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New Keynesian versus old Keynesian government spending multipliers – A comment

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Abstract: Cogan et al. (2009, 2010) claim that the stimulus package passed by the United States Congress in February 2009 had a multiplier far below one. However, the stimulus' multiplier strongly depends on the assumed monetary policy response. Based on official statements from the Fed chairman, the economic outlook, past behavior of the FOMC, optimal policy considerations, and financial market expectations, we find that in February 2009 a period of monetary accommodation of three years would have been a reasonable prediction. This implies that an appropriate real time assessment of the stimulus' effects would have been more optimistic than Cogan et al.'s.

Keywords: Obama fiscal stimulus, fiscal multiplier, interest rate forecasts.

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Introduction

Shortly after the stimulus package of the Obama administration (labeled American Reconstruction and Reinvestment Act=ARRA) cleared the United States Congress on February 13th 2009, Cogan et al. (2009,2010) (henceforth referred to as CCTW) circulated an analysis quantifying the effects of the package on GDP and other variables using the DSGE model estimated by Smets and Wouters (2007), but restricted their simulation to the component of ARRA representing government purchases of goods and services. The simulated impact on GDP was only a fraction of what was claimed by members of the president's economic team (Bernstein and Romer (2009)) and significantly smaller than the size of the stimulus package itself, implying substantial crowding out of private expenditure. Woodford (2011), Christiano et al. (2011) and Coenen et al. (2012) have argued that the small GDP effects found by CCTW were caused by the briefness of the period of monetary accommodation in their simulation relative to the duration of the stimulus. CCTW assume that the central bank holds the interest rate constant for 4 quarters, during which time only about 13% of the total increase in government purchases comes online. Starting in the fifth quarter, monetary policy responds to the simulated deviations of inflation and the output gap from their values in the absence of fiscal expansion according to the interest feedback rule suggested by Taylor (1993).

Figure 1 confirms that the fiscal expansion's effect on GDP indeed strongly increases in the period of monetary accommodation. Holding the interest rate constant for 4 quarters (monetary accommodation MA=4q) as assumed by CCTW implies that private expenditure declines as the central bank increases the nominal interest rate after 4 quarters and by implication the real interest rate in response to the increase in inflation and the output gap. Extending the period of monetary accommodation lowers the real interest rate path and thus boosts the trajectory of private expenditure, with both consumption and investment strongly increasing if the period of monetary accommodation amounts to three years. As a result, the cumulative multiplier increases from 0.33 in CCTW's simulation to 2.5 (Table 1).

Table 1: Cumulative multipliers, varying lengths of monetary accommodation

Number of years	Cumulative multiplier
1	0.3
2	0.6
3	2.5

Note: The table reports the cumulative multiplier $m(h) = \frac{\sum_{t=1}^h dY_{t+i}}{\sum_{t=1}^h dG_{t+i}}$, with dY_{t+i} and dG_{t+i} denoting the effect of the stimulus on GDP and

government spending in period $t+i$, respectively. h was set sufficiently high to ensure that $dY_{t+h}, dG_{t+h} \approx 0$.

Although CCTW's results – and hence the associated policy implications – are extremely sensitive to the *assumed* length of monetary accommodation, they do not offer a detailed justification of their assumption. Instead, they simply state that assuming a constant interest rate of two years, let alone more than two years, would not be “realistic”. At the time of writing, the Federal Open Market Committee (FOMC) has kept the Federal Funds rate close to zero for more than four years. Moreover, as early as May 2009, Rudebusch (2009) predicted that the Federal Funds rate would remain at the zero lower bound for several years. We therefore examine whether, based on information available around the time ARRA was debated in the United States Congress, the period that the Federal Funds rate would remain at its zero lower bound could have been predicted. Specifically, we draw on the following sources to support our argument: testimonies by the Chairman of the Federal Reserve Ben Bernanke in Congress dealing with the desirability of fiscal stimulus as a response to the financial crisis (section 1); predictions from the FOMC and private sector forecasters around the time ARRA was debated in Congress in conjunction with descriptive and econometric evidence on past interest setting behavior of the Fed (section 2); optimal policy considerations (section 3); and the financial market expectations embedded in implied Federal Funds Futures rates (section 4). Section 5 discusses the relation of our results to interest rate expectations embedded in the Blue Chip financial forecasts. We conclude that for the US economy at the beginning of 2009, a period of three years at the zero lower bound would have been a reasonable assumption to make. Hence, based on the Smets and Wouters (2007) model, a more optimistic real time assessment of the effects of the US fiscal stimulus would have been appropriate.

1. Bernanke on fiscal stimulus

In this section, we evaluate two testimonies of Fed Chairman Ben Bernanke to the committee on the budget of the United States House of Representatives, one from the beginning and one from the end of 2008, to illustrate the shift in Bernanke's views on the desirability of fiscal stimulus and the importance of implementation speed as the economic outlook darkened. In his first testimony on January 17th 2008, Bernanke (2008a) was rather skeptical. While acknowledging that fiscal stimulus "could be helpful in principle", he went out of his way to stress that a stimulus package would be desirable only if implemented very quickly, even explicitly specifying over which horizon it should be effective: Any package "should be implemented quickly and structured so that its effects on aggregate spending are felt as much as possible within the next twelve months or so ". By contrast, stimulus that was implemented too late would be "quite counterproductive", "will not help to support economic activity in the near term", "could be actively destabilizing", and thus "any program should be explicitly temporary [...] to avoid unwanted stimulus beyond the near-term horizon".

This assessment was consistent with the economic outlook the Federal Open Market Committee (FOMC) held at the time. In January, the FOMC expected only a temporary slowdown in GDP growth and thus expected the slack in the economy to be small and of limited persistence. As Table 2 shows, the FOMC expected the unemployment gap to peak in 2008Q4 at only 0.3-0.4% and to practically vanish by the end of 2010. Correspondingly, core PCE inflation was expected to remain close to 2%. With the Federal Funds rate still at 4.25%, monetary policy appeared to have ample scope to stimulate the economy. At the same time, any stimulus package would have to be agreed on by a Republican president and a Democratic congress during a presidential election year. This setup was likely to lengthen the legislative process and increase the likelihood that expenditure items to be increased would be chosen according to political considerations rather than according to whether the agreed expenditure could be rolled out quickly. All in all, there was a certain danger of a delayed fiscal policy response stimulating demand during a period when slack in the economy had vanished, which may explain why Bernanke was wary of policymakers pursuing this option.

Table 2: Unemployment gap and inflation projections of the FOMC, %

FOMC Meeting	Unemployment gap			Core PCE inflation		
	Jan 17th 2008	Oct. 20th 2008	Jan 27th 2009	Jan 17th 2008	Oct. 20th 2008	Jan 27th 2009
2008 Q4	0.3-0.4	1.4-1.6		2.0-2.2	2.3-2.5	
2009 Q4	0.1-0.4	2.2-2.7	3.6-3.9	1.7-2.0	1.5-2.0	0.9-1.1
2010 Q4	0-0.2	1.6-2.4	3.1-3.4	1.7-1.9	1.3-1.8	0.8-1.5
2011 Q4	-	0.5-1.6	1.8-2.6		1.3-1.7	0.7-1.5

Note: The forecasts are based on the central tendency forecasts from the FOMC's Summary of Economic Projections (SEP) published after the respective meetings (FOMC (2008a), (2008b) and FOMC (2009a)). The core-PCE inflation projection is taken directly from respective SEP. The unemployment gap projection is calculated by subtracting midpoint of the central tendency projection of the long-run unemployment rate reported in the January 27-28th 2009 SEP (4.8-5%) from the unemployment rate projection made at the respective meeting, as the FOMC started publishing projections for the longer run unemployment rate only at the January 27-28th 2009 meeting.

By contrast, in his second appearance in the House of Representatives on October 20th 2008, the chairman (Bernanke (2008b)) endorsed fiscal stimulus. After first elaborating on how the recent intensification of the financial crisis was strengthening an ongoing broad-based economic downturn, he stated that "with the economy likely to be weak for several quarters, and with some risk of a protracted slowdown, consideration of a fiscal package by the Congress at this juncture seems appropriate." In stark contrast to his dire warnings in early 2008 of a scenario where delayed fiscal stimulus would overheat the economy, on the issue of implementation speed Bernanke merely said that "To best achieve its goals, any fiscal package should be structured so that its peak effects on aggregate spending and economic activity are felt when they are most needed, namely, during the period in which economic activity would otherwise be expected to be weak." This lack of emphasis on the timing issue is all the more remarkable as a shift from a Republican to a Democratic administration was looking likely in the presidential election of November 2008, thus implying that the decision lag would be longer than in January 2008, while the overall size of the stimulus was likely to be bigger. However, Bernanke's modified message was consistent with the substantial deterioration of the FOMC's economic outlook over the course of the year. Growth throughout 2008 had strongly undershot the FOMC's expectations, and some members expected the economy to contract over the course of 2009. Therefore the FOMC now expected an unemployment gap of a substantial magnitude over a three year horizon, with a range between 2.2-2.7% at the end of 2009,

and 0.5-1.6% by the end of 2011Q4.⁵ At the same time, the FOMC now expected inflation to remain significantly below 2% in 2010 and 2011. In such a scenario, even a drawn-out stimulus could stabilize the economy by moving output closer to its potential.

