Macroeconomic Effects of FOMC Forward Guidance*

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Abstract

A large output gap accompanied by stable inflation close to its target calls for further monetary accommodation, but the zero lower bound on interest rates has robbed the FOMC of the usual tool for its provision. This paper examines how public statements of FOMC intentions – forward guidance – can substitute for lower interest rates at the zero lower bound. We distinguish between *Odyssean* forward guidance, which publicly commits the FOMC to a future action, and *Delphic* forward guidance which merely forecasts future macroeconomic performance and likely monetary policy actions. Eggertsson and Woodford (2003) show how Odyssean forward guidance that commits to keep rates at zero for longer than conditions would otherwise warrant can provide monetary easing presently *if* the public trusts it. We empirically characterize the responses of asset prices and private macroeconomic forecasts to FOMC forward guidance, both before and since the recent financial crisis. Our results show that the FOMC has extensive experience successfully telegraphing its intended adjustments to evolving macroeconomic conditions, so communications difficulties do not present an insurmountable barrier to monetary policy based on Odyssean forward guidance. Using an estimated DSGE model, we then investigate how pairing Odyssean forward guidance with "bright-line" rules for launching rate increases can mitigate risks to the Federal Reserve's price stability mandate.

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1 Introduction

From the onset of the financial crisis and through the Great Recession and ensuing modest recovery, the Federal Open Market Committee (FOMC) has commented upon the likely duration of monetary policy accommodation in the formal statement that follows each of its meetings. In December 2008 it said "the Committee anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time." In March 2009, when the first round of large scale purchases of Treasury securities was announced, "extended period" replaced "some time." The August 2011 FOMC statement gave specificity to "extended period" by anticipating exceptionally low rates "at least as long as mid-2013," and the January 2012 FOMC statement lengthened the anticipated period of exceptionally low rates even further to "late 2014," language that remained in the March 2012 statement. These communications are referred to as *forward guidance*.

The nature of this most recent forward guidance is the subject of substantial debate. Monetary policy studies by Krugman (1999), Eggertsson and Woodford (2003), and Werning (2012) suggest that a monetary policy-maker encountering the zero lower bound (ZLB) on the policy rate can stimulate current aggregate demand by credibly promising to keep the rate at zero longer than required by economic conditions and thereby create an economic boom in the future. So, one might interpret "late 2014" as such a credible promise. Alternatively, "late 2014" might merely describe the prescription of the FOMC's policy reaction function if current forecasts of sluggish economic activity and low inflation through that date come to pass.[1] "Late 2014" predicts unusually accommodative policy whenever the underlying policy reaction function would dictate earlier lift-off dates given the identical conditioning data.

Motivated by the competing interpretations of "late 2014," we distinguish between two kinds of forward guidance. *Delphic* forward guidance forecasts future macroeconomic performance and likely or intended monetary policy actions based on the FOMC's potentially superior information about future macroeconomic fundamentals and policy goals. Such forward guidance presumably improves macroeconomic outcomes by reducing private decision-makers' uncertainty. Importantly, these forecasts do not publicly commit policy-makers to a particular course of action. *Odyssean* forward guidance publicly commits policy-makers to a future action, just as Odysseus committed himself to staying on ship by binding himself to the mast. Tying one's hands in the face of an uncertain future might seem like a foolish sacrifice for no apparent gain, but economic fluctuations routinely present opportunities for monetary policy to benefit from Odyssean forward guidance. This is because policy-makers

[1] Since one of the authors regularly attends meetings of the FOMC, perhaps it is tempting to just ask him this question directly. The vantage point of this paper is a research inquiry: how can these questions be answered from the standpoint of economic researchers with only publicly-available information?

can change public expectations of their future actions to improve current macroeconomic performance.[2]

Nevertheless, the implementation of Odyssean policy faces a fundamental challenge. When the appointed time for action arrives, the beneficial effects of the policy's anticipation will be bygones that nothing can change. Therefore, both the monetary policy-maker and the public will prefer a policy that addresses only the present circumstances and ignores the beneficial effects of its anticipation on past macroeconomic performance. For example, when it comes time to launch a boom promised to raise aggregate demand at an earlier date, the FOMC will be concerned about its price stability mandate and, acting as it has always done in normal times, will not want to follow through.[3] If the public believes that such promises will not indeed be kept, then they can do no good. Just as Odysseus anticipated regretting his commitment to stay aboard ship when he heard the Sirens' song, so a monetary policy-maker might anticipate regretting the commitments of Odyssean forward guidance. While Odysseus used the rope binding him to the mast to make his commitment credible, monetary policy-makers must rely on their reputations for accuracy and honesty.

The Odyssean monetary policies elucidated by Krugman (1999), Eggertsson and Woodford (2003) and Werning (2012) have inspired several recent proposals for providing more accommodation at the ZLB. The more aggressive policy alternatives proposed include Evans's (2012) state-contingent price-level targeting, nominal income-targeting as advocated by Romer (2011), and conditional economic thresholds for exiting the ZLB proposed by Evans (2011). The main challenge facing the FOMC to implementing any of these policies is convincing the public that it will follow through on a particular course of action in the future. This paper sheds light on the FOMC's ability to meet this challenge and on the possible benefits of doing so.

The FOMC used forward guidance implicitly through speeches and testimony or explicitly through formal FOMC statements long before the financial crisis, so the question of whether the FOMC can clearly communicate its future policy intentions can be addressed empirically. Accordingly the first part of this paper examines data from before and after the crisis to measure the impact FOMC communications have had on private expectations. We begin by studying market responses to FOMC statements, building on prior work by Gürkaynak, Sack, and Swanson (2005). They follow **?** by identifying the information disseminated from FOMC meetings with changes to federal funds rate futures prices in short windows of time surrounding the release of their accompanying statements. Using a sample from July 1991 through December 2004, they find that FOMC statements are associated with

[2]Romer and Romer (2000) and Ellingsen and Söderström (2001) characterize forward guidance similarly.
[3]This is an example of a *time inconsistent* policy, first considered by **?**.

significant affects on federal funds futures and on Treasury yields that are not due to surprise changes in the federal funds target itself. That is, market participants believe that FOMC statements contain reliable information about *future* monetary policy actions. We verify that their findings continue to hold when the sample is extended to July 2007, just prior to the crisis.

One might doubt the relevance of these findings for the present situation, because the attainment of the ZLB has robbed the FOMC of its principal policy lever. Focusing on FOMC communications on large scale asset purchases, "QE1" and "QE2," **?** and Krishnamurthy and Vissing-Jorgensen (2011) provide evidence of significant asset price affects since the crisis. To complement these studies and provide more assurance that forward guidance unaccompanied by material policy action can move asset prices, we apply Gürkaynak, Sack, and Swanson (2005)'s methodology to study FOMC statements since the crisis and find results similar to theirs.

FOMC actions that influence asset prices are merely means towards the end of fulfilling the dual mandate of maximum sustainable employment and price stability. To evaluate the contributions of FOMC statements towards this ultimate goal, we examine how revisions to the Blue Chip Consensus Forecasts of the unemployment rate and CPI inflation respond to the policy innovations identified by Gürkaynak, Sack, and Swanson (2005). For the sample period February 1994 to June 2007, a positive innovation to future federal funds rates is associated with *decreases* in unemployment forecasts for the subsequent three quarters; a positive innovation to future rates is associated with *higher* CPI inflation in the current and subsequent quarters. We never find a statistically-significant reaction of either forecast to policy innovations of the "correct" sign that arises from a New Keynesian response to an exogenous policy shock. From this we conclude that the monetary policy surprises identified with high-frequency data have a substantial Delphic component despite the fact that the methodology of Gürkaynak, Sack, and Swanson (2005) inherently controls for publicly known macroeconomic fundamentals. That is, professional forecasters infer that the FOMC's unexpected policy adjustments are responses to its non-public information regarding future economic strength.[4] We find qualitatively similar results for the crisis period, but the estimates are too imprecise to draw firm quantitative conclusions.

The FOMC does not rely solely on meeting statements to communicate its policies. To get a broader perspective on the influence of FOMC communications on private expectations, we proceed to examine monetary policy surprises identified from a simple interest rate rule like those of Taylor (1993, 1999) and Reifschneider and Williams (2000). Using the Blue

[4]Such information might reflect the Federal Reserve staff's possibly superior ability to process incoming data. It does not have to involve proprietary access to data or private information on future policy intentions.

Chip forecasts and interest rate futures prices aggregated to the quarterly level, we estimate such a rule and decompose its residual into the part revealed when the spot policy rate is set and the parts revealed to the public in the prior four quarters.

We highlight here four results based on data from 1996 through 2007. First, the standard deviation of the expected interest rate four quarters out minus its value from the rule equals only 9 basis points. Thus, the rule describes medium run forecasts of FOMC behavior extremely well. Apparently the FOMC has successfully communicated its typical behavior to the public. While this need not reflect an Odyssean commitment, it is observationally equivalent to one. Second, the FOMC telegraphs forty percent of its deviations from the interest rate rule exactly one quarter in advance and another forty percent two or more quarters in advance. Third, the identified forward guidance residuals have much stronger effects on asset prices than do Gürkaynak, Sack, and Swanson (2005) surprises. For example, a one basis point innovation to next quarter's expected funds rate raises both the two and five year Treasury rates by about 2 basis points. The corresponding effects estimated with the GSS methodology are under one basis point. Fourth, the identified forward guidance residuals are *negatively* correlated with unemployment forecast revisions and *positively* correlated with inflation forecast revisions, just like the statement-date-based Gürkaynak, Sack, and Swanson (2005) shocks. Apparently, the residuals reflect, at least in part, anticipated deviations from the policy rule that nevertheless are motivated by recent news of economic fundamentals. Phrased differently, the FOMC's behavior has been *history dependent*: the committee reacts more aggressively to economic weakness revealed only shortly before its onset than to weakness foreseen four quarters in advance.

The estimated effects of FOMC forward guidance on asset prices and private forecasts suggest that the FOMC has had some success communicating its future intentions to the public.[5] This suggests that communications difficulties do not present an insurmountable barrier to monetary policy based on Odyssean forward guidance. The second part of our paper investigates the consequences of interpreting the "late 2014" statement language as Odyssean forward guidance that implements the policy recommendations of Eggertsson and Woodford (2003) and others. There are legitimate concerns that forward guidance of this kind places the FOMC's mandated price stability goal at risk. We consider these by forecasting the path of the economy with the present forward guidance and subjecting that forecast to two upside risks: higher inflation expectations and faster deleveraging by households and

[5]Both our inferences of forward guidance and those from the more familiar event-study approach use market prices to measure the quantitative content of FOMC communication. In standard models, the process of communication is transparent and frictionless, so it is tempting to suppose that the FOMC can fine-tune its statements to achieve any desired market impact. However, one must acknowledge frictions in the communication process that make market responses to FOMC statements unpredictable to the FOMC itself.

firms.

This policy analysis uses a medium-scale dynamic stochastic general equilibrium (DSGE) model adapted from Justiniano, Primiceri, and Tambalotti (2011) at the Federal Reserve Bank of Chicago. The model strongly resembles other medium-scale DSGE models in the literature and is very similar to models used at central banks around the world.[6] Importantly for our purposes, it embodies the basic mechanisms that make forward guidance attractive at the ZLB. Furthermore, the model has unique features which improve its relevance to practical forecasters.

Evans (2011) has proposed that the FOMC pledge to begin lifting its policy rate from zero if either the unemployment rate falls below 7 percent or expected inflation over the medium term rises above 3 percent. This threshold rule is designed to maintain low rates even as the economy begins expanding on its own (as prescribed by Eggertsson and Woodford (2003)), while providing safeguards against unexpected developments that may put the FOMCs price stability mandate in jeopardy. Our policy analysis suggests that such conditioning, if credible, could be helpful in limiting the inflationary consequences of a surge in aggregate demand arising from an early end to the post-crisis deleveraging.

2 FOMC Statements and Private Expectations

The FOMC's use of forward guidance since long before the financial crisis makes it possible to assess empirically its ability to communicate future policy intentions. In this section, we do so by applying the methodology of Gürkaynak et al. (2005) (GSS henceforth). They use high-frequency data on federal funds futures and Eurodollar futures contracts to measure *unanticipated* changes in expected future spot rates associated with FOMC statements. Two estimated factors, a *target* factor that moves the current policy rate and a *path* factor that moves only expected future rates, account for most of these changes. GSS show that yields on longer duration treasury notes respond substantially to the path factor.

We extend the GSS analysis in three ways. First, we examine the responses of yields on corporate bonds to the factors and confirm that the a positive realization of the path factor (which raises expected future policy rates) raises corporate borrowing rates as well. That is, forward guidance influences interest rates that are directly relevant for private investment decisions. Second, we examine how revisions to professional forecasts of unemployment and CPI inflation respond to the factors. If the public and the FOMC were equally well informed about macroeconomic fundamentals, then the factors must reflect the revelation of

[6]The FOMC's minutes describe a discussion of DSGE models within the Federal Reserve System at its June 2011 meeting.

FOMC policy preferences. In that case, we would expect forecast revisions to match the equilibrium response to an unanticipated monetary policy shock. However, we find that the statistically significant responses all have the sign *opposite* to that predicted by the standard New Keynesian (NK) model. Unanticipated increases in the path factor lead to *decreases* in expected unemployment and *increases* in expected inflation. From this, we conclude that professional forecasters believe that FOMC policy surprises contain useful and otherwise unavailable macroeconomic information. That is, the FOMC's policy surprises have a Delphic component. Third, we extend the sample period to examine FOMC announcements since the onset of the financial crisis in August 2007. The relatively small sample makes our estimates of professional forecasters' responses to surprise monetary policy moves too imprecise to draw firm conclusions, but the estimates of asset price responses remain accurate enough to show that they differ little from their pre-crisis values.

2.1 Forward Guidance before the Financial Crisis

Rudebusch and Williams (2008) describe the modern history of explicit forward guidance before the financial crisis. From 1983 to 1999 the FOMC's views about the future policy path were put to a vote at each meeting. The vote was on the expected direction of future changes in the stance of policy between meetings. However, this information was only made public after the following meeting, when it was outdated and presumably of limited use to the public. In February 1994 the FOMC began issuing a statement describing the current policy stance following each meeting, and in May 1999 it began including explicit language about the future stance of policy in these statements. The first forward-looking statement language read in part "the Committee ... adopted a directive that is tilted toward the possibility of a firming in the the stance of monetary policy." The language guiding expectations would change over time as the FOMC sought ways of maintaining transparency without confusing markets and adjusted to the evolving policy environment. But, language of one form or another describing the expected future stance of policy was to be a fixture of statement language going forward.[7]

When measuring the market impact of FOMC statements, one must confront the possibility that their content is more confirming of macroeconomic conditions already known by

[7]Here are some examples. At the start of 2000, the direct signals of policy inclinations were replaced with language describing the "balance of risks" regarding the FOMC's mandated goals of maximum employment and price stability. The FOMC included "... the Committee believes that policy accommodation can be maintained for a considerable period" in its August 2003 statement. In January 2004 the forward looking language was "the Committee believes that it can be patient in removing its policy accommodation," and in May 2004 they used "policy accommodation can be removed at a pace that is likely to be measured." As inflation fears became elevated, in the December 2005 the statement included "further policy firming may be needed."

market participants than revealing of adjustments to policy. Not controlling for statements' confirming content could lead to incorrectly attributing outcomes to statements that are in fact due to other factors driving revisions to expectations of growth and inflation. GSS overcome this difficulty by studying the behavior of expected federal funds rates in symmetric 30 and 60 minute windows surrounding the release of FOMC statements. Focusing on the narrow window surrounding the release of statements keeps the economic information available to market participants essentially fixed.

