Macroeconomic Effects of FOMC Forward Guidance*

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Abstract

We distinguish between two kinds of FOMC forward guidance. *Odyssean* forward guidance changes private expectations by publicly committing the FOMC to future deviations from its underlying policy rule. Circumstances will tempt the FOMC to renege on these promises precisely because the policy rule describes its preferred behavior. All other forward guidance is *Delphic* in the sense that it merely forecasts the future. Prominent monetary policy proposals for providing more accommodation at the zero lower bound, such as the one elucidated by Eggertsson and Woodford (2003), rely on Odyssean forward guidance. Are these policies viable? We develop a new methodology based on a traditional interest rate policy rule that uses data on federal funds futures and market participant's expectations of future economic conditions to measure Odyssean forward guidance. Our empirical evidence suggests that the public has experience with Odyssean forward guidance, so monetary policies that rely upon it may be viable. Armed with this evidence, we investigate the consequences of providing Odyssean forward guidance at this time.

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1 Introduction

Since the onset of the financial crisis, Great Recession and modest recovery, the Federal Reserve has employed new language and tools to communicate the likely nature of future monetary policy accommodation. The most prominent developments have manifested themselves in the formal statement that follows each meeting of the Federal Open Market Committee (FOMC). In December 2008 it said "the Committee anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time." In March 2009, when the first round of large scale purchases of Treasury securities was announced, "extended period" replaced "some time." In the face of a modest recovery, the August 2011 FOMC statement gave specificity to "extended period" by anticipating exceptionally low rates "at least as long as mid-2013." The January 2012 FOMC statement lengthened the anticipated period of exceptionally low rates even further to "late 2014." These communications are referred to as *forward guidance*.

The nature of this most recent forward guidance is the subject of substantial debate. Is "late 2014" an unconditional promise to keep the funds rate at the zero lower bound (ZLB) beyond the time policy would normally involve raising the federal funds rate? One might reach this conclusion because such a policy is suggested by the monetary policy studies of Krugman (1999), Eggertsson and Woodford (2003) and Werning (2012). Alternatively, is "late 2014" simply conditional guidance based upon the sluggish economic activity and low inflation expected through this period?[1] At the most intuitive level, "late 2014" is simply a factual declaration of future policy intentions if the FOMC's underlying interest-rate reaction function, or policy rule, currently indicates a lift-off from the ZLB within the late 2014 time-frame. "Late 2014" has a prescriptive component whenever the underlying interest-rate reaction function would dictate earlier lift-off dates given the identical conditioning data.

Our paper sheds light on these issues and the potential role of forward guidance in the current policy environment. Motivated by the competing interpretations of "late 2014," we distinguish between two kinds of forward guidance. *Odyssean* forward guidance changes private expectations by publicly committing the FOMC to future deviations from its underlying policy rule. Circumstances will tempt the FOMC to renege on these promises precisely because the policy rule describes its preferred behavior. Hence this kind of forward guidance resembles Odysseus commanding his sailors to tie him to the ship's mast so that he can enjoy the Sirens' music.

All other forward guidance is *Delphic* in the sense that it merely forecasts the future.

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

Delphic forward guidance encompasses statements that describe only the economic outlook and typical monetary policy stance. Such forward guidance about the economic outlook influences expectations of future policy rates only by changing market participants views about likely outcomes of variables that enter the FOMC's policy rule.

Forward guidance can be *revealing* or *confirming*. Odyssean forward guidance is always revealing in the sense that it tells market participants something of which they were unaware before it was communicated. Delphic forward guidance can be revealing, for example if the FOMC is believed to have superior knowledge about the future path of the economy, but it can also be confirming in the sense that it merely reflects private agents' expectations back at them. These distinctions are similar to those made by Ellingsen and Söderström (2001), Romer and Romer (2000) and Kohn and Sack (2003).

The monetary policies elucidated by Krugman (1999), Eggertsson and Woodford (2003) and Werning (2012) rely on Odyssean forward guidance, and these have inspired several policy proposals for providing more accommodation at the ZLB. The more aggressive policy alternatives proposed include Evans's (2012) state-contingent price-level targeting, nominal income-targeting as advocated by Romer (2011), and conditional economic thresholds for exiting the ZLB proposed by Evans (2011). These proposals' benefits depend on the effectiveness of FOMC communications in influencing expectations. Fortunately, there exists historical precedent with which we can assess whether FOMC forward guidance has actually had an impact. The FOMC has been using forward guidance implicitly through speeches or explicitly through formal FOMC statements since at least the mid-1990s. Language of one form or another describing the expected future stance of policy has been a fixture of FOMC statement language since May 1999. The first part of this paper uses data from this period as well as from the crisis period to answer two key questions. Do markets listen? When they do listen, do they hear the oracle of Delphi forecasting the future or Odysseus binding himself to the mast?

Our examination of whether markets are listening to forward guidance builds on prior work by Gürkaynak et al. (2005). They follow Kuttner (2001) by overcoming the usual problem of monetary policy endogeneity with observations of federal funds rate futures prices in short windows of time surrounding the release of FOMC statements. Using a sample covering July 1991 through December 2004, they find that FOMC statements are associated with significant affects on federal funds futures and on Treasury yields that are not due to surprise changes in the federal funds target itself. For the current situation, this evidence is suggestive but not conclusive because it covers a period before the attainment of the ZLB robbed the FOMC of its principal policy lever. Evidence that FOMC statements have had significant affects in this period is found in Gagnon et al. (2010) and Krishnamurthy and

Vissing-Jorgensen (2011). These papers focus on FOMC statements announcing large scale asset purchases, "QE1" and "QE2," and find they have had significant affects on asset prices. Complementary to these studies we use Gürkaynak et al. (2005)'s methodology to study the asset price effects of *all* FOMC statements during and after the crisis pertaining specifically to monetary policy (as opposed to policies aimed at helping the functioning of credit markets). We find results that are similar to, if not even stronger than, those of Gürkaynak et al. (2005). That is, we confirm that during and after the crisis, FOMC statements have had significant affects on long term Treasuries and also corporate bonds and that these effects appear to be driven by forward guidance.

Studying federal funds futures rates during the day FOMC statements are released identifies forward guidance, but does not disentangle its Odyssean and Delphic components. If the public believes that the FOMC reveals proprietary information about the economy's future path in its statements, then asset markets will respond. In such a scenario the identified forward guidance would be Delphic. To answer our second key question, we develop a framework for measuring forward guidance based on a traditional interest rate rule that identifies only Odyssean forward guidance. The identification cleanses changes in expected federal funds rates of revisions to private expectations of future economic activity. By definition all Delphic forward guidance embodies itself within these expectations, so the "cleansed" residuals from the interest rate rule applied to federal funds futures data reflect Odyssean guidance. We employ this framework using data from 1996 through 2007 using expectations observations from the Blue Chip Survey of Economic Forecasters. We highlight here two results. First, the FOMC telegraphs most of its deviations from the interest rate rule at least one quarter in advance. Second, the Odyssean forward guidance successfully signaled that monetary accommodation would be provided much more quickly than usual and taken back more quickly during the 2001 recession and its aftermath. Overall, our empirical work provides evidence that the public has at least some experience with Odyssean forward guidance, so the monetary policies that rely upon it should not appear entirely novel.

The second part of the present paper investigates the consequences the Odyssean forward put in place with the "late 2014" statement language. On the one hand this language resembles the policy recommendations of Eggertsson and Woodford (2003) and could be the right policy for an economy struggling to emerge from a liquidity trap. On the other hand there are legitimate concerns that this forward guidance places the FOMC's mandated price stability goal at risk. We consider the plausibility of these clashing views 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.

We do this policy analysis using a medium-scale dynamic stochastic general equilibrium model (DSGE) developed at the Federal Reserve Bank of Chicago for just such a purpose. The model strongly resembles other DSGE models in the literature and is very similar to models used in central banks around the world.[2] Importantly, the model inherits the basic mechanisms that make forward guidance effective at the ZLB. The model includes some novel features designed to improve its empirical predictions but otherwise it should be familiar.

Evans (2011) has proposed conditioning the FOMC's forward guidance on outcomes of unemployment and inflation expectations. His proposal involves the FOMC announcing specific conditions under which it will begin lifting its policy rate above zero: either unemployment falling below 7 percent or expected inflation over the medium term rising above 3 percent. We refer to this as the 7/3 threshold rule. It is designed to maintain low rates even as the economy begins expanding on its own (as prescribed by Eggertsson and Woodford (2003)), while providing safeguards against unexpected developments that may put the FOMCs price stability mandate in jeopardy. Our policy analysis suggests that such conditioning, if credible, could be helpful in limiting the inflationary consequences of a surge in aggregate demand arising from an early end to the post-crisis deleveraging.

