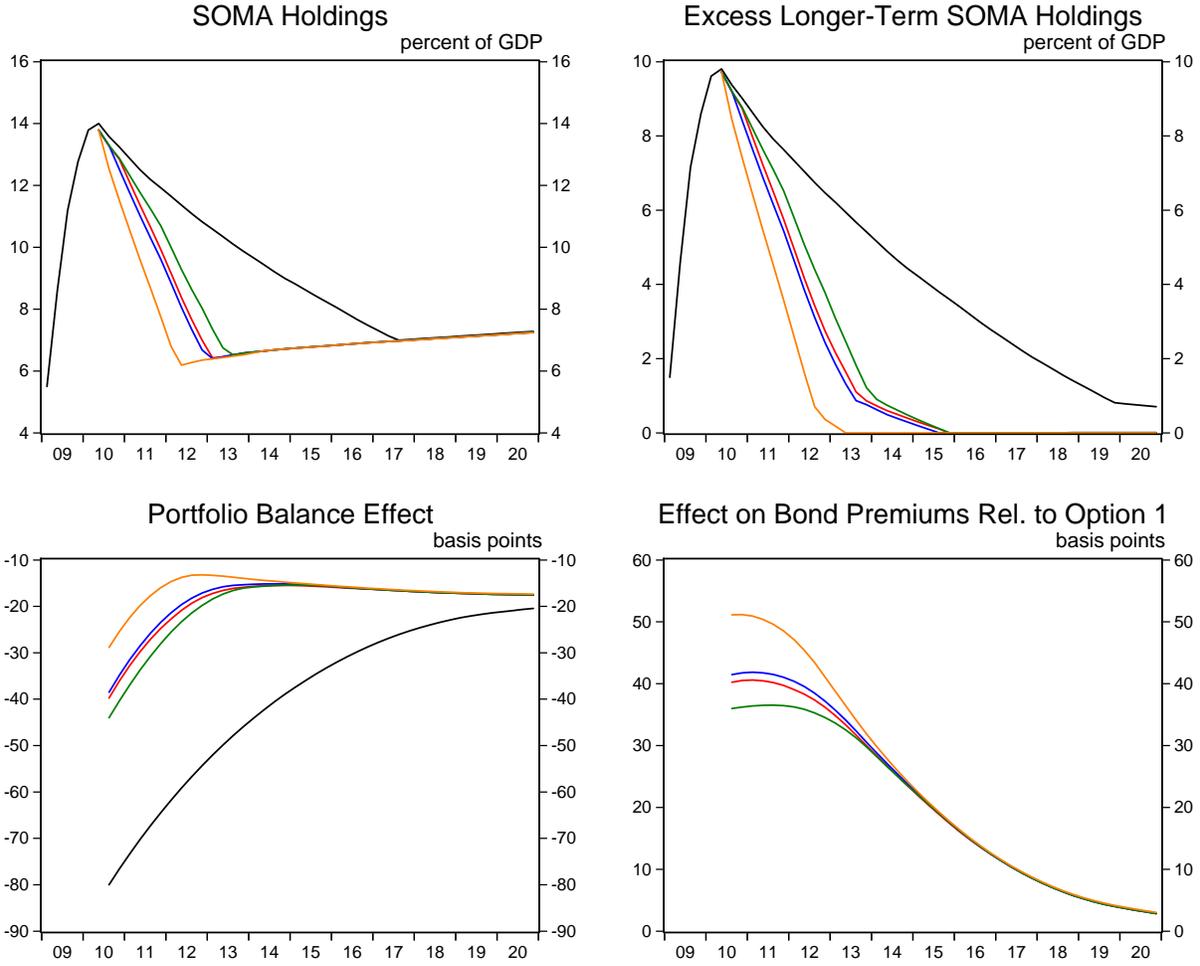


Figure 2
 Implications of Various Asset Sale Strategies for SOMA Holdings,
 the Portfolio Balance Effect, and Bond Premiums under Greenbook Conditions