Hence the chairman's recommendations to lawmakers, in conjunction with FOMC's expectation of persistent downturn, are much more in line with Bernanke anticipating monetary accommodation of a stimulus package even if implemented over several years than with an expectation of a Federal Funds rate hike at the beginning of 2010 as in the CCTW baseline case. Note also that by the end of January 2009, when a first draft of ARRA had just passed the House of Representatives, the FOMC expected the unemployment gap to be substantially bigger and inflation to be substantially lower over the forecast horizon than at the time of Bernanke's second testimony (Table 2).

2. Pre-2009 behavior of the Federal Reserve during high unemployment periods

In this section we examine how past behavior of the FOMC during periods of high unemployment could be used to forecast the path of the Federal Funds rate for the 2009-2011 period. We first discuss some descriptive evidence regarding the incidence of Federal Funds rate hikes during periods with a high real time unemployment gap. We then take a more formal approach and derive Federal Funds rate predictions by combining FOMC and private sector forecasts of economic activity and inflation from the time ARRA was passed with a number of established and estimated interest feedback rules.

2.1 Some descriptive evidence

As mentioned above, at the time ARRA was making its way through Congress, the FOMC expected an unemployment gap significantly exceeding 2 percentage points to last at least until the end of 2011 (Table 2). It can be shown that before 2009, such conditions have very rarely been associated with a Federal Funds rate hike. To demonstrate this, we compute a real time unemployment gap from

⁵ As we will discuss below, private sector forecasts of unemployment were even more pessimistic.

monthly real time unemployment data (first releases) and the value of the long-run unemployment rate or NAIRU estimated by the staff of the Federal Reserve board and published in the Greenbook and Bluebook on the occasion of FOMC meetings.⁶ The resulting series covers the period from January 1980 to December 2003.⁷ Figure 2 plots the difference between Federal Funds target rate on the last day of a month and the last day of the previous month and the lagged unemployment gap, in order to take account of the one month publication lag of the unemployment rate. It turns out that Federal Funds rate hikes coinciding with an unemployment gap exceeding 1 PP are very uncommon. Indeed, they are located exclusively in the period of Paul Volcker's chairmanship, lasting from August 1979 to August 1987. Interest rate increases do not occur during the periods of high unemployment gaps associated with the recessions of 1990/91 and 2001. Moreover, during most of Volcker's tenure inflation was at far higher levels than anticipated for 2009-2011, and the FOMC was thus primarily focused on reestablishing price stability. Furthermore, during this era the FOMC was targeting monetary aggregates rather than directly setting the Federal Funds rate, which made the Federal Funds rate much more volatile than in earlier or later periods (B. Friedman (2005)). Hence this simple analysis of past Fed behavior suggests that the Fed typically does not tighten policy when unemployment is high unless inflation is undesirably high, implying that a Federal Funds rate hike during the 2009-2011 period was unlikely.

2.2 Predictions from interest feedback rules

Since Taylor (1993), researchers have characterized the determination of the Federal Funds Rate by using interest feedback rules which relate the Federal Funds rate to some measure of (current, lagged, or expected future) inflation and the output gap. We therefore compute the interest rate implied by a number of such rules for the 2009-2011 period based on the expectations of the FOMC and the private sector regarding inflation and the output gap. A similar exercise was conducted by

⁶Orphanides (2001) notes that Greenbook forecasts are a useful approximation of the forecasts of the FOMC.

⁷From 1980-1988, these long run unemployment rates appear in the notes attached to the table reporting the structural (or "high employment") budget deficit, which is published in at least one Greenbook each year except for 1987. From 1989-2003, we use NAIRU estimates from the Bluebook, which are provided by the Federal Reserve Bank of Philadelphia. We consider only the period up to 2003 as at the beginning of 2009 no more recent Bluebooks and Greenbooks were available due to a 5 year publication lag.

Rudebusch (2009) in May 2009, who predicted that the Federal Funds rate would remain at the zero lower bound until 2011 based on a single estimated interest feedback rule and FOMC forecasts.

While obtaining inflation expectations is straightforward, for the output gap we can only calculate expectations implied by expectations of other variables. We follow two approaches to calculate the output gap. The first uses the “gap version” of Okun’s law, which relates the output gap linearly to the negative of a measure of the unemployment gap. We again define the unemployment gap as the deviation of actual unemployment from the FOMC’s estimate of the long-run sustainable unemployment rate, and use an Okun coefficient of 1.88, as estimated by Lee (2000), slightly smaller than an estimate by Knotek (2007). The second approach calculates expectations of the output gap by combining an assumption concerning the output gap in 2008Q4 with predictions of actual and potential GDP growth over the forecast horizon. For details see the note below Figure 3.

Predictions from the FOMC and the private sector regarding inflation and unemployment as well as actual and potential GDP growth are based on the Summary of Economic Projections (SEP) produced during the FOMC’s meeting on January 27th-28th 2009 and two well-established surveys of private sector forecasters conducted over the following two weeks, namely the “Survey of Professional Forecasters” (SPF) and the survey conducted by Consensus Economics (Consensus Forecast (CF)). We then conduct our own calculations based on these sources and our own assumptions: see Table 3. Both FOMC members and the surveyed private sector forecasters were assuming that a stimulus package would be passed, although its exact size and composition was uncertain at the time the forecasts were recorded. Hence any interest rate prediction generated below includes the expected effect of ARRA on the Federal Funds rate.

The resulting output gap and inflation series are displayed in Figure 3. The output gap series distilled from the expectations of the FOMC and the private sector are at first very similar but then diverge, reflecting to a large extent the more pessimistic predictions of the private sector regarding the speed

of the recovery. The FOMCs outlook for inflation is also a bit more favorable than that of the private sector.⁸

Table 3: Forecasts of actual and potential GDP growth, actual and structural unemployment, and inflation, %

Year	GDP growth				Pot. GDP growth		Unemployment		Structural unemployment, FOMC	Inflation, Q4/Q4		
	Annual average		Q4/Q4		FOMC	CF	FOMC, Q4	SPF/CF		FOMC, PCE	SOP, CPI	SOP, PCE
2009	0.0	0.0	-0.9	-1.2	2.6	2.5	8.7	8.4	4.9	0.7	0.4	0.4
2010	0.0	0.0	2.9	2.8	2.6	2.5	8.2	8.8	4.9	1.3	1.9	1.8
2011	0.0	0.0	4.4	3.6	2.6	2.5	7.1	10.2	4.9	1.3	2.3	2.0
2012	4.1	3.6	3.8	3.5	2.6	2.5	6.4	9.6	4.9	1.6	2.3	2.0

Note: Forecasts labeled "FOMC" are based on the FOMC's Summary of Economic Projections made at the January 27th/28th meeting (FOMC (2009a)). Forecasts labeled CF and SF are based on the Consensus Forecasts survey of February 9th (Consensus Economics (2009)) and the Survey of Professional Forecasters of the Federal Reserve Bank of Philadelphia of February 13th (Federal Reserve Bank of Philadelphia (2009)), respectively. Numbers in standard print are obtained directly from the respective source, where FOMC numbers are the midpoints of the central tendency projection. Numbers in italics are calculated based on these numbers and our own assumptions. Details can be found in appendices A and B.

Figure 4 plots the Federal Funds rates implied by four different interest feedback rules using the expectations of inflation and the output gap of the FOMC and the private sector plotted in Figure 3. As we follow two approaches to calculate the output gap, each rule generates two predictions based on FOMC expectations and two predictions based on private sector expectations, thus four predictions in total. Under the rule calibrated following Taylor (1993), which is also the one used in CCTW's simulations, three of those predictions imply an exit from the zero lower bound in 2010Q1, as assumed by CCTW. Furthermore, the paths of the interest rate level predicted for 2010Q1 and after are sufficiently high to be consistent with the effect of ARRA on the interest rate simulated by CCTW (Figure 1) and thus the associated crowding out of consumption and investment. In the absence of ARRA, the path of the interest rate could have shifted downwards by the amount simulated by CCTW without hitting zero. By contrast, Orphanides' (2001) preferred interest feedback

⁸For the private sector, we plot expectations regarding both CPI and PCE-Inflation. Two of the four interest feedback rule estimates considered below, namely the rule of Bec et al. (2002) and Cukierman and Muscatelli (2008) use CPI inflation. The FOMC SEP does not contain CPI projections, so we use this measure instead. By contrast, both the original Taylor (1993) rule and the rule estimated by Orphanides (2001) refer to the GDP deflator. Since we do not have data on private sector expectations regarding this variable, we use the PCE deflator on the grounds that the share of Personal Consumption expenditure in US GDP is on average close to 70%.

rule estimated on real time data predicts an exit from the zero lower bound only in 2011Q4, with an increase of a mere 0.1%.