2 Do Markets Listen to FOMC Forward Guidance?

Since the FOMC used forward guidance implicitly through speeches or explicitly through formal FOMC statements long before the onset of the financial crisis there is data available to address the question posed in this section's title.[3] With these data Gürkaynak et al. (2005) (GSS) showed that forward guidance had a significant impact on asset prices prior to the crisis. In this section, we apply their methodology to measure forward guidance during the period beginning with the crisis to the end of 2011 and show that it has had similar effects on Treasury yields. That is, previous research shows that market participants *did* listen to the FOMC, and we confirm that they still *are* listening.

Rudebusch and Williams (2008) describe the modern history of explicit forward guidance before the financial crisis. From 1983 to 1999 the FOMC's views about the future policy path were put to a vote at each meeting. The vote was on the expected direction of future changes in the stance of policy between meetings. However, this information was only made public after the following meeting, when it was outdated and presumably of limited use to the

[2] As revealed in the minutes, the FOMC discussed DSGE models within the Federal Reserve System at the June 2011 meeting.

[3] From the beginning of his tenure as chairman of the FOMC, Alan Greenspan's speeches and Congressional testimony were studied to discern the direction of future policy. For example, The New York Times describes December 7, 1994 testimony before Congress as follows: "In an unusually clear signal that the Federal Reserve will continue raising interest rates, its chairman, Alan Greenspan, said today that inflation might rise soon and that the economy was growing briskly."

public. Following the May 1999 meeting the FOMC began including explicit language about the future stance of policy in the statements it releases after its meetings. The statement after that meeting included "the Committee ... adopted a directive that is tilted toward the possibility of a firming in the the stance of monetary policy." The language guiding expectations would change over time as the FOMC sought ways of maintaining transparency without confusing markets and adjusted to the evolving policy environment. But, language of one form or another describing the expected future stance of policy was to be a fixture of statement language going forward.[4]

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

GSS find that within the short time windows surrounding FOMC announcements from January 1990 through December 2004 there are significant changes in expected future federal funds rates.[5] They use factor analysis to gain insight into this finding. Factors are estimated from the behavior of five futures contracts that pin down the expected path of the federal funds rate over the next year without overlapping: the current-month and three-month-ahead federal funds futures contracts (with a scale factor to account for the timing of FOMC meetings within the month) and the two-, three-, and four-quarter-ahead Eurodollar futures contracts.[6] They find that just two factors explain more than 90 percent of the total variation in the futures contracts and reject the hypothesis that there are more than two fac-

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

[5] Prior to February 1994 the FOMC did not explicitly announce changes in its target for the federal funds rate. GSS show that nevertheless market participants were able to discern when the FOMC had changed its target within minutes of an open market operation.

[6] Avoiding overlap is desirable because very similar assets will tend to co-vary strongly, producing an additional factor even if that variation is orthogonal to all of the other assets being used to construct the factor.

tors. GSS emphasize the striking nature of these findings. 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 the surprise change in the federal funds rate target.

By performing a suitable rotation of the two unobserved factors, GSS show that they can be given a structural interpretation. One is a "target" factor, corresponding to surprise changes in the current federal funds target. The other is a "future path of policy," or simply "path," factor, corresponding to changes in futures rates that are independent of changes in the current funds rate target. The "path" factor is shown to be associated with significant changes in FOMC statement language. For example, its largest realization in absolute value occurs on January 28, 2004 when the federal funds target was not changed, but the phrase "policy accommodation can be maintained for a considerable period" was replaced with "the Committee believes it can be patient in removing its policy accommodation." This change in language was interpreted by markets as indicating the FOMC would begin tightening policy sooner than previously expected.

Using ordinary least squares regressions of changes in interest rates before and after the windows of time surrounding FOMC statements on the target and path factors they find that 75 to 90 percent of the explainable variation in five- and ten-year Treasury yields is due to the path factor rather than to changes in the federal funds rate target itself. Information in the statement about the future funds path that differs from prior market expectations or revelations about the FOMC's outlook for the economy that changes private expectations of that outlook both should affect anticipated future federal funds rates. Therefore their evidence strongly suggests that forward guidance, broadly conceived, has had an impact on asset prices prior to the financial crisis.

This evidence is suggestive for the current situation, but not conclusive, since it covers a period before the financial crisis and the attainment of the ZLB robbed the FOMC of its principal policy tool. Research on monetary policy announcements since the onset of the crisis has focused almost exclusively on the impact of announcing large scale asset purchases (LSAPs).[7] There is significant evidence that LSAP policies can alter long-term interest rates. For example, Gagnon, Raskin, Remache, and Sack (2010) present an event study of QE1 that documents large reductions in interest rates on dates associated with announcements of LSAPs. Also using an event-study methodology, Krishnamurthy and Vissing-Jorgensen (2011) evaluate the impact on interest rates of announcements associated with both QE1

[7] An 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.

and QE2. They uncover several channels through which these announcements have had an impact on asset prices. With QE2 a major role is ascribed to a “signalling” channel whereby financial markets interpreted LSAPs as signalling lower federal funds rates going forward. 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 had a significant impact in the recent period. However, the impact of “pure” forward guidance, where the policy action is solely reflected in statement language, in the recent period remains unclear.

We now use the GSS methodology to study the impact of FOMC statements in the recent period. Since the onset of the financial crisis the Federal Reserve issued a large number of press releases. However many of these were focused on programs designed to promote the smooth functioning of credit markets. As such they should not be construed as relating to what is conventionally thought of as monetary policy. For our study, we focus on only those press releases that we determine to be specifically related to monetary stimulus. In all but one case, these are statements released by the FOMC. Our compilation of relevant statements is reported in Table 1. There we list thirty nine FOMC statements and one Federal Reserve press release and include the statement language of each announcement that is most pertinent to forward guidance. The November 25, 2008 press release by the Federal Reserve is included in this list because this announced its intention to initiate a program to purchase $100 billion in GSE direct obligations and up to $500 billion in agency mortgage backed securities. This announcement was essentially the first stage of QE1. While there are several instances in which speeches and testimony by Federal Reserve officials seem to have been interpreted by markets as forward guidance, we chose to exclude these from our analysis since it is difficult to find an objective criterion for including any given instance.[8]

Table 1: Recent Monetary Policy Forward Guidance

Date	Rate	Forward looking language in statement
8/7/2007	5.25	the Committee’s predominant policy concern remains the risk that inflation will fail to moderate as expected.
8/17/2007	5.25	the downside risks to growth have increased appreciably
9/18/2007*	4.75	Developments in financial markets . . . have increased the uncertainty surrounding the economic outlook
10/31/2007	4.50	the upside risks to inflation roughly balance the downside risks to growth

[8]Probably the most relevant instances in this regard are speeches on December 1, 2008 and August 27, 2010 by Chairman Bernanke which were interpreted by markets as opening the door to the first and second round of large scale purchases of Treasury securities, respectively.

12/11/2007	4.25	Recent developments ... have increased the uncertainty surrounding the outlook for economic growth and inflation.
1/22/2008	3.50	Appreciable downside risks to growth remain.
1/30/2008	3.00	downside risks to growth remain
3/18/2008	2.25	same
4/30/2008	2.00	The substantial easing of monetary policy to date, combined with ongoing measures to foster market liquidity, should help to promote moderate growth over time and to mitigate risks to economic activity.
6/25/2008	2.00	Although downside risks to growth remain, they appear to have diminished somewhat, and the upside risks to inflation and inflation expectations have increased.
8/5/2008	2.00	Although downside risks to growth remain, the upside risks to inflation are also of significant concern to the Committee.
9/16/2008	2.00	The downside risks to growth and the upside risks to inflation are both of significant concern to the Committee.
10/8/2008*	1.50	Incoming economic data suggest that the pace of economic activity has slowed markedly in recent months. Moreover, the intensification of financial market turmoil is likely to exert additional restraint on spending, partly by further reducing the ability of households and businesses to obtain credit. Inflation has been high, but the Committee believes that the decline in energy and other commodity prices and the weaker prospects for economic activity have reduced the upside risks to inflation.
10/29/2008	1.00	downside risks to growth remain.
11/25/2008*	0-25bp	purchases (of $100b GSEs and $500b MBS) ... are expected to take place over several quarters
12/16/2008	0-25bp	... the Committee anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time...The focus of the Committee's policy going forward will be to ... stimulate the economy through open market operations and other measures that sustain the size of the Federal Reserve's balance sheet at a high level ... The Committee is also evaluating the potential benefits of purchasing longer-term Treasury securities.
1/28/2009	0-25bp	The Committee continues to anticipate that economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time. The Committee also is prepared to purchase longer-term Treasury securities if evolving circumstances indicate that such transactions would be particularly effective in improving conditions in private credit markets.