The within-day data GSS rely upon are unavailable to us after 2004, so we extend their work using daily observations of implied future rates at the market's close from five futures contracts: the current-month and three-month-ahead federal funds futures contracts (with a scale factor to account for the timing of FOMC meetings within the month and a risk premium adjustment of one basis point per month) and the two-, three-, and four-quarter-ahead Eurodollar futures contracts (adjusted by the difference between the spot Eurodollar and federal funds rates summed with the one basis point per month risk price).[8] With data from the same contracts spanning February 1990 through February 2004, GSS show that just two factors explain more than 90 percent of the variation in these contracts' prices. Despite the potentially unlimited complexity of monetary policy statements, financial markets nonetheless have reacted as if there is essentially only one additional degree of information beyond surprise changes in the federal funds rate target. By performing a suitable rotation of the two factors, GSS show that they can be given "target" and "path" interpretations. The target accounts for most surprise changes in the current federal funds rate. By construction, the path only influences expected future rates.[9]

We begin our analysis by replicating theirs over a slightly longer time sample, February 1990 through June 2007. We have found that many of our results are sensitive to including the observation for September 2001, so we omit it from this and all subsequent analysis in this section (as do GSS). The first two columns of Table 1 report the fraction of innovation variance for each interest-rate futures contract rate that is due to the identified target and path factors over this sample period. The path factor accounts for no changes to the current quarter's interest rate by construction, and it accounts for only 14 percent of the variance in

[8] Our use of the daily window should not be too problematic since GSS's results are similar when they use the daily window. See their Table 1. The short windows studied by GSS are mostly relevant for the period before February 1994 when open market operations were sometimes conducted following the release of labor market data on the same day.

[9] GSS show that the path factor is associated with well-known significant changes in FOMC statement language. For example, its largest realization in absolute value occurs on January 28, 2004 when the federal funds target was not changed, but the phrase "policy accommodation can be maintained for a considerable period" was replaced with "the Committee believes it can be patient in removing its policy accommodation." This change in language was interpreted by markets as indicating the FOMC would begin tightening policy sooner than previously expected.

Table 1: Percentage of Expected Rate Changes Due to Target and Path Factors: Pre Crisis

	February 1990-June 2007		February 1994-June 2007	
Contract for	Target Factor	Path Factor	Target Factor	Path Factor
Current Quarter	98	0	97	0
Next Quarter	82	14	74	22
Two Quarters Hence	51	47	31	67
Three Quarters Hence	37	63	18	81
Four Quarters Hence	21	77	7	90

Note: Table entries are percentage of variation in the indicated expected future funds rate explained by each factor. The expected interest rates are measured using federal funds futures prices and Eurodollar futures prices as described in the text.

the interest rates expected for the next quarter. The target factor accounts for nearly all of the remaining variance from these two contracts. The path and target factors each explain about fifty percent of the variance in interest rates expected two quarters hence, and the path factor accounts for the clear majority of the variance in the two longest contracts.

Prior to February 1994 the FOMC did not explicitly announce changes in its target for the federal funds rate. Although GSS show that market participants were able to discern when the FOMC had changed its target within minutes of an open market operation prior to February 1994 when the FOMC issued no post meeting statements, one might suspect little forward guidance came out of these earlier FOMC meetings. The second two columns of Table 1 report the results when we discard these first four years. As expected, this sample period change increases the path factor's importance.

GSS document substantial positive regression relationships between their identified factors and yields on financial assets. In particular, a positive one hundred basis point realization of their target factor raises the yields on two, five, and ten year Treasury notes by 41, 37, and 28 basis points (bp), respectively.[10] Table 2 reports analogous regressions for the path and target factors as we identify them for the two samples. The table's first three rows report the regressions using the two, five, and ten year Treasury note yields. GSS find that the two factors explain 94 percent, 80 percent, and 74 percent of the variance in these rate changes. The two factors we identify have similarly strong explanatory power for both samples we consider. For the longer sample, all of the slopes multiplying the factors are positive and statistically significant at the one percent level. Their magnitudes are comparable to those reported by GSS, but our path factor slopes are somewhat larger and our target factor

[10]See the penultimate column of their Table 5 for these results.

Table 2: Asset Price Responses to Target and Path Factors: Pre Crisis

	February 1990-June 2007			February 1994-June 2007		
	Target Factor	Path Factor	R^2	Target Factor	Path Factor	R^2
Two-Year Note	0.474***	0.690***	0.88	0.287***	0.833***	0.86
	(0.030)	(0.032)		(0.034)	(0.044)	
Five-Year Note	0.319***	0.700***	0.83	0.141**	0.839***	0.82
	(0.043)	(0.041)		(0.061)	(0.047)	
Ten-Year Note	0.157***	0.571***	0.72	-0.014	0.673***	0.73
	(0.050)	(0.042)		(0.073)	(0.045)	
Aaa Corporate Bond	0.040	0.308***	0.44	-0.003	0.420***	0.48
	(0.033)	(0.041)		(0.045)	(0.054)	
Baa Corporate Bond	0.051*	0.311***	0.50	-0.018	0.388***	0.49
	(0.028)	(0.036)		(0.045)	(0.049)	

Note: Both samples exclude September 2001. Table entries are coefficients from regressing changes in yields of the indicated asset on the target and path factors and the corresponding R^2. Robust standard errors are in parentheses, and we denote statistical significance at the 10, 5, and 1 percent levels with $*$, $**$, and $***$.

slopes a bit smaller than theirs. Moving to the sample excluding the period without regular post FOMC meeting statements reduces the target factor's slopes and increases those of the path factor. The table's final two rows give the results using yields on Aaa and Baa corporate bonds with at least 20 years remaining before maturity. We find these to be of particular interest because they correspond to interest rates that are directly relevant for firms' investment decisions. Surprisingly to us, the target factor has no detectable influence on these regardless of which sample we use. In contrast, a one hundred basis point positive path factor realization raises both yields by about 30 to 40 bp depending on the sample used for estimation.

Our first substantial extension of GSS uses the identified factors and observations of private inflation and unemployment expectations to measure the macroeconomic effects of forward guidance. For this, we rely on the Blue Chip Economic Indicators forecast survey. At the beginning of each month, Blue Chip solicits projections for key economic variables, including quarterly growth in the Consumer Price Index and the civilian unemployment rate, from about fifty private forecasters. From these it compiles a "consensus" forecast for each variable, which are then published on the tenth of the month. The forecasts cover the previous quarter's data (which might not yet be published at the time of the survey) and each quarter in the current and next calendar years. Therefore, the data always report a one-quarter backcast, a current quarter nowcast, and forecasts for at least the next four quarters.[11]

For each month, we calculate the revisions to the forecasts of unemployment and CPI inflation for the current and next three quarters. Virtually by construction, these are uncorrelated across time.[12] We then regress these against the identified target and path factors. Table 3 reports the estimates (in bp) for both pre-crisis samples. The first notable result is that the R^2 measures for these regressions are far lower than those from the analogous asset-price regressions in Table 2. Since the regressions' residuals account for all macroeconomic news arriving in the month not contained in FOMC statements, this low explanatory power is expected.

If surprise FOMC policy announcements represent shocks to the stance of monetary policy unrelated to current macroeconomic circumstances, then a positive innovation to either factor should raise unemployment and lower inflation. Our estimates indicate that the opposite is more typical. For the longer sample, the target factor has statistically significant and *negative* coefficients on all four unemployment expectations. The path factor's coefficients are also

[11] The quarterly unemployment rate equals the average monthly value across the quarter's constituent months.

[12] **?** searches for bias and forecast error predictability in the Blue Chip consensus forecasts for GDP growth and finds none. Similarly, we find no evidence that the Blue Chip forecasts of inflation and unemployment are seriously deficient.

Table 3: Forecast Responses to Target and Path Factors: Pre Crisis

	February 1990-June 2007			February 1994-June 2007		
	Target Factor	Path Factor	R^2	Target Factor	Path Factor	R^2
Unemployment						
Current Quarter	-0.21***	-0.08	0.07	-0.01	-0.10	0.01
	(0.08)	(0.06)		(0.08)	(0.08)	
Next Quarter	-0.18**	-0.12	0.05	0.07	-0.20**	0.03
	(0.09)	(0.07)		(0.10)	(0.09)	
2 Quarters Hence	-0.27***	-0.13*	0.09	-0.06	-0.20*	0.03
	(0.08)	(0.07)		(0.11)	(0.10)	
3 Quarters Hence	-0.26***	-0.08	0.07	-0.03	-0.23**	0.04
	(0.09)	(0.08)		(0.09)	(0.09)	
CPI Inflation						
Current Quarter	0.25	0.47	0.02	-0.13	0.69*	0.02
	(0.33)	(0.36)		(0.34)	(0.37)	
Next Quarter	0.14	0.30	0.03	0.25**	0.14	0.03
	(0.11)	(0.24)		(0.13)	(0.15)	
2 Quarters Hence	0.11	-0.06	0.01	0.14	-0.05	0.01
	(0.14)	(0.12)		(0.10)	(0.19)	
3 Quarters Hence	0.13	0.07	0.01	0.04	0.33	0.03
	(0.20)	(0.20)		(0.14)	(0.29)	

Note: Both samples exclude September 2001. Table entries are coefficients from regressing changes in forecasts of the indicated variable on the target and path factors and the corresponding R^2. Robust standard errors are in parentheses, and we denote statistical significance at the 10, 5, and 1 percent levels with $*$, $**$, and $***$.

all negative and in one case statistically significant at the ten percent level. Switching to the shorter sample brings the estimates of the target factor's coefficients close to zero and amplifies the negative coefficients on the path factor. Only three of the sixteen estimated coefficients for CPI inflation are negative, and none of these are statistically significant. However, the coefficients multiplying the path factor in the current quarter's regression and the target factor in the next quarter's regression are significant at the ten percent level in the later sample.

The counterintuitive signs of the estimates in Table 3 require an explanation. The one we favor interprets the GSS forward guidance as Delphic: the public believes that the FOMC has additional information about macroeconomic fundamentals and that monetary policy surprises arise from this informational advantage. In this case, the forecast revision following a positive policy rate innovation encompasses the revelation of unexpectedly strong macroeconomic fundamentals as well as contractionary effects of the innovation itself.

2.2 Forward Guidance since the Financial Crisis

The evidence that market participants and professional forecasters were influenced by FOMC forward guidance is suggestive for the current situation, but we hesitate to apply it directly to the present when the ZLB has robbed the FOMC of its principal policy tool. Research on monetary policy announcements since the onset of the crisis has focused almost exclusively on the impact of announcing large scale asset purchases (LSAPs).[13] There is significant evidence that LSAP policies can alter long-term interest rates. For example, **?** present an event study of QE1 that documents large reductions in interest rates concurrent with LSAP announcements. Krishnamurthy and Vissing-Jorgensen (2011) evaluate the impact on interest rates of announcements associated with both QE1 and QE2. They uncover several channels through which these announcements have had an impact on asset prices and ascribe a major role to LSAP announcements signaling lower future federal funds rates. This suggests that one feature of LSAPs resembles forward guidance and so the findings of Krishnamurthy and Vissing-Jorgensen (2011) can be interpreted as supporting the view that forward guidance significantly influenced asset prices in the recent period. However, the recent impact of "pure" forward guidance, where the policy action is solely reflected in statement language, remains unclear.

To shed further light on the impact of forward guidance, we apply the GSS methodology

[13] One exception is **?** who documents the effects of monetary policy surprises on long term interest rates since the attainment of the ZLB. His analysis draws on identification by heteroskedasticity, and does not distinguish between two factors capturing surprises at different horizons over the expected policy path. **?** also discuss the effects of FOMC announcements on long-term yields, but they focus on the responses of medium and longer term interest rates to macroeconomic news.

to FOMC statements issued since the onset of the financial crisis.[14] Our compilation of relevant statements is reported in Table 4. There we list thirty nine FOMC statements and one Federal Reserve Board of Governors press release and include the statement language of each announcement that is most pertinent to forward guidance. The list includes every scheduled and unscheduled FOMC meeting since August 2007 as well as the November 25, 2008 Board of Governors press release that announced the first stage of QE1. We include the latter date since all subsequent LSAP announcements were made in FOMC statements. While there are several instances in which speeches or testimony by Federal Reserve officials seem to have been interpreted by markets as forward guidance, we exclude these from our analysis since it is difficult to find an objective criterion for including any given instance.[15]

Table 4: Recent Monetary Policy Forward Guidance

Date	Rate	Forward looking language in statement
8/7/2007	5.25	the Committee's predominant policy concern remains the risk that inflation will fail to moderate as expected.
8/17/2007	5.25	the downside risks to growth have increased appreciably
9/18/2007*	4.75	Developments in financial markets ... have increased the uncertainty surrounding the economic outlook
10/31/2007	4.50	the upside risks to inflation roughly balance the downside risks to growth
12/11/2007	4.25	Recent developments ... have increased the uncertainty surrounding the outlook for economic growth and inflation.
1/22/2008*	3.50	Appreciable downside risks to growth remain.
1/30/2008	3.00	downside risks to growth remain
3/18/2008	2.25	same
4/30/2008	2.00	The substantial easing of monetary policy to date, combined with ongoing measures to foster market liquidity, should help to promote moderate growth over time and to mitigate risks to economic activity.
6/25/2008	2.00	Although downside risks to growth remain, they appear to have diminished somewhat, and the upside risks to inflation and inflation expectations have increased.
8/5/2008	2.00	Although downside risks to growth remain, the upside risks to inflation are also of significant concern to the Committee.
9/16/2008	2.00	The downside risks to growth and the upside risks to inflation are both of significant concern to the Committee.

[14]Our study omits the large number of Federal Reserve press releases focused on programs designed to promote the smooth functioning of credit markets because they did not concern the traditional focus of countercyclical monetary policy.

[15]Probably the most relevant instances in this regard are speeches on December 1, 2008 and August 27, 2010 by Chairman Bernanke which were interpreted by markets as opening the door to the first and second round of large scale purchases of Treasury securities, respectively. With the exception of the December 1, 2008 speech, our compilation includes every QE1 and QE2 date employed in Krishnamurthy and Vissing-Jorgensen's (2011) event study.