Both the original Taylor rule and the Orphanides (2001) rule are linear in inflation and the output gap. However, there is evidence that Federal Funds rate's response to inflation and the output gap changes depend on the state of the economy. Taylor (2007) himself criticizes the FOMC for keeping the Federal Funds rate several percentage points below the level prescribed by his rule for four years in the aftermath of the burst of the dot-com bubble.⁹ As the financial crisis of 2007-2009 was of much bigger proportions, an even stronger deviation was to be expected during its aftermath. Furthermore, the relationship between the level of the unemployment gap and the incidence of an interest rate increase or decrease discussed above also suggests that the interest setting behavior of the FOMC depends on the state of the economy. Therefore the other two rules we consider allow for nonlinearities. Béc et al. (2002, labeled BSC) estimate a piecewise-linear rule where the Federal Funds rate responds to one-year-ahead forecasts of inflation and the output gap and coefficients may differ depending on whether the lagged output gap is positive or negative. They find a statistically insignificant response to inflation during periods with negative output gaps. Cukierman and Muscatelli (2008) (labeled CM) allow the coefficients on one-quarter ahead forecasts of inflation and the output gap to depend on the hyperbolical tangent of the respective target variable, and find that during the Greenspan period, the FOMC's output gap response was higher for more negative output gaps.¹⁰ Figure 4 shows that the rule estimated by CM would prescribe a negative Federal Funds rate over the whole 2009-2011 period, regardless of whether expectations are based on the SEP or the two surveys of private sector forecasters. The BSC rule also predicts a negative rate for

⁹Bernanke (2010) shows that an inflation forecast-based Taylor rule using real time data matches the actual Federal Funds rate much better than the simple Taylor rule. However, even the rule suggested by Bernanke prescribes a path for the Federal Funds rate during the 2002Q1-2006Q1 period exceeding the actual rate by 1 percentage point or more roughly half of the time.

¹⁰Surico (2007) finds no evidence in favor of non-linearities over the Volcker-Greenspan period. According to Cukierman and Muscatelli (2008), pooling the terms of office of the two chairmen may be responsible for this result. Our own descriptive results on the incidence of Federal Funds rate increases presented above also suggest strong differences in the determination of the Federal Funds rate between Volcker disinflation and the period thereafter.

this period if applied to private sector expectations. Only if applied to FOMC expectations, does it predict an exit of the zero lower bound in 2011Q1 and a level of 0.4% in 2011Q4.

Hence, by and large, applying our constructed output gap and inflation expectations to our choice of estimated policy rules yields predictions which tend to confirm the assumption of a three year zero lower bound. Furthermore, it is important to note that only part of the interest rate increase above zero observed in the FOMC expectations case applied to the BSC rule can be attributed to ARRA. The reason the BSC rule predicts an interest rate increase starting 2011Q1 is an increase in the expected output gap in 2012. However, in 2012 the output effects of ARRA were already comparatively small, even at long lengths of monetary accommodation (Figure 1). To get a rough idea of the increase in the Federal Funds rate really attributable to ARRA, we subtract the output gap increase simulated under 12 quarters of monetary accommodation from our constructed FOMC output gap expectations to get a path of the output gap with the ARRA effects cleaned out.¹¹ We then apply this output gap path to the BSC rule to get a prediction for the path of the Federal Funds rate in the absence of ARRA, and subtract this from the path plotted in Figure 4. This procedure yields an estimate of the effect of ARRA on the Federal Funds rate. It turns out that for the 2011Q1-2011Q4 period, ARRA increased the path of the Federal Funds rate by only 0.1%. If we redo the simulation of ARRA assuming that in 2011 the nominal interest rate increases exogenously by this amount while remaining constant in 2009-2010, the cumulative multiplier amounts to 2, which is still far higher than the result under the CCTW baseline of a four quarter-long constant interest rate.

3. Insights from a simple loss function

In this section, we examine how standard assumptions regarding the preferences of monetary policy makers could have been used to forecast the path of the Federal Funds rate for the 2009-2011 period. We assume that the FOMC was aiming to minimize the following quadratic loss function

¹¹ We use the difference between actual and flexible price output as a percentage of flexible price output as the Smets and Wouter's model's equivalent to the output gap. Using the deviation of output from its steady state yields almost identical results.

$$L = \sum_{t=1}^{12} \beta^{t-1} \frac{1}{2} (\hat{\pi}_t^2 + \alpha \hat{y}_t^2), \alpha \geq 0, \beta \leq 1$$

over the 12 quarters starting in 2009Q1, with $\hat{\pi}_t$ and \hat{y}_t denoting respectively the annualized deviations of inflation and the output gap from their target values. We set the FOMC's inflation target equal to 1.85%, which is the midpoint of the central tendency forecast for "long-run" PCE-inflation from the January 27th-28th 2009 SEP (FOMC (2009a)). We also assume that the FOMC believed, as CCTW do, the Smets and Wouters (2007) model to be a reasonable framework to assess the effects of fiscal stimulus under varying lengths of monetary accommodation.

We will evaluate this loss function for the alternative inflation and output paths associated with alternative lengths of monetary accommodation i , with $0 \leq i \leq 12$, assuming that for $t > i$, monetary policy follows the interest feedback rule in the model. For that purpose, we draw on the FOMC's inflation forecasts and the implicit output gap expectations constructed in the previous section. We assume that those expectations did not incorporate any monetary accommodation of ARRA. That means we assume that policymakers expected to respond to the deviations of inflation and output from their non-stimulus baseline values starting in 2009Q1, rather than in 2010Q1 as assumed by CCTW. We denote those policymaker expectations as $\hat{\pi}_{t,i=0}$ and $\hat{y}_{t,i=0}$, where i denotes the length of monetary accommodation. Hence for each length of monetary accommodation we can compute the paths of inflation and the output gap as $\hat{\pi}_{t,i} = \hat{\pi}_{t,i=0} + d\pi_{t,i} - d\pi_{t,0}$ and $\hat{y}_{t,i} = \hat{y}_{t,noARRA} + dy_{t,i} - dy_{t,0}$, where $d\pi_{t,i}$ and $dy_{t,i}$ denote the simulated effects of ARRA on inflation and the output gap for i quarters of monetary accommodation.¹² So $d\pi_{t,i} - d\pi_{t,0}$ and $dy_{t,i} - dy_{t,0}$ denote the effects of increasing the length of monetary accommodation from 0 to i periods on inflation and the output gap.

Note that the press release issued after the January 27-28th 2009 FOMC meeting (FOMC (2009b)) says that "The Committee continues to anticipate that economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time." Thus, by not being stripped of the

¹²We use the difference between actual and flexible price output as a percentage of flexible price output as the Smets and Wouter's model's equivalent to the output gap. Using the deviation of output from its steady state yields even stronger results.

likely positive expected effects of the monetary accommodation intended by the FOMC on the path of inflation and output, our assumed values of $\hat{\pi}_{t,i=0}$ and $\hat{y}_{t,i=0}$ will be biased upwards, possibly substantially as illustrated by Figure 1. This upward bias implies that the length of monetary accommodation we find to minimize the FOMC's loss will tend to be biased downwards, as, due to the nonlinearity of the objective, the marginal reduction in the loss caused by a given increase in inflation and output due to a longer period of monetary accommodation will be lower if the respective starting value is higher.

Regarding $\hat{\pi}_{t,noARRA}$, we assume that core-PCE inflation enters the loss function, as it is the inflation measure the Fed officially uses to measure deviations from price stability. But we also consider PCE-inflation figures as a robustness check. Regarding $\hat{y}_{t,noARRA}$, we consider both our unemployment gap-based output gap measure and the alternative. We assume a discount rate $\beta=0.99$, but our results are also robust at higher values. We first consider the case where the FOMC has no preferences over output stabilization, i.e. $\alpha=0$. With such preferences, the length of monetary accommodation minimizing the loss function would equal 11 quarters, rather than four as assumed by CCTW. If we use headline inflation, the optimal length of monetary accommodation would increase to 12 quarters. As can be seen in Figure 5, the FOMC expected inflation to be substantially below target over the 2009-2011 period. Therefore the higher inflation associated with longer lengths of monetary accommodation actually helps the FOMC to meet its target.

Furthermore, if we relax the assumption that the FOMC does not care about output gap stabilization, the FOMC prefers 12 quarters of monetary accommodation to all shorter periods for any value of $\alpha > 0.0089$. This is lower than what is typically used in the literature on monetary policy analysis. For instance, Woodford (2003) reports a value of 0.048 for his household utility-based loss function, with the underlying household preference and technology parameter values as estimated by Rotemberg and Woodford (1997). Barro and Broadbent (1997), who also estimate a model but allow the output gap weight in the policymaker's loss function to vary freely, estimate a value of 1/3, somewhat higher than the value of 0.25 used by Jensen (2002) or McCallum and Nelson (2000) in

their theoretical analysis. More recently, Chen et al. (2013) investigate the preferences of the Fed by estimating a DSGE model for various forms of optimal policy, and allow the relative weight of other objectives relative to inflation to follow a two-regime Markov switching process. The relative output weights equal 0.64 under the less conservative and 1.46 under the more conservative regime. In the aftermath of the dot-com crash, their estimated probability of being in the less conservative regime exceeded 50% for several years. Hence we conclude that, for reasonably parameterized preferences, the FOMC would have preferred a 12 quarter constant interest rate to all shorter lengths.

