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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 Federal Open Market Committee (FOMC) of the usual tool for its provision. We examine how public statements of FOMC intentions—forward guidance—can substitute for lower rates at the zero bound. We distinguish between Odyssean forward guidance, which publicly commits the FOMC to a future action, and Delphic forward guidance, which merely forecasts macroeconomic performance and likely monetary policy actions. Others have shown how forward guidance that commits the central bank to keeping rates at zero for longer than conditions would otherwise warrant can provide monetary easing, 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 conditions, so communication difficulties do not present an insurmountable barrier to Odyssean forward guidance. Using an estimated dynamic stochastic general equilibrium model, we investigate how pairing such guidance with bright-line rules for launching rate increases can mitigate risks to the Federal Reserve's price stability mandate.

From the onset of the financial crisis and through the Great Recession and ensuing modest recovery, the Federal Open Market Committee (FOMC) of the Federal Reserve 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

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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, "an extended period" replaced "some time" in the formal statement. The August 2011 FOMC statement gave specificity to "an extended period" by announcing that the committee expected the funds rate to remain exceptionally low until "at least . . . mid-2013." The January 2012 statement lengthened the anticipated period of exceptionally low rates even further, to "late 2014," language that remained in the March 2012 statement. Such communications of monetary authorities' intentions are referred to as forward guidance.

The nature of this most recent forward guidance by the FOMC is the subject of substantial debate. Studies by Paul Krugman (1999) and by Gauti Eggertsson and Michael Woodford (2003) before the recent episode and by Iván Werning (2012) more recently suggest that a monetary policymaker encountering the zero lower bound (ZLB) on the policy interest rate can stimulate current aggregate demand by credibly promising to keep the rate at zero longer than required by economic conditions and thereby creating an economic boom in the future. One might interpret "late 2014" as such a credible promise, but one also might interpret it as merely describing what the FOMC's policy reaction function would prescribe 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 an earlier "liftoff" of the funds rate from zero given the identical conditioning data.

Motivated by these competing interpretations of "late 2014," we distinguish between two kinds of forward guidance. Delphic forward guidance publicly states a forecast of macroeconomic performance and likely or intended monetary policy actions based on the policymaker's potentially superior information about future macroeconomic fundamentals and its own policy goals.[2] Such forward guidance presumably improves macroeconomic outcomes by reducing private decisionmakers' uncertainty.

1. Since one of the authors regularly attends meetings of the FOMC, it may be tempting just to 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?

2. The classical Delphic oracle famously made ambiguous utterances. We do not mean "Delphic" in this sense. We use the term simply to describe FOMC statements about the future.

Importantly, however, it does not publicly commit the policymaker to a particular course of action. Odyssean forward guidance, in contrast, does publicly commit the policymaker, just as Odysseus committed himself to staying on his ship by having himself bound 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 issuing Odyssean forward guidance. The reason is that by so doing, policymakers can change public expectations of their actions tomorrow in a way that improves macroeconomic performance today.[3]

Nevertheless, the implementation of Odyssean policy faces a fundamental challenge. When the appointed time for action arrives, any beneficial effects of the policy's anticipation will be bygones that nothing can change. Therefore, both the monetary policymaker and the public will at that later time 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 keep an earlier promise to raise aggregate demand, 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.[4] Just as Odysseus anticipated that on hearing the Sirens' song he would regret his commitment to stay aboard his ship, so might monetary policymakers anticipate regretting their commitment to ease policy. If the public understands this and therefore believes that such promises will not be kept, they will not have the intended effect. Odysseus could use the rope that bound him to the mast to enforce his commitment. Lacking such an enforcement mechanism, monetary policymakers must rely on their reputations for accuracy and honesty to make their commitments credible.

The Odyssean monetary policies elucidated by Krugman, Eggertsson and Woodford, and Werning have inspired several recent proposals to provide more accommodation at the ZLB. The more aggressive policy alternatives that have been proposed include Evans's (2012) state-contingent price-level targeting, nominal income targeting as advocated by Christina Romer,[5] and

3. Romer and Romer (2000) and Ellingsen and Söderström (2001) characterize forward guidance similarly.

4. This is an example of a time-inconsistent policy, first considered by Kydland and Prescott (1977).

5. Christina D. Romer, "Dear Ben: It's Time for Your Volcker Moment," *The New York Times,* October 29, 2011.

conditional economic thresholds for exiting the ZLB as proposed by Evans (2011). The main challenge facing the FOMC in implementing any of these policies is convincing the public that it will follow through on the promised future course of action. This paper sheds light on the FOMC's ability to meet this challenge and on the possible benefits of doing so.

The FOMC has used forward guidance implicitly, through speeches and testimony by its members, and explicitly, through formal committee statements, since 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 that FOMC communications have had on private expectations. We begin by studying market responses to FOMC statements, building on prior work by Refet Gürkaynak, Brian Sack, and Eric Swanson (2005). Those authors follow Kenneth Kuttner (2001) by analyzing changes in prices on federal funds rate futures in short windows of time surrounding the release of FOMC statements. Using a sample from June 1991 through December 2004, Gürkaynak and his coauthors find that FOMC statements are associated with significant effects, both on federal funds futures prices and on Treasury yields, that are not due to surprise changes in the federal funds target itself. That is, their results show that market participants believe that FOMC statements contain reliable information about future monetary policy actions. We verify that these findings continue to hold when the sample is extended to July 2007, just before 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. But evidence exists that the FOMC can still exert influence in the presence of a binding ZLB. Focusing on FOMC communications about its recent large-scale asset purchases, known as QE1 and QE2, Joseph Gagnon and coauthors (2010) and Arvind Krishnamurthy and Annette Vissing-Jorgensen (2011) provide evidence of significant asset price effects 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 and his coauthors' methodology to FOMC statements since the crisis and find results similar to theirs.

FOMC actions that influence asset prices are merely means toward the end of fulfilling the Federal Reserve's dual mandate of maximum sustainable employment and price stability. To evaluate the contributions of

FOMC statements toward this ultimate goal, we examine how revisions to the Blue Chip consensus forecasts of the unemployment rate and consumer price index (CPI) inflation respond to the policy innovations identified by Gürkaynak and others (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 3 quarters and with higher forecasts of CPI inflation in the current and subsequent quarters. We never find a statistically significant reaction of either forecast that is of the "correct" sign, that is, one that indicates 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 and others inherently controls for publicly known macroeconomic fundamentals. That is, professional forecasters infer that the FOMC's unexpected policy adjustments are responses to nonpublic information that the FOMC possesses regarding the future strength of the economy.[6] We find qualitatively similar results for the crisis period, but the estimates are too imprecise to allow firm quantitative conclusions.

The FOMC does not rely solely on postmeeting public 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 John Taylor (1993, 1999) and David Reifschneider and John Williams (2000). Using the Blue 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 4 quarters.

We highlight here four results based on data from 1996 through 2007. First, the standard deviation of the expected interest rate 4 quarters out minus its value from the rule is only 9 basis points (bp). Thus, the rule describes medium-run forecasts of FOMC behavior extremely well. Apparently, the FOMC has been successful in communicating its typical behavior to the public. Although this need not reflect an Odyssean commitment, it is observationally equivalent to one. Second, the FOMC telegraphs

6. 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 information held only by the FOMC about its future policy intentions.

40 percent of its deviations from the interest rate rule exactly 1 quarter in advance and another 40 percent 2 or more quarters in advance. Third, the identified forward guidance residuals have much stronger effects on asset prices than do surprises of the type described by Gürkaynak and others (2005). For example, a 1-bp innovation to next quarter's expected federal funds rate moves both the 2-year and the 5-year Treasury rate by about 2 bp. The corresponding effects estimated with the methodology of Gürkaynak and others are under 1 bp. 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 shocks in Gürkaynak and others (2005). 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 4 quarters in advance.

The estimated effects of FOMC forward guidance on asset prices and private forecasts suggest that the FOMC has had some success in communicating its future intentions to the public.[7] This suggests that communication 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 concerns 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.

This policy analysis uses a medium-scale dynamic stochastic general equilibrium (DSGE) model adapted from Justiniano, Giorgio Primiceri, and Andrea Tambalotti (2011) at the Federal Reserve Bank of Chicago. The model strongly resembles other medium-scale DSGE models in the

7. 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.

literature and is very similar to models used at central banks around the world.[8] Importantly for our purposes, it embodies the basic mechanisms that make forward guidance attractive at the ZLB.

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 "7/3" threshold rule is designed to maintain low interest 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 FOMC's 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 deleveraging observed since the financial crisis.

I. 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 its future policy intentions. In this section we do so by applying the methodology of Gürkaynak, Sack, and Swanson (2005; GSS henceforth). They use high-frequency data on prices of federal funds futures and Eurodollar futures contracts to measure unanticipated changes in expected future spot interest 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 a positive realization of the path factor raises not only expected future policy rates but 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 FOMC policy preferences. In that case one would expect forecast revisions to match the equilibrium response to an

8. The FOMC's minutes for the June 2011 meeting describe a discussion of DSGE models within the Federal Reserve System at that meeting.

unanticipated monetary policy shock. Instead, however, we find that the statistically significant responses all have the sign opposite to that predicted by the standard New Keynesian 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, they have a Delphic component. Third, we extend the sample period so as to examine FOMC announcements since the onset of the financial crisis in August 2007. Here the relatively small sample makes our estimates of professional forecasters' responses to surprise monetary policy moves too imprecise to allow firm conclusions, but the estimates of asset price responses remain accurate enough to show that they differ little from their precrisis values.