Table 4: Recent Monetary Policy Forward (continued)

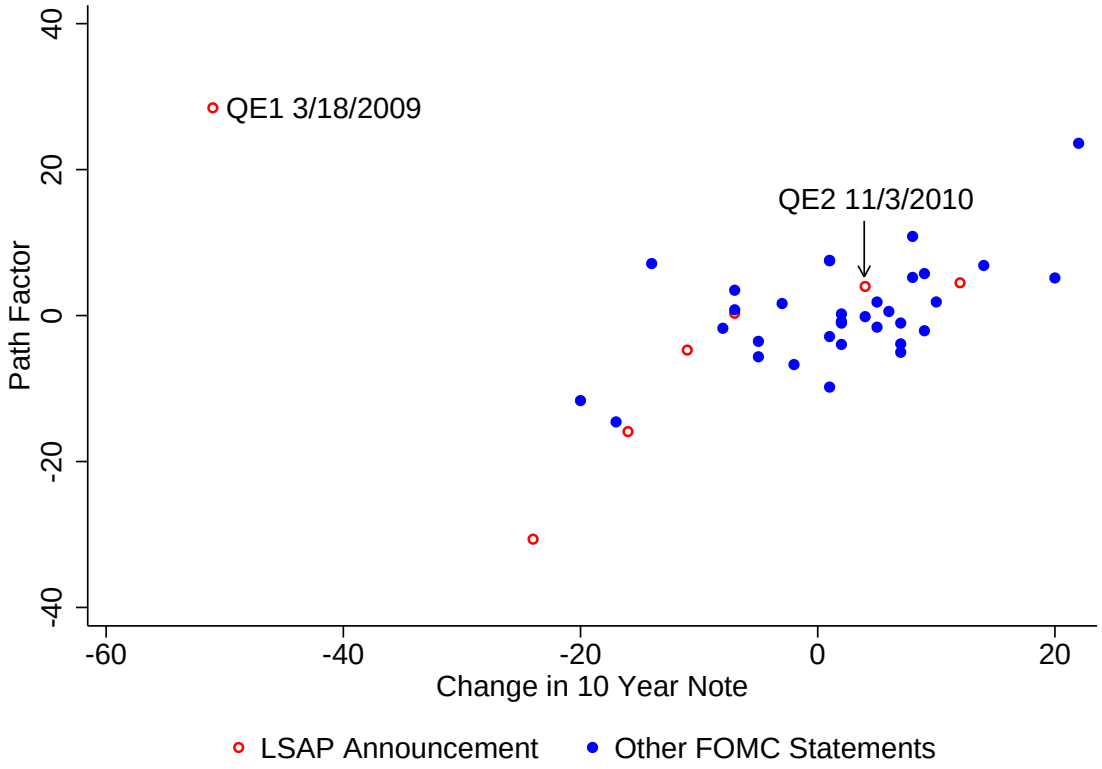
Date	Rate	Forward looking language in statement
10/8/2008*	1.50	Incoming economic data suggest that the pace of economic activity has slowed markedly in recent months. Moreover, the intensification of financial market turmoil is likely to exert additional restraint on spending, partly by further reducing the ability of households and businesses to obtain credit. Inflation has been high, but the Committee believes that the decline in energy and other commodity prices and the weaker prospects for economic activity have reduced the upside risks to inflation.
10/29/2008	1.00	downside risks to growth remain.
11/25/2008*	0-25 bp	purchases (of $100b GSEs and $500b MBS) ... are expected to take place over several quarters
12/16/2008	0-25 bp	... the Committee anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time...The focus of the Committee's policy going forward will be to ... stimulate the economy through open market operations and other measures that sustain the size of the Federal Reserve's balance sheet at a high level ... The Committee is also evaluating the potential benefits of purchasing longer-term Treasury securities.
1/28/2009	0-25 bp	The Committee continues to anticipate that economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time. The Committee also is prepared to purchase longer-term Treasury securities if evolving circumstances indicate that such transactions would be particularly effective in improving conditions in private credit markets.
3/18/2009	0-25 bp	... the Committee will maintain the target range for the federal funds rate at 0 to 1/4 percent and anticipates that economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period. The Committee sees some risk that inflation could persist for a time below rates that best foster economic growth and price stability in the longer term ... The Committee decided today to increase the size of the Federal Reserve's balance sheet further by purchasing up to an additional $750 billion of (MBS), bringing its total purchases of these securities to up to $1.25 trillion this year, and to increase its purchases of (GSE) debt this year by up to $100 billion to a total of up to $200 billion ... the Committee decided to purchase up to $300 billion of longer-term Treasury securities over the next six months. [QE1]
4/29/2009	0-25 bp	Committee sees some risk that inflation could persist for a time below rates that best foster economic growth and price stability in the longer term. ... economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period
6/24/2009	0-25 bp	economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period ... the Committee expects that inflation will remain subdued for some time.

Table 4: Recent Monetary Policy Forward (continued)

Date	Rate	Forward looking language in statement
8/12/2009	0-25 bp	Although economic activity is likely to remain weak for a time, the Committee continues to anticipate that policy actions to stabilize financial markets and institutions, fiscal and monetary stimulus, and market forces will contribute to a gradual resumption of sustainable economic growth in a context of price stability... substantial resource slack is likely to dampen cost pressures, and the Committee expects that inflation will remain subdued for some time.
9/23/2009	0-25 bp	economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period ... (MBS & GSE purchases will finish by) end of the first quarter of 2010.
11/4/2009	0-25 bp	economic conditions... are likely to warrant exceptionally low levels of the federal funds rate for an extended period (and will complete purchases of GSE debt of about $175b)
12/16/2009	0-25 bp	economic conditions... are likely to warrant exceptionally low levels of the federal funds rate for an extended period
1/27/2010	0-25 bp	same
3/16/2010	0-25 bp	same
4/28/2010	0-25 bp	same
6/23/2010	0-25 bp	same
8/10/2010	0-25 bp	same + the Committee will keep constant the Federal Reserve's holdings of securities at their current level by reinvesting principal payments from agency debt and agency mortgage backed securities in longer-term Treasury securities.
9/21/2010	0-25 bp	same + The Committee also will maintain its existing policy of reinvesting principal payments from its securities holdings.
11/3/2010	0-25 bp	same + In addition, the Committee intends to purchase a further $600 billion of longer-term Treasury securities by the end of the second quarter of 2011 [QE2]
12/14/2010	0-25 bp	same
1/26/2011	0-25 bp	same
3/15/2011	0-25 bp	same
4/27/2011	0-25 bp	same
6/22/2011	0-25 bp	same
8/9/2011	0-25 bp	economic conditions... are likely to warrant exceptionally low levels of the federal funds rate at least through mid-2013
9/21/2011	0-25 bp	same
11/2/2011	0-25 bp	same
12/13/2011	0-25 bp	same

Note: Dates labeled with an asterisk indicate the statement came between regularly scheduled FOMC meetings. All statements except the Board of Governors press release of 11/25/2008 were issued by the FOMC.

Figure 1: Path Factor and Changes in 10 Year Treasury Note on Statement Dates



Note: LSAP announcements correspond to the seven FOMC and Board of Governors statements included in Krishnamurthy and Vissing-Jorgensen's (2011) event study.

Mimicking the analysis from the pre-crisis period, we estimate factors based on changes in expected future federal funds rates between the close of business the day before and the day of the announcements listed in Table 4. Because the horizon over which forward guidance has been issued since the crisis seems to be longer than it was during the pre-crisis period we examine the behavior of seven futures contracts that pin down the expected path of the federal funds rate over the next year and a half without overlapping: the current-month and three-month-ahead federal funds futures contracts (with a scale factor to account for the timing of FOMC meetings within the month and a risk premium adjustment of one basis point per month) and the two-, three-, four-, five and six-quarter-ahead Eurodollar futures contracts (adjusted by the difference between the spot Eurodollar and federal funds rates summed with the one basis point per month risk price). Just as in the pre-crisis period, two factors explain most of the variability in the futures data. Henceforth we focus on the first two factors after they have been rotated as in GSS.

Figure 1 presents a scatter plot of the path factor and changes in the yield on 10-year Treasury notes for the forty dates listed in Table 4. Open circles indicate announcements

Table 5: Percentage of Expected Rate Changes Due to Target and Path Factors: Post Crisis

	August 2007-December 2011	
	Target Factor	Path Factor
Current Quarter	94	0
Next Quarter	98	0
Two Quarters Hence	93	3
Three Quarters Hence	57	35
Four Quarters Hence	44	53
Five Quarters Hence	31	68
Six Quarters Hence	16	79

Note: Table entries are percentages of variation in the indicated expected future funds rate due to each factor.

of LSAPs and the statements most closely associated with QE1 and QE2 are labeled. The most striking feature of Figure 1 is how much of an outlier the QE1 announcement of March 18, 2009 is. On that date, the ten year note's yield fell (as intended) 51 bp while the path factor *rose* 28 bp. Markets interpreted the FOMC's announcement as indicating the recovery would come sooner than previously thought and that consequently lift-off in the funds rate would come earlier than previously anticipated; the two-quarter-ahead futures contract rose 60bp from the day before. Based on Figure 1, QE2 appears very much like the other FOMC announcements, which indicate a positive relationship between the path factor and changes in the 10-year yield. Indeed, Krishnamurthy and Vissing-Jorgensen (2011) find that "(t)he main effect on corporate bonds and MBSs in QE2 appears to have been through a signaling channel, whereby financial markets interpreted QE as signaling lower federal funds rates going forward." The apparently very different response to the March 18, 2009 QE1 announcement motivates us to exclude it from the remainder of our factor analysis.

Table 5 reports the fraction of variance in changes to expected future interest rates explained by target and path factors estimated from all the announcements in Table 4 except the outlier associated with QE1. The target factor dominates the variation in the current quarter futures rate and the one-, two- and three-quarter ahead rates, while the path factor explains the majority of variation in the three longer rates and negligible shares of the two shortest contracts beyond that for the current quarter. This pattern is broadly similar to that for the pre-crisis period reported in Table 1. The main difference is that the path factor only dominates changes in expected interest rates four, five, and six quarters ahead.

Table 6 reports asset price regression estimates based on the post-crisis factors analogous

Table 6: Responses of Asset Prices to Target and Path Factors since the Financial Crisis

	August 2007-December 2011		
	Target Factor	Path Factor	R^2
Two-Year Note	0.592***	0.613***	0.79
	(0.096)	(0.136)	
Five-Year Note	0.404***	0.768***	0.66
	(0.143)	(0.141)	
Ten-Year Note	0.250*	0.750***	0.57
	(0.131)	(0.088)	
Aaa Corporate Bond	0.058	0.539***	0.45
	(0.079)	(0.073)	
Baa Corporate Bond	0.065	0.476***	0.34
	(0.085)	(0.100)	

Note: Table entries are coefficients from regressing changes in yields of the indicated asset on the target and path factors and the corresponding R^2. Robust standard errors are in parentheses, and we denote statistical significance at the 10, 5, and 1 percent levels with $*$, $**$, and $***$.

to those of Table 2. Since this sample is smaller, the estimates' associated standard errors are larger. The estimates strongly resemble those from before the crisis. Both factors have a large positive influence on two- and five-year notes' yields, and the path factor substantially influences the yields of the ten-year note and seasoned Aaa and Baa corporate bonds. Given the disparity in the associated economic conditions between the pre and post-crisis sample periods, the similarity of forward guidance effects on asset prices is a striking finding.

Table 7 reports the regression estimates for the forecast innovation regressions using the post-crisis data. The estimated standard errors greatly exceed those from the analogous regressions estimated with pre-crisis data, so only two of the sixteen reported coefficients are statistically significant. Nevertheless, all sixteen of the estimates have the "wrong" sign. The coefficient estimates for the revisions to current quarter inflation expectations are very large, and the factors have a surprisingly high R^2 of 0.22. It turns out that these estimates are extremely sensitive to the exclusion of observations from the last quarter of 2008, when inflation expectations were marked down sharply and the FOMC strongly signaled future policy accommodation. Excluding that quarter's three observations dramatically reduces

Table 7: Forecast Responses to Target and Path Factors since the Financial Crisis

	August 2007-December 2011		
	Target Factor	Path Factor	R^2
Unemployment			
Current Quarter	-0.27	-0.06	0.03
	(0.27)	(0.28)	
Next Quarter	-0.34	-0.17	0.04
	(0.33)	(0.39)	
2 Quarters Hence	-0.42	-0.22	0.05
	(0.40)	(0.51)	
3 Quarters Hence	-0.51	-0.27	0.06
	(0.45)	(0.60)	
CPI Inflation			
Current Quarter	2.90	3.88	0.22
	(1.85)	(2.52)	
Next Quarter	0.83	0.78	0.09
	(0.57)	(0.99)	
2 Quarters Hence	0.20	0.03	0.02
	(0.25)	(0.18)	
3 Quarters Hence	0.21**	0.24**	0.07
	(0.09)	(0.11)	

Note: Table entries are coefficients from regressing changes in forecasts of the indicated variable on the target and path factors and the corresponding R^2. Robust standard errors are in parentheses, and we denote statistical significance at the 10, 5, and 1 percent levels with $*$, $**$, and $***$.

that regression's estimated coefficients and their standard errors. Nevertheless, they remain statistically insignificant. Omitting these observations also sharply reduces the estimated coefficients in the regression for expectations of CPI inflation three quarters hence. Although we conclude that our regression estimates of the effects of forward guidance on macroeconomic expectations since the financial crisis are too imprecise to draw strong quantitative conclusions, the estimates are broadly consistent with those from the pre-crisis period.

3 Forward Guidance through an Interest Rate Rule

The event study approach used above isolates "pure" forward guidance associated with distinct policy announcements from other monetary policy actions, but it fails to identify any forward guidance communicated through other channels. In this section, we present a new and complementary methodology that identifies forward guidance communicated through all the channels available to the FOMC which builds on the longstanding practice of summarizing monetary policy with a parsimonious rule for setting the policy rate. By applying such a rule both to actual policy decisions and to observations of private expectations, we are able to identify consensus expectations of how the FOMC will deviate from the monetary policy rule at a specific date in the future.

The empirical implementation of our methodology inserts the Blue Chip forecasts and interest rate futures prices examined above aggregated to the quarterly frequency into an interest rate rule with two lags of the interest rate and measures of the unemployment gap and inflation. The rule's novelty lies in its residual, which sums components gradually revealed to the public up to four quarters before the policy action. The interest rate futures and professional forecasts together are sufficient to identify these forward guidance shocks. For the period 1996:I through 2007:II, the estimated rule describes the four-quarter ahead expectation of the interest rate very well: the standard deviation of the four-quarter ahead forward guidance shock equals only 9 bp. The standard deviation of the interest rate rule's total residual (which sums the forward guidance shocks with a traditional unanticipated policy shock) equals 30 bp. However, the standard deviation of the anticipated component equals 28 bp. That is, the Federal Reserve successfully telegraphs most departures from the interest rate rule in advance.

The forward guidance shocks we identify from the interest rate rule differ from the statement-date-based shocks of GSS in some ways and resemble them in others. The most notable difference is their factor structure. The contemporaneous policy shock and four forward guidance shocks revealed every quarter have a single factor that explains most of the four-quarter-ahead forward guidance but much less at closer horizons. A positive realization

of this factor speeds up the usual interest rate changes following a contemporaneous monetary policy shock, so we call it the *policy acceleration* factor. The FOMC seems to have used this factor heavily during the 2001 recession and in its aftermath. The similarities between GSS-style forward guidance shocks and those measured with an interest rate rule become apparent when calculating their effects on asset prices and macroeconomic forecasts. Positive forward guidance shocks raise both Treasury and corporate bond yields. By construction the interest rate rule accounts for the FOMC's typical responses to varying economic fundamentals as measured by inflation and the unemployment gap. Nevertheless, regressions analogous to those in Table 3 indicate that the same anticipated deviations from this rule effect unemployment and inflation forecasts with the "wrong" sign, just like the statement-date-based GSS shocks. We interpret these results as arising from the FOMC adjusting policy quickly when revisions to macroeconomic expectations catch it "behind the curve."