4. Financial market (private sector) expectations

A natural alternative to trying to predict the Federal Funds rate on the basis of the economic outlook and past systematic monetary policy responses is to derive financial market participants' expectations from Federal Funds futures (FFF). Such futures have been traded at the Chicago Board of Trade since the late 1980s. They are essentially bets on the average Federal Funds rate that prevails over month $t+n$, with the payoff given by $(f_t^n - r_{t+n})$ times the size of the contract, where f_t^n and r_{t+n} denote the return fixed in the n -month FFF and the average of the Federal Funds rate prevailing in month $t+n$, respectively. Under the pure expectation hypothesis, f_t^n would be an unbiased predictor of r_{t+n} . The maximum horizon of FFFs traded in the market is 24 months. In early 2009, f_t^{24} varied between 100 and 200 basis points (Figure 6), which appears to support CCTWs assumption that the Federal Funds rate would remain at zero for less than two years.

However, Piazzesi and Swanson (2008, henceforth referred to as PS) have provided strong evidence that the failure of the pure expectations hypothesis is also true for the FFF market. They find that the excess return $(f_t^n - r_{t+n})$ on the FFF contracts they consider is on average positive, time varying and partly predictable. The standard economic explanation for this phenomenon is (time-varying) risk premia exist in asset prices. Specifically, they find that the (expected) rate of return on holding FFF contracts is negatively related to year-on-year employment (monthly non-farm payroll) growth. As employment was shrinking extraordinarily fast in the year leading up to January 2009, f_t^n would be

expected to give an especially biased prediction of r_{t+n} . We therefore follow PS and estimate a forecast equation for $E_t\{f_t^n - r_{t+n}\}$ using data up to December 2008, and then use the relation $E_t\{r_{t+n}\} = f_t^n - E_t\{f_t^n - r_{t+n}\}$ to forecast the Federal Funds rate two years ahead.

Due to the fact that 24-month FFFs were established only in 2008, we also have to follow PS and use the 6-months-ahead FFF contract in our estimation. Of course, there is a priori no direct connection with the excess returns for the 24-month horizon. However, we make use of the fact reported by PS, as well as Hamilton and Okimoto (2010), that expected excess returns of FFF contracts tend to rise with the contract maturity. Assuming that this positive relationship also holds for longer maturities, our results should constitute an upper bound for the actual 24-months-ahead market expectations for the Fed funds rate.

Just as PS do, we find that lagged real time non-farm payroll growth over the past 12 month and the implied FFF rate itself are the most important predictors of excess FFF returns, although we also experimented with term spreads, corporate bond spreads, and lagged interest rates.¹³ The fact that we estimate an equation suitable for forecasting in real time prevents us from using the first five lags of the dependent variable as regressors since future values of the Federal Funds rate are unknown at the time a forecast is made. We therefore use robust HAC standard errors in order to deal with residual autocorrelation.

The estimation results are reported in Table 4, and the fitted (predicted) values are compared to actual excess returns in Figure 7.

Table 4: Forecast equation for excess returns (6-month ahead horizon)

	coefficient	std. error	t-ratio	p-value
Constant	-29.51	14.11	-2.09	0.038
FFF implied rate 6m	0.170864	0.0439514	3.888	0.000
employment growth (lagged, annualized)	-1728.37	593.320	-2.913	0.004
excess returns 6m (2nd lag)	0.366941	0.123528	2.971	0.003
R-squared 0.33	Adjusted R-squared 0.33			

Notes: Sample 1990m1-2008m12 (T = 228), HAC standard errors (bandwidth 4, Bartlett kernel), Durbin-Watson-Stat: 0.29

¹³ As in PS, we use lagged employment in order account for the one-month publication lag.

Using our estimated equation we can now calculate an upper bound for $E_t\{r_{t+24}\}$ by plugging our estimate of the lower bound of the maturity-adjusted expected excess returns $E_t\{f_t^n - r_{t+24}\}$ into $E_t\{r_{t+24}\} = f_t^{24} - E_t\{f_t^{24} - r_{t+24}\}$.¹⁴ The upper bound of $E_t\{r_{t+24}\}$ is plotted in Figure 8, where for comparison we also include the 24-months lead of the Federal Funds rate actually realized ex post. It turns out that, after adjusting for time varying risk premia, the two-year-ahead expectations of the Federal Funds rate hit zero in December 2008 and do not become positive again until November 2009.¹⁵

Indeed, one may argue that markets expected a zero Federal Funds rate to persist for some time after January 2011 if one were to interpret the negative prediction of the Federal Funds rate as the markets' view of the rate the FOMC would like to set given the state of the economy if it were not constrained by the zero lower bound. Under this interpretation, the desired Federal Funds rate predicted in January 2009 for January 2011 equaled -170 basis points. A predicted negative rate of this magnitude presumably implies that market participants expected economic slack to be very high and inflation to be low by the beginning of 2011. In order to conclude that the actual Federal Funds rate would increase soon after, market participants would have had to expect a dramatic pace of recovery during 2011, which appears *a priori* implausible. Therefore we interpret the above results to be consistent with a duration of the zero lower bound of three years, although our findings are nominally limited to two years.

¹⁴ This statement refers to excess returns multiplied by the ratio of the holding periods; since the excess returns of a FFF contract with a duration of 6 months can be realized four times in a row (*ceteris paribus*) until the expiry of the 24-month FFF contract, we follow PS's practice and multiply the (expected) excess returns of the 6-month contract by four before subtracting it from the implied rate of the 24-month FFF contract.

¹⁵ The latest available expectation in this sample is for the period August 2013 with a value of 303 basis points. This value appears quite high given the data constellation and monetary policy stance prevailing in real time, but it may be worth repeating that this constitutes just an upper bound, where the true expectation may be lower by an unknown amount.

5. Relation of our results to the Blue Chip financial forecasts

The Blue Chip survey of 49 professional forecasters contains predictions of the path of the Federal Funds rate over the current and 6 following quarters. According to the survey published on February 1st 2009, the panel on average predicted a Federal Funds rate increase above 0.25% in 2010Q1, which contradicts our own real time forecast. Twenty-eight of the institutions covered by the panel are also included in the Survey of professional forecasters of the Federal Reserve Bank of Philadelphia, and some are also contained in the Consensus forecast survey.¹⁶

The key question is whether the expected increase of the Federal Funds rate and the decline in private expenditure it caused was due to ARRA. We would argue that it was not. For our forecasts of a three-year zero lower bound period were derived by combining verbal, descriptive and formal evidence as well as optimal policy considerations available at the beginning of 2009 on how the Fed responds to inflation, unemployment and the output gap with (implicit) forecasts of these variables. Hence assuming that we did a good job, the rate increase expected by the Blue Chip panel cannot have been related to the private sector's inflation and output gap forecasts, nor to the effect of ARRA on these forecasts. To put it differently, the blue chip forecasters would have expected the increase even in the absence of ARRA.

We have three conjectures why private sector forecasters predicted a Federal Funds rate increase inconsistent with past Fed responses to inflation and the output gap. Firstly, a sustained period of the Federal Funds rate being at the zero lower bound had not occurred since the Great Depression. This experience might have made it hard for forecasters to envisage a period at the zero lower bound exceeding one year, and distracted their focus from inflation and the output gap.

Secondly, when predicting the Fed Funds rate, private sector forecasters might place relatively more weight on prospective GDP growth rather than on the level of GDP relative to some unobservable measure of potential output, unlike central bank or academic economists. Private sector forecasters expected the US economy to stop contracting in 2009 Q3 (+0.9% Annualized Percentage Rate), and

¹⁶The Blue Chip survey also contains a consensus forecast of quarterly GDP growth until 2010Q2. The predicted GDP path closely matches the consensus of the Survey of Professional Forecasters.

expected growth to accelerate to 2.4% in 2010Q1 and 3.6% in 2011Q1. However, as can be obtained from Figure 1, for every length of monetary accommodation considered, the bulk of the effects of ARRA on the level of GDP had already taken place by 2009Q3, with the peak effect located in 2010Q1. Hence the expected increase in the Federal Funds rate coincides with the quarter where the quarter-on-quarter growth effects of ARRA turn negative, suggesting that ARRA did not increase the Federal Funds rate expected by the Blue Chip panel even if they focused on GDP growth.

Finally, possibly being unaware of Piazzesi and Swanson (2008), Blue Chip forecasters may have placed too much weight on the prediction implied by 12- month Federal Funds Futures, which equaled 0.62%. Such reliance would tend to bias their predictions from the beginning of 2009 upwards as the strongly negative employment growth over the past 12 months increased the predictable component of excess returns. However, the size of this bias would be unrelated to ARRA as it likely had no effect on the change of employment from January 2008 to January 2009.