I.A. Forward Guidance before the Financial Crisis

Glenn 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 made public only after the following meeting, when it was outdated and presumably of limited use to the public. In February 1994 the FOMC began issuing immediately after each meeting a statement describing the current policy stance, and in May 1999 it began including explicit language about the future stance of policy in these statements. The first of these forward-looking statements read in part as follows: "The Committee . . . adopted a directive that is tilted toward the possibility of a firming in the stance of monetary policy." The language intended to guide expectations has changed over time as the FOMC has sought ways of maintaining transparency without confusing markets, and as it has adjusted to the evolving policy environment. But language of one form or another describing the expected future stance of policy has come to be a fixture of these statements.[9]

9. 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 August 2003 FOMC statement said, "The Committee believes that policy accommodation can be maintained for a considerable period." In January 2004 the forward-looking language was "the Committee believes that it can be patient in removing its policy accommodation," and that of May 2004 was "policy accommodation can be removed at a pace that is likely to be measured." As inflation fears rose thereafter, the December 2005 statement included the words "further policy firming may be needed."

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 market participants than revealing of adjustments to policy. Failure to control for statements' confirming content could lead to incorrectly attributing to them outcomes 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 these narrow windows keeps the economic information available to market participants essentially fixed.

The within-day data on which GSS rely are unavailable to us after 2004, so we extend their work using daily observations of implied future interest rates at the market's close from five futures contracts: the current-month and 3-month-ahead federal funds futures contracts (with a scale factor to account for the timing of FOMC meetings within the month) and the 2-, 3-, and 4-quarter-ahead Eurodollar futures contracts (adjusted by the difference between the spot Eurodollar and federal funds rates); to each of these we add a risk premium of 1 bp per month.[10] Using data from the same contracts spanning February 1990 through February 2004, GSS find 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 factor accounts for most of the surprise change in the current federal funds rate. By construction, the path factor influences only expected future rates.[11]

We begin our analysis by replicating theirs over a slightly longer time sample, February 1990 through June 2007. We have found that many of

10. 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.

11. 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 that the FOMC would begin tightening policy sooner than previously expected.

Table 1. Decomposing the Variance in Changes in Expected Federal Funds Rates, 1990–2007 and 1994–2007[a]

Percent

	Share of variance due to indicated factor			
	February 1990–June 2007 sample		*February 1994–June 2007 sample*	
Federal funds rate futures contract	*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	36	63	18	81
Four quarters hence	21	77	7	90

Source: Authors' calculations.

a. Expected interest rates are measured using daily federal funds futures prices and Eurodollar futures prices as described in the text. Numbers do not sum to 100 because the two factors do not explain all the variation in the expected rate changes.

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 in their online appendix). The first two columns of table 1 report the fractions of innovation variance for each interest rate futures contract rate that are due to the identified target factor and to the identified path factor 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 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 50 percent of the variance in interest rates expected 2 quarters hence, and the path factor accounts for the clear majority of the variance in the two longest contracts.

Before February 1994 the FOMC did not explicitly announce changes in its target for the federal funds rate. Although GSS show that even before that date, market participants were able to discern within minutes of an open-market operation whether the FOMC had changed its target, one might reasonably suspect that 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 4 years. As expected, this change in the sample period increases the path factor's importance.

GSS document substantial positive statistical relationships between their identified factors and yields on financial assets. In particular, a positive 100-bp realization of their target factor raises 2-, 5-, and 10-year Treasury yields by 41, 37, and 28 bp, respectively (penultimate column of their table 5). Table 2 reports analogous regressions for the path and target factors as we identify them for the two samples. (We normalize the target factor loading on the current funds rate and the path factor loading on the 4-quarters-ahead futures rate to be unity. GSS use a slightly different normalization. The normalization has no impact on statistical significance or decomposition of variance.) The table's top panel reports the regressions using the 2-, 5-, and 10-year Treasury yields. GSS find that the two factors explain 94 percent, 80 percent, and 74 percent of the variance in these rate changes, respectively. The two factors we identify have similarly strong explanatory power for both samples we consider. For the longer sample (first two columns), all of the slopes multiplying the factors are positive and statistically significant at the 1 percent level. Their magnitudes are comparable to those reported by GSS, but our path factor slopes are somewhat larger and our target factor slopes a bit smaller than theirs. For the sample excluding the period without regular post-FOMC meeting statements (last two columns), the target factor's slopes are smaller and those of the path factor larger than for the longer sample. The table's bottom panel reports the results using yields on Aaa/AAA- and Baa/BBB-rated 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 yields, regardless of which sample we use. In contrast, a 100-bp positive path factor realization raises both yields by about 30 to 35 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 analysis 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 changes in the CPI and the civilian unemployment rate, from about 50 private forecasters. From these it compiles a "consensus" forecast for each variable, which is then published on the 10th 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 1-quarter backcast, a current-quarter nowcast, and forecasts for at least the next 4 quarters.[12]

12. The quarterly unemployment rate is expressed as the average monthly value across the quarter's constituent months.

Table 2. Regressions Estimating Asset Price Responses to Target and Path Factors, 1990–2007 and 1994–2007[a]

	February 1990–June 2007 sample			*February 1994–June 2007 sample*		
Asset	*Target factor*	*Path factor*	*Adjusted R^2*	*Target factor*	*Path factor*	*Adjusted R^2*
Treasuries						
2 years to maturity	0.474***	0.695***	0.87	0.287***	0.698***	0.85
	(0.030)	(0.032)		(0.034)	(0.037)	
5 years to maturity	0.319***	0.705***	0.82	0.141**	0.703***	0.82
	(0.043)	(0.041)		(0.061)	(0.039)	
10 years to maturity	0.157***	0.575***	0.72	–0.014	0.564***	0.73
	(0.050)	(0.042)		(0.073)	(0.037)	
Corporate bonds[b]						
Aaa/AAA-rated	0.040	0.310***	0.41	–0.003	0.352***	0.44
	(0.033)	(0.041)		(0.046)	(0.045)	
Baa/BBB-rated	0.051*	0.313***	0.45	–0.018	0.325***	0.44
	(0.028)	(0.036)		(0.046)	(0.042)	

Source: Authors' regressions.

a. Each row in each panel reports coefficients from a regression of daily changes in yields of the indicated asset on the two factors. Both samples exclude September 2001. Robust standard errors are in parentheses. Asterisks indicate statistical significance at the *10 percent, **5 percent, and ***1 percent level.

b. Both samples include only bonds with 20 or more years to maturity.

For each month we calculate the revisions to the forecasts of unemployment and CPI inflation for the current and next 3 quarters. Virtually by construction, these are uncorrelated across time.[13] We then regress these revisions against the identified target and path factors. Table 3 reports the estimates (in basis points per positive 1-bp factor realization) for both precrisis samples. The first notable result is that the R^2s 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 except that 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 coefficients on the target factor are statistically significant and negative for unemployment expectations at all four horizons (top panel of table 3). The path factor's coefficients are also all negative, but in only one case is the coefficient statistically significant (at the 10 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 3 of the 16 estimated coefficients for inflation (bottom panel) are negative, and none of these are statistically significant. However, the coefficient on the path factor in the current quarter's regression and that on the target factor in the next quarter's regression are significant at the 10 percent and the 5 percent level, respectively, 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 information about macroeconomic fundamentals that the public does not, and that monetary policy surprises arise from this informational advantage. In that case the forecast revision following a positive policy rate innovation encompasses the revelation of unexpectedly strong macroeconomic fundamentals as well as the contractionary effects of the innovation itself.

I.B. Forward Guidance since the Financial Crisis

The evidence that market participants and professional forecasters are influenced by FOMC forward guidance is suggestive for the current

13. Krane (2011) 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. Regressions Estimating Private Forecast Responses to Target and Path Factors, 1990–2007 and 1994–2007[a]

	February 1990–June 2007 sample			*February 1994–June 2007 sample*		
Forecast	*Target factor*	*Path factor*	*Adjusted R^2*	*Target factor*	*Path factor*	*Adjusted R^2*
Unemployment rate						
Current quarter	–0.21***	–0.08	0.07	–0.01	–0.08	0.01
	(0.08)	(0.06)		(0.08)	(0.07)	
Next quarter	–0.18**	–0.12	0.05	0.07	–0.16**	0.03
	(0.09)	(0.08)		(0.10)	(0.08)	
2 quarters hence	–0.27***	–0.13*	0.09	–0.06	–0.16*	0.03
	(0.08)	(0.07)		(0.11)	(0.09)	
3 quarters hence	–0.26***	–0.08	0.07	–0.03	–0.19**	0.04
	(0.09)	(0.08)		(0.09)	(0.08)	
CPI inflation						
Current quarter	0.25	0.47	0.02	–0.13	0.57*	0.02
	(0.33)	(0.36)		(0.34)	(0.31)	
Next quarter	0.14	0.30	0.03	0.25**	0.12	0.03
	(0.11)	(0.24)		(0.13)	(0.12)	
2 quarters hence	0.11	–0.06	0.01	0.14	–0.04	0.01
	(0.14)	(0.13)		(0.10)	(0.16)	
3 quarters hence	0.13	0.07	0.01	0.04	0.27	0.03
	(0.20)	(0.20)		(0.14)	(0.25)	

Source: Authors' regressions.

a. Each row in each panel reports coefficients from a regression of changes in monthly forecasts of either the unemployment rate or CPI inflation on the two factors. Both samples exclude September 2001. Robust standard errors are in parentheses. Asterisks indicate statistical significance at the *10 percent, **5 percent, and ***1 percent level.