3.1 Rule-Based Measurement of Forward Guidance

We consider interest rate rules for the average policy rate over quarter t, r_t, of the following form:

$$r_t = \mu + \rho_1 r_{t-1} + \rho_2 r_{t-2} + (1 - \rho_1 - \rho_2)\left(\phi_\pi \widetilde{\pi}_t + \phi_u \widetilde{u}_t\right) + \sum_{j=0}^{M} \nu_{t-j,j}. \tag{1}$$

The variables $\widetilde{\pi}_t$ and $\widetilde{u}_t$ are the policy-relevant measures of the inflation rate and unemployment gap (the difference between unemployment and a measure of the economy's "natural" unemployment rate). Parameters ρ_1, ρ_2, ϕ_π, and ϕ_u determine the degree of interest smoothing and how the policy rate responds to typical changes in macroeconomic conditions.

The distinguishing feature of (1) is the last term involving the $M+1$ disturbances, $\nu_{t-j,j}$ for $j = 0, 1, \ldots, M$. The first of these, $\nu_{t,0}$, is the monetary policy disturbance that appears in conventional interest rate rules. It captures the Fed's response to extraordinary events that warrant a rapid but temporary deviation from the normal policy prescription, such as 9/11 or the 1997 Asian currency crisis. The remaining disturbances are *forward guidance shocks*, because they are revealed to the public before they are applied to the interest rate rule. The public sees $\nu_{t,j}$ in quarter t, and the FOMC applies it to the rule j quarters hence. Gather all of the shocks revealed in quarter t into the vector $\vec{\nu}_t \equiv (\nu_{t,0}, \nu_{t,1}, \ldots, \nu_{t,M})$. Each realization of $\vec{\nu}_t$ influences the expected path of interest rates. To identify the forward guidance shocks, we wish to map expectation revisions, which are uncorrelated over time by construction, into realizations of $\vec{\nu}_t$; so we assume that $\vec{\nu}_t$ is also uncorrelated over time. That is, we assume that the elements of $\vec{\nu}_t$ are *news* relative to the public information set at the end of $t-1$. For M sufficiently large and under rational expectations, this is without

loss of generality.[16] Although $\vec{\nu}_t$ is uncorrelated over time, its elements may be correlated with each other. Allowing for this correlation admits the possibility that the FOMC provides information on multiple future quarters' monetary policy shocks in the same communication.

The practice of including exogenous shocks to the interest rate is commonplace. Our specification differs from conventional interest rate rules only in the assumption that the public observes some of the interest rate shocks before their implementation. The most similar recent work is that of Laséen and Svensson (2011), who propose modeling forward guidance with an interest rate rule as we do when calculating the equilibrium of an NK model.

One can recover $\vec{\nu}_t$ using data on private expectations of unemployment, inflation, and the federal funds rate with values of ρ_1, ρ_2. ϕ_π and ϕ_y in hand. Here and henceforth, conditional expectations at quarter t are defined in terms of information at the *beginning* of the quarter.[17] For any variable x, we denote its realization in quarter t with x_t. Then we use the notation x_t^j to denote the time $t-j$ conditional expectation of variable x_t. Since not all variables dated t are known by economic agents at the start of the quarter they are realized, the "nowcast" x_t^0 does not necessarily equal the realized x_t. For example, r_t^0 is the expectation at the beginning of t of the quarter's average policy rate, which can clearly change over the quarter. If x is not even revealed to the public during the quarter of its realization, then the "backcast" x_t^{-1} also might not equal x_t. The unemployment rate provides a relevant example. Its backcast differs from its realized value because the time taken for its tabulation delays its release.

To measure $\nu_{t-M,M}$, suppose that the public expects the FOMC to follow (1) on average. Then, taking expectations given information at the start of period $t-M+1$ yields

$$r_t^{M-1} = \mu + \rho_1 r_{t-1}^{M-2} + \rho_2 r_{t-2}^{M-3} + (1-\rho_1-\rho_2)\left(\phi_\pi \widetilde{\pi}_t^{M-1} + \phi_u \widetilde{u}_t^{M-1}\right) + \nu_{t-M,M}. \tag{2}$$

The residual term in (2) equals $\nu_{t-M,M}$ because $\mathbb{E}_{t-M+1}[\nu_{t,j}] = 0$ for $j = 0, \ldots, M-1$. Thus, $\nu_{t-M,M}$ equals the deviation of the expected interest rate $M-1$ quarters ahead from its value dictated by the interest rate rule's expected value. To recover the other errors, we take expectations of (1) at two adjacent dates and difference the results. For $0 \leq j < M$ we

[16] This is because a time series variable at time t always can be decomposed into the sum of its expected value based on information available at $t-1$ and an orthogonal innovation.

[17] This conforms to the timing convention used for the Blue Chip macroeconomic expectations data.

obtain

$$\begin{aligned} r_t^{j-1} - r_t^j =& \rho_1 \left(r_{t-1}^{j-2} - r_{t-1}^{j-1} \right) + \rho_2 \left(r_{t-2}^{j-3} - r_{t-2}^{j-2} \right) \\ &+ (1 - \rho_1 - \rho_2) \left(\phi_\pi \left(\widetilde{\pi}_t^{j-1} - \widetilde{\pi}_t^j \right) + \phi_u \left(\widetilde{u}_t^{j-1} - \widetilde{u}_t^j \right) \right) \\ &+ \nu_{t-j,j}. \end{aligned} \tag{3}$$

Equation (3) shows that $\nu_{t-j,j}$ equals the change within quarter $t-j$ in the expected interest rate for quarter t corrected for the change in the interest rate rule's expected value arising from revisions in private expectations of inflation and unemployment. This disturbance embodies expected deviations from "typical" monetary policy. Forward guidance influences $\nu_{t-j,j}$ when the FOMC communicates a prospective change in its short-run policy goals with or without a credible Odyssean commitment. The anticipated residuals might also arise from external factors omitted from the rule, but only to the extent that they affect the policy rate through channels other than the forecasts of the unemployment gap and inflation that already appear in the rule. How much weight is given to a conditioning variable when constructing a forecast depends on the prevailing economic conditions. For example, before the increase in foreign trade associated with globalization there was less need to pay attention to foreign inflation and the exchange rate than there is today. This does not necessarily mean that the policy rule incorrectly omits foreign inflation or the exchange rate because these variables are an input into agents' forecasts.

3.2 Estimation

Implementing this methodology requires observations of private expectations and the estimation of $\mu, \rho_1, \rho_2, \phi_\pi$, and ϕ_u. The Blue Chip consensus forecasts give us u_{t-1}^{-1} and π_{t-1}^{-1} (backcasts), u_t^0 and π_t^0 (nowcasts) and u_{t+j}^j and π_{t+j}^j for $j = 1, \ldots, 4$ (forecasts). In March and October, Blue Chip survey participants report forecasts for each variable's average value seven to eleven years after the current calendar year. We use the most recently made consensus long-run forecast for the unemployment rate as a measure of each quarter's natural rate of unemployment, u_t^*. With this, we construct the expected unemployment gap in quarter $t+j$ as $\hat{u}_t^j \equiv u_t^j - u_t^*$. Our Blue Chip data contains observations from the period beginning in 1989:II and extending to 2011:IV.

Our implementation of the interest rate rule employs averages of the expected unemployment gap and expected inflation over the previous, current, and next quarters as perceived

at the beginning of the next quarter. That is

$$\begin{aligned}\widetilde{u}_t &= \frac{1}{3}\sum_{j=-1}^{1}\hat{u}_{t-j}^{j-1} \\ \widetilde{\pi}_t &= \frac{1}{3}\sum_{j=-1}^{1}\pi_{t-j}^{j-1}\end{aligned}$$

Here, we have abused our notation by supposing that $\widetilde{u}_t$ and $\widetilde{\pi}_t$ are realized "at the end" of quarter t even though they depend on information available "at the beginning" of quarter $t+1$. We can construct forecasts of $\widetilde{u}_t$ and $\widetilde{\pi}_t$ from the Blue Chip data up to three quarters ahead, so we set M in (1) to 4. That is, we assume that the process of communicating forward guidance begins four quarters before the policy decision in question.

Although the Blue Chip data contain forecasts of the federal funds rate, we prefer to base our measures of expected interest rates on the futures' market prices used in Section 2 from each quarter's final trading day. Our estimation uses only data from the period in which federal funds futures were actively traded, which **?** identify as beginning sometime in 1994. Because the estimation requires lags, we begin our sample with the forecasts of interest rates that prevailed in 1996:I.[18] These prices give us the interest rates our procedure requires when M equals 4, $r_t^0, r_t^1, \ldots, r_t^5$. The other observations required to calculate $\vec{\nu}_t$ are $\widetilde{u}_t^0, \ldots, \widetilde{u}_t^3$ and $\widetilde{\pi}_t^0, \ldots, \widetilde{\pi}_t^3$. We can calculate these with the backcast, nowcast, and four quarterly forecasts in the Blue Chip data.

One frequent approach to estimating the parameters of an interest rate rule simply assumes that the autoregressive terms in (1) sufficiently capture the interest rate's serial correlation, so that the policy shock is serially uncorrelated and ordinary least squares can be employed. This assumption fails if past forward guidance influences the unemployment gap and inflation, so we require an alternative estimator. We turn to a GMM implementation of an instrumental variables' strategy. From the Blue Chip data we can calculate $\hat{u}_t^M$ and π_t^M. These, r_{t-2}^{M-2}, and r_{t-1}^{M-1} are valid instruments for $\nu_{t,0}, \nu_{t-1,1}, \ldots, \nu_{t-M,M}$ because those monetary policy shocks are all revealed *after* the beginning of quarter $t-M$. Therefore, we can construct a valid GMM estimator based on the population moment conditions

$$\mathbb{E}\left[g_t(\gamma) \otimes Z_t\right] = 0.$$

[18] Beginning the sample in 1996:I excludes an outlying observation from the Eurodollar futures market in 1994:IV from our analysis. In that quarter, the Eurodollar rate for delivery in 1995:IV (averaged across that quarter's months) rose from 6.7 to 8 percent. However, it returned to 6.5 percent by the end of 1995:I. Such large changes in expected future interest rates were common in the early 1990s, but occurred much less frequently in our sample period.

Here, $\gamma = (\mu, \rho_1, \rho_2, \phi_\pi, \phi_u)$ is the parameter vector, $g_t(\cdot)$ is a function that takes parameter values and returns the vector $(\nu_{t,0}, \nu_{t-1,1}, \ldots, \nu_{t-M,M})$, and $Z_t = (\hat{u}_t^M, \pi_t^M, r_{t-2}^{M-2}, r_{t-1}^{M-1})$ is the vector of instruments. With $M = 4$, this provides sixteen moment restrictions to estimate four parameters.

This moment condition underlying our GMM estimator depends on the assumption that our interest rate rule omits no relevant information known in quarter $t - M$. This would be violated if the FOMC gave forward guidance more than 4 quarters in advance. In this case, the value of $\nu_{t,4}$ inferred using the interest rate rule's correct parameter values should be correlated with the instruments in Z_t. The "considerable period" language provides one obvious potential example of such long-term forward guidance. The relevant part of the August 12, 2003 statement that introduced it reads

> The Committee judges that, on balance, the risk of inflation becoming undesirably low is likely to be the predominant concern for the foreseeable future. In these circumstances, the Committee believes that policy accommodation can be maintained for a considerable period.

The statement's emphasis on anticipated inflation leads us to read this as Delphic rather than Odyssean, so we expect it to have operated through the interest rate rule rather than through its residuals. We can think of no other concrete examples of long-term forward guidance of any sort during our sample period, so we believe any biases from choosing M to conform with the Blue Chip forecast horizon to be small.[19]

As noted above, our estimation sample begins in 1996:I. We consider the crisis period that arguably began in 2007:III to be "special", and so we end our estimation sample with 2007:II. The estimated interest rate rule is

$$\begin{aligned} r_t = &- \underset{(0.02)}{0.05} + \underset{(0.02)}{1.60} \times r_{t-1} - \underset{(0.02)}{0.66} \times r_{t-2} - (1 - 0.94) \times \underset{(0.28)}{1.10}\ \widetilde{u}_t \\ &+ (1 - 0.94) \times \underset{(0.18)}{2.32}\ \pi_t + \sum_{j=0}^{4} \nu_{t-j,j} \end{aligned}$$

Heteroskedasticity and autocorrelation consistent standard errors appear below each estimate in parentheses. The estimates' associated J-statistic is very small (0.25), so the estimates clearly pass the test of overidentifing restrictions.

[19] A violation of our moment condition could also arise from miss-measurement of private expectations. If the Blue Chip survey measures equal the public's true expectations summed with a classical measurement error, then the measurement errors contribute to $g_t(\gamma)$. This biases our GMM estimator only to the extent that the same errors influence the measured values of $\hat{u}_t^4$ and π_t^4 in Z_t.

Two features of the interest rate rule are worth noting. First, we find an important role for second-order autoregressive dynamics. This gives the interest rate's response to a one-time innovation (holding $\widetilde{u}_t$ and $\widetilde{\pi}_t$ fixed) a hump shape. Monetary policy adjustments start small, grow, and persist. Second, the estimated rule satisfies the Taylor principle that the long-run interest rate rises more than one-for-one with a persistent increase in inflation. The standard error on this coefficient is small enough to comfortably exclude the possibility that this arises only from sampling error.

3.3 How Well Does the Public Forecast Deviations from the Interest Rate Rule?

Given the estimated parameter values, we follow the procedure presented above to recover the history of $\vec{\nu}_t$ from the available data. The top panel of Table 8 reports their sample standard deviations. As noted above, the four-quarter-ahead forward guidance shock $\nu_{t,4}$ has a standard deviation of only 9 bp. In this sense, the estimated rule summarizes medium-run expectations of the federal funds rate very well. The contemporaneous shock, $\nu_{t,0}$, has a 12 basis point standard deviation, and that for $\nu_{t,1}$ equals 20 bp. We can use these estimates to calculate a variance decomposition of the interest rate rule's intercept.[20] Overall, it appears that the FOMC communicates about 40 percent of the monetary policy variance in the quarter before its realization and another 40 percent one to three quarters before then.

Figure 2 gives a visual perspective on this decomposition. Its solid blue line plots the composite residual for the interest rate rule – $\sum_{j=0}^{4} \nu_{t-j,j}$ – and its dashed red line plots its *forward guidance component*, which simply drops the contemporaneous shock $\nu_{t,0}$. Overall, the two series track each other quite closely. Indeed, their sample correlation equals 0.9. At the onset of the 2001 recession the two series differ by 62 bp. This reflects the well-known sudden reversal of the monetary policy stance at that date. In the second quarter of 2001, the difference equals 37 bp. Two events that do *not* show up with particularly large values of $\nu_{t,0}$ are the Asian financial crisis and 9/11. The estimated $\nu_{1997{:}III,0}$ equals only -0.8 bp. It turns out that markets anticipated most of the monetary policy accommodation provided in that quarter during the previous quarter. The FOMC increased accommodation following 9/11 only in 2001:IV, because the Federal Reserve concentrated on maintaining the orderly functioning of financial markets in the final weeks of 2001:III. Nevertheless, market participants anticipated this move, so it shows up in $\nu_{2001{:}\text{III},1}$, -85 bp.

Since each realization of $\vec{\nu}_t$ moves the entire expected path of interest rates, it is reasonable

[20] Although the elements of $\vec{\nu}_t$ are correlated with each other, we assume that its realizations are independent *over time*. Therefore, the five shocks contributing to the interest rate rule's intercept in a given quarter are mutually independent.