6. Conclusion

In this paper, we critically examine Cogan et al.'s (2010) argument that the government purchases component of the American Recovery and Reinvestment Act (ARRA) passed in February 2009 would have only a small effect on US GDP due to substantial crowding out effects. We show that this result is extremely sensitive to the time at which the Federal Funds rate is expected to exit the zero lower bound, which they assume to occur in 2010Q1. What is more, drawing on official statements of the Fed chairman, predictions of FOMC members and private sector forecasters, evidence on past interest rate setting behavior of the Fed, optimal policy considerations, and financial market expectations embedded in implied Federal Funds Futures rates, we argue that a more reasonable prediction of the period the economy would remain at the zero lower bound would have been closer to three years, implying a strong crowding in of private expenditure and thus a cumulative multiplier of the increase in government consumption strongly exceeding one.

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7. Appendix A: Expectations data sources

From the FOMC's Summary of Economic Projections made at its January 27-28th 2009 meeting (FOMC (2009a)), we obtain the midpoint of members' central tendency forecast for the 2009-2011 period regarding Q4/Q4 real GDP growth, Q4 unemployment, the Q4/Q4 change in the headline PCE deflator and the core PCE deflator. We also use members' estimates of the "longer run" values of GDP growth (2.6%) and unemployment (4.9%) as proxies for potential GDP growth and the NAIRU, respectively.

For private sector forecasts, we draw on the Consensus Forecasts survey (CF) of February 9th 2009 (Consensus Economics (2009)) and the Survey of Professional Forecasters (SPF) of the Federal Reserve Bank of Philadelphia of February 13th 2009 (Federal Reserve Bank of Philadelphia (2009)). Specifically, for the 2009-2011 period we obtain year-on-year GDP growth from CF because it covers the complete 2009-2011 period, while SPF covers only the years 2009-2010 for these variables. However, year-on-year GDP growth rates projected by the SPF for 2009 and 2010 differ only marginally from those in the Consensus Forecasts (CF). Therefore we also make use of the quarterly GDP growth forecasts published in the SPF for the 2009Q1-2010Q1 period. We also use the CF for average annual growth over the period 2012-2016 in order to construct an expected year-on-year growth rate for 2012.

Furthermore, we obtain a forecast of average annual unemployment for 2009 and 2010 from SPF, which only marginally differs from the CF, as well as quarterly unemployment rates for 2009Q1-2010Q1. For both PCE-Deflator and the CPI, we obtain quarterly growth rates for the 2009Q1-2010Q1 period as well as the Q4/Q4 change for 2009-2011 from the SPF, as the CF of consumer price inflation covers only 2009-2010. The CF survey only contains predictions regarding average annual CPI inflation and thus cannot be directly compared to the SPF forecast.

As a proxy for potential GDP growth expectations of the private sector we use the CF of average annual GDP growth during the 2017-2021 period, which equals 2.5%. All forecasts cited above refer to seasonally adjusted data.

8. Appendix B: Construction of expected quarterly GDP growth, unemployment and inflation projections for 2009-2012

Inflation

For the 2009Q1-2012Q4 period, FOMC expectations of quarterly PCE core and headline inflation were set as follows:

1. FOMC members' forecast Q4/Q4 inflation for 2009-2011 is reported in the SEP. For 2012, we assume that members expected Q4/Q4 inflation to equal 1.6%, implying that it converges halfway towards its expected long-run value of 1.85%.
2. We then interpolate quarterly core and headline PCE inflation rates to match these Q4/Q4 inflation rates. For 2009Q1-2010Q1, the quarterly core and headline PCE inflation rates we set closely match the quarterly rates published in the SPF (neither the February 2009 CF survey nor the FOMC's SEP contain predictions of quarterly PCE inflation), while for the remaining period quarterly inflation rates within a given year are assumed to be identical.

We also assume that the FOMC had a good nowcast of the first estimate of the 2008Q4 value of the PCE deflator, released on January 30th 2009, which we obtain from the ALFRED Database.¹⁷

The private sector's expectations of CPI and PCE-deflator inflation are largely analogously calculated based on the SPF. Regarding 1., we assume Q4/Q4 inflation in 2012 to equal its 2011 value. The resulting year-on-year CPI-inflation for 2009 and 2010 differs only marginally from the CF.

¹⁷ This matters only for the prediction of the simple Taylor rule for 2009Q1-2009Q3, which says that the interest rate depends on the change in the respective price index over its value in the same quarter of the previous year.

Note our assumptions regarding 2012Q2-Q4 inflation matter only for Federal Funds rate predictions of the Orphanides et al. rule. Bec et al. (2002, labeled BSC) find a statistically insignificant and negative response to inflation during periods with a negative output gap, which is why we set the inflation response in this rule equal to zero. Regarding the Cukierman and Muscatelli (2008, labeled CM) rule, only the Federal Funds rate predicted for 2011Q4 depends on inflation expectations for 2012 – specifically the 2012Q1 forecast. The 2011Q4 prediction is very robust to the assumed 2012Q1 expected inflation rate. The interest rate predicted for 2011Q4 would turn positive only if the FOMC and the private sector expectations for 2012Q1 inflation were to exceed 3% and 5%, respectively.

GDP

FOMC expectations of quarterly GDP growth rates for the 2009Q1-2012Q4 period are constructed as follows:

1. The FOMC members' forecast Q4/Q4 GDP for 2009-2011 is reported in the SEP. For 2012, we assume that members expected the same acceleration in year-on-year GDP growth as the private sector (more on this below). This assumption implies that for 2012 (just as for 2009-2011), the FOMC is more optimistic than the private sector both regarding annual average and quarterly GDP growth.
2. We interpolate quarterly GDP growth rates to match these targets. For 2009Q1-2010Q1, the quarterly GDP growth rates we set closely match the quarterly rates published in the SPF (the FOMC's SEP does not contain predictions of quarterly growth rates), while for the remainder quarterly growth rates within a given year are assumed to be identical.

For the private sector, we proceed analogously. Regarding 1., we use the year-over-year growth rates contained in the CF survey for 2009-2011 as targets, and the first estimate of GDP inclusive of 2008Q4 GDP, released on January 30th 2009, which we obtain from the ALFRED Database.

For 2012, the year-on-year GDP growth forecast is based on the CF of average annual growth over the 2012-2016 period, which equals 2.8%. This number translates into the expected 3.5% for 2012 reported in Table 3 by assuming that a) forecasters did not expect GDP growth to undershoot its potential during the 2012-2016 period and b) a convergence of actual growth towards potential growth in equal-sized steps was expected to take place. Quarterly rates are then set as in step two above.

Note that regarding the interest rate rule-based Federal Funds rate predictions reported in 2.2, the expected path for 2012 GDP growth (and unemployment) matters chiefly for our 2011 interest rate prediction made with the BSC rule, which features the one-year-ahead output gap. By contrast, in the CM rule the Federal Funds rate depends on the one-quarter-ahead expected output gap. Hence only the Federal Funds rate predicted for 2011Q4 depends on output gap expectations for 2012, namely the 2012Q1 forecast.

Unemployment

Expectations of quarterly unemployment for the 2009Q1-2012Q4 period are constructed as follows:

- FOMC: When interpolating quarterly rates, we always impose that the expected unemployment rate moves from the Q4 of one year to the Q4 of the following year in equal-sized steps. FOMC members' expectations of Q4 unemployment for 2009-2011 are reported in the SEP. The Q4 2008 unemployment rate required for our computations is calculated from monthly data released on January 9th 2009, obtained from the ALFRED database. For 2012, we first calculate average annual unemployment for 2011 and then use the 2012 year-on-year GDP growth rate and Okun's law to project a 2012 average annual unemployment rate. We then set the Q4 unemployment rate such that the 2012 average annual unemployment rate equals this estimate.
- Private sector: Quarterly unemployment forecasts for the 2009Q1-2010Q1 period as well as average annual unemployment for 2010 are contained in the SPF. We construct annual

average unemployment for 2011 and 2012 using Okun's law and the respective year-on-year GDP growth rates. We assume that the expected unemployment rate moves from the Q4 of one year to the Q4 of the following year in equal-sized steps, and then set the Q4 unemployment rate such that the average annual rate equals our estimate.

Whenever we use Okun's law to calculate missing unemployment expectations from the GDP growth rate expectations constructed above, we use an Okun coefficient (i.e. the effect of a percentage point change in unemployment on GDP growth in percentage points) of 1.84 as reported by Lee (2000) for annual data, and the estimates of potential GDP growth of the FOMC (2.6%) or the private sector (2.5%).

9. Appendix C: Interest feedback rules

In section 2.2, we consider the following four interest feedback rules, where π_t^{index} and \hat{y}_t denote the annualized quarterly change of the respective price index used to calculate inflation and the output gap, respectively.

The simple Taylor rule is given by

$$i_t = i + 1.5 \left(\frac{\pi_t^{GDP-Defl.} + \pi_{t-1}^{GDP-Defl.} + \pi_{t-2}^{GDP-Defl.} + \pi_{t-3}^{GDP-Defl.}}{4} - 1.85 \right) + 0.5\hat{y}_t$$

where, following Talyor (1993) i equals the sum of target inflation, assumed here to equal 1.85%, the midpoint of the central tendency forecast for "long-run" PCE-inflation from the January 27th-28th 2009 SEP, and the respective potential output growth rate estimate.