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 the FOMC's announcements of large-scale asset purchases (LSAPs).[14] There is significant evidence that LSAP policies can alter long-term interest rates. For example, Gagnon and others (2010) 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 their signaling of 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 has significantly influenced asset prices in the recent period. However, the recent impact of "pure" forward guidance, where the policy action is reflected solely in statement language, remains unclear.

To shed further light on the impact of forward guidance, we apply the GSS methodology to FOMC statements issued since the onset of the financial crisis. Table 4 presents our compilation of relevant statements and the language in each that we judge most pertinent to forward guidance.[15] The list includes the statements following every scheduled and unscheduled FOMC meeting since August 2007 (39 in all) as well as the November 25, 2008, Board of Governors press release that announced the first stage of QE1. (All LSAP announcements since that press release have been made in postmeeting FOMC statements.) Although several remarks in speeches and testimony by Federal Reserve officials also seem to have been interpreted by markets as forward guidance, we exclude

14. One exception is Wright (2012), 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. Swanson and Williams (2012) 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.

15. We omit 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.

Table 4. Forward Guidance in Official FOMC Statements, August 2007–December 2011[a]

Date of statement	*Federal funds target rate (%)*	*Relevant language*
August 7, 2007	5.25	". . . the Committee's predominant policy concern remains the risk that inflation will fail to moderate as expected."
August 17, 2007	5.25	". . . the downside risks to growth have increased appreciably."
September 18, 2007[b]	4.75	"Developments in financial markets . . . have increased the uncertainty surrounding the economic outlook."
October 31, 2007	4.50	". . . the upside risks to inflation roughly balance the downside risks to growth."
December 11, 2007	4.25	"Recent developments . . . have increased the uncertainty surrounding the outlook for economic growth and inflation."
January 22, 2008[b]	3.50	"Appreciable downside risks to growth remain."
January 30, 2008	3.00	". . . downside risks to growth remain."
March 18, 2008	2.25	Same as previous
April 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."
June 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."
August 5, 2008	2.00	"Although downside risks to growth remain, the upside risks to inflation are also of significant concern to the Committee."
September 16, 2008	2.00	"The downside risks to growth and the upside risks to inflation are both of significant concern to the Committee."
October 8, 2008[b]	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."
October 29, 2008	1.00	". . . downside risks to growth remain."
November 25, 2008[b] (press release)	0–0.25	". . . purchases [of $100 billion of GSEs and $500 billion of MBSs] are expected to take place over several quarters."

Table 4. Forward Guidance in Official FOMC Statements, August 2007–December 2011[a] (*Continued*)

Date of statement	*Federal funds target rate (%)*	*Relevant language*
December 16, 2008	0–0.25	". . . 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."
January 28, 2009	0–0.25	"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."
March 18, 2009 (QE1 announcement)	0–0.25	". . . the Committee will maintain the target range for the federal funds rate at 0 to ¼ 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 [MBSs], 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."
April 29, 2009	0–0.25	". . . 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."
June 24, 2009	0–0.25	". . . 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."

(*continued*)

Table 4. Forward Guidance in Official FOMC Statements, August 2007–December 2011[a] (*Continued*)

Date of statement	*Federal funds target rate (%)*	*Relevant language*
August 12, 2009	0–0.25	"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."
September 23, 2009	0–0.25	". . . economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period. . . . [MBS and GSE purchases will finish by the] end of the first quarter of 2010."
November 4, 2009	0–0.25	". . . economic conditions . . . are likely to warrant exceptionally low levels of the federal funds rate for an extended period [and the Committee will complete purchases of GSE debt of about $175 billion]."
December 16, 2009	0–0.25	". . . economic conditions . . . are likely to warrant exceptionally low levels of the federal funds rate for an extended period."
January 27, 2010	0–0.25	Same as previous
March 16, 2010	0–0.25	Same as previous
April 28, 2010	0–0.25	Same as previous
June 23, 2010	0–0.25	Same as previous
August 10, 2010	0–0.25	Same as previous, plus "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 [MBSs] in longer-term Treasury securities."
September 21, 2010	0–0.25	Same as June 23, plus "The Committee also will maintain its existing policy of reinvesting principal payments from its securities holdings."
November 3, 2010 (QE2 announcement)	0–0.25	Same as previous, plus "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."
December 14, 2010	0–0.25	Same as previous
January 26, 2011	0–0.25	Same as previous
March 15, 2011	0–0.25	Same as previous
April 27, 2011	0–0.25	Same as previous
June 22, 2011	0–0.25	Same as previous
August 9, 2011	0–0.25	". . . economic conditions . . . are likely to warrant exceptionally low levels of the federal funds rate at least through mid-2013."
September 21, 2011	0–0.25	Same as previous
November 2, 2011	0–0.25	Same as previous
December 13, 2011	0–0.25	Same as previous

Source: Board of Governors of the Federal Reserve System website at www.federalreserve.gov/newsevents/press/monetary/2012monetary.htm.

a. The November 28, 2008, press release was issued by the Board of Governors of the Federal Reserve System. All other statements were issued by the FOMC. GSE = government-sponsored enterprise; MBS = mortgage-backed security.

b. Statement was issued between regularly scheduled FOMC meetings.

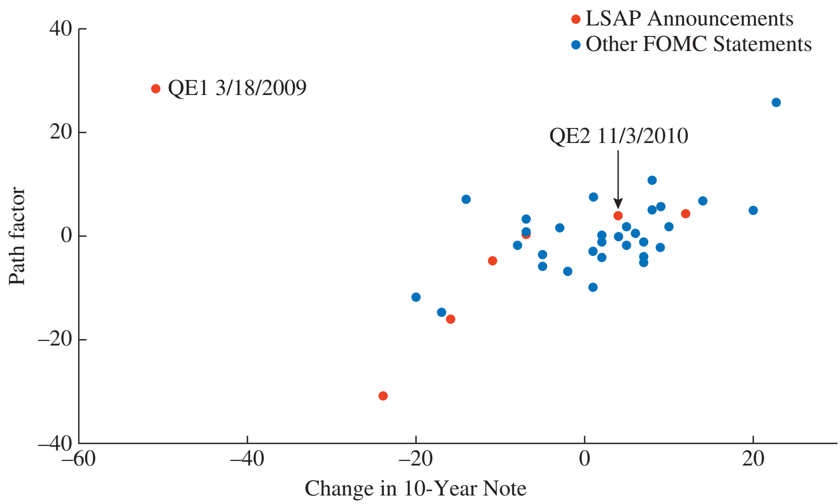
these from our analysis, since it is difficult to find an objective criterion for including any given instance.[16]

Mimicking our analysis of the precrisis period, we estimate factors from changes in expected future federal funds rates between the close of business the day before and the day of each of the announcements listed in table 4. Because the horizon over which forward guidance is issued seems to be longer since the crisis than it was during the precrisis 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 3-month-ahead federal funds futures contracts (again with a scale factor to account for the timing of FOMC meetings within the month) and the 2-, 3-, 4-, 5-, and 6-quarter-ahead Eurodollar futures contracts (again adjusted by the difference between the spot Eurodollar and federal funds rates). As before, we also adjust all rates for an assumed risk premium of 1 bp per month. Just as in the precrisis 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 is a scatterplot of the path factor against changes in the 10-year Treasury yield for the 40 dates listed in table 4. We distinguish statements containing announcements of LSAPs from other statements, and the statements most closely associated with QE1 and QE2 (March 18, 2009, and November 3, 2010, respectively) are labeled. The most striking feature of figure 1 is how much of an outlier the March 18, 2009, announcement is. On that date the 10-year yield fell (as intended) 51 bp while the path factor rose 32 bp. Markets interpreted the FOMC's announcement as indicating that the recovery would come sooner than previously thought and that, consequently, liftoff in the federal funds rate from the ZLB would come earlier than previously anticipated; the 2-quarter-ahead futures contract rose 60 bp from the day before. In contrast, the response to the QE2 announcement appears very much like the responses to 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, p. 217) find that "the

16. Probably the most relevant instances in this regard are speeches on December 1, 2008, and August 27, 2010, by Federal Reserve Chairman Ben 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.

Figure 1. Path Factor and Changes in 10-Year Treasury Yields on FOMC Statement Dates



Source: Haver Analytics/Federal Reserve H.15 and authors' calculations based on Chicago Mercantile Exchange data.

main effect on corporate bonds and [mortgage-backed securities] 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 fractions of variance in changes to expected future federal funds rates explained by the target and by the path factor estimated from all the announcements in table 4 except the outlier associated with QE1. The target factor dominates the variation in the current-quarter rate and the 1-, 2-, and 3-quarter-ahead rates, whereas the path factor explains the majority of variation in the three longer rates and negligible shares of the three shortest contracts. This pattern is broadly similar to that for the precrisis period reported in table 1. The main difference is that here the path factor dominates only those changes in expected interest rates that are 4 or more quarters ahead.