Figure 2: The Interest Rate Rule's Residual and its Forward Guidance Component

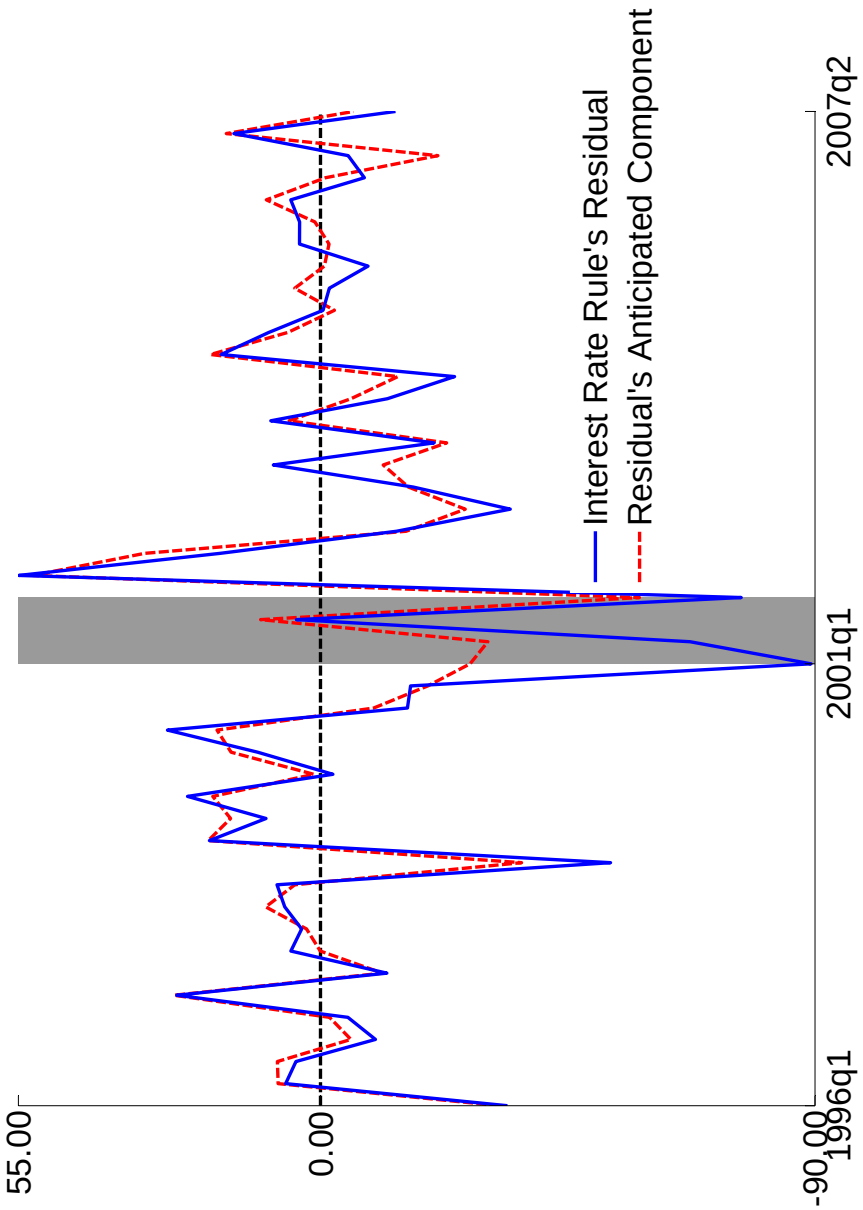


Table 8: Summary Statistics

Standard Deviations
(in basis points)

$\nu_{t,0}$	$\nu_{t,1}$	$\nu_{t,2}$	$\nu_{t,3}$	$\nu_{t,4}$
12	20	13	11	9

Correlations

	$\nu_{t,0}$	$\nu_{t,1}$	$\nu_{t,2}$	$\nu_{t,3}$	$\nu_{t,4}$
$\nu_{t,0}$	1.00				
$\nu_{t,1}$	0.02	1.00			
$\nu_{t,2}$	-0.05	0.22	1.00		
$\nu_{t,3}$	-0.32	0.03	-0.17	1.00	
$\nu_{t,4}$	-0.32	-0.26	-0.22	0.16	1.00

to suppose that its elements correlate with each other. Indeed, such correlation underlies the factor analysis of GSS. The bottom panel of Table 8 gives the sample correlation matrix. Its first column shows that $\nu_{t,0}$ is *negatively* correlated with both $\nu_{t,3}$ and $\nu_{t,4}$, so the public apparently expects some "last-minute" monetary policy adjustments to be reversed in the relatively near future. The other forward guidance shocks are uncorrelated with $\nu_{t,0}$, and they display relatively low correlations with each other.

3.4 Factor Analysis

Although the correlations between the five shocks contributing to the interest rate rule's intercept are not large, GSS's successful use of factor analysis motivates us to investigate how a factor model explains them. The negative correlations of $\nu_{t,0}$ with $\nu_{t,3}$ and $\nu_{t,4}$ hint at a single factor structure in which the factor "tilts" the monetary policy shocks, giving accommodation today while promising to take it away later. We investigate this impression by estimating

$$\vec{\nu}_t = \Lambda f_t + e_t.$$

Here, Λ is a 5×1 matrix of factor loadings, f_t is a scalar factor with mean zero and variance one, and e_t is a 5×1 vector of mutually independent "idiosyncratic" errors.

Table 9 reports this model's maximum-likelihood parameter estimates. Inspection of the

Table 9: Factor Model Parameter Estimates

	$\nu_{t,0}$	$\nu_{t,1}$	$\nu_{t,2}$	$\nu_{t,3}$	$\nu_{t,4}$
Factor Loading	-5	-6	-4	3	7
Idiosyncratic Error's Standard Deviation	11	19	13	10	6

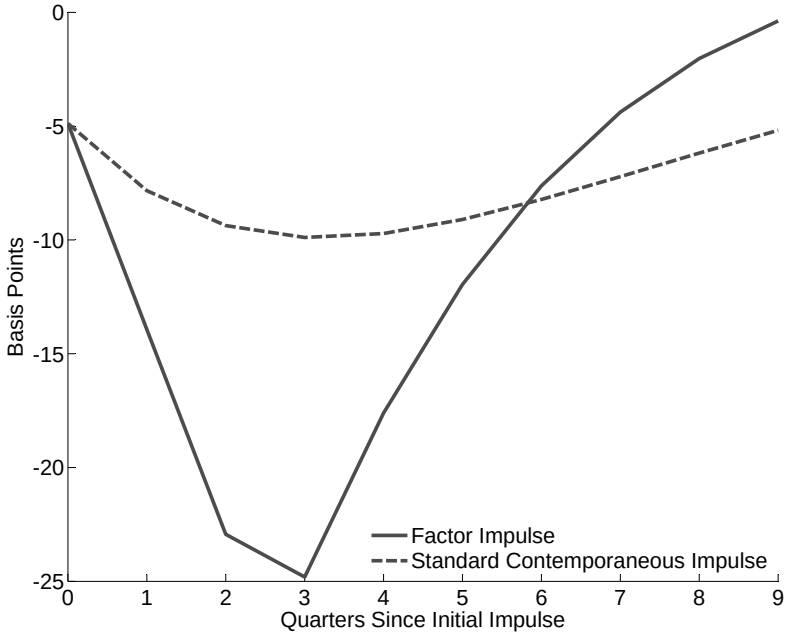
Note: All parameter estimates are expressed in basis points.

loadings reveals that the factor does indeed tilt the path of monetary accommodation. A one-standard deviation realization lowers the interest rate rule's intercept by about 5 bp for the next three quarters and increases it by about the same amount for the following two quarters. The factor model's remaining parameters describe the standard deviations of the idiosyncratic errors in e_t. These estimates show that the factor accounts for about 15 percent of the variance of $\nu_{t,0}$, about ten percent of the variance of $\nu_{t,1}$, $\nu_{t,2}$, and $\nu_{t,3}$, and about sixty percent of the variance of $\nu_{t,4}$. That is, the factor accounts for most of four-quarter ahead forward guidance but leaves most forward guidance issued at shorter horizons unexplained.

In Figure 3, we plot the direct effects of a one standard deviation shock to the factor on the interest rate. This does *not* take into account any possible endogenous responses of inflation or unemployment to the original shock. For comparison, we also plot the response to a standard contemporaneous impulse that initially lowers the interest rate by the same amount, 5 bp. As dictated by the second-order autoregressive parameters, the interest rate falls for three quarters after a contemporaneous one standard deviation impulse and then begins a slow rise back to its mean. The interest rate also falls for three quarters following a factor shock, but it falls much more relative to the initial response. Thereafter, the impulse's effects dissipate quickly. After nine quarters, the interest rate has returned to its mean. To us, these responses suggest labeling this factor *policy acceleration*. When the factor equals zero, policy adjustments proceed at their normal pace. A negative realization increases the speed of the interest rate's decline and recovery, while positive realizations increase the speed of contractionary policy.

Figure 4 plots the identified policy acceleration factor scaled by its impact on the *current* interest rate. This achieved its maximum value in 1999:II, 9 bp, although its value in the next quarter almost exactly offset this promised accelerated stimulus. Its minimum occurred in the wake of the 2001 recession in 2002:II, -21 bp. In that quarter, the one, two and three quarter ahead forecasts of the unemployment rate all rose 30 bp. (For a point of comparison, these revisions' sample standard errors are 17, 20, and 21 bp.) Its other large and negative realizations occurred during the prior recession itself, when the upward unemployment fore-

Figure 3: Direct Effects of Monetary Policy Shocks on the Interest Rate



cast revisions were even larger. It appears that the FOMC successfully signaled its intention to accelerate accommodation following adverse unemployment news in 2001 and 2002.

3.5 Asset Price and Forecast Responses to Interest-Rate-Rule Forward Guidance Shocks

One clear virtue of the GSS path factor is its documented impacts on asset prices relevant for private decisions. We now examine the impact on asset prices of the forward guidance shocks identified from the interest rate rule by regressing the same financial variables used in Table 2 on them. Since our data are quarterly, we measure bond yields and the stock market index on the quarter's final trading day. The changes in these from the previous quarter are our dependent variables. For independent variables, we use a constant and all five of the ν shocks. Table 10 reports the estimated coefficients, their standard errors, and the regressions' R^2 values. We express all of the variables in basis points, so the coefficients can be read as the basis-point response to a one-basis-point change in the right-hand side variable.

Although the coefficients' standard errors are not small, the regression estimates clearly show that the identified forward guidance shocks substantially influence (in the regression sense) asset prices. A 100 basis point increase in $\nu_{t,1}$ raises the 2 and 5 year Treasury yields

Figure 4: The Estimated Policy Acceleration Factor

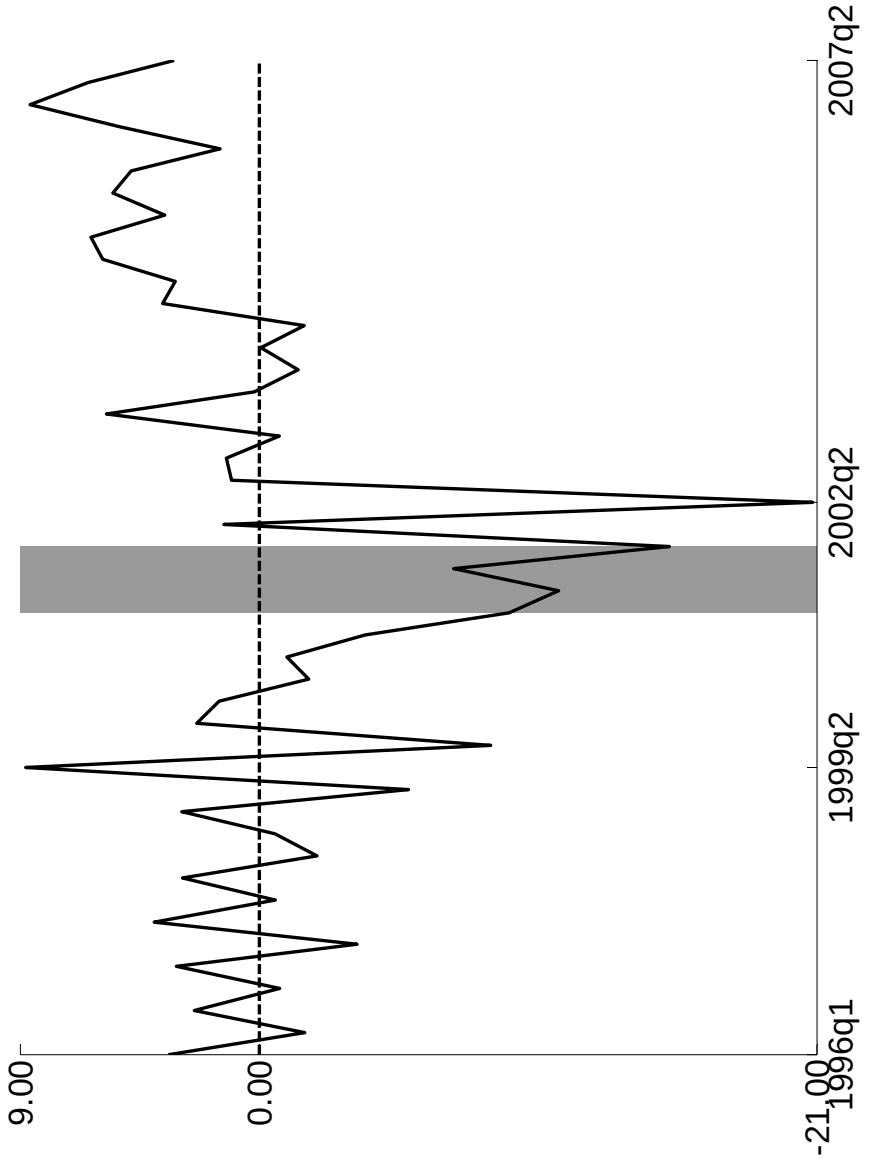


Table 10: Asset Price Responses to Interest-Rate-Rule Forward Guidance Shocks

	Const.	$\nu_{t,0}$	$\nu_{t,1}$	$\nu_{t,2}$	$\nu_{t,3}$	$\nu_{t,4}$	R^2
2-Year Note	5.90	1.08***	1.98***	1.56***	0.70*	0.89*	0.77
	(4.47)	(0.37)	(0.22)	(0.33)	(0.42)	(0.50)	
5-Year Note	3.46	0.61*	1.83***	1.91***	1.43***	1.25**	0.78
	(4.31)	(0.36)	(0.21)	(0.32)	(0.40)	(0.49)	
10-Year Note	1.57	0.38	1.48***	1.60***	1.41***	1.29***	0.70
	(4.44)	(0.37)	(0.22)	(0.33)	(0.42)	(0.50)	
Aaa Corporate Bond	0.60	0.19	0.65***	0.75**	0.86**	0.17	0.33
	(4.63)	(0.38)	(0.23)	(0.34)	(0.43)	(0.52)	
Baa Corporate Bond	0.57	0.13	0.69***	0.71**	1.00***	0.37	0.42
	(4.01)	(0.33)	(0.20)	(0.30)	(0.38)	(0.45)	

Note: The regression sample extends from 1996:I through 2007:II. The main text defines the independent variables $\nu_{0,t}, \ldots, \nu_{4,t}$. Robust standard errors are in parenthesis; and $*$, $**$ and $***$ indicate significance at 10 percent, 5 percent, and 1 percent respectively.

by almost 200 bp and the 10 year Treasury yield by about 150 bp. The effects on the two corporate bonds are more modest, 65 and 69 bp. In light of the standard errors, we judge the estimated effects of $\nu_{t,2}$ and $\nu_{t,3}$ on these bond yields to be about the same. The relatively small variance of $\nu_{t,4}$ translates into relatively large standard errors for its estimated effects on bond yields. Nevertheless, the point estimates for the effects of $\nu_{t,4}$ are statistically significant for the 5 and 10 year Treasury yields. Overall, the estimated asset-price effects of forward guidance inferred from the interest rate rule are much larger than the corresponding effects of forward guidance identified from the GSS event-study methodology.