— option 1 — option 2
 — option 3 — option 4
 — option 5

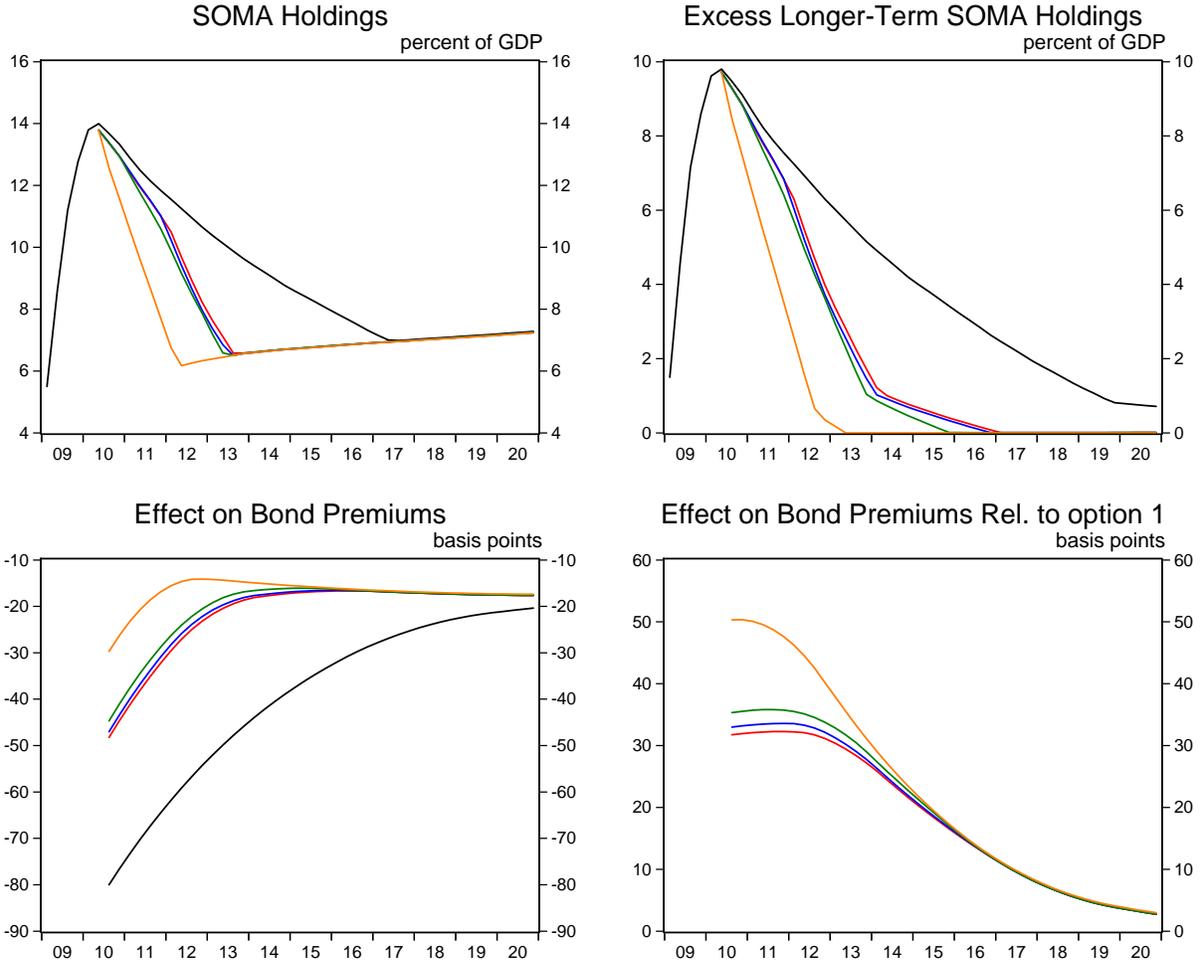


Figure 3
Macroeconomic Consequences of Option 5 Under BlueChip Conditions
and Alternative Federal Funds Rate Responses When Market Participants
Fully Understand the Policy Implications of Asset Sales

— option 1 (baseline)
 — option 5 under the Taylor rule
 — option 5 under a more accommodative monetary policy