Table 6 reports asset price regression estimates analogous to those of table 2, based on the postcrisis factors. Since this sample is smaller, the estimates' associated standard errors are larger. These estimates strongly

Table 5. Decomposing the Variance in Changes in Expected Federal Funds Rates, August 2007–December 2011[a]
Percent

	Share of variance due to indicated factor	
Federal funds rate futures contract	*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

Source: Authors' calculations.

a. Expected interest rates are measured using daily federal funds futures prices and Eurodollar futures prices as described in the text. Numbers do not sum to 100 because the two factors do not explain all the variation in the expected rate changes.

Table 6. Regressions Estimating Asset Price Responses to Target and Path Factors, August 2007–December 2011[a]

Asset	*Target factor*	*Path factor*	*Adjusted R^2*
Treasuries			
2 years to maturity	0.592***	0.716***	0.79
	(0.096)	(0.160)	
5 years to maturity	0.404***	0.898***	0.66
	(0.143)	(0.165)	
10 years to maturity	0.250*	0.877***	0.58
	(0.131)	(0.103)	
Corporate bonds[b]			
Aaa/AAA-rated	0.058	0.631***	0.45
	(0.079)	(0.085)	
Baa/BBB-rated	0.065	0.556***	0.34
	(0.085)	(0.117)	

Source: Authors' regressions.

a. Each row in each panel reports coefficients from a regression of daily changes in yields of the indicated asset on the two factors. Robust standard errors are in parentheses. Asterisks indicate statistical significance at the *10 percent, **5 percent, and ***1 percent level.

b. Both samples include only bonds with 20 or more years to maturity.

resemble those from before the crisis. Both factors have a large positive influence on the 2- and 5-year yields, and the path factor substantially influences the 10-year Treasury yield and yields on seasoned Aaa/AAA- and Baa/BBB-rated corporate bonds. Given the disparity in economic conditions between the pre- and postcrisis sample periods, the similarity of forward guidance effects on asset prices is a striking finding.

Table 7. Regressions Estimating Private Forecast Responses to Target and Path Factors, August 2007–December 2011[a]

Forecast	*Target factor*	*Path factor*	*Adjusted R^2*
Unemployment rate			
Current quarter	–0.21	0.01	0.02
	(0.19)	(0.31)	
Next quarter	–0.29	0.02	0.03
	(0.26)	(0.47)	
2 quarters hence	–0.33	0.11	0.04
	(0.34)	(0.62)	
3 quarters hence	–0.35	0.15	0.03
	(0.39)	(0.73)	
CPI inflation			
Current quarter	1.80	2.05	0.07
	(1.82)	(4.17)	
Next quarter	0.53	0.44	0.04
	(0.64)	(1.43)	
2 quarters hence	–0.01	–0.02	0.00
	(0.12)	(0.27)	
3 quarters hence	0.07	0.23	0.03
	(0.11)	(0.29)	

Source: Authors' regressions.

a. Each row in each panel reports coefficients from a regression of changes in monthly forecasts of either the unemployment rate or CPI inflation on the two factors. Robust standard errors are in parentheses.

Table 7 reports estimates for the forecast innovation regressions using the postcrisis data. The estimated standard errors greatly exceed those from the analogous regressions estimated with precrisis data (table 3), so that none of the reported coefficients are statistically significant. Although we conclude that our regression estimates of the effects of forward guidance on macroeconomic expectations since the financial crisis are too imprecise to allow strong quantitative conclusions, the estimates are broadly consistent with those from the precrisis period.

II. 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. This approach builds on the long-standing 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 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 4 quarters before the policy action. The interest rate futures and professional forecasts together are sufficient to identify these forward guidance shocks. For the period 1996Q1 through 2007Q2, the estimated rule describes the 4-quarter-ahead expectation of the interest rate very well: the standard deviation of the 4-quarter-ahead forward guidance shock is 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) is 30 bp. However, the standard deviation of the anticipated component is 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 the four forward guidance shocks revealed every quarter have a single factor that explains most of the 4-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 we calculate 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 affect unemployment and inflation forecasts with the "wrong" sign, just as do 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."

II.A. 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:

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

The variables $\tilde{\pi}_t$ and $\tilde{u}_t$ are the policy-relevant measures of the inflation rate and the unemployment gap (the difference between the unemployment rate and a measure of the economy's non-accelerating-inflation, or "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 equation 1 is the last term, which involves 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 Federal Reserve's response to extraordinary events, such as the September 11 terrorist attacks or the 1997 Asian currency crisis, that warrant a rapid but temporary deviation from the normal policy prescription. 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. We 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 revisions to expectations, which are uncorrelated over time by construction, onto 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 sufficiently large *M* and under rational expectations, this can be done without loss of generality.[17] Although $\vec{\nu}_t$ is uncorrelated over time, its elements may be correlated

17. The reason is that 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.

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 Stefan Laséen and Lars Svensson (2011), who propose modeling forward guidance with an interest rate rule as we do when calculating the equilibrium of a New Keynesian 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.[18] 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 quarter 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 equation 1 on average. Then, taking expectations given information at the start of period $t-M+1$ yields

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

The residual term in equation 2 equals $\nu_{t-M,M}$ because the expected value $E_{t-M+1}[\nu_{t,j}] = 0$ 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

18. This conforms to the timing convention used for the Blue Chip macroeconomic expectations data.

expectations of equation 1 at two adjacent dates and difference the results. For $0 \leq j < M$ we obtain

$$(3) \qquad r_t^{j-1} - r_t^j = \rho_1 \left(r_{t-1}^{j-2} - r_{t-1}^{j-1} \right) + \rho_2 \left(r_{t-2}^{j-3} - r_{t-2}^{j-2} \right) + \left(1 - \rho_1 - \rho_2\right)\left[\phi_\pi \left(\tilde{\pi}_t^{j-1} - \tilde{\pi}_t^j \right) + \phi_u \left(\tilde{u}_t^{j-1} - \tilde{u}_t^j \right)\right] + \nu_{i-j,j}.$$

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.

II.B. Estimation

Implementing this methodology requires observations of private expectations and the estimation of μ, ρ_1, ρ_2, ϕ_π, 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 of each variable's average value 7 to 11 years after the current calendar year. We use the most recently published consensus long-run forecast for the unemployment rate as a measure of each quarter's natural rate of unemployment, u_t^*. From 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 contain observations for the period 1989Q2 through 2011Q4.

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:

$$\tilde{u}_t = \frac{1}{3}\sum_{j=-1}^{1}\hat{u}_{t+j}^{j-1}$$

$$\tilde{\pi}_t = \frac{1}{3}\sum_{j=-1}^{1}\pi_{t+j}^{j-1}.$$

Here we have abused our notation by supposing that $\tilde{u}_t$ and $\tilde{\pi}_t$ 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 $\tilde{u}_t$ and $\tilde{\pi}_t$ from the Blue Chip data up to 3 quarters ahead, so we set M in equation 1 equal to 4. That is, we assume that the process of communicating forward guidance begins 4 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 I from each quarter's final trading day. Our estimation uses only data from the period in which federal funds futures have been actively traded in large volume, which James Hamilton and others (2011) identify as beginning sometime in 1994. Because the estimation requires lags, we begin our sample with the forecasts of interest rates that prevailed in 1996Q1.[19] These prices give us the interest rates that our procedure requires when M equals 4: $r_t^0, r_t^1, \ldots, r_t^5$. The other observations required to calculate $\vec{v}_t$ are $\tilde{u}_t^0, \ldots, \tilde{u}_t^3$ and $\tilde{\pi}_t^0, \ldots, \tilde{\pi}_t^3$. 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 equation 1 sufficiently capture the interest rate's serial correlation, so that the policy shock is serially uncorrelated and ordinary least squares estimation 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 generalized

19. Beginning the sample in 1996Q1 also excludes an outlying observation from the Eurodollar futures market in 1994Q4 from our analysis. In that quarter the Eurodollar rate for delivery in 1995Q4 (averaged across that quarter's months) rose from 6.7 percent to 8.0 percent. However, it had returned to 6.5 percent by the end of 1995Q1. Such large changes in expected future interest rates were common in the early 1990s but occurred much less frequently in our sample period.

method of moments (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 $\nu_{t0}, \nu_{t-1,1}, \ldots, \nu_{t-M,M}$ 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

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

Here, $\gamma = (\mu, \rho_1, \rho_2, \phi_\pi, \phi_u)$ is the parameter vector, $g_t(\cdot)$ is a function that takes the parameter values and returns the vector $(\nu_{t0}, \nu_{t-1}, 1, \ldots, \nu_{t-M,M})$, 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 16 moment restrictions to estimate 4 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 assumption would be violated if the FOMC gave forward guidance more than 4 quarters in advance. In that 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.[20]

As noted above, our estimation sample begins in 1996Q1. We consider the crisis period that arguably began in 2007Q3 to be unique, and

20. A violation of our moment condition could also arise from mismeasurement 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 $g(\gamma)$. 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.

so we end our estimation sample with 2007Q2. The estimated interest rate rule is

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

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 overidentifying restrictions.