We find one aspect of the results in Table 10 puzzling: the forward guidance shocks have much larger estimated effects on bond yields than does the contemporaneous monetary policy shock, but the only substantial difference between $\nu_{t,j}$ and $\nu_{t,0}$ is a j-quarter implementation delay. If the Treasury rates correspond to the appropriate average of expected short rates plus a term premium and the forward guidance only impacted the expected short rates, then the responses should be nearly identical. The fact that they are not strongly suggests that our identified forward guidance shocks are impacting term premiums. Fully exploring this intriguing result lies beyond the scope of the present paper.

Table 11 reports the results from regressing the eight forecast revisions against a constant and the five ν's. With rational expectations, the constant term should be irrelevant. It is indeed so for three of the four unemployment forecast revisions, but the Blue Chip forecast-

Table 11: Forecast Revision Responses to Interest-Rate-Rule Forward Guidance

	Constant	$\nu_{t,0}$	$\nu_{t,1}$	$\nu_{t,2}$	$\nu_{t,3}$	$\nu_{t,4}$	R^2
$\hat{u}_t^{-1} - \hat{u}_t^0$	-6.82***	-0.37*	-0.20	-0.13	-0.38	0.46	0.28
	(2.47)	(0.20)	(0.12)	(0.18)	(0.23)	(0.28)	
$\hat{u}_{t+1}^0 - \hat{u}_{t+1}^1$	-4.02	-0.34	-0.30**	-0.05	-0.27	0.54	0.27
	(2.92)	(0.24)	(0.14)	(0.22)	(0.27)	(0.33)	
$\hat{u}_{t+2}^1 - \hat{u}_{t+2}^2$	-3.39	-0.46*	-0.47***	-0.02	-0.20	0.30	0.34
	(2.93)	(0.24)	(0.14)	(0.22)	(0.27)	(0.33)	
$\hat{u}_{t+3}^2 - \hat{u}_{t+3}^3$	-2.86	-0.31	-0.47***	-0.00	-0.07	0.26	0.34
	(2.65)	(0.22)	(0.13)	(0.20)	(0.25)	(0.30)	
$\pi_t^{-1} - \pi_t^0$	1.83	-0.35	0.23	-0.08	-0.61	-0.09	0.05
	(5.55)	(0.46)	(0.27)	(0.41)	(0.52)	(0.63)	
$\pi_{t+1}^0 - \pi_{t+1}^1$	-5.20*	-0.18	0.17	0.05	-0.44	0.07	0.10
	(2.91)	(0.24)	(0.14)	(0.21)	(0.27)	(0.33)	
$\pi_{t+2}^1 - \pi_{t+2}^2$	-7.55***	-0.05	0.15	0.11	0.35	-0.02	0.10
	(2.69)	(0.22)	(0.13)	(0.20)	(0.25)	(0.30)	
$\pi_{t+3}^2 - \pi_{t+3}^3$	-5.32**	-0.25	0.18*	-0.07	0.09	-0.04	0.14
	(2.11)	(0.18)	(0.10)	(0.16)	(0.20)	(0.24)	

Note: The regression sample extends from 1996:I through 2007:II. The main text defines the independent variables $\nu_{0,t}, \ldots, \nu_{4,t}$. Robust standard errors are in parenthesis; and $*$, $**$ and $***$ indicate significance at 10 percent, 5 percent, and 1 percent respectively.

ers consistently made a small (but statistically significant) 7 basis point error in their final unemployment forecast. We see similar small but systematic errors in the inflation expectations. The slope coefficients' standard errors are quite large (on the order of 20 to 30 bp), but nevertheless many of the coefficients multiplying $\nu_{t,1}$ in the unemployment regressions are *negative* and statistically significant. That is, promises of more restrictive policy in the next quarter are associated with reductions of unemployment expectations. Although the analogous coefficients from the inflation regressions are not statistically significant, it is also worth noting that they are positive.

Of course, the NK model requires unanticipated reductions to current and future interest rates to lower expected unemployment and raise expected inflation, so the negative reaction of unemployment to $\nu_{t,1}$ clearly cannot be interpreted as the direct macroeconomic effects of unanticipated forward guidance. However, they also cannot be interpreted as reflecting *simple* reverse causality from publicly known macroeconomic circumstances to monetary policy, because the interest rate rule accounts for typical monetary policy choices given expectations of unemployment and inflation. One possibility worth considering is that the effects arise because the FOMC systematically responds to recent revisions in expectations.

To understand this further, consider the following augmented interest rate rule:

$$r_t = \mu + \rho_1 r_{t-1} + \rho_2 r_{t-2} + (1 - \rho_1 - \rho_2)\left(\phi_\pi \widetilde{\pi}_t + \phi_u \widetilde{u}_t\right) + \eta\left(\widetilde{u}_t - \widetilde{u}_t^L\right) + \sum_{j=0}^{M} \nu_{t-j,j}, \qquad (4)$$

Here, $\eta < 0$ measures the extent to which the FOMC reacts to unemployment news received over the last L quarters, specified here as $\widetilde{u}_t - \widetilde{u}_t^L$. We might suppose that η will be large and negative if the FOMC becomes systematically worried about "getting behind the curve" following unemployment surprises. If $L \leq M$, then the newly added term in (4) is orthogonal to the instruments we used for estimation, so its presence will not impact our estimates of ρ_1, ρ_2, ϕ_π, and ϕ_u. However, it will change the inferred values of the interest rate rule's expected intercept and through this influence the estimated ν's. Under this interpretation of the results in Table 11, the FOMC's actions are *history dependent*. The estimated interest rate rule gives the typical policy stance given economic conditions forecasted four quarters in advance, but the FOMC would respond more aggressively to the same set of circumstances if it forecasted them only shortly before their arrival.[21]

[21] We *cannot* estimate coefficients like η in Equation (4) by regressing the measured values of $\vec{\nu}_t$ on expectations revisions, because the true values of $\vec{\nu}_t$ should be endogenously correlated with the expectations revision. Since the expectations revision is uncorrelated over time virtually by construction, we also cannot employ an instrumental variables estimator with lagged information as instruments. This leads us to believe that the cross-equation restrictions of structural models will be essential for identification and estimation of the real effects of forward guidance.

3.6 Summary

What does the analysis of forward guidance identified from a standard interest rate rule tell us? First and perhaps most importantly for the potential viability of forward-guidance based strategies today, the public and FOMC together have extensive experience with the communication of relatively short term forward guidance. Indeed, the FOMC used forward guidance to signal its acceleration of accommodation in late 2001 and early 2002. Overall, the public anticipated about forty percent of the variance in the interest rate rule's disturbance three or four quarters in advance. Second, unanticipated accommodative forward guidance reduces interest rates relevant for households' and firms' economic decisions. That is, it seems possible for the FOMC to change longer term interest rates out of its direct control by communicating its intention to lower the short-term policy rate persistently.

4 Using Odyssean Forward Guidance

The foregoing analysis suggests that the FOMC has experience successfully communicating its future behavior in response to prevailing macroeconomic conditions. We interpret this to mean that communication difficulties do not present an insurmountable barrier to monetary policies based on Odyssean forward guidance and that therefore it is worth considering the practical consequences of adopting such policies. Currently the FOMC has an extraordinary degree of forward guidance in place with the "late 2014" statement language. In this section we investigate the consequences of interpreting the "late 2014" statement language as Odyssean forward guidance that implements the policy recommendations of Eggertsson and Woodford (2003) and others. There are legitimate concerns that forward guidance of this kind places the FOMC's mandated price stability goal at risk. We consider these by forecasting the path of the economy with the present forward guidance and subjecting that forecast to two upside risks: higher inflation expectations and faster deleveraging by households and firms. We do this analysis using the medium-scale DSGE model developed at the Federal Reserve Bank of Chicago for just such a purpose.

Evans (2011) has proposed conditioning the FOMC's forward guidance on outcomes of unemployment and inflation expectations. His proposal involves the FOMC announcing specific conditions under which it will begin lifting its policy rate above zero: either unemployment falling below 7 percent or medium term expected inflation rising above 3 percent triggers lift-off from the ZLB. Bright-line threshold rules such as this are designed to maintain low rates even as the economy begins expanding on its own (as prescribed by Eggertsson and Woodford (2003)) while providing safeguards against unexpected developments that may put

the FOMCs price stability goal in jeopardy. We illustrate that such conditioning, if credible, could be helpful in limiting the inflationary consequences of an unexpectedly early end to the post-crisis deleveraging.

Our conclusions obviously depend on the assumed structure of the model economy and the values we assign its parameters. So one might doubt the usefulness of our model-based experiments since there is little consensus on what the "right" structural model is and even when there is agreement on the model there is often disagreement over its parameter values. Nevertheless we believe our experiments are interesting and policy-relevant. First of all the model is very similar to other widely used models and is essentially the standard structural tool for monetary policy analysis in the US and around the world. Furthermore the model's parameters are estimated using a rich array of macroeconomic data so that our analysis has a firm empirical grounding.

We now briefly describe the model, its estimation, and how we calibrate it to the current policy environment. Then we present our baseline forecast and the consequences for monetary policy of two alternative scenarios.

4.1 The Model

The model is adapted from Justiniano et al. (2011) and so it closely resembles many medium-scale empirical NK models.[22] There is a single representative household that owns all firms and supplies the economy's labor. Final goods are produced with differentiated intermediate goods which themselves are produced with capital and differentiated labor. The intermediate goods market and the labor market are monopolistically competitive. Prices of both kinds of differentiated inputs are sticky and are subject to partial indexation.[23] Hence standard forward-looking Phillips curves connect wage and price inflation with the marginal rate of substitution between consumption and leisure and marginal cost, respectively. Other frictions include endogenous capacity utilization, costs of adjusting investment growth, and internal habit preferences.[24] The combination of all these features is very close to Christiano, Eichenbaum, and Evans (2005), Smets and Wouters (2007), and many other models, so that knowledge of these models is sufficient for understanding the results.

The model has one feature which distinguishes it from other NK frameworks: the monetary policy interest rate rule.[25] The interest rate rule is given by (1), except that we set

[22] The model is described in more detail in **?**

[23] Each period wages and prices have a constant probability of being optimally reset otherwise they are exogenously indexed to a convex combination of steady-state inflation, last period's inflation, and (for wages) productivity growth.

[24] Internal habit refers to current utility being diminishing in lagged own consumption.

[25] The model and estimation involve other unique features but these do not change the model's shock

$\rho_2 = 0$ and replace $\widetilde{u}_t$ with the policy relevant output gap, $\widetilde{y}_t$.[26] The policy relevant measure of inflation in (1) is defined by

$$\widetilde{\pi}_t = \frac{1}{4}\sum_{j=-1}^{2} \mathbb{E}_t \widehat{\pi}_{t+j} - \widehat{\pi}_t^*, \tag{5}$$

Equation (5) says policy relevant inflation is the deviation of a four quarter average of inflation from the time-varying inflation anchor $\hat{\pi}^*$. The model's inflation anchor varies exogenously and follows an AR(1) process. It is included to account for low frequency movements in inflation and to consider policy experiments in which inflation expectations become "unanchored." The four quarter moving average of inflation includes both lagged, current and future values of inflation. The monetary authority uses the structure of the model to forecast the future terms.

We define the output gap as

$$\widetilde{y}_t = \frac{1}{4}\sum_{j=-1}^{2} \mathbb{E}_t \widehat{x}_{t+j}. \tag{6}$$

$$\mathbb{E}_t[\left(1 + \lambda(1-L)^2(1-F)^2\right)\widehat{x}_t] = \mathbb{E}_t[\lambda(1-L)^2(1-F)^2\widehat{y}_t] \tag{7}$$

where L and F are the lag and lead operators and λ is a smoothing parameter. Equation (6) defines the output gap as a four quarter moving average of detrended model output. Following Cúrdia, Ferrero, Ng, and Tambalotti (2011) the monetary authority detrends output using the filter given by (7).[27] This detrending approximates the Hodrick-Prescott filter. The moving average of filtered output has the same lead-lag structure as inflation and so also includes forward looking terms which embody news about the inflation and output gaps up to two quarters ahead.

We use the GSS factor structure to limit the number of parameters to be estimated for the forward guidance shocks in equation (1). In particular we allow there to be a target and a path factor driving forward guidance where these factors are *i.i.d.* over time. All current and forward guidance shocks load onto the target factor and all but the contemporaneous policy shock load onto the path factor. For the pre-crisis sample we set $M = 4$ in (1) and estimate the factor loadings, the two factor variances and variances for the idiosyncratic shocks at each horizon of forward guidance. Agents in the model therefore see a credible

propagation mechanisms which continue to resemble those in other medium scale NK models. The model includes a financial accelerator as in **?**, but this ends up being unimportant for the results.

[26] In future work we intend to consider the $\rho_2 \neq 0$ case.

[27] We only consider stationary solutions to (7).

commitment to deviate from the typical response of policy to current economic conditions going out 4 quarters. Within the context of the model the forward guidance shocks are entirely Odyssean because they are a (credible) commitment to a future action.

We identify the contemporaneous, forward guidance, and inflation anchor shocks using data on the federal funds rate, federal funds rate futures, and long run (10 year) inflation expectations taken from the Survey of Professional Forecasters. The current policy shock moves the current rate more than future rates, while the forward guidance and the inflation anchor shocks move expected future federal funds rates more than the current rate. This difference is a key source of identification. Both the inflation anchor and forward guidance shocks influence inflation, with the effects of the latter arising through the Phillips curve. We assume the inflation anchor is very persistent so the effects of forward guidance shocks on inflation expectations are comparatively more concentrated at shorter horizons. As a result, the forward guidance shocks are identified from changes in futures rates that are larger than changes in the current rate and are associated with only small movements in long run inflation expectations. We do not use the Blue Chip data to identify forward guidance in the model because we want to consider horizons of forward guidance beyond one year during the period in which the ZLB is binding.

A natural objection to using forward guidance as a tool for generating additional monetary accommodation is that by doing so the monetary authority risks inflation expectations becoming unhinged. In our sample inflation expectations exhibit a downward trend so we strongly suspect that episodes of forward guidance raising long run inflation expectations are absent from our pre-crisis sample. That being said, we need to be wary of this possibility in the current environment.

In addition to the monetary policy shocks the model's fluctuations are driven by eight "structural" shocks. With one exception noted below, these shocks are AR(1). Four of these shocks move real GDP and GDP deflator inflation in the *same* direction on impact so we refer to these as *demand shocks*. One changes the households' rate of time discount, the discount shock. Two are financial disturbances: the spread shock generates fluctuations in the external finance premium beyond the level warranted by current economic conditions, and the net worth shock generates exogenous fluctuations in private balance sheets.[28] The fourth demand shock, called the government shock, is a shock to the sum of government spending, net exports and the change in valuation of inventories. Four shocks move real GDP and GDP deflator inflation in *opposite* directions on impact and so we call these *supply shocks*.