3/18/2009	0-25bp	. . . the Committee will maintain the target range for the federal funds rate at 0 to 1/4 percent and anticipates that economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period. The Committee sees some risk that inflation could persist for a time below rates that best foster economic growth and price stability in the longer term . . . The Committee decided today to increase the size of the Federal Reserve's balance sheet further by purchasing up to an additional $750 billion of (MBS), bringing its total purchases of these securities to up to $1.25 trillion this year, and to increase its purchases of (GSE) debt this year by up to $100 billion to a total of up to $200 billion . . . the Committee decided to purchase up to $300 billion of longer-term Treasury securities over the next six months. [QE1]
4/29/2009	0-25bp	Committee sees some risk that inflation could persist for a time below rates that best foster economic growth and price stability in the longer term. . . . economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period
6/24/2009	0-25bp	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.
8/12/2009	0-25bp	Although economic activity is likely to remain weak for a time, the Committee continues to anticipate that policy actions to stabilize financial markets and institutions, fiscal and monetary stimulus, and market forces will contribute to a gradual resumption of sustainable economic growth in a context of price stability. . . substantial resource slack is likely to dampen cost pressures, and the Committee expects that inflation will remain subdued for some time.
9/23/2009	0-25bp	economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period . . . (MBS & GSE purchases will finish by) end of the first quarter of 2010.
11/4/2009	0-25bp	economic conditions... are likely to warrant exceptionally low levels of the federal funds rate for an extended period (and will complete purchases of GSE debt of about $175b)
12/16/2009	0-25bp	economic conditions... are likely to warrant exceptionally low levels of the federal funds rate for an extended period
1/27/2010	0-25bp	same
3/16/2010	0-25bp	same
4/28/2010	0-25bp	same
6/23/2010	0-25bp	same
8/10/2010	0-25bp	same
9/21/2010	0-25bp	same

11/3/2010	0-25bp	same (and) In addition, the Committee intends to purchase a further $600 billion of longer-term Treasury securities by the end of the second quarter of 2011 [QE2]
12/14/2010	0-25bp	same
1/26/2011	0-25bp	same
3/15/2011	0-25bp	same
4/27/2011	0-25bp	same
6/22/2011	0-25bp	same
8/9/2011	0-25bp	economic conditions... are likely to warrant exceptionally low levels of the federal funds rate at least through mid-2013
9/21/2011	0-25bp	same
11/2/2011	0-25bp	same
12/13/2011	0-25bp	same

Note: Dates labeled with an asterisk indicate the statement came between regularly scheduled FOMC meetings. All statements except one were issued by the FOMC. The exception is 11/25/2008 which was issued by the Federal Reserve Board of Governors.

We estimate factors based on changes in expected future federal funds rates between the close of business the day before and the day of the announcements listed in Table 1.[9] Since the horizon over which forward guidance has been issued seems to be longer than the period studied by GSS we add two contracts to the set of contracts they examine. In particular our factors are estimated from the behavior of seven futures contracts that pin down the expected path of the federal funds rate over the next year and a half without overlapping: the current-month and three-month-ahead federal funds futures contracts (with a scale factor to account for the timing of FOMC meetings within the month) and the two-, three-, four-, five and six-quarter-ahead Eurodollar futures contracts. Similar to GSS we find that two factors explain most of the variability in the futures data. Henceforth we focus on the first two factors after they have been rotated as in GSS.

Figure 1 presents a scatter plot of the path factor and changes in the yield on 10-year Treasury notes for the forty dates listed in Table 1. Open circles indicate announcements of LSAPs and the statements most closely associated with QE1 and QE2 are indicated. The most striking feature of Figure 1 is how much of an outlier QE1 is. Whereas the other announcements indicate a positive relationship between the path factor and changes in the 10-year yield, QE1 indicates a negative relationship. Indeed on that day markets interpreted the FOMC's announcement as indicating the recovery would come sooner than previously thought and that consequently lift-off in the funds rate would come earlier than previously anticipated; the two-quarter-ahead futures contract rises 60bps from the day before. Based on Figure 1, QE2 appears very much like the other FOMC announcements. This difference is very much in line with the conclusions reached by Krishnamurthy and Vissing-Jorgensen (2011). In fact, Krishnamurthy and Vissing-Jorgensen (2011) pose the question in their introduction of whether the main impact of QE2 "may have been achievable with a statement by the Federal Reserve committing to lower federal funds rates, that is, without the Fed putting its balance sheet at risk in order to signal lower future rates." The apparently very different response to QE1 motivates us to exclude it from the remainder of our factor analysis.

When the target and path factors are calculated using all the announcements in Table 1 except the one associated with QE1 they explain 96 percent of the total variation in the seven futures contracts we employ for their estimation. The target factor alone explains 79 percent of the variation. Table 2 reports the fraction of variation in each of the seven futures

[9]We do not have access to the tick-by-tick data underlying the short windows of time studied by GSS but this should not be problematic since their 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 on the day of release of labor market data. When we use the daily windows on the GSS data post-February 1994 we find that the path factor we estimate is nearly identical to the analogous short-window-based path factor.

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

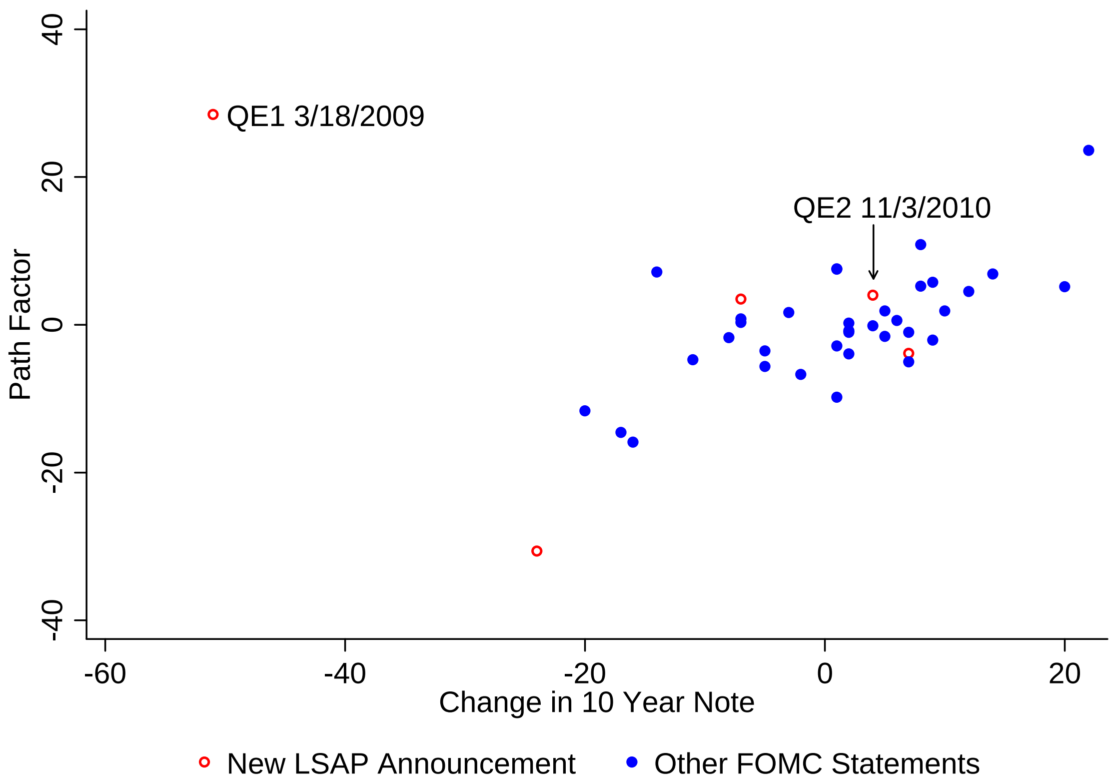


Table 2: Variation of Expected Rate Changes Due to Target and Path Factors

Changes in Expected Future Funds Rate	Target Factor	Path Factor
Current quarter	0.936	0
One-quarter ahead	0.980	0.001
Two-quarters ahead	0.926	0.025
Three-quarters ahead	0.566	0.346
Four-quarters ahead	0.441	0.530
Five-quarters ahead	0.313	0.675
Six-quarters ahead	0.162	0.792

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

contracts explained by each of the two factors. The target factor dominates the variation in the current quarter futures rate and the one-, two- and three-quarter ahead rates, while the path factor explains the majority of variation in the three longer rates and negligible share of the two shortest contracts after the current quarter one. This pattern is broadly similar to the one obtained by GSS. The main differences are that in our case the target factor accounts for a somewhat larger share of variation at the short end, while the path factor's explanatory power is more concentrated toward the long end. Still, the overall impression is that the impact of FOMC statements in the recent period is not very different from prior to the financial crisis. Given the disparity in the associated economic conditions this is a striking finding.