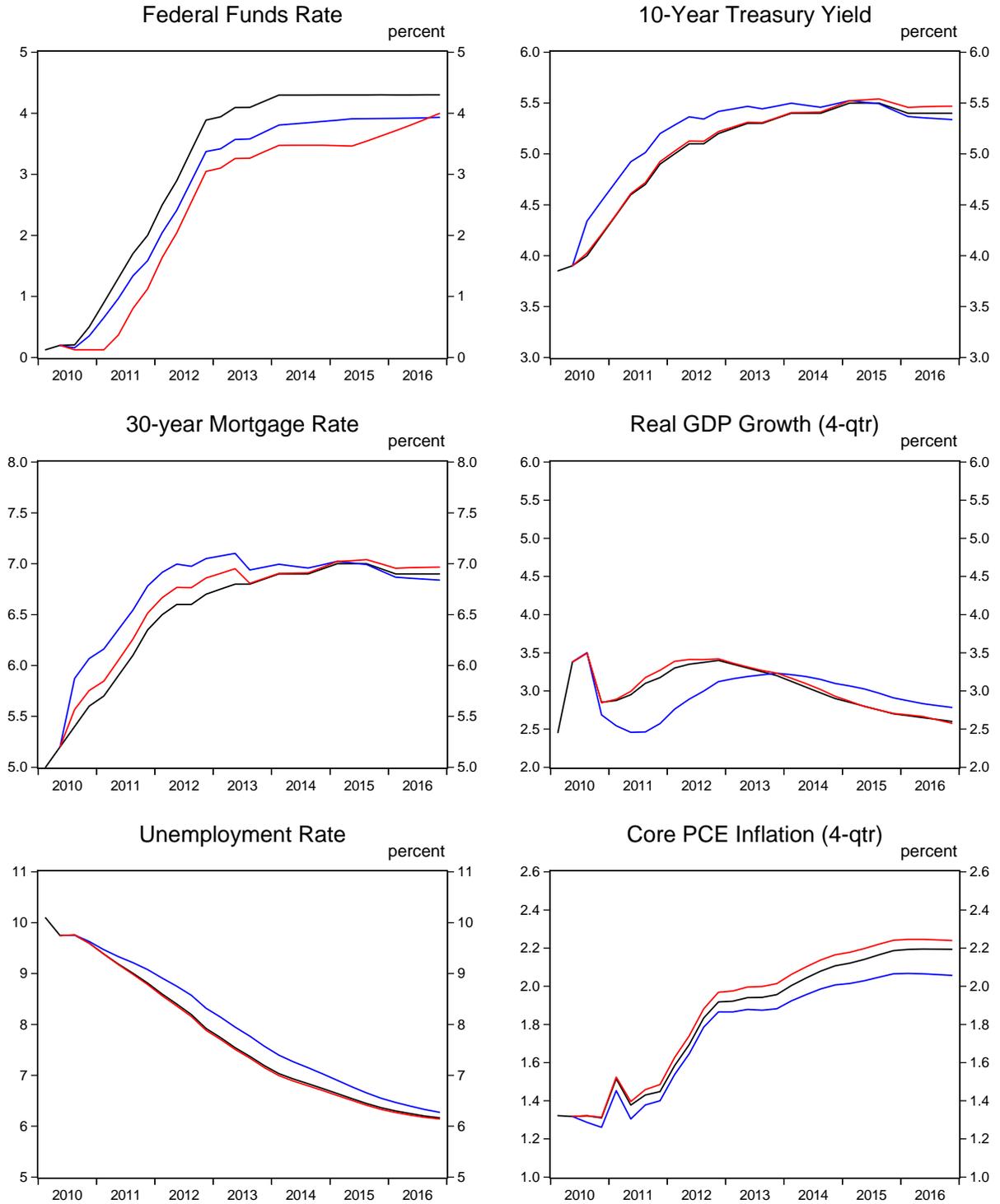


Figure 4
Macroeconomic Consequences of Option 5 Under Greenbook Conditions and Alternative Federal Funds Rate Responses When Market Participants Fully Understand the Policy Implications of Asset Sales

— option 1 (baseline)
 — option 5 under the Taylor rule
 — option 5 under a more accommodative monetary policy