[28]These shocks enter because of the financial accelerator mentioned in footnote 25. The net worth shock plays a negligible role in fluctuations while the spread shock is a major driver of fluctuations. The model propagates the spread shock essentially as it does a shock to the marginal efficiency of investment identified using spread data.

These shocks directly change neutral technology, investment-specific technology, markups of intermediate goods prices, and households' disutility from labor. The latter shock is assumed to be an ARMA(1,1) to parsimoniously address low frequency dynamics in hours worked and high frequency variation in hourly wages. Other shocks that are of small importance in accounting for the data are shocks that do not impact agents' decisions: idiosyncratic shocks to the various price measures used in estimation and measurement error in the two financial variables described below.[29]

4.2 Estimation

We use a two step procedure to assign values to our DSGE model's parameters. First, we estimate the model over the period 1989:II (when federal funds futures contract data begins) to 2007:II (just before the onset of the financial crisis) under the assumption that forward guidance extends out four quarters. Second, for the period 2007:III-2011:IV we fix the non-forward guidance parameters at their estimated values (with four exceptions highlighted below) and re-estimate forward guidance under the assumption that it extends out ten quarters. Our policy experiments are based on this new set of monetary policy parameters, but the model's determination of the state of the economy takes into account the data prior to 2007:III as well as the parameter values that were in force at that time.

Our estimates for the period 1989:II-2007:II imply that most fluctuations are driven by the demand shocks.[30] The data used to estimate the model include growth rates of nominal per capita GDP, consumption, and investment; the level of per capita hours worked in the non-farm business sector; nominal compensation per hour worked in non-farm business; the GDP deflator, the deflators corresponding to model-based measures of consumption and investment; the core PCE deflator; core CPI, ten-year ahead forecasts of CPI; an interest rate spread; the ratio of private credit to GDP; the federal funds rate; and contemporaneous expectations of the federal funds rate 1 to 4 quarters hence. Consumption is measured as consumption of non-durable goods and services; and investment includes business fixed investment, residential investment, and personal consumption expenditures on durable goods.[31] The interest rate spread is a weighted average of high-yield corporate and mortgage-backed

[29]Model-consistent measures of consumption prices do not correspond well with either of the measures commonly referenced by policy-makers and market participants, core-PCE and core-CPI. We use a factor structure to model three consumption price series, the two popular core measures and the measure designed to be consistent with the model. Doing this delivers predictions for core-PCE and core-CPI and it limits the structural impact of high frequency fluctuations in inflation that are likely driven by measurement error. Model-based inflation is identified with the common factor.

[30]Technical details of the estimation are discussed in **?**.

[31]The remaining components of aggregate expenditures – government spending, net exports and private inventory accumulation – are modeled as the government shock.

bond spreads with the 10-year Treasury and an asset-backed bond spread with the 5-year Treasury; where the weights equal the shares of nonfinancial business, household mortgage, and household consumer debt in private credit. Our measure of private credit includes both households' and nonfinancial businesses' debts.

? report the parameter estimates in more detail. Here we highlight two sets of parameters that have important implications for the outcomes of the policy experiments. First, the monetary policy rule displays a high degree of interest rate smoothing, the inflation gap coefficient obeys the Taylor principle, and the output gap coefficient is smaller than the one for inflation. Reflecting the downward trend in inflation over our sample, the inflation anchor is very persistent. The plausibility of the policy rule depends in part on the nature of the output gap in the rule. **?** demonstrate that the model's output gap corresponds well with the gap published by the Congressional Budget Office.

Second, the estimated model has large nominal and real rigidities. Due partly to the sample over which it is estimated, the slope of the price Phillips curve is very small, about an order of magnitude smaller than single equation estimates, *e.g.* Galí and Gertler (1999), Eichenbaum and Fisher (2007). The wage slope is also small, but is more in line with estimates that do not rely on the full structure of the model, such as those in Sbordone (2006). Our estimates imply that there is limited feedback from aggregate activity to wage or price inflation in the model. The estimated real rigidities as implied by the capacity utilization elasticity, investment adjustment costs, and habit are similar in magnitude to other estimates in the literature, *e.g.* Justiniano et al. (2011), and impart considerable inertia in response to shocks.

4.3 Policy Experiments

The macroeconomic outcomes from 2007:III to 2011:IV are unusual compared to the data used to estimate the model. Therefore to conduct policy experiments relevant to the current economic environment we calibrate some of the model's parameters and re-estimate forward guidance. The latter is particularly important because of the relatively long horizon over which forward guidance has been issued by the FOMC during the recent period.

We calibrate three parameters for the period 2007:III-2011:IV: the persistence of the discount shock, the variance of the inflation anchor shock and the coefficient on the output gap in the policy rule. To capture the idea that deleveraging by households and firms following the financial crisis is unusually slow, we raise the persistence of the discount shock from its estimated value in the pre-crisis sample.[32] Consequently the model sees discount shocks

[32]The discount factor is commonly used to model episodes in which the ZLB is binding. See for example

playing a larger role than otherwise since 2007:II, leading to much lower aggregate demand at the end of the sample. Essentially the model interprets much of the weakness in the data as reflecting agents' desires to save much more than they have at other times under similar conditions. We set the inflation anchor innovation variance to one fourth its estimated value from the pre-crisis period. This is motivated by the fact that inflation expectations exhibit a downward trend in the first part of our sample but have fluctuated considerably less since. Finally, we work with a coefficient on the output gap in the model's policy rule that is three times the size of the pre-crisis estimate. Our motivation for this last assumption is that the FOMCs policy response to a very large recession may be more aggressive than to a modest recession. These assumptions combined increase the likelihood that the ZLB is binding at any given quarter since 2007:III.

Given the calibrated parameters and pre-crisis estimates for the remaining parameters excluding forward guidance and the discount shock's variance, we re-estimate the factor loadings, factor variances and idiosyncratic variances that characterize forward guidance as well as the discount shocks' variance over the period 2007:III to 2011:IV under the assumption that forward guidance extends out ten quarters.[33] Our estimation of forward guidance in the later period uses expected future federal funds rates going out 10 quarters from each date in the sample. With estimates in hand and data for the period 2007:III through 2011:IV, the Kalman smoother is used to back out the model's interpretation of the shocks hitting the economy since the crisis and their implications for the model's state variables as of 2011:IV. One important implication of our calibration and estimated forward guidance is that the model sees the ZLB as binding from 2008:IV until the end of our sample in 2011:IV.[34] At this last date the model can be used to generate a forecast under the assumption that no further shocks hit the economy. This is our baseline forecast.

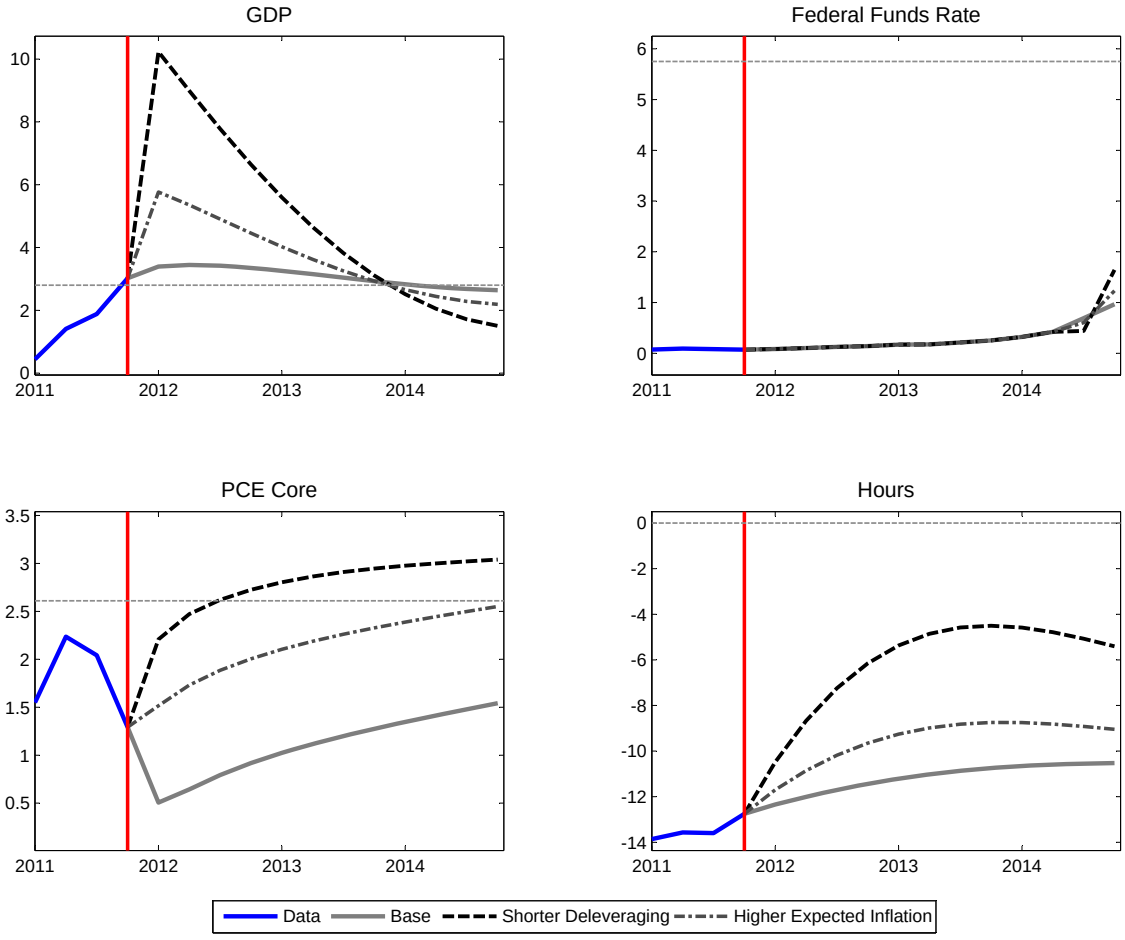
Figure 5 displays the baseline forecast along with forecasts corresponding to the two alternative scenarios described below. The horizontal line in each plot indicates the long run average of the variable in question over the sample 1989:II-2007:II (log hours has a mean that is very close to zero.) The forward guidance in the baseline forecasts has been estimated to fit the federal funds rate futures path through mid-2014 after which the model predicts a mild lift-off with the funds rate about 1 percent at the end of 2014. This path is roughly in line with the January and March 2012 FOMC statements' "late 2014" forward guidance.

Christiano et al. (2011)

[33] We re-estimate the discount shock's variance to ameliorate concerns that we have imposed excessive weight on this shock in explaining the crisis.

[34] We say the ZLB is binding at any given date if, when all but the forward guidance factor shocks were fed into the model to generate a conditional forecast beginning in 2008:III, the forecasted path of the federal funds rate at each date would be below zero for at least 1 period at short horizons.

Figure 5: Baseline and Alternative Projections



Corresponding to this path for the funds rate, the baseline forecast is for slightly above trend growth for 2012, returning to trend in 2013 and 2014. Growth is sufficiently tepid that per capita hours is still 10 log points below its steady state level by the end of the forecast horizon. Core-PCE inflation, after initially dropping, is forecasted to rise slowly toward its long run average.

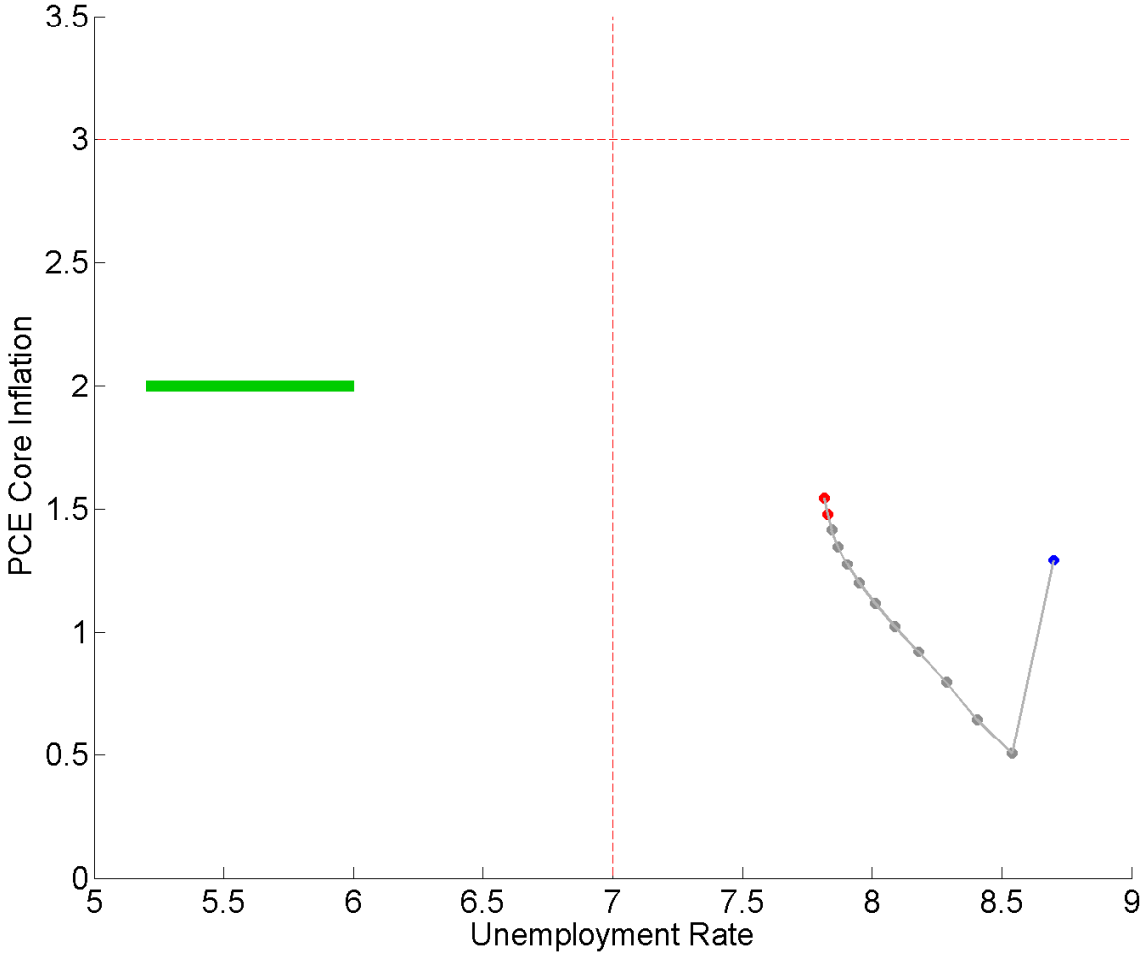
Figure 6 shows the baseline forecast in inflation-unemployment space.[35] The green bar represents the FOMC's policy objectives, an inflation goal of 2 percent as described in the FOMC document "Longer-Run Goals and Policy Strategy," and the central tendency of longer run unemployment reported in the January release of FOMC participants' economic projections. The blue dot indicates the 2011:IV launch date for the forecast with the economy's path proceeding from there. Grey dots indicate the period of a near zero federal funds rate and the red dots indicate forecast dates where the federal funds rate has risen above the ZLB. The red lines mark the bright-line thresholds.