GSS documented substantial positive regression relationships between their identified factors and yields on financial assets. In particular, a positive one standard deviation realization of their Target factor raised the yields on two, five, and ten year Treasury notes by 41, 37, and 28 basis points, respectively.[10] Table 3 reports analogous regressions for the path and target factors as we identified them during the crisis period. Its first row reports results from regressing the day's change in the S&P 500 index on the factors, which displays no substantial relationship. This contrasts sharply with the GSS's finding that a one standard deviation realization of the target factor decreases the index by 4.3 percentage points. The next three rows report the regressions using the two, five, and ten year Treasury note yields. These resemble the estimates of GSS much more. Although our estimates are less precise than theirs, all of the estimated slopes are positive and all but one is statistically significant

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

Table 3: Response of Asset Prices to Target and Path Factors

	Constant	Target Factor	Path Factor	R^2
S&P 500	0.630**	0.034	-.023	0.05
	(0.286)	(0.029)	(0.034)	
Two-Year Note	-0.871	0.592***	0.613***	0.79
	(0.715)	(0.096)	(0.136)	
Five-Year Note	0.256	0.404***	0.768***	0.66
	(1.011)	(0.143)	(0.141)	
Ten-Year Note	0.590	0.250*	0.750***	0.57
	(1.100)	(0.131)	(0.088)	
Aaa Corporate Bond	2.051**	0.058	0.539***	0.45
	(0.969)	(0.079)	(0.073)	
Baa Corporate Bond	1.384	0.065	0.476***	0.38
	(1.087)	(0.085)	(0.100)	

Note: Sample is all FOMC statements on monetary policy, excluding announcements of programs to improve the functioning of credit markets. See Table 1. Target and path factors are defined in the main text. Heteroskedasticity consistent standard errors are in parenthesis; *, ** and *** indicate significance at 10 percent, 5 percent, and 1 percent respectively.

at the one percent level. Furthermore, our point estimates are somewhat larger than theirs. The table's final two rows give the results using yields on Aaa and Baa corporate bond 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. In contrast, a one-standard deviation positive path factor realization raises the Aaa yield by 54 basis points and the Baa yield by 48 basis points.[11]

3 Do Markets Hear the Oracle of Delphi or Odysseus?

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 or to separate its Odyssean and Delphic components. In this section, we present a new methodology which complements the event-study approach by identifying (in principal) all Odyssean forward guidance at the quarterly frequency. For this, we build on the longstanding practice of summarizing mone-

[11]We have confirmed that the implied six basis point drop in the quality spread is statistically insignificant.

tary policy with a parsimonious rule for setting the policy rate as a function of current or expected economic conditions.[12] By applying these rules both to actual policy decisions and 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. By construction, these anticipated deviations account for publicly known economic conditions, so they embody only Odyssean forward guidance.

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 simple quantitative models, the process of communication is transparent and frictionless, so it is tempting to equate the immediate market impacts of FOMC statements with the statements themselves. However, one must acknowledge frictions in the communication process that cloud such an interpretation. With this caveat, our work below will employ the stylistically useful shorthand of equating changes in market forecasts of interest rates adjusted for changes in expected macroeconomic conditions with the FOMC's Odyssean forward guidance.

We use our framework to answer this section's titular question in four stages. First, we show that market participants anticipate most deviations from the interest rate rule during our sample period, which runs from 1996:I through 2007:II. In this specific sense, the FOMC heavily uses Odyssean forward guidance. Because its use is so common and because our procedure does not restrict guidance to come from specific meetings or statements, we make no attempt in this paper to identify the specific messages behind particular realizations of our identified forward guidance shocks. Nevertheless, we do pause to show that many of the specific events GSS identify with large innovations to their path factor hardly register in our quarterly rule-based measures. Second, we follow GSS by regressing changes in yields and stock prices on the identified shocks. Like them, we find a substantial influence of forward guidance on Treasury yields. Furthermore, we show that expansionary forward guidance substantially lowers corporate bond yields. Third, we examine the effects of forward guidance on private expectations of unemployment and inflation. Although these estimates are somewhat imprecise, we find counterintuitive *negative* effects of contractionary forward guidance on unemployment expectations. We interpret them as arising from the FOMC adjusting policy quickly when revisions to unemployment expectations catch it "behind the curve." Fourth and finally, we examine the factor structure of our identified shocks. Whereas GSS find that only two factors explain most interest rate variation over the next year, we find evidence for only a single factor that explains most of the forward guidance at the farthest horizon we consider (four quarters) but much less at closer horizons. Nevertheless, we find this factor of interest because its horizon makes it the most relevant prior example

[12]See for example rules specified in Taylor (1993, 1999) and Reifschneider and Williams (2000).

of forward guidance for the current policy environment. The FOMC seems to have used this factor heavily during the 2001 recession and in its aftermath to promise an acceleration of its accommodation and an accompanying acceleration of its eventual removal.

3.1 Rule-Based Measurement of Odyssean Forward Guidance

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

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

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

The distinguishing feature of (1) is the last term involving the $M+1$ disturbances, $\nu_{t-j,j}$ for $j = 0, 1, \ldots, M$. The first of these, $\nu_{t,0}$, is the usual monetary policy disturbance that appears in conventional interest rate rules. It captures the Fed's response to extraordinary events that warrant a rapid but temporary deviation from the normal policy prescription, such as 9/11 or the Asian currency crisis of the late 1990s. The remaining disturbances are *forward guidance shocks*, because they are revealed to the public before they are applied to the interest rate rule. The public sees $\nu_{t,j}$ in quarter t, and the FOMC applies it to the rule j quarters hence. Gather all of the shocks revealed in quarter t into the vector $\vec{\nu}_t \equiv (\nu_{t,0}, \nu_{t,1}, \ldots, \nu_{t,M})$. Each realization of $\vec{\nu}_t$ influences the expected path of interest rates. To identify Odyssean forward guidance, we wish to map expectation revisions, which are uncorrelated over time by construction, into realizations of $\vec{\nu}_t$; so we assume that $\vec{\nu}_t$ is also uncorrelated over time. For M sufficiently large and under rational expectations, this is without loss of generality.[13] Although $\vec{\nu}_t$ is uncorrelated over time, its elements may be correlated with each other.

The practice of including exogenous shocks to the interest rate is commonplace. These shocks are not to be interpreted literally. Rather they absorb the effects of information that because of the practical need for parsimony we cannot include in the analysis. Our specification differs from conventional interest rate rules only in the assumption that the public observes some of the interest rate shocks before their implementation. The most similar recent work is that of Laséen and Svensson (2011), who propose modeling the interest

[13]This is because at any point in time a time series variable can be decomposed into the sum of its expected value based on an earlier information set and an orthogonal innovation.

rate rule as we do when calculating the equilibrium of an NK model with forward guidance.

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.[14] For any variable x, we denote its realization in quarter t with x_t. Then we use the notation x_t^j to denote the time $t-j$ conditional expectation of variable x_t. Since not all variables dated t are known by economic agents at the start of the quarter they are realized, the "nowcast" x_t^0 does not necessarily equal the realized x_t. For example, r_t^0 is the expectation at the beginning of t of the quarter's average policy rate, which can clearly change over the quarter. If x is not even revealed to the public during the quarter of its realization, then the "backcast" x_t^{-1} also might not equal x_t. The unemployment rate provides a relevant example. Its backcast differs from its realized value because the time taken for its tabulation delays its release.

To measure $\nu_{t-M,M}$, suppose that the public expects the FOMC to follow (1) on average. Then, using the public's expectations given information at the start of period $t-M+1$ yields

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

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

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

Equation (3) shows that $\nu_{t,j}$ equals the change within quarter $t-j$ in the expected interest rate for quarter t corrected for the change in the interest rate rule arising from revisions in private expectations. To understand its content, imagine the public reaction to an FOMC statement that contains pure Delphic forward guidance. By definition, this statement should lead the public to revise expectations for inflation and unemployment. However, because it is Delphic, the associated revision in interest rate expectations can be constructed from these more "fundamental" expectations and the interest rate rule (1). The inferred value of

[14] This conforms to the timing convention used for the macroeconomic expectations data we use for estimation.

$\nu_{t,j}$ remains unchanged. In contrast, Odyssean forward guidance contains information about future deviations from the interest rate rule. It is the direct effects of such announcements on interest rates that $\nu_{t,j}$ captures. Although Odyssean forward guidance also generally should influence private expectations of inflation and unemployment, such indirect effects get accounted for by the expectations data and do not manifest themselves in the measured Odyssean forward guidance shocks.