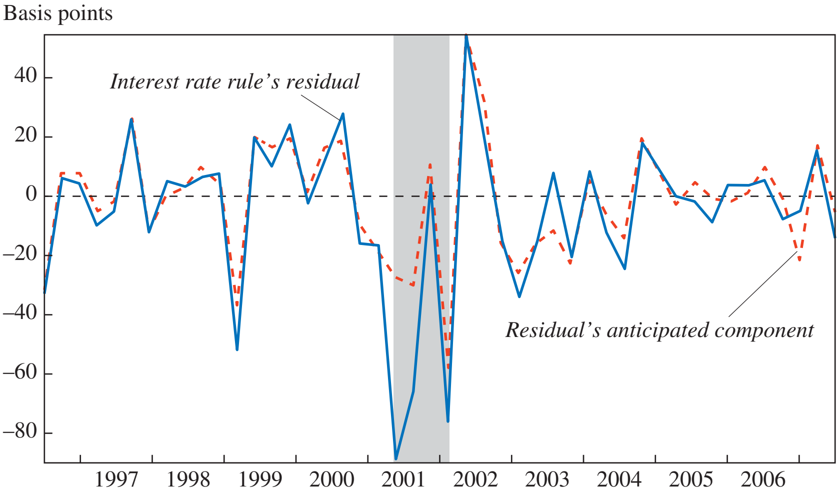
Two features of the interest rate rule are worth noting. First, we find an important role for second-order autoregressive dynamics. This gives the interest rate's response to a one-time innovation (holding $\tilde{u}_t$ and $\tilde{\pi}_t$ fixed) a hump shape: monetary policy adjustments start small, 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.

II.C. 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 standard deviations of the forward guidance shocks by horizon are 12, 20, 13, 11, and 9 bp for $\nu_{t,0}$ through $\nu_{t,4}$, respectively. As noted above, the fact that the 4-quarter-ahead forward guidance shock $\nu_{t,4}$ has such a small standard deviation suggests that the estimated rule summarizes medium-run expectations of the federal funds rate very well. We can use these estimates to calculate a variance decomposition of the interest rate rule's intercept.[21] 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 in the 1 to 3 quarters before then.

21. 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, 1996–2007[a]



Source: Authors' calculations.
a. Shading indicates the 2001 recession.

Figure 2 gives a visual perspective on this decomposition. It plots the composite residual for the interest rate rule $\sum_{j=0}^{4} \nu_{t-j,j}$ as well as 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 is 0.9. At the onset of the 2001 recession, however, the two series differ by 62 bp, reflecting the well-known sudden reversal of the monetary policy stance at that date. In the second quarter of 2001, the difference is 37 bp. Two events that do not show up with particularly large values of $\nu_{t,0}$ are the Asian financial crisis and September 11. The estimate of $\nu_{1997Q3,0}$ is only –0.8 bp. It turns out that markets anticipated during the previous quarter most of the monetary policy accommodation provided in that quarter. Following September 11, the FOMC increased accommodation only in 2001Q4, because the Federal Reserve concentrated on maintaining the orderly functioning of financial markets in the final weeks of 2001Q3. Nevertheless, market participants anticipated this move, so it shows up in $\nu_{2001Q3,1}$, estimated at –85 bp.

Since each realization of $\vec{\nu}_t$ moves the entire expected path of interest rates, it is reasonable to suppose that its elements correlate with each other. Indeed, such correlation underlies the factor analysis of GSS. The sample correlation matrix is as follows:

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

The fact that $\nu_{t,0}$ is negatively correlated with both $\nu_{t,3}$ and $\nu_{t,4}$ suggests that the public 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.

II.D. Factor Analysis

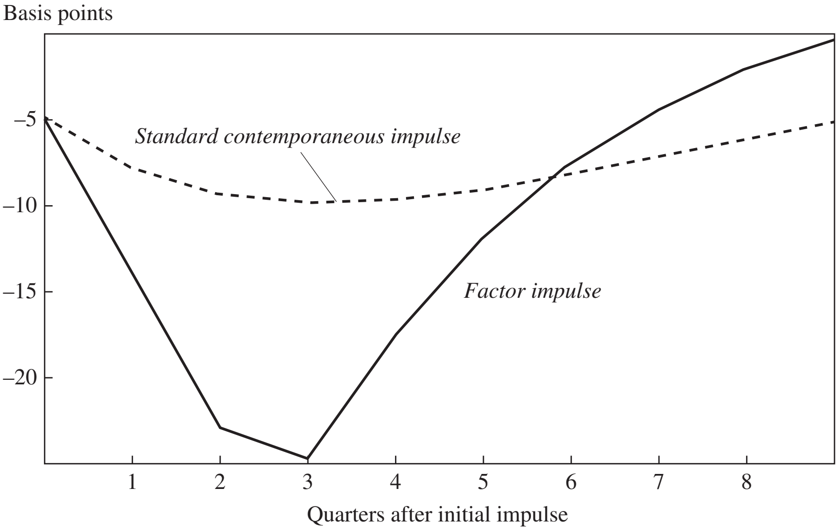
Although the correlations among the five shocks contributing to the interest rate rule's intercept are not large, GSS's successful use of factor analysis motivates us to investigate how a factor model explains them. The negative correlations of $\nu_{t,0}$ with $\nu_{t,3}$ and $\nu_{t,4}$ hint at a single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

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

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

The maximum-likelihood estimates of the factor loadings from this model are 5, 6, 4, –3, and –7 basis points for $\nu_{t,0}$ through $\nu_{t,4}$, respectively. These estimates reveal that the factor does indeed tilt the path of monetary accommodation: a 1-standard-deviation negative realization lowers the interest rate rule's intercept by about 5 bp for each of the next 3 quarters and increases it by about the same amount for the following 2 quarters. The factor model's remaining parameters describe the standard deviations of the idiosyncratic errors in e_t. These estimates—11, 19, 13, 10, and 6 for $\nu_{t,0}$ through $\nu_{t,4}$, respectively—show that the factor accounts for about 15 percent of the variance of $\nu_{t,0}$, about 10 percent of the variance of $\nu_{t,1}$, $\nu_{t,2}$, and $\nu_{t,3}$, and about 60 percent of the variance of $\nu_{t,4}$. That is, the factor

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



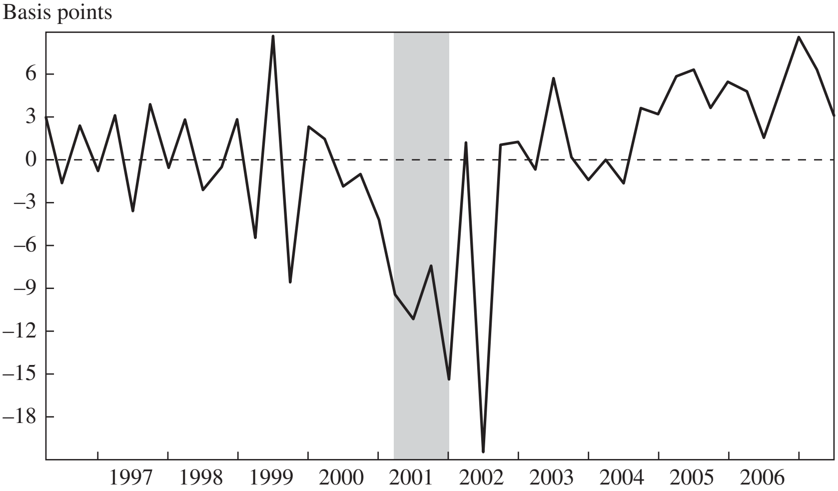
Source: Authors' calculations.

accounts for most of 4-quarter-ahead forward guidance but leaves most forward guidance issued at shorter horizons unexplained.

Figure 3 plots the direct interest rate effects (that is, omitting any possible endogenous responses of inflation or unemployment) over 9 quarters of a 1-standard-deviation shock to the factor. 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 3 quarters after the standard contemporaneous impulse and then begins a slow rise back to its mean. The interest rate also falls for 3 quarters following the factor shock, but it falls much more relative to the initial response. Thereafter the impulse's effects dissipate quickly: after 9 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, whereas positive realizations increase the speed of impact of contractionary policy.

Figure 4 plots over time the identified policy acceleration factor scaled by its impact on the current interest rate. This measure achieved its maximum value of 9 bp in 1999Q2, although its value in the next quarter almost

Figure 4. Estimated Policy Acceleration Factor, 1996–2007



Source: Authors' calculations.
a. Shading indicates the 2001 recession.

exactly offset this promised accelerated stimulus. Its minimum of −21 bp occurred in the wake of the 2001 recession, in 2002Q2. In that quarter the 1-, 2-, and 3-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, respectively.) Its other large and negative realizations occurred during the 2001 recession itself, when the upward unemployment forecast revisions were even larger. It appears that the FOMC successfully signaled its intention to accelerate accommodation following adverse unemployment news in 2001 and 2002.