By the end of 2014, core inflation is closer to the FOMC's explicit objective in the baseline forecast. However, the endpoint for unemployment seems high relative to *any* rate that would be consistent with the FOMC's mandated goal of maximum sustainable employment. Compared to the baseline scenario, it would bring policy closer to the optimum identified by Eggertsson and Woodford (2003) and Werning (2012) if the time the FOMC keeps the federal funds rate at zero were to be lengthened. The FOMC may be disinclined to push the limit of monetary policy accommodation very far in this dimension. Although calendar-date communications may have an Odyssean component, most market analysis seems to interpret the dates as Delphic communications, possibly limiting its stimulating effect. Finding acceptable bright-line thresholds might impart a larger commitment to accommodation. In the baseline scenario the forecast does not breach either the 7 percent unemployment threshold or the 3 percent inflation threshold. So, the threshold rule would prescribe keeping the funds rate low for a longer period.

Having suggested the threshold rule can provide additional Odyssean forward guidance, it is important to emphasize that such a rule also offers a risk-management approach to guarding against unforeseen circumstances. To illustrate this point, we consider two experiments that simulate the effects of developments that give rise to greater inflation concerns. In each case we calculate the model's forecast from 2011:IV under the assumption that an unanticipated event occurs in 2012:I. The state of the economy in 2011:IV includes all prior realizations of forward guidance and agents in the model see exceptionally low interest rates through to

[35] Our model does not have unemployment in it. However an OLS regression of unemployment on per capita hours fits extremely well. We use this regression model to map our forecast for per capita hours into a forecast for unemployment.

Figure 6: Inflation and Unemployment in the Baseline Forecast



late 2014. Our scenarios evaluate the consequences of maintaining this policy regardless of developments that could lead the FOMC to start raising the federal funds rate earlier. We do not impose the threshold policy in either scenario. Rather, we simply monitor the boundaries to examine whether such conditional forward guidance would call for a lift-off from the ZLB sooner than currently anticipated.

For each scenario we assume either a permanent change in a single model parameter or the realization of a shock for one period. In the scenario with a parameter change we resolve the model and use this solution for the associated forecast. In both scenarios we compute a forecast starting from the same estimated state of the economy used to construct the baseline forecast. In the "sudden increase in long run inflation expectations" scenario the unanticipated event is an unusually large and persistent innovation to the inflation anchor. We assume a single innovation to the inflation anchor that generates an immediate increase in long run inflation expectations of 1 percentage point.[36] In the "rapid deleveraging" scenario we assume that the persistence of the discount rate shock drops from its calibrated level of 0.95 to its pre-crisis level of 0.75, but do not consider any shocks. In this scenario past realizations of the discount shock die out much sooner than anticipated in the baseline forecast (the half life of a discount shock declines from 3.4 *years* to 2.4 *quarters*.)

Each scenario involves solving for the forward guidance that reproduces the expected funds path through 2014:II. This is accomplished by setting one of the idiosyncratic shocks to zero and then solving for the realization of the target and path factors in the first period, plus the other nine idiosyncratic shocks such that the funds path is matched exactly through 2014:II (we apply the estimated factor loadings underlying the baseline forecast to calculate the forward guidance shocks.) As Figure 5 illustrates, both alternative scenarios generate fast growth immediately: faster deleveraging through a less contractionary discount factor and higher expected inflation through lower real interest rates. Therefore, maintaining the funds rate path requires very large expansionary realizations of the path factor – essentially large expansionary forward guidance. With this large amount of monetary accommodation in place, inflation rises above 2 percent in both scenarios, although per capita hours remains relatively low. Presumably less expansionary monetary policy involving an earlier lift-off of the funds rate would be required to forestall the higher inflation, but this would be at the expense of an even weaker labor market.

Figures 7 and 8 show the two alternative scenarios in inflation-unemployment space. These figures are similar to Figure 6 except that they also include the baseline forecast (the line without dots) for comparison. Under faster deleveraging unemployment falls faster and

[36] Given the high persistence of the inflation anchor, the increase in average expected inflation over the next 40 quarters is actually hump shaped, and therefore higher in later quarters.

Figure 7: Inflation and Unemployment with Shorter Deleveraging

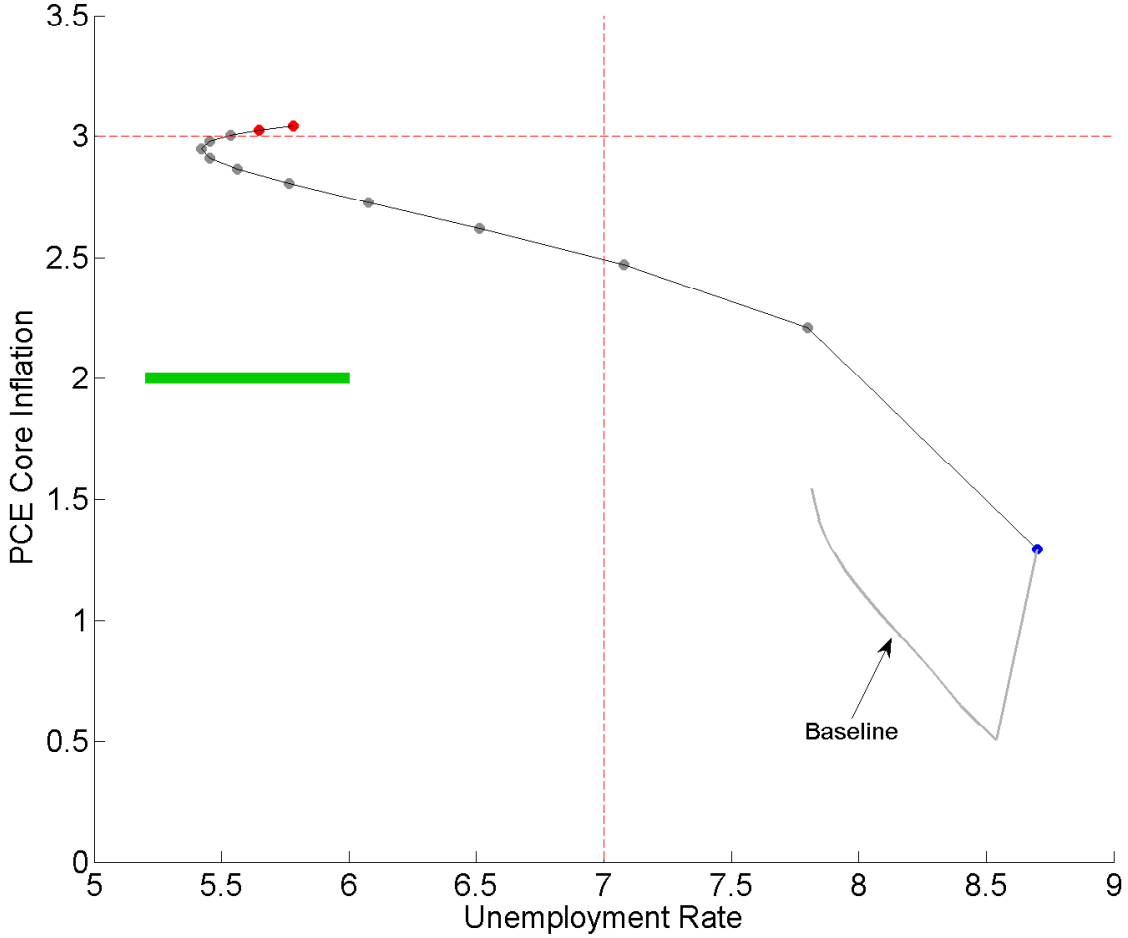
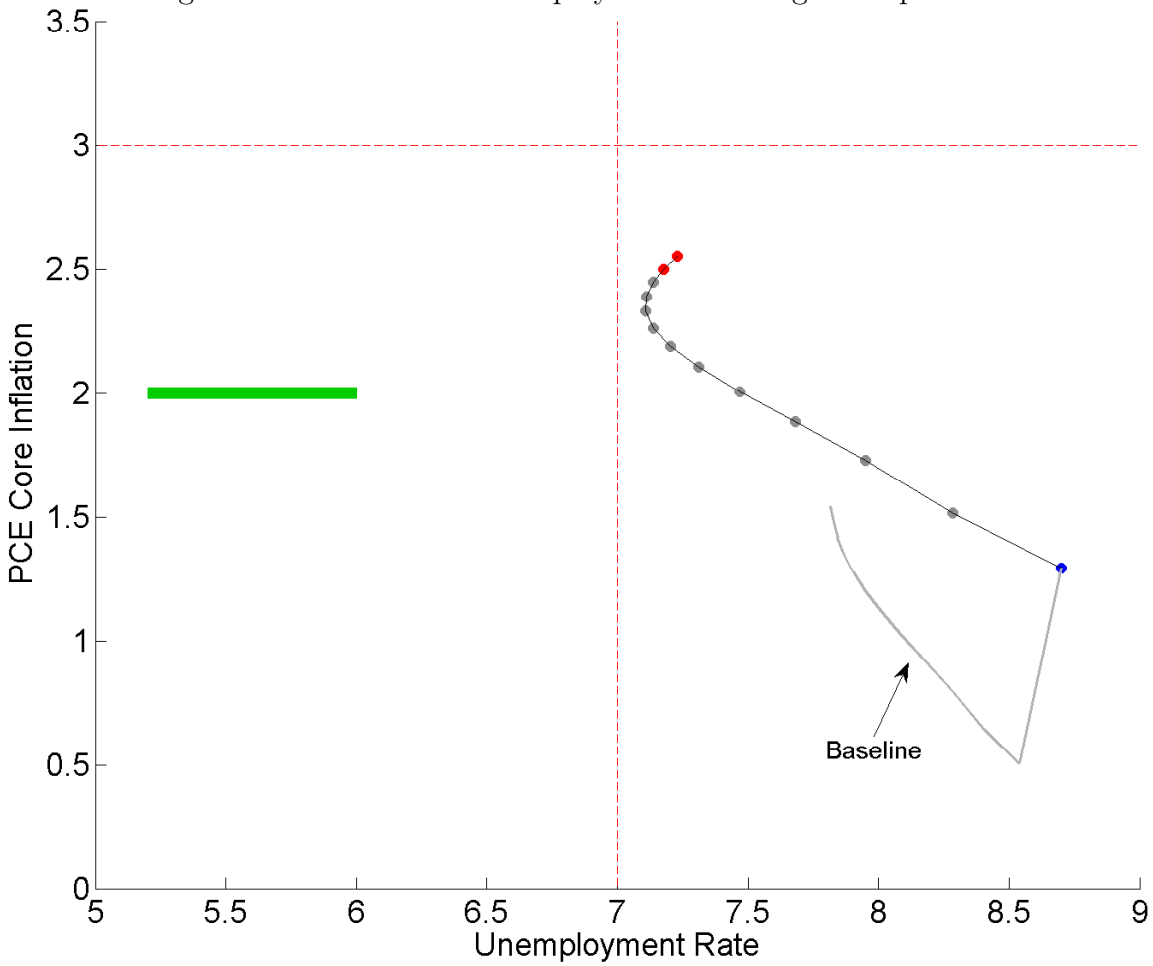


Figure 8: Inflation and Unemployment with Higher Expected Inflation



inflation rises by more than in the baseline. The economy crosses the 7 percent unemployment threshold in 2012:III and reaches the 3 percent inflation threshold in late 2013. Therefore, adherence to the 7/3 threshold policy dictates liftoff from the ZLB in late 2012. Given the improvement in the economy and labor markets, an earlier exit seems palatable.

Now consider the higher expected inflation scenario. Note that generating the increase in inflation expectations in this scenario requires a shock that is more than *four* standard deviations of the inflation anchor innovation as estimated in the pre-crisis sample. The resulting forecast conditioning on exceptionally low rates through at least the next ten quarters, does generate a big boom in GDP growth. However, due to the strong real and nominal rigidities we have estimated, neither unemployment nor inflation cross their thresholds within the next 3 years. The unemployment rate skirts its 7 percent threshold without crossing it and inflation remains well below the 3 percent inflation threshold through the end of 2014. While the 7/3 threshold policy would dictate keeping rates at the ZLB, the turn in direction of unemployment toward the end of the forecast horizon is worrisome.

The higher expected inflation scenario illustrates a striking feature of NK models estimated using post-1970s data. Because of the very flat price Phillips curve, very large innovations to inflation expectations do not lead to high inflation even with extraordinarily accommodative monetary policy, at least over a three year horizon. This result depends on the assumed credibility of the model's policy rule and invariance of price-setting behavior to inflation expectations. If attempted use of Odyssean forward guidance weakens credibility or changes price setting behavior then this kind of policy experiment might be very misleading. Nevertheless nothing in the experience of the last twenty-five years suggests that a persistent change in inflation expectations necessarily generates a destabilizing loss of credibility.

5 Conclusion

The empirical context we provide above shows that the FOMC has extensive experience broadcasting its intended responses to macroeconomic developments. Indeed, macroeconomic forecasters and market participants anticipate about 80 percent of its deviations from a simple interest rate rule in advance. These communications have not been limited to a single "tight-loose" dimension. The FOMC successfully informed markets that it would accelerate its accommodation in late 2001 and early 2002 and accelerate its removal. Our results also show that surprises associated with FOMC policy announcements substantially influence Treasury bond rates, corporate borrowing rates, and private macroeconomic forecasts. News of substantial monetary tightening raises interest rates as expected, but it also raises inflation forecasts and lowers unemployment forecasts. This counterintuitive finding suggests to us

that private forecasters believe that the Federal Reserve's additional information about future economic conditions instigate some FOMC actions that were unanticipated by the public. That is, the public sometimes imputes Delphic content to policy announcements that are not explicitly tied to economic fundamentals.

Presently, the FOMC

> ... anticipates that economic conditions–including low rates of resource utilization and a subdued outlook for inflation over the medium run–are likely to warrant exceptionally low levels for the federal funds rate at least through late 2014.

We began this paper with the question of whether this statement reflects an Odyssean commitment to lower rates or a Delphic forecast of economic conditions and the FOMC's likely response to them. Our empirical results reassure us that communications difficulties present no insurmountable obstacle to the FOMC stressing the Odyssean interpretation and thereby providing additional monetary accommodation, but other objections to such a policy remain. In particular, one might worry that an Odyssean commitment to low rates places the FOMC's price stability mandate in jeopardy.

We have addressed this concern with simulations of two adverse scenarios from the Chicago Fed's estimated DSGE model. The deleveraging process that presently keeps the economy at the zero lower bound accelerates and finishes sooner than expected in the first scenario, and long-run inflation expectations suddenly rise one full percentage point in the second. We compare both simulations with the "bright-line" threshold policy proposal of Evans (2011) that calls for rate increases to begin when either unemployment falls below 7 percent or medium term expected inflation rises above 3 percent. With faster deleveraging beginning in 2012:Q1, the unemployment rate falls below its threshold for triggering rate increases in 2012:Q3. In this case, the policy provides useful insurance against the inflationary consequences of an unforeseen economic recovery. With the exogenous rise in inflation expectations occurring in 2012:Q1, the economy comes close to (but does not cross) the unemployment threshold at the start of 2014 and comes nowhere near the inflation threshold. We conclude from these experiments that the risks of Odyssean forward guidance to the Federal Reserve's price-stability mandate can be managed with such conditional forward guidance.

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