3.2 Estimation

Operationalizing the interest rate rule requires observations of private expectations and the estimation therewith of ρ_1, ρ_2, ϕ_π, and ϕ_u. For observations of inflation and unemployment expectations, we rely on the Blue Chip Economic Indicators forecast survey. At the beginning of each month, Blue Chip solicits projections for key economic variables, including quarterly growth in the Consumer Price Index and the civilian unemployment rate from about fifty private forecasters. From these it compiles a "consensus" forecast for each variable, which are then published on the tenth of the month. The forecasts cover the previous quarter's data (which might not yet be published at the time of the survey) and each quarter in the current and next calendar years. Therefore, the data always report a one-quarter backcast, a current quarter nowcast, and forecasts for at least the next four quarters.[15] These give us u_{t-1}^{-1} and π_{t-1}^{-1} (the 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, survey participants also report forecasts for each variable's average value seven to eleven years after the current calendar year. We use the most recently made consensus long-run forecast for the unemployment rate as a measure of each quarter's natural rate of unemployment, u_t^*. With this, we construct the expected unemployment gap in quarter $t+j$ as $\hat{u}_t^j \equiv u_t^j - u_t^*$. Our data set contains observations from the period beginning in 1989:II and extending to 2011:IV.[16]

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

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

[16] Krane (2011) searched for bias and forecast error predictability in the Blue Chip consensus forecasts for GDP growth and found none. Similarly, our investigations have revealed no evidence that the Blue Chip forecasts of inflation and unemployment are seriously deficient.

at the beginning of the next quarter. That is

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

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

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

Although the Blue Chip data contain forecasts of the federal funds rate, we prefer to base our measures of expected interest rates on futures' market prices. For this, we use transactions prices from the federal funds futures markets and from Eurodollar futures markets. In 1989, the Chicago Board of Trade introduced federal funds futures contracts that settled one to three months from the present at the average daily federal funds rate. These were very lightly traded until the FOMC began announcing the policy rate after each meeting in February 1994. Thereafter, the CBOT added contracts settling four to six months from the present. For estimation, we use only data from the period in which federal funds futures were actively traded, which Hamilton et al. (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 1996:I.[17] We measure expected interest rates for the next two quarters using market maker's quotes from the quarter's final trading day with a risk premium adjustment of one basis point per month. Expected interest rates at longer horizons are measured using analogous Eurodollar futures rates adjusted by the difference between the spot Eurodollar and federal funds rates summed with the one basis point risk price. Together, these two markets' prices give us the interest rates our procedure requires when M equals 4, $r_t^0, r_t^1, \ldots, r_t^5$. The other observations required to calculate $\vec{\nu}_t$ are $\widetilde{u}_t^0, \ldots, \widetilde{u}_t^3$ and $\widetilde{\pi}_t^0, \ldots, \widetilde{\pi}_t^3$. We can calculate these with the backcast, nowcast, and four quarterly forecasts in the Blue Chip data.

One frequent approach to estimating the parameters of an interest rate rule simply assumes that the autoregressive terms in (1) sufficiently capture the interest rate's serial cor-

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

relation, so that the policy shock is serially uncorrelated and ordinary least squares can be employed. Obviously, the presence of forward guidance violates this assumption, so we require an alternative estimator. We turn to a GMM implementation of an instrumental variables' strategy. From the Blue Chip data we can calculate $\hat{u}_t^M$ and π_t^M. These, r_{t-2}^{M-2}, and r_{t-1}^{M-1} are valid instruments for $\nu_{t,0}, \nu_{t-1,1}, \ldots, \nu_{t-M,M}$ because those monetary policy shocks are all revealed *after* the beginning of quarter $t - M$. Therefore, we can construct a valid GMM estimator based on the population moment conditions

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

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

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

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

The statement's emphasis on anticipated inflation outlooks leads us to read this as Delphic rather than Odyssean. 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.[18]

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

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

2007:II. The estimated interest rate rule is

$$r_t = -\underset{(0.02)}{0.05} + \underset{(0.02)}{1.60} \times r_{t-1} - \underset{(0.02)}{0.66} \times r_{t-2} - (1-0.94) \times \underset{(0.28)}{1.10}\ \widetilde{u}_t$$

$$+ (1-0.94) \times \underset{(0.18)}{2.32}\ \pi_t + \sum_{j=0}^{4} \nu_{t-j,j}$$

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

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

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

Given the estimated parameter values, we follow the procedure presented above to recover the history of $\vec{\nu}_t$ from the available data. Figure 2 uses these to provide a first indication of the importance of forward guidance. Its blue line plots the composite residual for the interest rate rule – $\sum_{j=0}^{4} \nu_{t-j,j}$ – and its green line plots its *forward guidance component*, which simply drops the contemporaneous shock $\nu_{t,0}$. At the onset of the 2001 recession the two series differ by 62 basis points. This reflects the well-known sudden reversal of the monetary policy stance at that date. In the second quarter of 2001, the difference equals 37 basis points. Two events that do *not* show up with particularly large values of $\nu_{t,0}$ are the Asian financial crisis and September 11. The estimated $\nu_{1997:III,0}$ equals only -0.8 basis points. It turns out that markets anticipated most of the monetary policy accommodation given during that quarter during the previous quarter. The FOMC increased accommodation following September 11 only in 2001:IV, because the Federal Reserve concentrated on maintaining the orderly functioning of financial markets in the final weeks of 2001:III. Nevertheless, market participants anticipated this move, so it shows up in $\nu_{2001:\mathrm{III},1}$, -85 basis points. Overall, the two series track each other quite closely. Indeed, their sample correlation equals 0.9.

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

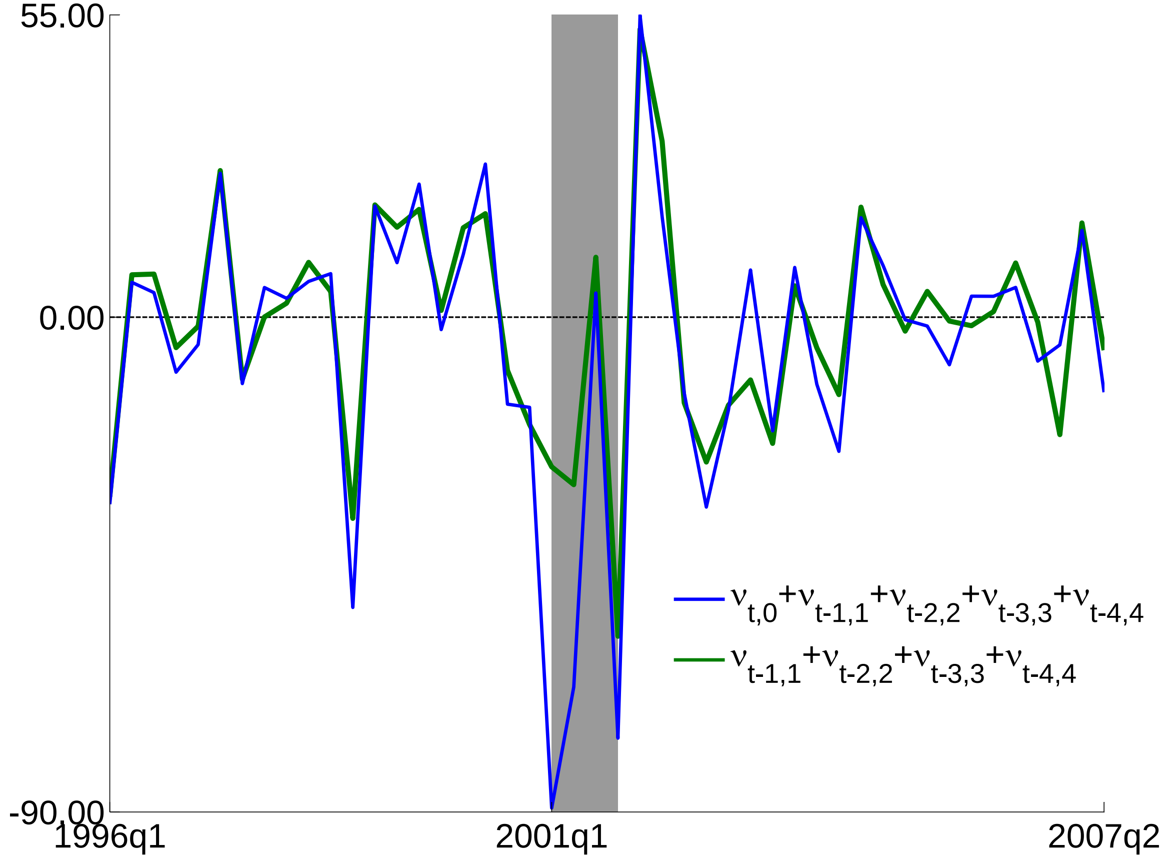


Table 4: Summary Statistics

Standard Deviations
(in basis points)

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

Correlations

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

This is the first noteworthy conclusion of our empirical analysis: the public anticipated most monetary policy "shocks" before their implementation.

Figure 2 begs the question of *when* the public divines the FOMC's intentions. Table 4 sheds some light on this issue with sample statistics for the elements of $\vec{\nu}_t$. Its top panel reports their sample standard deviations. The contemporaneous shock, $\nu_{t,0}$, has a 12 basis point standard deviation, and that for $\nu_{t,1}$ equals 20 basis points. The other standard deviations are between 9 and 13 basis points. We can use these estimates to calculate a variance decomposition of the interest rate rule's intercept.[19] Overall, it appears that the FOMC communicates about 40 percent of the monetary policy shock in the quarter before its realization and another 40 percent one to three quarters before then.

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 bottom panel of Table 4 gives the sample correlation matrix. Its first column shows that $\nu_{t,0}$ is *negatively* correlated with both $\nu_{t,3}$ and $\nu_{t,4}$, so the public apparently expects some "last-minute" monetary policy adjustments to be reversed in the relatively near future. Otherwise, $\nu_{t,0}$ is uncorrelated with any of the forward guidance shocks. These shocks also display relatively low correlations with each other. Overall, it is hard to

[19] 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.

conclude that one or two factors can account for most of the variance of these shocks.