From Table 6 of Orphanides (2001), we obtain the following rule estimated on real time data:

$$i_t = 0.66i_{t-1} + (1 - 0.66) \left(1.8 + 1.64E_t \left\{ \frac{\pi_{t+4}^{GDP-Defl.} + \pi_{t+3}^{GDP-Defl.} + \pi_{t+2}^{GDP-Defl.} + \pi_{t+1}^{GDP-Defl.}}{4} \right\} + 0.97\hat{y}_t \right)$$

Orphanides prefers this specification because it is forward-looking and the inflation coefficient is significantly greater than one.

From Table 1 of Bec et al. (2002), we employ the estimates of their piecewise linear rule allowing for interest rate smoothing. As Bec et al. (2002) estimate their rule on monthly data, we used their estimates of the effect of the one-month and two-month lag of the Federal Funds rate on its current level ρ_1 and ρ_2 to compute a lagged interest rate coefficient applicable to quarterly data as $(\rho_1 + \rho_2)^3$. Furthermore, we report only the estimate for the case of a negative output gap, and ignore the inflation term as its coefficient was insignificant and negative.

$$i_t = 0.9i_{t-1} + (1 - 0.9)(5.262 + 1.237E_t\hat{y}_{t+4})$$

Finally, from Table 2 of Cukierman and Muscatelli (2008), we employ the coefficient estimates reported for the Greenspan period, ignoring the term involving the hyperbolical tangent on inflation as the associated coefficient is insignificant and negative:

$$i_t = 0.81i_{t-1} + (1 - 0.81) \left(5.279 + 1.01(E_t\pi_{t+1}^{CPI} - 2.9) + 0.88E_t\hat{y}_{t+1} \right. \\ \left. - 0.84E_t\hat{y}_{t+1} \text{TANHYP}(0.2E_t\hat{y}_{t+1}) \right)$$

$\text{TANHYP}(\dots)$ denotes the hyperbolical tangent of the term in brackets.

10. Figures

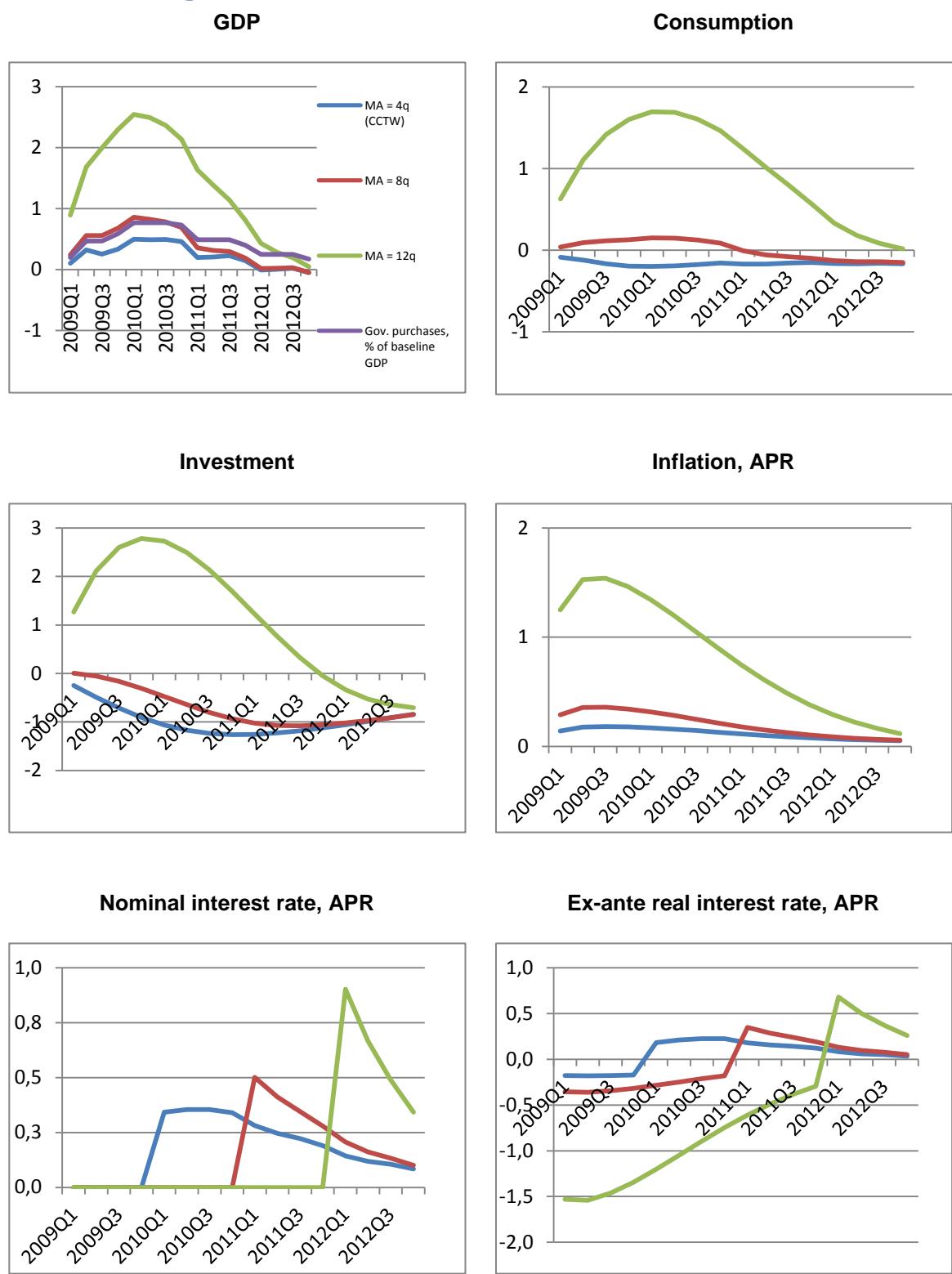


Figure 1: Effect of the increase in government purchases legislated by ARRA on GDP and other variables assuming varying lengths of the period of monetary accommodation, APR=Annualized Percentage Rate.