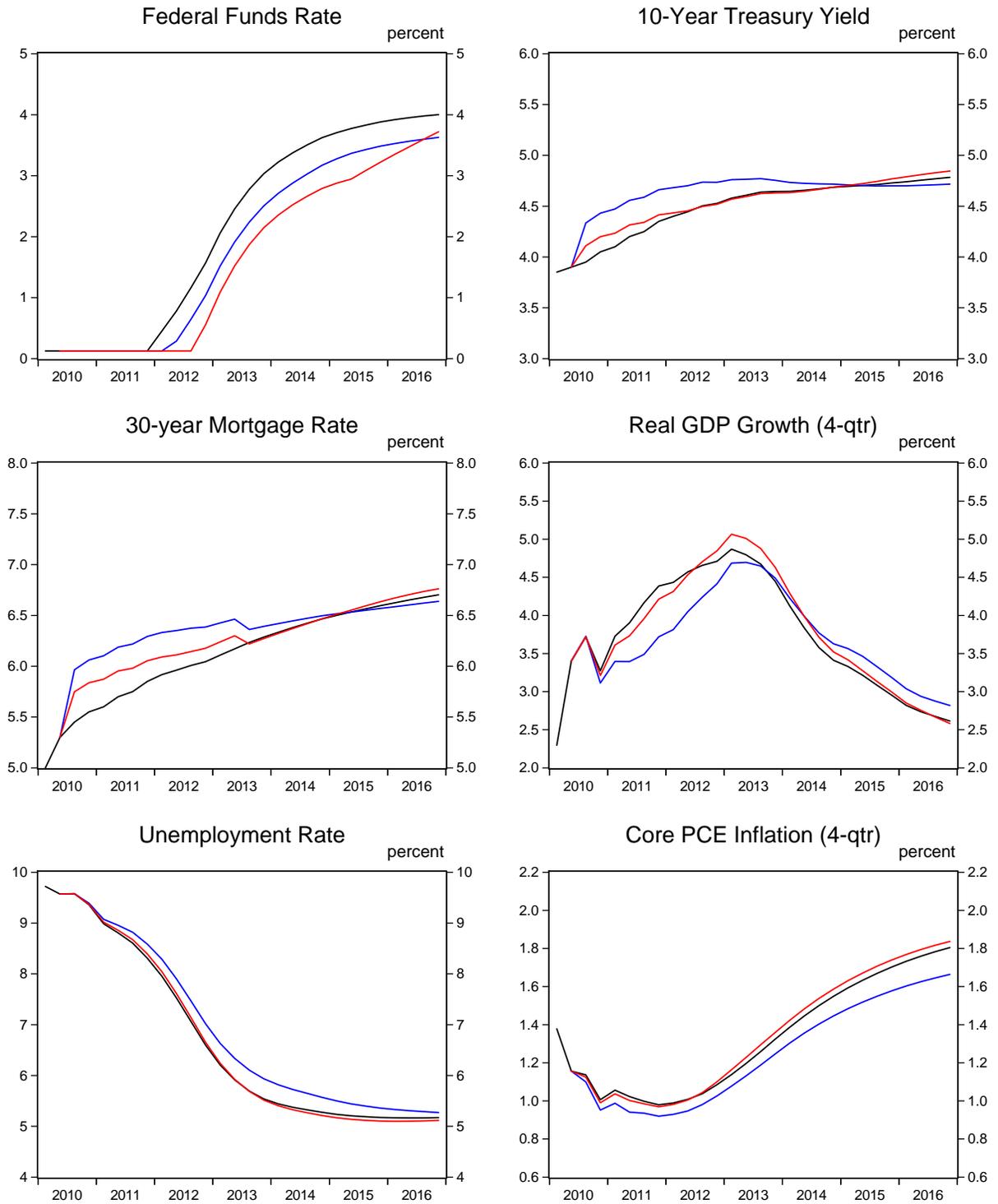


Figure 5
Macroeconomic Consequences of Option 5 Under Greenbook Conditions and Alternative Federal Funds Rate Responses When Market Participants Have a Limited Understanding of the Policy Implications of Asset Sales

- option 1 (baseline)
- option 5 under the Taylor rule
- option 5 under a more accommodative monetary policy