II.E. Asset Price and Forecast Responses to Forward Guidance Shocks Identified from an Interest Rate Rule

One clear virtue of the GSS path factor is its documented impacts on asset prices that are 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 8 reports the estimated

Table 8. Regressions Estimating Asset Price Responses to Forward Guidance Shocks Identified from an Interest Rate Rule, 1996Q1–2007Q2[a]

		Shock					
Asset	*Constant*	$\nu_{t,0}$	$\nu_{t,1}$	$\nu_{t,2}$	$\nu_{t,3}$	$\nu_{t,4}$	*Adjusted* R_2
Treasuries							
2 years to maturity	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 years to maturity	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 years to maturity	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)	
Corporate bonds[b]							
Aaa/AAA-rated	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/BBB-rated	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)	

Source: Authors' regressions.

a. Each row reports coefficients from a regression of changes in yields of the indicated asset from the last trading day of a quarter to that of the next on a constant and on shocks $\nu_{t,0}$ through $\nu_{t,4}$, where $\nu_{t,0}$ is the monetary policy shock that occurs contemporaneously with announcement *t,* and the remaining shocks $\nu_{t,j}$ are forward guidance shocks indicating the change in monetary policy announced at *t* to occur in quarter *j.* The regression coefficients can be interpreted as the response (in basis points) of the indicated asset price to a 1-basis-point change in the indicated $\nu_{t,j}$. Standard errors are in parentheses. Asterisks indicate statistical significance at the *10 percent, **5 percent, and ***1 percent level.

b. Both samples include only bonds with 20 or more years to maturity.

coefficients, their standard errors, and the regressions' R^2s. We express all of the variables in bp, so the coefficients can be read as the response in basis points to a 1-bp 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 are associated with substantial changes in asset prices. A 100-bp increase in $\nu_{t,1}$ raises the 2- and 5-year Treasury yields 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.

Table 9. Regressions Estimating Forecast Revisions in Response to Forward Guidance Identified from an Interest Rate Rule, 1996Q1–2007Q2[a]

Change in forecast[b]	*Constant*	*Shock* $\nu_{t,0}$	$\nu_{t,1}$	$\nu_{t,2}$	$\nu_{t,3}$	$\nu_{t,4}$	*Adjusted* R_2
Unemployment rate							
$u_t^{-1} - u_t^0$	–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)	
$u_{t+1}^0 - u_{t+1}^1$	–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)	
$u_{t+2}^1 - u_{t+2}^2$	–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)	
$u_{t+3}^2 - u_{t+3}^3$	–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)	
Inflation							
$\pi_t^{-1} - \pi_t^0$	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)	

Source: Authors' regressions.

a. Each row reports coefficients from a regression of quarterly revisions to forecasts of the unemployment gap or CPI inflation on a constant and on shocks $\nu_{t,0}$ through $\nu_{t,4}$, where $\nu_{t,0}$ is the monetary policy shock that occurs contemporaneously with announcement *t*, and the remaining shocks $\nu_{t,j}$ are forward guidance shocks indicating the change in monetary policy announced at *t* to occur in quarter *j*. Standard errors are in parentheses. Asterisks indicate statistical significance at the *10 percent, **5 percent, and ***1 percent level.

b. Each forecast revision is expressed as the forecast value for the period $t + j$ outcome made at time $t + j - n$ minus the same forecast value made at time $t + j - n - 1$, where $t + j$ is the subscript and n and $n + 1$ are the superscripts.

We find one aspect of the results in table 8 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-term rates plus a term premium, and the forward guidance affects only the expected short-term rates, then the responses should be nearly identical. The fact that they are not strongly suggests that our identified forward guidance shocks are affecting term premiums. Fully exploring this intriguing result lies beyond the scope of the present paper.

Table 9 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 forecasters consistently made a small (but statistically significant) 7-bp error in their final unemployment forecast. We see similar small but systematic errors in inflation expectations. The slope coefficients' standard errors are quite large (on the order of 20 to 30 bp), but nevertheless many of the coefficients on $\nu_{t,1}$ in the unemployment regressions are negative and statistically significant. That is, promises of more-restrictive policy in the next quarter are associated with reductions in 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 New Keynesian model requires that reductions to current and future interest rates be unanticipated if they are 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 effect of unanticipated forward guidance. However, neither can it 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:

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

Here $\eta < 0$ measures the extent to which the FOMC reacts to unemployment news received over the last L quarters, specified here as $\tilde{u}_t - \tilde{u}_t^L$. One might suppose that η will be large and negative if the FOMC becomes systematically worried about falling behind the curve following unemployment surprises. If $L \leq M$, then the newly added term in equation 4 is orthogonal to the instruments we used for estimation, so its presence will not affect 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 will influence the estimated ν's. Under this interpretation of the results in table 9, the FOMC's actions are history dependent. The estimated interest rate rule states the typical policy stance given economic conditions forecasted 4 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.[22]

II.F. Summary

What does the analysis of forward guidance identified from a standard interest rate rule tell us? First, and perhaps most important for the potential viability of forward guidance–based strategies today, the public and the 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 40 percent of the variance in the interest rate rule's disturbance 3 or 4 quarters in advance. Second, unanticipated accommodative forward guidance reduces the interest rates relevant for households' and firms' economic decisions. That is, it seems possible for the FOMC to influence longer-term interest rates that are outside of its direct control by communicating its intention to lower the short-term policy rate persistently.

III. Using Odyssean Forward Guidance

The foregoing analysis suggests that the FOMC has experience successfully communicating its intended 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 its "late 2014" statement language. In this section we investigate the consequences of interpreting that language as Odyssean forward guidance that implements the policy recommendations of Eggertsson and Woodford (2003) and others. There are legitimate concerns that forward guidance

22. We cannot estimate coefficients like η in equation 4 by regressing the measured values of $\vec{v}_t$ on expectations revisions, because the true values of $\vec{v}_t$ should be endogenously correlated with the expectations revision. Since the expectations revision is uncorrelated over time virtually by construction, neither can we 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.

of this kind places the FOMC's mandated price stability goal at risk. We consider these by forecasting the path of the economy under the present forward guidance and subjecting that forecast to two upside risks: higher inflation expectations and faster deleveraging by households and firms. We undertake 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. Under his proposal, the FOMC would announce specific conditions under which it will begin lifting its policy rate above zero: either unemployment falling below 7 percent or medium-term expected annual inflation rising above 3 percent would trigger liftoff from the ZLB. Bright-line threshold rules such as these are designed to maintain low interest rates even as the economy begins expanding on its own (as prescribed by Eggertsson and Woodford 2003) while providing safeguards against unexpected developments that might put the FOMC's 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 postcrisis deleveraging.

Our conclusions obviously depend on the assumed structure of the model economy and the values we assign its parameters. One might therefore 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 both interesting and relevant to policy, for at least two reasons. First, the model is very similar to other widely used models and is essentially the standard structural tool for monetary policy analysis in the United States and around the world. Second, the model's parameters are estimated using a rich array of macroeconomic data so that our analysis has a firm empirical grounding.

We begin by briefly describing 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.

III.A. The Model

The model is adapted from Justiniano and others (2011) and thus closely resembles many other medium-scale empirical New Keynesian models.[23] A single representative household owns all firms and supplies the economy's

23. The model is described in more detail in Brave and others (2012).

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.[24] Hence standard forward-looking Phillips curves connect wage and price inflation with the marginal rates 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, where "internal habit" refers to diminishing current utility in lagged own consumption. The combination of all these features is very close to that in models by Lawrence Christiano, Martin Eichenbaum, and Evans (2005), Frank Smets and Rafael Wouters (2007), and many others, so that knowledge of these models is sufficient for understanding the results.

The model has one feature that distinguishes it from other New Keynesian frameworks: the monetary policy interest rate rule.[25] This rule is given by equation 1, except that we set $\rho_2 = 0$ and replace $\tilde{u}_t$ with the policy-relevant output gap, $\tilde{y}_t$.[26] The policy-relevant measure of inflation in equation 1 is defined by

$$\tilde{\pi}_t = \frac{1}{4}\sum_{j=-1}^{2} E_t\hat{\pi}_{t+j} - \hat{\pi}_t^*, \tag{5}$$

where "^"denotes deviation from steady state. Equation 5 says that policy-relevant inflation is the deviation of a 4-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 4-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.

24. In 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.

25. The model and estimation involve other unique features, but these do not change the model's shock propagation mechanisms, which continue to resemble those in other medium-scale New Keynesian models. The model includes a financial accelerator as in Gilchrist, Ortiz, and Zakrajšek (2011), but this ends up being unimportant for the results.

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

We define the output gap as

$$\tilde{y}_t = \frac{1}{4}\sum_{j=-1}^{2} \mathrm{E}_t \hat{x}_{t+j}, \tag{6}$$

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

where L and F denote lags and leads, respectively, and λ is a smoothing parameter. Equation 6 defines the output gap as a 4-quarter moving average of detrended model output. Following Vasco Cúrdia and others (2011), the monetary authority detrends output using the filter given by equation 7. (We consider only stationary solutions.) This detrending approximates Hodrick-Prescott filtering. 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 inflation and the output gap up to 2 quarters ahead.

We use the GSS factor structure for the forward guidance shocks in equation 1. In particular, we allow there to be a target factor and a path factor driving forward guidance, both of which are independent and identically distributed 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. Corresponding to each current and forward guidance shock there is also an additive idiosyncratic shock. For the precrisis sample we set $M = 4$ in equation 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 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 prices, and long-run (10-year) inflation expectations taken from the Survey of Professional Forecasters. The current policy shock moves the current rate more than it does future rates, whereas the forward guidance and the inflation anchor shocks move expected future federal funds rates more than they do the current rate. This difference is a key source of identification.