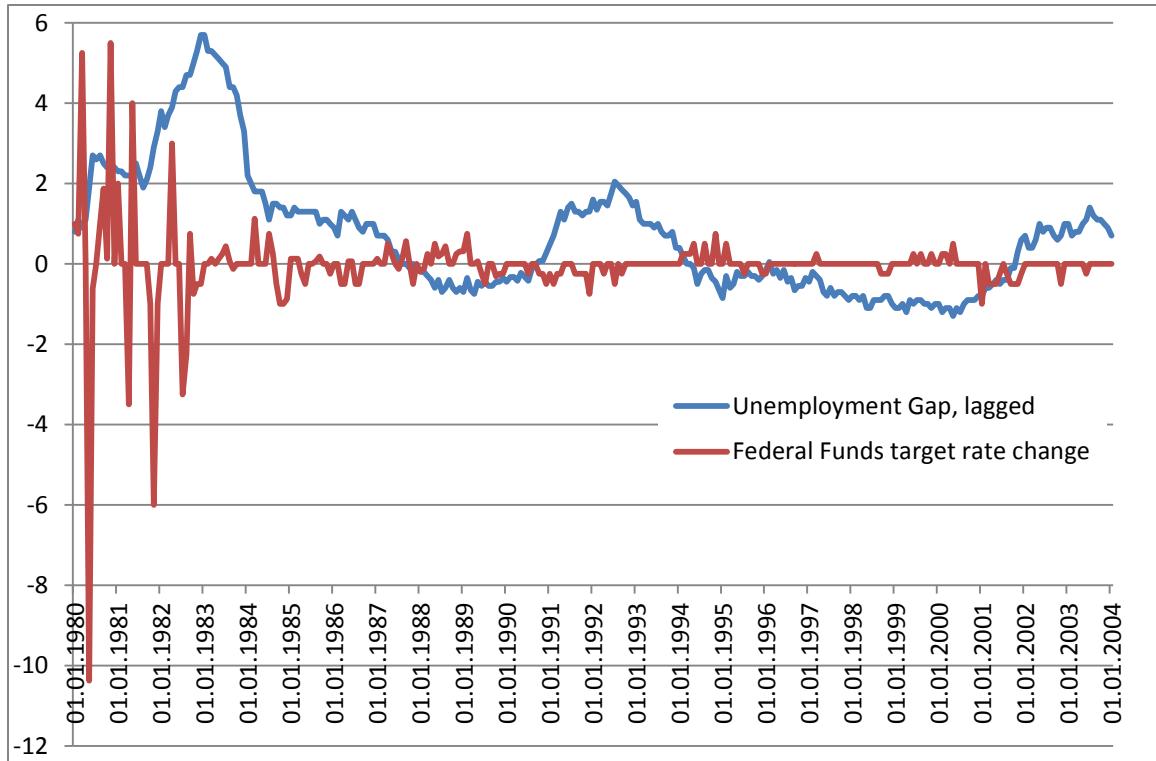


Figure 2: Unemployment gap and change in the Federal Funds target rate, %

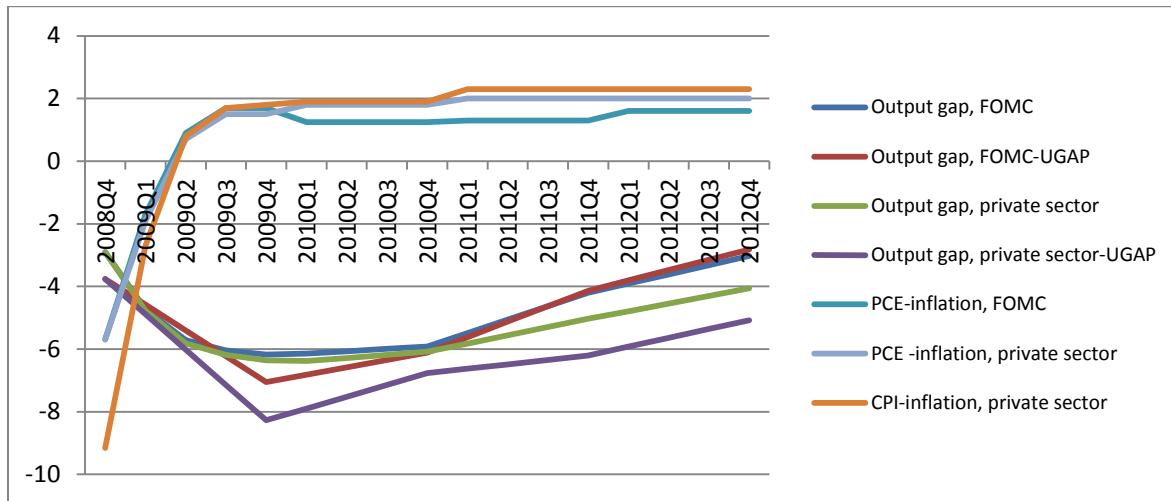


Figure 3: Implied output gap and quarterly annualized inflation expectations, %

Note: Output gap paths labeled “-UGAP based” are based on the “gap version” of Okun’s law, i.e. $Y_{\text{GAP}}(t) = -b * (U(t) - UN)$, where Y_{GAP} , U and UN denote the output gap, the FOMC’s or the private sector’s forecast of actual unemployment and the FOMC’s estimate of the long-run sustainable unemployment rate, respectively, while $b=1.88$, as estimated by Lee (2000). The remaining output gap paths are calculated as the difference between actual and potential GDP. The path of potential GDP is computed using the potential growth rates reported in Table 3, and by assuming an output gap in 2008Q4 of -2.9%, which is the median of seven estimates reported by Williams and Weidner (2009), and falls short of the Congressional Budget Office’s estimate of January 2009 by about one percentage point (CBO (2009)). The quarterly paths of GDP and unemployment used in these calculations, as well as the quarterly inflation paths plotted are based on the FOMC and private sector forecasts reported in Table 3. Their computation is detailed in appendices A and B.

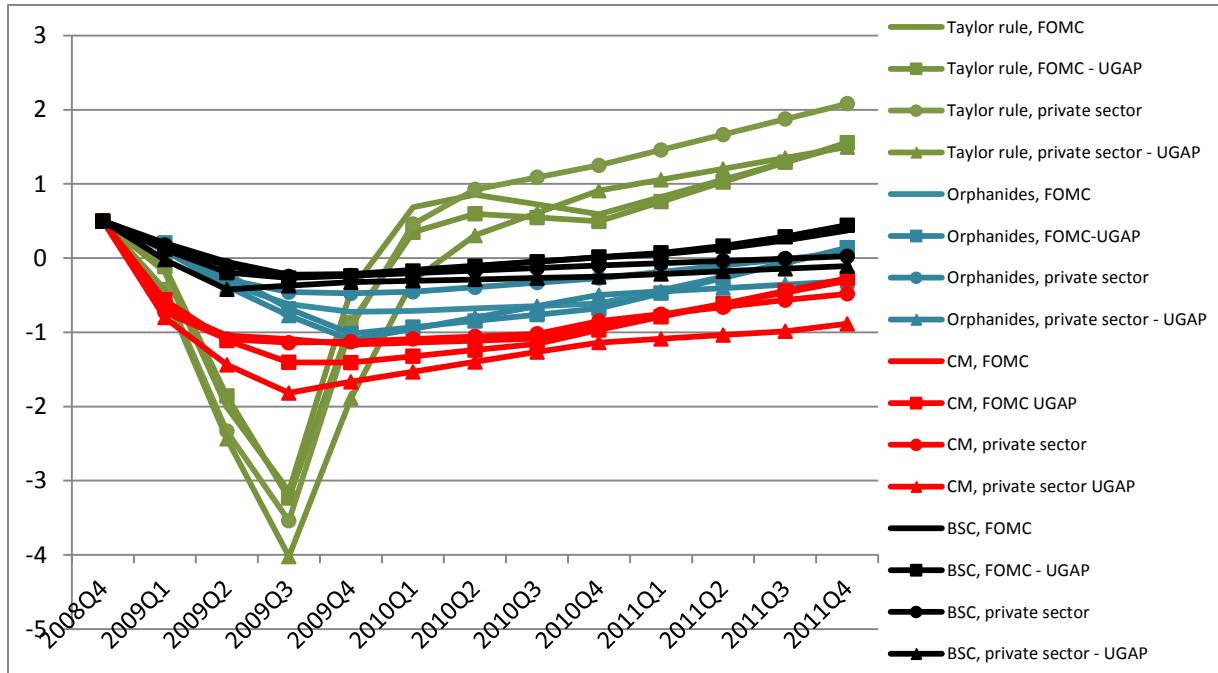


Figure 4: Federal Funds rate predicted by various interest feedback rules, %

Note: This figure plots the Federal Funds rate predictions resulting from combining the Taylor (1993) interest feedback rule, one of Orphanides (2001) forward-looking interest feedback rules estimated on real time data, as well as the non-linear rules estimated by Cukierman and Muscatelli (2008) (labeled CM) and Bec et al. (2002) (labeled BSC) with the output gap and inflation expectations plotted in Figure 3. Details of the rules used are reported in Appendix C. As we consider two ways to compute implied output gap expectations for both the FOMC and private sector, we have four interest rate predictions per policy rule. When forming a prediction with rules featuring a lagged interest rate term (i.e. CM and BSC), we set the t-1 interest rate to zero whenever the interest rate predicted for period t-1 is negative.

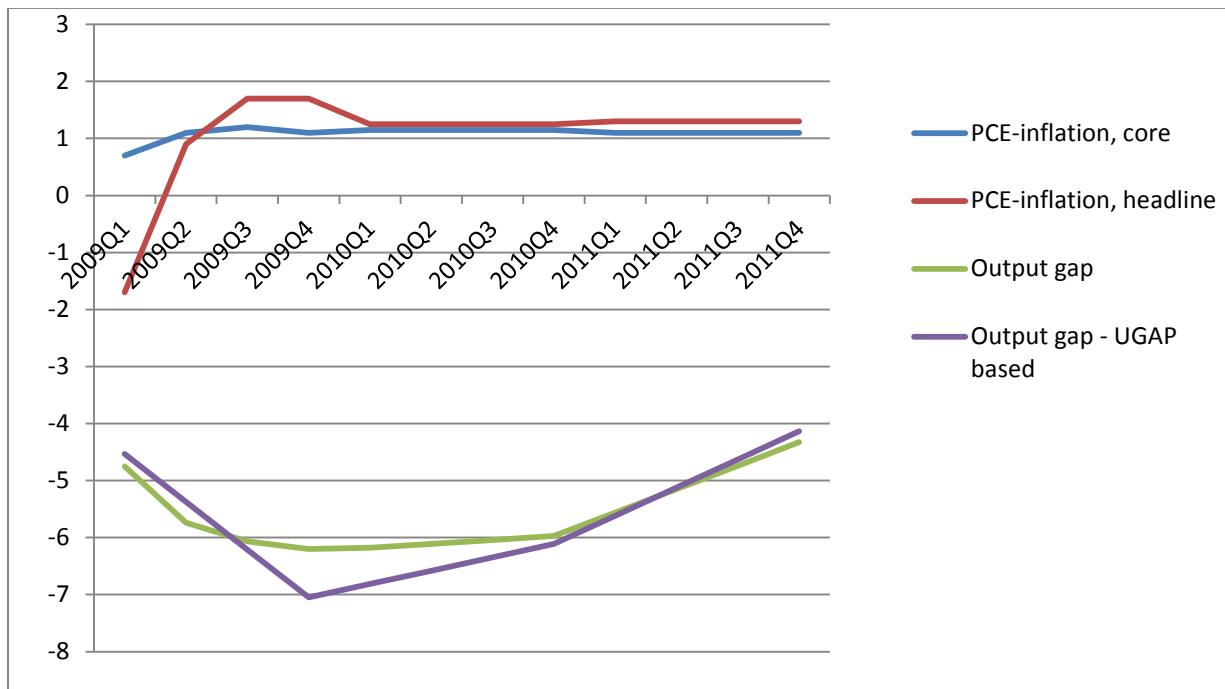


Figure 5: Inflation and implicit output gap expectations of the FOMC

Note: The paths of the output gap and PCE inflation are as in Figure 3. The path of PCE core inflation was derived in exactly the same way as the path of PCE inflation: see appendix B.