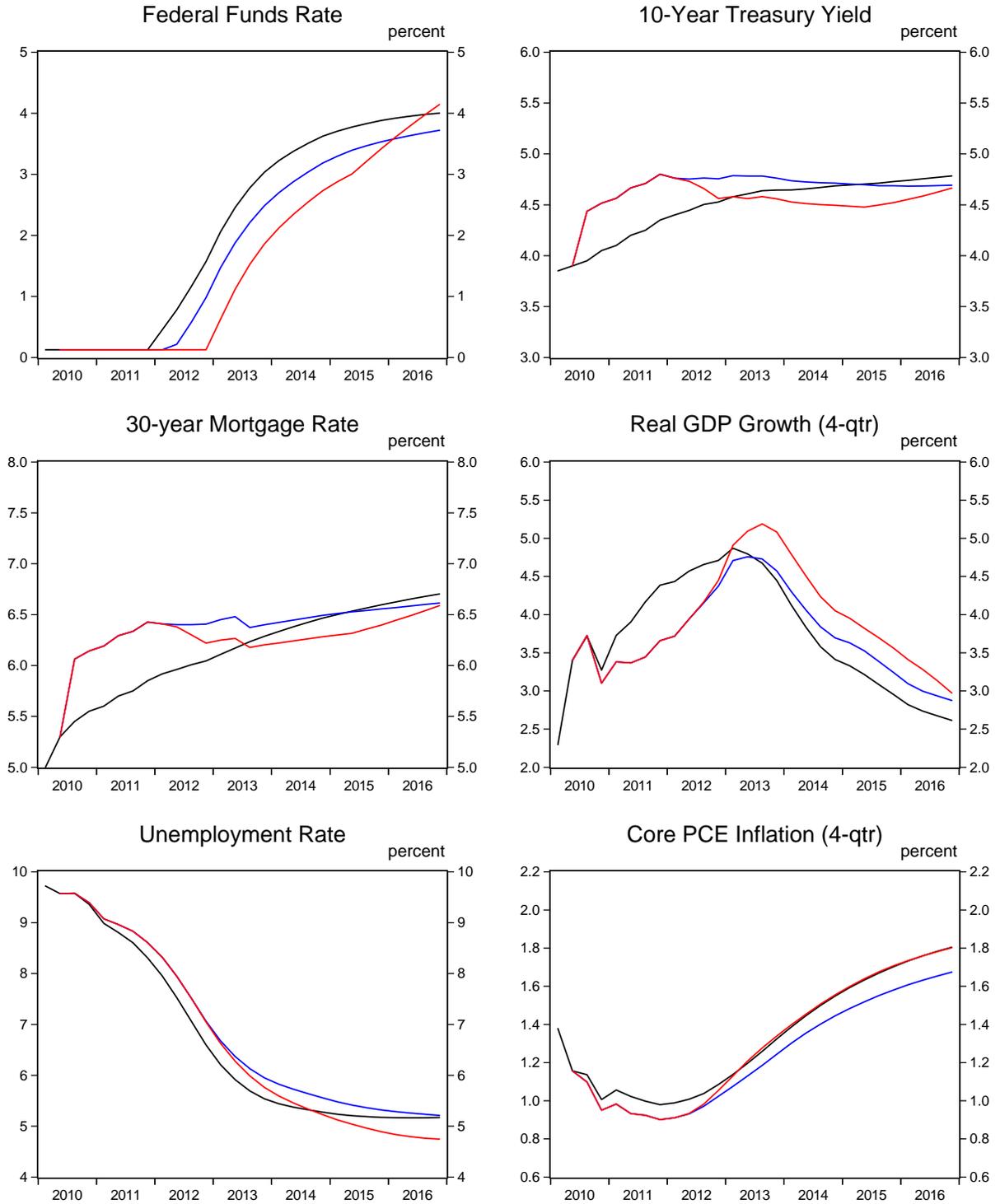


Figure 6
Effects of Options 1, 2, 3 and 5 in a Persistently Weak Economic Environment
Under the Taylor Rule, Assuming that Market Participants
Have a Limited Understanding of the Policy Implications of Asset Sales