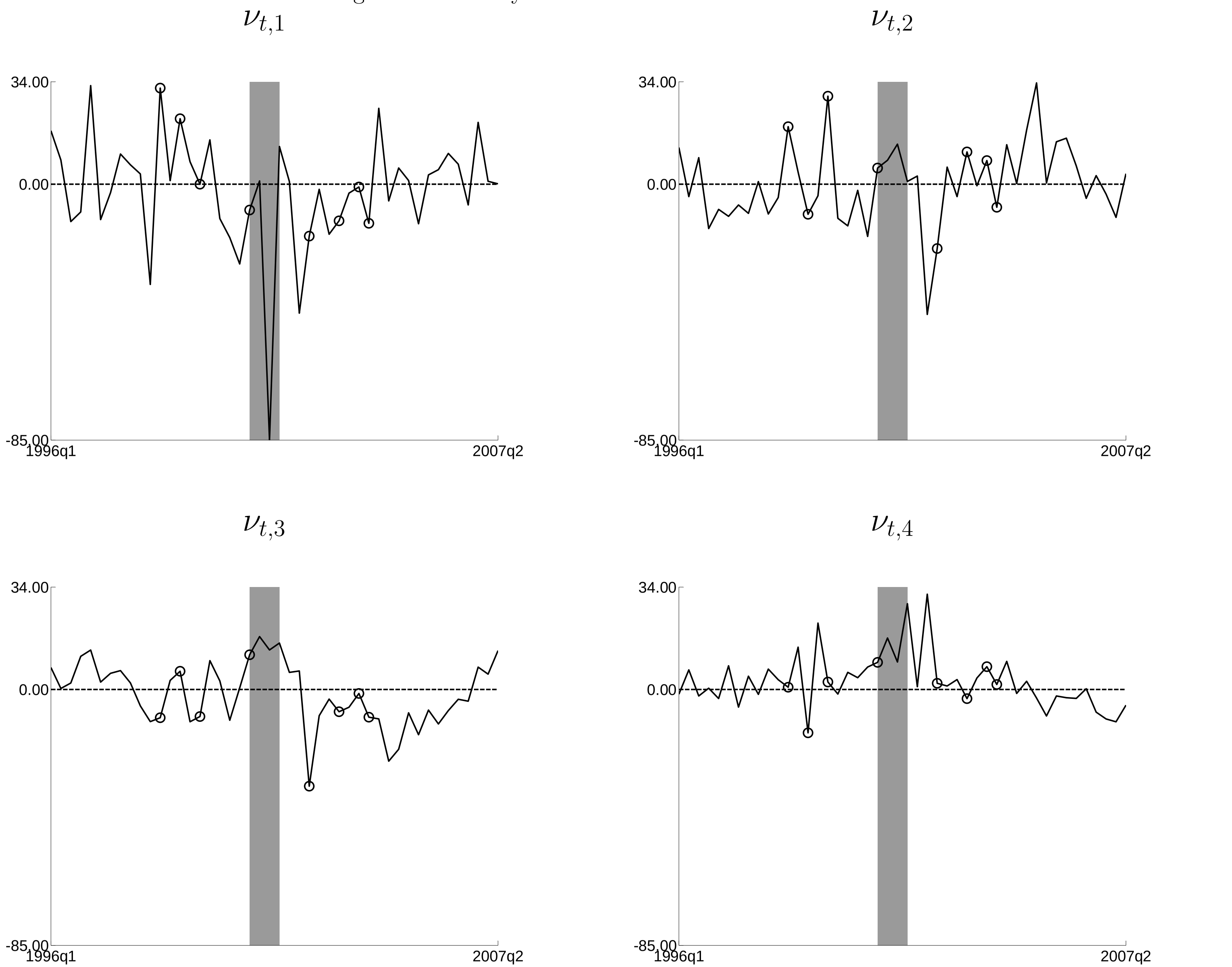
Since our estimated interest rate rule shocks clearly lack a strong factor structure, one might reasonably suspect that they differ substantially from the factors identified by GSS using much higher frequency data. We investigate the relationship between the rule-based shocks and the GSS factors further in Figure 3. Each of its four panels plots one of the four forward guidance shocks. On each plot, circles indicate the quarters containing the eight largest realizations of the path factor as reported by GSS in their Table 4 that occur within our sample period. The first of these occurs in 1998:IV. Although $\nu_{1,t}$ attains its highest value in that quarter, the path factor indicated *easing*. None of the other forward guidance shocks are particularly large and negative that quarter, so apparently the public eventually disregarded the statement accompanying the October 15 intermeeting rate cut that read in part

> Growing caution by lenders and unsettled conditions in financial markets more generally are likely to be restraining aggregate demand in the future. Against this backdrop, further easing of the stance of monetary policy was judged to be warranted to sustain economic growth in the context of contained inflation.

The next large realization of the path factor identified by GSS was in May 1999, when the FOMC statement focused on the possibility of rising inflation. That quarter's realization of $\nu_{1,t}$ was relatively high, 22 basis points, but not particularly exceptional. Another large path factor realization occurred two quarters hence in October 1999, when the statement read in part "... the Committee adopted a directive that was biased toward a possible firming of policy going forward." Although the statement further stressed that any future tightening would depend on "the balance of aggregate supply and demand and conditions in financial markets," the GSS path factor shot up and our estimate of $\nu_{t,2}$ equaled 29 basis points. Another example in which the GSS path factor and our forward guidance shocks agree comes from August 2002, when the path factor had its largest negative realization. Our estimate of $\nu_{t,3}$ hit its minimum in the sample -32 basis points, in the analogous quarter. Nevertheless, the quarters containing several of the path factor's largest realizations display unexceptional forward guidance from our perspective. The clearest example is the last. The largest positive realization of the path factor occurred on January 28, 2004 when the FOMC dropped "considerable period" from its statement. All four of our forward guidance shocks have relatively small realizations for the analogous quarter.

We can think of two possible reasons why large realizations of the path factor identified using high-frequency data fail to manifest themselves in our quarterly measures. First, it might be that at the daily frequency the FOMC statements contained Delphic content that

Figure 3: The Odyssean Forward Guidance Shocks



Note: In each plot, the circles correspond to quarters containing one of the ten largest realizations of the path factor identified by Gürkaynak, Sack, and Swanson (2005). The vertical axes measure each shock's realization in basis points.

eventually worked its way into the quarterly unemployment and inflation forecasts we use to measure public expectations. Second, market participants' first impressions of a given statement's content might not last through the current quarter. We have checked the first possibility by creating plots of revisions to unemployment and inflation forecasts that are analogous to those in Figure 3, and those revealed nothing worth reporting. Thus, we fall back on the second reason. The possibility that markets take time to eventually settle on the quantitative implications of a given qualitative statement from the FOMC seems to us worthy of further study.

3.4 Odyssean Forward Guidance and Macroeconomic Outcomes

One clear virtue of the GSS path factor is its documented impacts on asset prices relevant for private decisions. To achieve the same status for the identified Odyssean forward guidance shocks, we have regressed the same financial variables used in Table 3. 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 5 reports the estimated coefficients, their standard errors, and the regressions' R^2 values. We express all of the variables in basis points, so the coefficients can be read as the basis-point response to a one-basis-point change in the right-hand side variable.

Although the coefficients standard errors are not small, the regression estimates clearly show that the identified forward guidance shocks substantially influence (in the regression sense) asset prices. A one basis point increase in $\nu_{t,1}$ raises the 2 and 5 year Treasury yields by almost two basis points and the 10 year Treasury yield by about 1.5 basis points. The effects on the two corporate bonds are more modest, 0.65 and 0.69 basis points. 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.

We find two aspects of the results in Table 5 puzzling. First, the forward guidance shocks have much larger estimated effects on bond yields than does the contemporaneous monetary policy shock. However, the only substantial difference between $\nu_{t,j}$ and $\nu_{t,0}$ is a j-quarter implementation delay. If the Treasury rates correspond to the appropriate average of expected short rates plus a term premium and the forward guidance only impacted the expected short rates, then the responses should be nearly identical. The fact that they are not strongly suggests that our identified forward guidance shocks are impacting term premiums.