Both the inflation anchor and the forward guidance shocks influence inflation, with the effects of the latter arising through the Phillips curve. We assume that the inflation anchor is very persistent, so that 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 future 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 1 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 precrisis sample. That said, one needs 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 assumed to follow an AR(1) process. Four of these shocks move real GDP and inflation (as measured by the GDP deflator) in the same direction on impact, so we refer to these as demand shocks. One, the discount shock, changes households' rate of time discounting. Another 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.[27] 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 other shocks move real GDP and inflation in opposite directions on impact, and so we call these supply shocks. These shocks directly change neutral technology, investment-specific technology, markups of intermediate goods prices, and households' disutility from labor. The last of these is assumed to follow an ARMA(1,1) process, to parsimoniously address low-frequency dynamics in hours worked and high-frequency variation in hourly wages. Other shocks that

27. These shocks enter because of the financial accelerator mentioned earlier. The net worth shock plays a negligible role in fluctuations, but 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.

are of small importance in accounting for the data are shocks that do not affect agents' decisions: idiosyncratic shocks to the various price measures used in estimation, and measurement error in the two financial variables described below.[28]

III.B. Estimation

We use a two-step procedure to assign values to our DSGE model's parameters. First, we estimate the model over the period from 1989Q2 (when federal funds futures contract data begin) to 2007Q2 (just before the onset of the financial crisis) under the assumption that forward guidance extends out 4 quarters. Second, for the period 2007Q3–2011Q4 we fix the non–forward guidance parameters at their estimated values (with four exceptions highlighted below) and reestimate forward guidance under the assumption that it extends out 10 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 from before 2007Q4 as well as the parameter values that were in force at that time.

Our estimates for the period 1989Q2–2007Q2 imply that most fluctuations are driven by the demand shocks.[29] The data used to estimate the model include growth rates of nominal GDP per capita, consumption, and investment; hours per capita worked in the nonfarm business sector; nominal compensation per hour worked in nonfarm business; the GDP deflator; the deflators corresponding to model-based measures of consumption and investment; the core personal consumption expenditures (PCE) deflator; core CPI; 10-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 nondurable goods and services, and investment includes business fixed investment, residential investment, and PCE on durable goods.[30] The interest rate spread is a weighted average of high-

28. Model-consistent measures of consumption prices do not correspond well with either of the measures commonly referenced by policymakers 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 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.

29. Technical details of the estimation are discussed in Brave and others (2012).

30. The remaining components of aggregate expenditures—government spending, net exports, and private inventory accumulation—are modeled as the government shock.

yield corporate and mortgage-backed bond spreads over 10-year Treasuries and an asset-backed bond spread over 5-year Treasuries, where the weights equal the shares of nonfinancial business, household mortgage, and household consumer debt in a measure of total private credit that includes both households' and nonfinancial businesses' debts.

Brave and others (2012) 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 coefficient 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. Brave and others (2012) demonstrate that the model's output gap corresponds well to the gap published by the Congressional Budget Office.

Second, the estimated model has large nominal and real rigidities. Partly because of 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 (for example, those of Galí and Gertler 1999 and Eichenbaum and Fisher 2007). The wage Phillips curve slope is also small but more in line with estimates that do not rely on the full structure of the model, such as those by Argia 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 elasticity of capacity utilization, investment adjustment costs, and habit are similar in magnitude to other estimates in the literature (for example, Justiniano and others 2011) and impart considerable inertia in response to shocks.

III.C. Policy Experiments

The macroeconomic outcomes from 2007Q3 to 2011Q4 are unusual compared with those of the period 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 reestimate the effects of forward guidance. This reestimation 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 2007Q3–2011Q4: 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 precrisis sample.[31] Consequently, the model sees discount shocks playing a larger role since 2007Q2 than at other times, 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 variance of the inflation anchor innovation to one-fourth its estimated value from the precrisis period. This choice 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 then. Finally, we assume a coefficient on the output gap in the model's policy rule that is three times the size of the precrisis estimate. Our motivation here is that the FOMC's policy response to a very large recession may be more aggressive than to a modest one. Together these assumptions increase the likelihood that the ZLB is binding in any given quarter since 2007Q3.

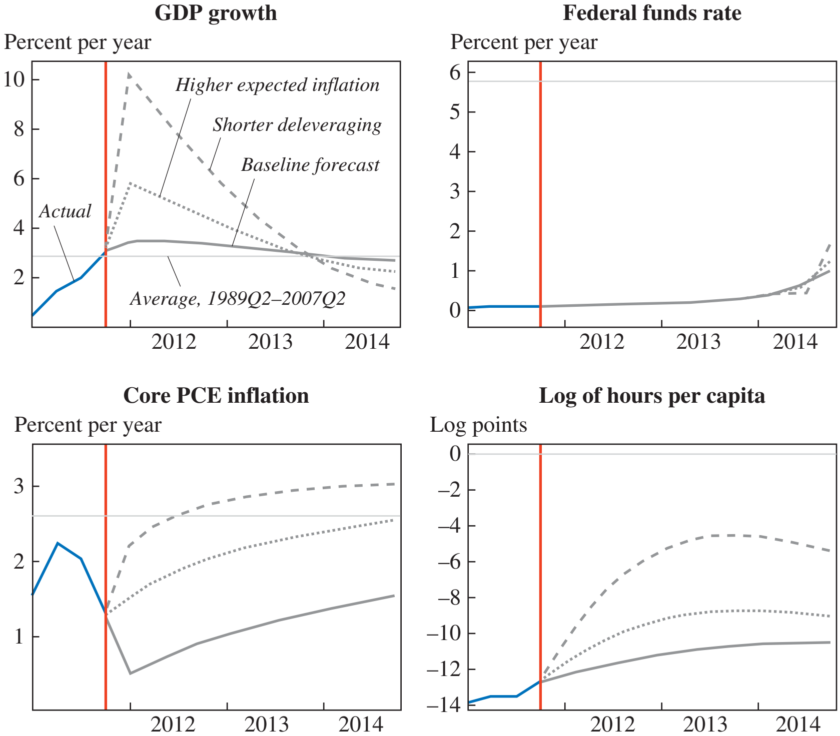
Given the calibrated parameters and precrisis estimates for the remaining parameters excluding forward guidance and the discount shock's variance, we reestimate the factor loadings, factor variances, and idiosyncratic variances that characterize forward guidance as well as the discount shocks' variance over the period 2007Q3–2011Q4 under the assumption that forward guidance extends out 10 quarters.[32] Our estimation of forward guidance in this period uses expected future federal funds rates going out 10 quarters from each date in the sample. With estimates in hand and data for this period, 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 2011Q4. One important implication of our calibration and estimated forward guidance is that the model sees the ZLB as binding from 2008Q4 until the end of our sample in 2011Q4.[33] 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.

31. The discount factor is commonly used to model episodes in which the ZLB is binding. See, for example, Christiano and others (2011).

32. We reestimate the discount shock's variance to ameliorate concerns that we have imposed excessive weight on this shock in explaining the crisis.

33. We say the ZLB is binding at any given date if, when all but the forward guidance factor shocks have been fed into the model to generate a conditional forecast beginning in 2008Q3, the forecasted path of the federal funds rate at each date would be below zero for at least one period at short horizons.

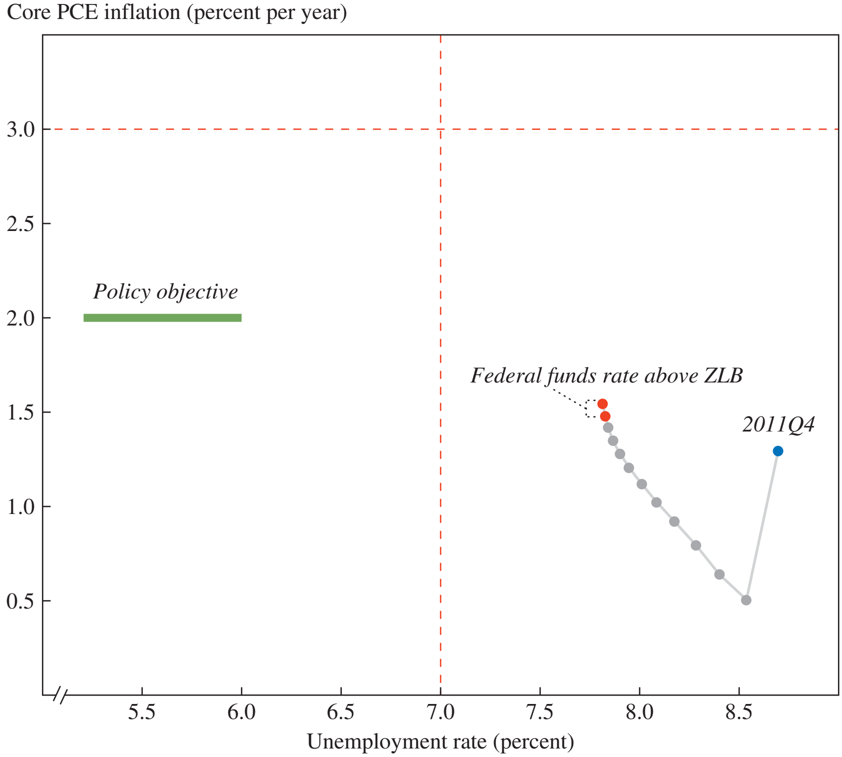
Figure 5. Baseline and Alternative Projections



Source: Authors' calculations.