— option 1 — option 5
 — option 2 — option 3

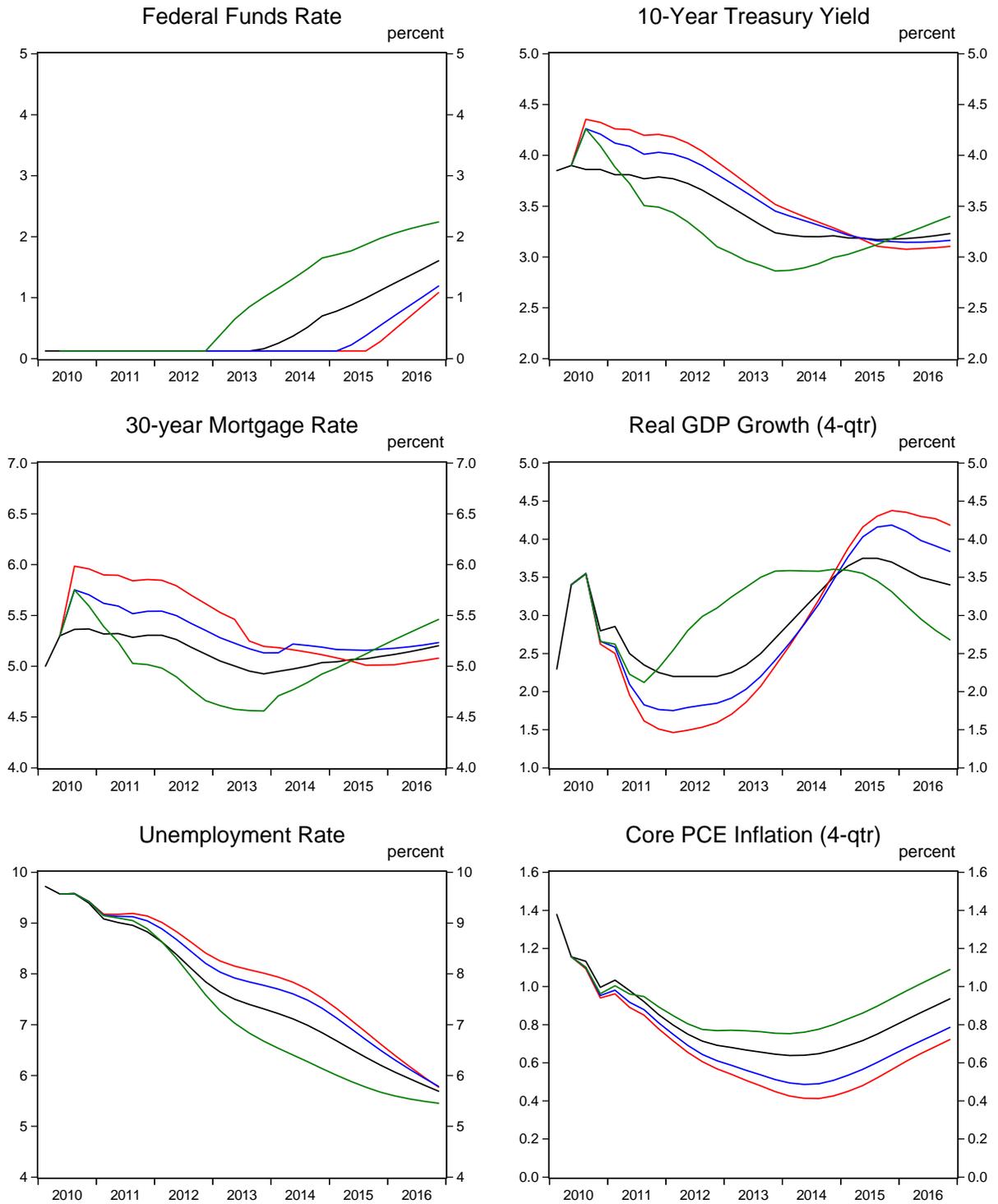


Figure 7
Comparative Macroeconomic Effects of Options 1 and 5
When Inflation Expectations Are Sensitive to Federal Reserve Asset Holdings,
Assuming that Federal Funds Rate Follows the Taylor Rule

— option 1 with anchored inflation expectations (baseline)
 — option 1 with drifting inflation expectations
 — option 5