Table 5: Response of Asset Prices to Odyssean Forward Guidance

	Const.	$\nu_{t,0}$	$\nu_{t,1}$	$\nu_{t,2}$	$\nu_{t,3}$	$\nu_{t,4}$	R^2
2 Year Treasury	5.90	1.08***	1.98***	1.56***	0.70*	0.89*	0.77
	(4.47)	(0.37)	(0.22)	(0.33)	(0.42)	(0.50)	
5 Year Treasury	3.46	0.61*	1.83***	1.91***	1.43***	1.25**	0.78
	(4.31)	(0.36)	(0.21)	(0.32)	(0.40)	(0.49)	
10 Year Treasury	1.57	0.38	1.48***	1.60***	1.41***	1.29***	0.70
	(4.44)	(0.37)	(0.22)	(0.33)	(0.42)	(0.50)	
Aaa Corporate Bond	0.60	0.19	0.65***	0.75**	0.86**	0.17	0.33
	(4.63)	(0.38)	(0.23)	(0.34)	(0.43)	(0.52)	
Baa Corporate Bond	0.57	0.13	0.69***	0.71**	1.00***	0.37	0.42
	(4.01)	(0.33)	(0.20)	(0.30)	(0.38)	(0.45)	
S&P 500	324.44***	15.93*	20.43***	20.21***	18.95**	-1.54	0.49
	(100.39)	(8.34)	(4.95)	(7.40)	(9.40)	(11.33)	

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

Second and even more puzzling, contractionary forward guidance seems to have *increased* the S & P 500 index quite dramatically. Here, the estimated responses are quite similar across the different ν's (with the exception of the exceptionally imprecisely measured effect of $\nu_{t,4}$). Fully exploring these intriguing results lies beyond the scope of the present paper.

The Odyssean forward guidance we identify apparently influences interest rates relevant for households' and firms' savings and investment decisions, so we expect that it should have corresponding real macroeconomic effects. Nevertheless, more direct evidence on the macroeconomic effects of such an influence would be welcome. Since forward guidance theoretically operates through changes in *expectations*, we examine next how private forecasts of the unemployment rate and CPI inflation respond (in a regression sense) to the identified Odyssean shocks. For this, we examine the revisions in the forecasts for the unemployment gap ($\hat{u}_t$ defined above) and the inflation rate in the current quarter and next three quarters.

Table 6 reports the results from regressing these 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 basis point error in their final unemployment forecast. We see similar small but systematic errors in the inflation expectations. The slope coefficients' standard errors are quite large (on the order of 20 to 30 basis points),

Table 6: Response of Forecast Revisions to Odyssean Forward Guidance

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

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

but nevertheless many of the coefficients multiplying $\nu_{t,1}$ in the unemployment regressions are *negative* and statistically significant. That is, promises of less accommodative policy in the next quarter are associated with reductions of unemployment expectations. Although the analogous coefficients from the inflation regressions are not statistically significant, it is also worth noting that they are positive.

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

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

Here, $\eta < 0$ measures the extent to which the FOMC reacts to recent unemployment news, specified here as $\widetilde{u}_t - \widetilde{u}_t^L$. We might suppose that η will be large and negative if the FOMC becomes systematically worried about "getting behind the curve" following unemployment surprises.

If $L \leq M$, then the newly added term in (4) is orthogonal to the instruments we used for estimation, so its presence will not impact our estimates of ρ_1, ρ_2, ϕ_π, and ϕ_u. However, it will change the inferred values of the interest rate rule's expected intercept and through this influence the estimated ν's. In this sense, the estimated Odyssean forward guidance shocks can be "endogenous" to perceived macroeconomic conditions. Endogeneity of these shocks does not effect either of our earlier conclusions: The public unambiguously forecasts most deviations from the estimated interest rate rule before they occur, and these forecasted deviations are associated with substantial asset price movements. However, it does imply that simple regressions such as those in Table 6 do not provide a reliable guide to the effects of a particular exogenous change in forward guidance.

Table 7: Factor Model Parameter Estimates

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

Note: All parameter estimates are expressed in basis points. The two factors are mutually orthogonal and each have unit variance.

3.5 Factor Analysis

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

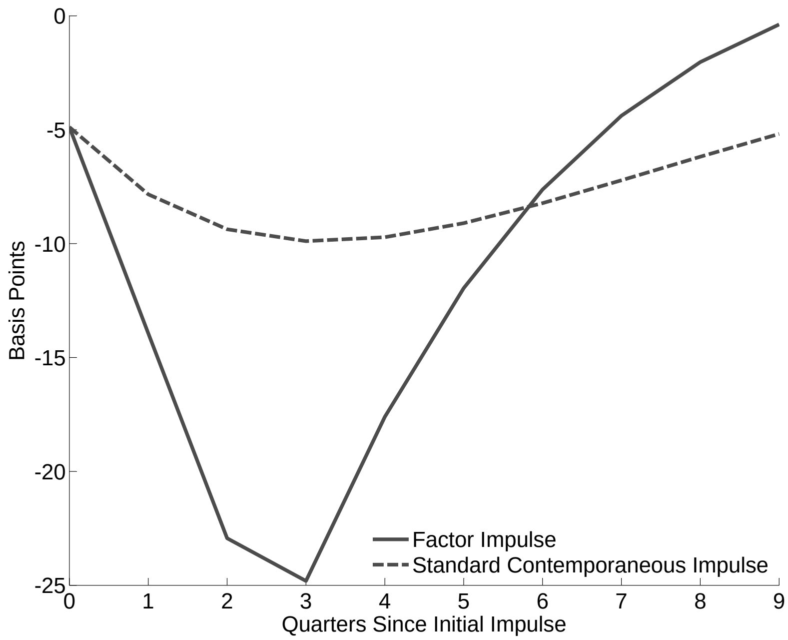
$$\vec{\nu}_t = \Lambda f_t + e_t.$$

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

Table 7 reports this model's maximum-likelihood parameter estimates. Inspection of the loadings reveals that the factor does indeed tilt the path of monetary accommodation. A one-standard deviation realization lowers the interest rate rule's intercept by about five basis points for the next three quarters and increases it by about the same amount for the following two quarters. The factor model's remaining parameters describe the standard deviations of the idiosyncratic errors in e_t. These estimates show that the factor accounts for about 15 percent of the variance of $\nu_{t,0}$, about ten percent of the variance of $\nu_{t,1}$, $\nu_{t,2}$, and $\nu_{t,3}$, and about sixty percent of the variance of $\nu_{t,4}$. That is, the factor accounts for most of four-quarter ahead forward guidance but leaves most forward guidance issued at shorter horizons unexplained.

In Figure 4, we plot the direct effects of a one standard deviation shock to the factor on the interest rate. This does *not* take into account any possible endogenous responses of inflation or unemployment to the original shock. For comparison, we also plot the response to a standard contemporaneous impulse that initially lowers the interest rate by the same amount, five basis points. As dictated by the second-order autoregressive parameters, the interest rate falls for three quarters after a standard impulse and then begins a slow rise

Figure 4: Direct Effects of Monetary Policy Shocks on the Interest Rate



back to its mean. The interest rate also falls for three quarters following a factor shock, but it falls much more relative to the initial response. Thereafter, the impulse's effects dissipate quickly. After nine quarters, the interest rate has returned to its mean. To us, these responses suggest labeling this factor *Policy Acceleration*. When the factor equals zero, policy adjustments proceed at their normal pace. A negative realization increases the speed of the interest rate's decline and recovery, while positive realizations increase the speed of contractionary policy.

Figure 5 plots the identified Policy Acceleration factor scaled by its impact on the *current* interest rate. This achieved its maximum value in 1999:II, nine basis points, although its value in the next quarter almost exactly offset this promised accelerated stimulus. Its minimum occurred in the wake of the 2001 recession in 2002:II, -21 basis points. In that quarter, the one, two and three quarter ahead forecasts of the unemployment rate all rose 30 basis points. (For a point of comparison, take these revisions' sample standard errors: 17, 20, and 21 basis points.) Its other large and negative realizations occurred during that 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.

Figure 5: The Estimated Policy Acceleration Factor

3.6 Summary

What does the analysis of Odyssean forward guidance identified from a standard interest rate rule tell us? First and perhaps most importantly for the potential viability of forward-guidance based strategies today, the public typically anticipated most deviations from the FOMC's interest rate rule at least one quarter before they occurred. Indeed, about forty percent of the variance in the interest rate rule's "shock" can be explained by interest rate changes anticipated three or four quarters in advance. Therefore, the public and the FOMC together have experience in the communication of relatively short term forward guidance. Second, unanticipated accommodative forward guidance reduces interest rates relevant for households' and firms' economic decisions. That is, it seems possible for the FOMC to change longer term interest rates out of its control by promising to persistently lower the shorter-term rates within its control. Third, endogeneity arising from the FOMC reacting aggressively to unemployment news apparently clouds simple regression estimates of the impact of forward guidance shocks on unemployment and inflation. 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.

4 Odyssean Forward Guidance Currently

The foregoing analysis provides evidence that the public has had some experience with Odyssean forward guidance, so monetary policies that rely upon it should not appear entirely novel and therefore may be viable. Currently the FOMC has an extraordinary degree of forward guidance in place with the "late 2014" statement language. On the one hand this language resembles the policy recommendations of Eggertsson and Woodford (2003) and Werning (2012) and could be the right policy for an economy struggling to emerge from a liquidity trap. On the other hand there are legitimate concerns that this forward guidance places the achievement of the FOMC's price stability goal at risk. In this section we consider the plausibility of these two views 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 than expected deleveraging. We do this analysis using the medium-scale DSGE model developed at the Federal Reserve Bank of Chicago for just such a purpose.