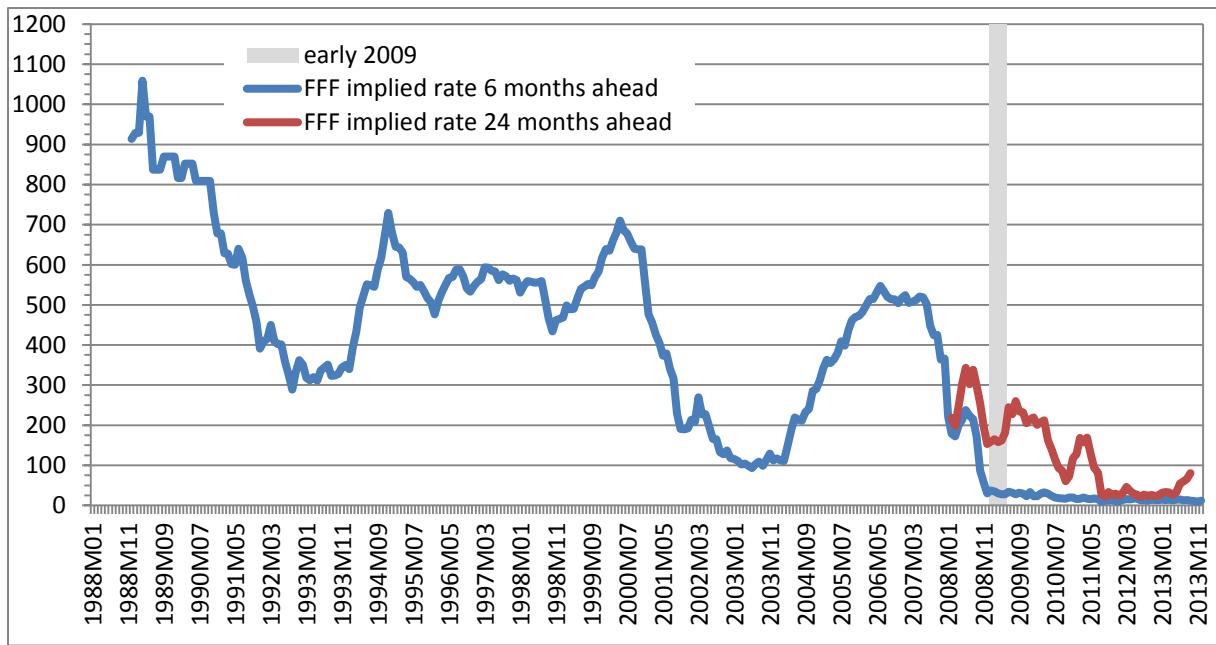


Figure 6: FFF implied rates for 6 months maturity and 24 months maturity, monthly averages of daily data, basis points.

Note: The shaded area highlights the first half of 2009. Source: Macrobond.

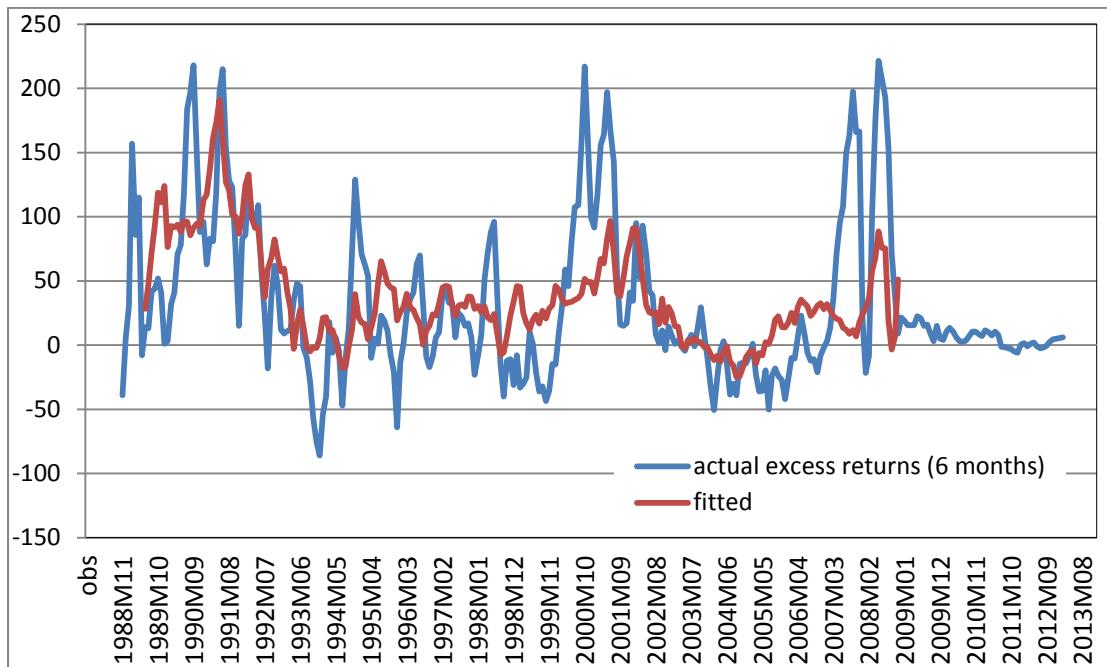


Figure 7: Predicted excess returns for the 6-month FFF contract in-sample.

Note: Returns are "as is" for the 6-month horizon, i.e. not made comparable with the 24-month horizon. The time axis refers to the period of forecast formation (FFF purchase time).

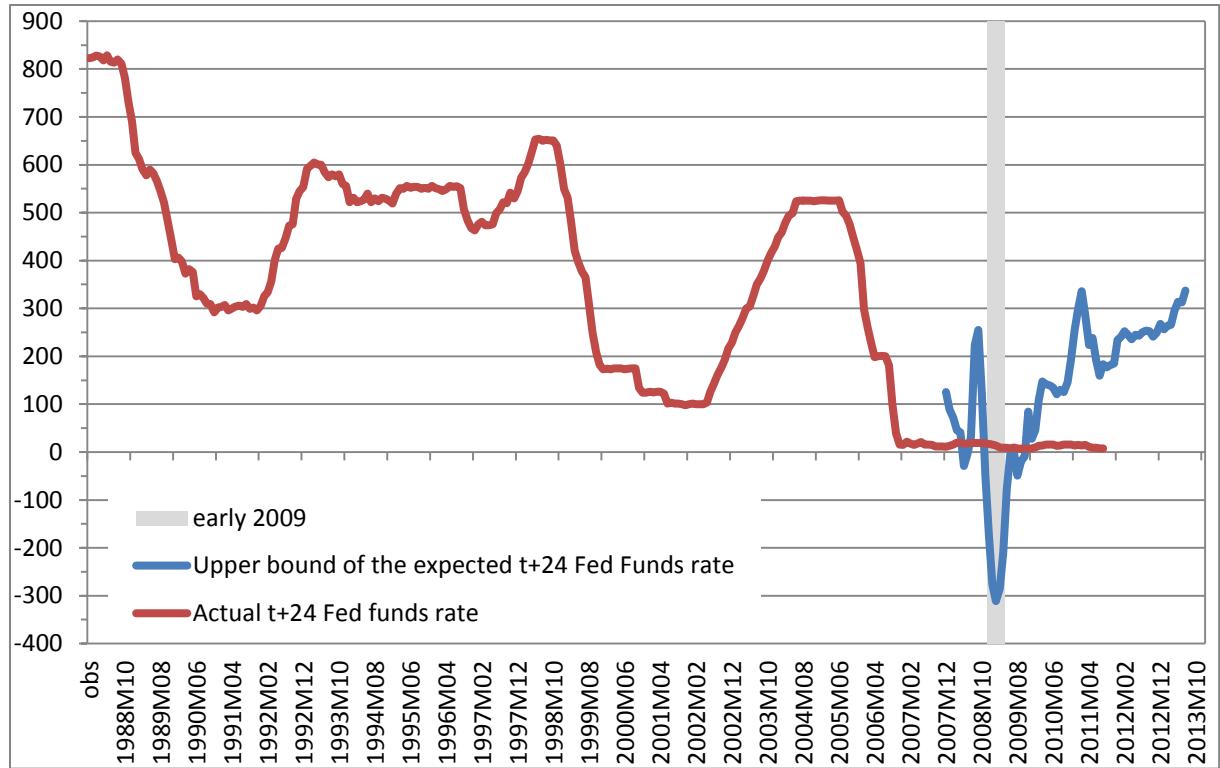


Figure 8: Expected and actual Fed funds rates, 24-months horizon.

Note. The blue line is an upper bound of the Federal Funds rate expected in period t for $t+24$, i.e. $E_t\{r_{t+24}\}$ (see the text; except when the zero lower bound is binding). The shaded area highlights the first half of 2009.