Figure 5 displays the baseline forecast along with forecasts corresponding to two alternative scenarios described below. The horizontal line in each plot indicates the long-run average of the variable in question over the sample 1989Q2–2007Q2 (the logarithm of hours per capita 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 liftoff in the funds rate to about 1 percent at the end of 2014. This path is roughly in line with the "late 2014" forward guidance in the January and March 2012 FOMC statements. Corresponding to this path for the funds rate, the baseline forecast calls for growth slightly above trend for 2012, returning to trend in 2013 and 2014. Growth is sufficiently tepid that the log of hours per capita 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. Inflation and Unemployment in the Baseline Forecast



Source: Projections of the authors' model described in the text.

Figure 6 shows the baseline forecast in inflation-unemployment space.[34] The horizontal bar represents the FOMC's policy objective of 2 percent annual inflation, as described in the FOMC document "Longer-Run Goals and Policy Strategy," and the "central tendency" of longer-run unemployment of 5.2 to 6.0 percent reported in the January 2012 release of FOMC participants' economic projections. The 2011Q4 launch date for the forecast is labeled, with the economy's path proceeding from there. The smaller dots along the path indicate the period of a near-zero federal funds rate, and the two dots at the far end of the path indicate forecast dates where the

34. Our model does not have unemployment in it. However, an ordinary least squares regression of unemployment on hours per capita fits extremely well. We use this regression model to map our forecast for hours per capita into a forecast for unemployment.

federal funds rate has risen above the ZLB. The bright-line thresholds of 7 percent unemployment and 3 percent inflation are also shown.

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

It is worth emphasizing that beyond providing additional Odyssean forward guidance, such a threshold rule 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 2011Q4 onward under the assumption that an unanticipated event occurs in 2012Q1. The state of the economy in 2011Q4 includes all prior realizations of forward guidance, and agents in the model foresee exceptionally low interest rates through to 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 liftoff 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 the forecast starting from the same estimated state of the economy used to construct the baseline forecast. In the scenario with a sudden increase in long-run inflation expectations, 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.[35] 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 precrisis level of 0.75 but do not consider any additional 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.)

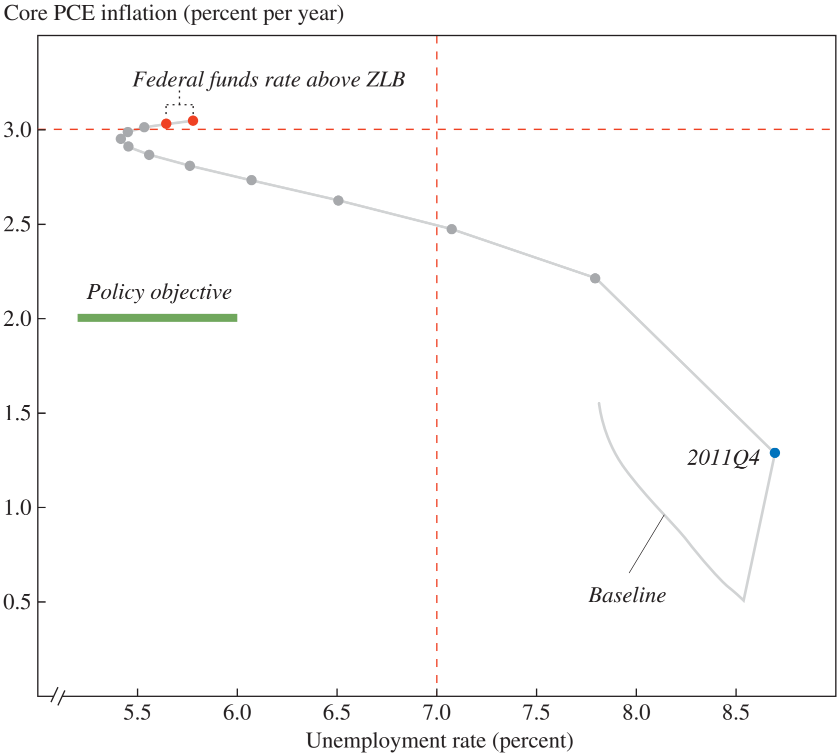
Each scenario involves solving for the forward guidance that reproduces the expected funds path through 2014Q2. This is accomplished by setting one of the idiosyncratic shocks to zero and then solving for the realization of the target and path factors in the first period, plus the other nine idiosyncratic shocks such that the funds path is matched exactly through 2014Q2. (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 occurs 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, annual inflation rises above 2 percent in both scenarios, although hours per capita remain relatively low. Presumably less expansionary monetary policy, involving an earlier liftoff of the funds rate from zero, would be required to forestall this 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 for comparison. Under faster deleveraging, unemployment falls faster and inflation rises by more than in the baseline. The economy crosses the 7 percent unemployment threshold in 2012Q3 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.

We 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 4 standard deviations of the inflation anchor innovation as estimated in the precrisis sample. The resulting forecast, condi-

35. 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 in the Forecast with Shorter Deleveraging

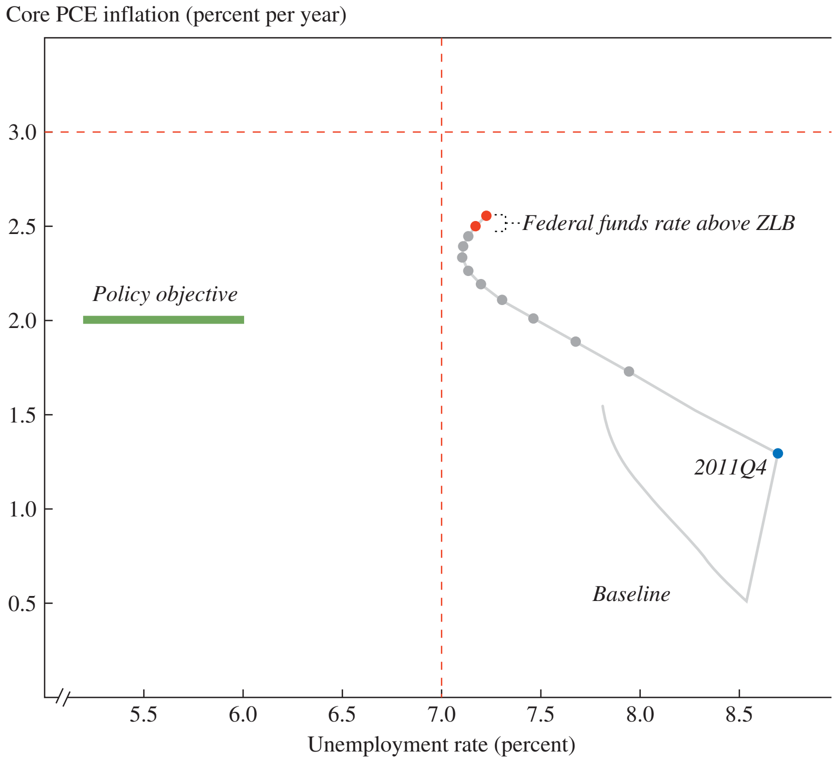


Source: Projections of the authors' model described in the text.

tioning on exceptionally low rates through at least the next 10 quarters, does generate a boom in GDP growth. However, because of the strong real and nominal rigidities we have estimated, neither unemployment nor inflation crosses its threshold within the next 3 years. The unemployment rate skirts its 7 percent threshold without crossing it, and inflation remains well below its 3 percent threshold, through the end of 2014. Although the 7/3 threshold policy would dictate keeping rates at the ZLB in this scenario, the turn in the direction of unemployment toward the end of the forecast horizon is worrisome.

This scenario illustrates a striking feature of New Keynesian 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 3-year horizon. This result depends on the assumed credibility

Figure 8. Inflation and Unemployment in the Forecast with Higher Expected Inflation



Source: Projections of the authors' model described in the text.

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, this kind of policy experiment might be very misleading. Nevertheless, nothing in the experience of the last 25 years suggests that a persistent change in inflation expectations necessarily generates a destabilizing loss of credibility.

IV. Conclusion

The empirical context we have provided shows that the FOMC has extensive experience at broadcasting its intended responses to macroeconomic developments. Indeed, macroeconomic forecasters and market participants anticipate about 80 percent of the FOMC's deviations from a simple interest rate rule. These communications have not been limited to a single "tight-versus-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 nonpublic information held by the Federal Reserve about future economic conditions instigates 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.

As expressed in its April 2012 statement, the most recent as of this writing, 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 by asking 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 by using the Chicago Federal Reserve Bank's estimated DSGE model to simulate two adverse scenarios. In the first, the deleveraging process presently keeping the economy at the ZLB accelerates and finishes sooner than expected, and in the second, long-run inflation expectations suddenly rise 1 full percentage point. We compare both simulations with the "bright-line" threshold policy proposal of Evans (2011), which calls for rate increases to begin when either unemployment falls below 7 percent or medium-term expected annual inflation rises above 3 percent. With faster deleveraging beginning in 2012Q1, the unemployment rate falls below its threshold for triggering rate increases in 2012Q3. In this case the policy provides useful insurance against the inflationary consequences of an unforeseen economic recovery. With an exogenous rise in inflation expectations occurring in 2012Q1, 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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