Evans (2011) has proposed conditioning the FOMC's forward guidance on outcomes of unemployment and inflation expectations. Evans' proposal involves the FOMC announcing specific conditions under which it will begin lifting its policy rate above zero. In particular, either unemployment falling below 7 percent or expected inflation over the medium term rising above 3 percent triggers lift-off from the ZLB. The 7/3 threshold rule is designed to maintain low rates even as the economy begins expanding on its own (as prescribed by Eggertsson and Woodford (2003)) while providing safeguards against unexpected developments that may put the FOMCs price stability goal in jeopardy. We illustrate that such conditioning, if credible, could be helpful in limiting the inflationary consequences of an early end to the deleveraging that has been underway since the onset of the financial crisis.

To perform policy analysis we require values for the model's parameters. We adopt a two step process for assigning parameter values. First, we estimate the model over the period 1989:II to 2007:II under the assumption that forward guidance extends out four quarters. Second, for the period 2007:III-2011:IV we fix the non-forward guidance parameters at their estimated values (with four exceptions highlighted below) and re-estimate forward guidance under the assumption that it extends out ten quarters. Our policy experiments are based on this new set of parameters, but the model's determination of the state of the economy takes into account the data prior to 2007:III as well as the parameter values that were in force at that time.

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

4.1 The Model

The model resembles other medium-scale empirical NK frameworks in most ways. There is a single representative household that owns all firms and supplies the economy's labor. Final goods are produced with differentiated intermediate goods which themselves are produced with capital and differentiated labor. The intermediate goods market and the labor market are monopolistically competitive. Prices of both kinds of differentiated inputs are sticky and are subject to partial indexation.[20] Hence standard forward-looking Phillips curves connect wage and price inflation with the marginal rate of substitution between consumption and leisure and marginal cost, respectively. Other frictions include variable capacity utilization, investment adjustment costs and habit-based preferences. The combination of these features is very close to Christiano et al. (2005), Smets and Wouters (2007), and many other models.

The model has two features which distinguish it from other NK frameworks: the interest rate rule and the inclusion of a financial accelerator mechanism.[21] The interest rate rule is

[20]Each period individual wage and price have a constant probability of being able to optimally reset their wage or price otherwise they index their wage or price using an exogenous rule.

[21]The model and estimation involve some other unique features but these are not important for understanding the workings of the model. Knowledge of existing medium scale NK models is sufficient for understanding our results.

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

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

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

We follow Cúrdia, Ferrero, Ng, and Tambalotti (2011) by defining the output gap in (1) as

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

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

where L and F are the lag and lead operators and λ is a smoothing parameter. Equation (6) defines the output gap as a four quarter moving average of detrended model output. The monetary authority detrends output using the filter given by (7).[22] This detrending approximates the Hodrick-Prescott filter. The moving average of filtered output has the same lead-lag structure as inflation and so also includes forward looking terms. By including forward looking terms for policy relevant inflation and the output gap in the interest rate rule we eliminate from our forward guidance shocks news about the inflation and output gap up to two quarters ahead.

We use the GSS factor structure to limit the number of parameters to be estimated for the forward guidance shocks. In particular we allow there to be a target and a path factor driving forward guidance. All current and forward guidance shocks load onto the target factor and all but the contemporaneous policy shock load onto the path factor. For the pre-crisis sample we set $M = 4$ and estimate the factor loadings, the variance of each factor and the variance of each idiosyncratic shock.

We identify the contemporaneous policy, forward guidance, and inflation anchor shocks using data on the federal funds rate, federal funds rate futures, and long run (10 year)

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

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

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

The second distinguishing characteristic of the model is that it includes a financial accelerator mechanism following the approach taken in Gilchrist et al. (2011). For this we introduce risk-neutral entrepreneurs who purchase capital goods from capital installers using a mix of internal and external resources. These entrepreneurs optimally choose their rate of capital utilization and rent the effective capital stock to goods producing firms. The dependence on internal resources explicitly links fluctuations in the external finance premium, private net worth, and the state of the economy. We think it is important to include a financial accelerator in the model because of the compelling evidence that financial factors are an important factor in recent history as well as in the current environment. Including this feature in the model allows for financial variables to influence our policy experiments.

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 all assumed to be AR(1). Four structural non-policy shocks move real GDP and GDP deflator inflation in the *same* direction on impact so we refer to these as *demand shocks*. One changes the households' rate of time discount, the discount shock. Two are financial disturbances; the spread shock generates fluctuations in the external finance premium beyond the level warranted by current economic conditions, and the net worth shock generates exogenous fluctuations in private balance sheets. 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 inventories. Four shocks move real GDP and GDP deflator 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 latter shock is assumed to be an ARMA(1,1), which is a parsimonious way of addressing both high and low frequency movements in hours worked. Other shocks that are of small importance in accounting for the data are shocks that do not impact agents' decisions: idiosyncratic shocks to the various price measures used in estimation and measurement error in the interest rate spread used to identify the external finance premium.

4.2 Estimation

The technical details of our model's estimation are discussed in Campbell et al. (2012). Describing the data we use in estimating the model for the period 1989:II-2007:II illustrates the wealth of information underlying our estimation of the model's parameters and shocks. The data include growth rates of nominal per capita GDP, consumption and investment, the level of per capita hours worked in the non-farm business sector, nominal compensation per hour worked in non-farm business, the GDP deflator, the deflator corresponding to our measure of consumption, the deflator corresponding to our measure of investment, core PCE, core CPI, ten-year ahead forecasts of CPI, an interest rate spread, the ratio of private credit to GDP, the federal funds rate, and contemporaneous expectations of the federal funds rate 1 to 4 quarters hence.[23] Consumption is measured as consumption of non-durable goods and services; and investment includes business fixed investment, residential investment, and personal consumption expenditures on durable goods. The interest rate spread is measured as a weighted average of high-yield corporate and mortgage-backed bond spreads with the 10-year Treasury and an asset-backed bond spread with the 5-year Treasury; where the weights equal the shares of nonfinancial business, household mortgage, and household consumer debt in private credit. Our measure of private credit sums household and nonfinancial business credit market debt outstanding. We include household credit since because our measure of investment includes residential investment and durable goods consumption. The remaining components of aggregate expenditures – government spending, net exports and private inventory accumulation – are implicitly modeled as the government shock.

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

Campbell et al. (2012) discuss the parameter estimates in more detail. Here we highlight key estimates that influence our 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 much smaller than the one for inflation. Reflecting the downward trend in inflation over our sample, the inflation anchor is quite persistent. The plausibility of the feedback component of the policy rule depends in part on the nature of the output gap in the rule. Campbell et al. (2012) demonstrate that the model's output gap is within the realm of plausibility since it corresponds well with the gap published by the Congressional Budget Office.

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

Lastly, the financial accelerator is estimated to be quite weak. In particular the elasticity of the spread with respect to net worth is estimated to be small. This is in part due to the relative absence of finance-related events in our sample. It has the implication that the net worth shock has virtually no impact on the model's dynamics. The spread shock is a major source of fluctuations, with implications similar to shocks to the marginal efficiency of investment informed by spread data.

4.3 Policy Experiments

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

We calibrate three parameters for the period 2007:III-2011:IV, the persistence of the discount shock, the variance of the inflation anchor shock and the coefficient on the output gap in the policy rule. To capture the idea that deleveraging by households and firms following the financial crisis is unusually slow, we raise the persistence of the discount shock from its estimated value in the pre-crisis sample, 0.75, to 0.95.[24] This increase in persistence raises the half-life of a discount shock from a little over half a year to more than three years. Consequently the model sees discount shocks playing a larger role than otherwise since 2007:II, leading to much lower aggregate demand. 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. We set the inflation anchor innovation variance to one fourth its estimated value from the pre-crisis period. This is motivated by the fact that inflation expectations exhibit a downward trend in the first part of our sample but have fluctuated considerably less since. Finally, we work with a coefficient on the output gap in the model's policy rule that is three times the size of the pre-crisis estimate. Our motivation for this last assumption is that the FOMCs policy response to a very large recession may be more aggressive than to a modest recession. These assumptions combined increase the likelihood that the ZLB is binding at any given date.

Given the calibrated parameters and pre-crisis estimates for the remaining parameters excluding forward guidance and the discount shock's variance, we re-estimate the factor loadings, factor variances and idiosyncratic variances that characterize forward guidance and the discount shocks's variance over the period 2007:III to 2011:IV under the assumption that forward guidance extends out ten quarters, *i.e.* with $M = 10$.[25] 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 the period 2007:III through 2011:IV, the Kalman smoother is used to back out the model's interpretation of the shocks hitting the economy over this period and their implications for the model's state variables as of 2011:IV. One important implication of our calibration and estimated forward guidance is that the model sees the ZLB as binding from 2008:IV until the end of our sample in 2011:IV.[26] At this date the model can be used to generate a forecast under the assumption that no further shocks hit the economy. This is our baseline forecast.

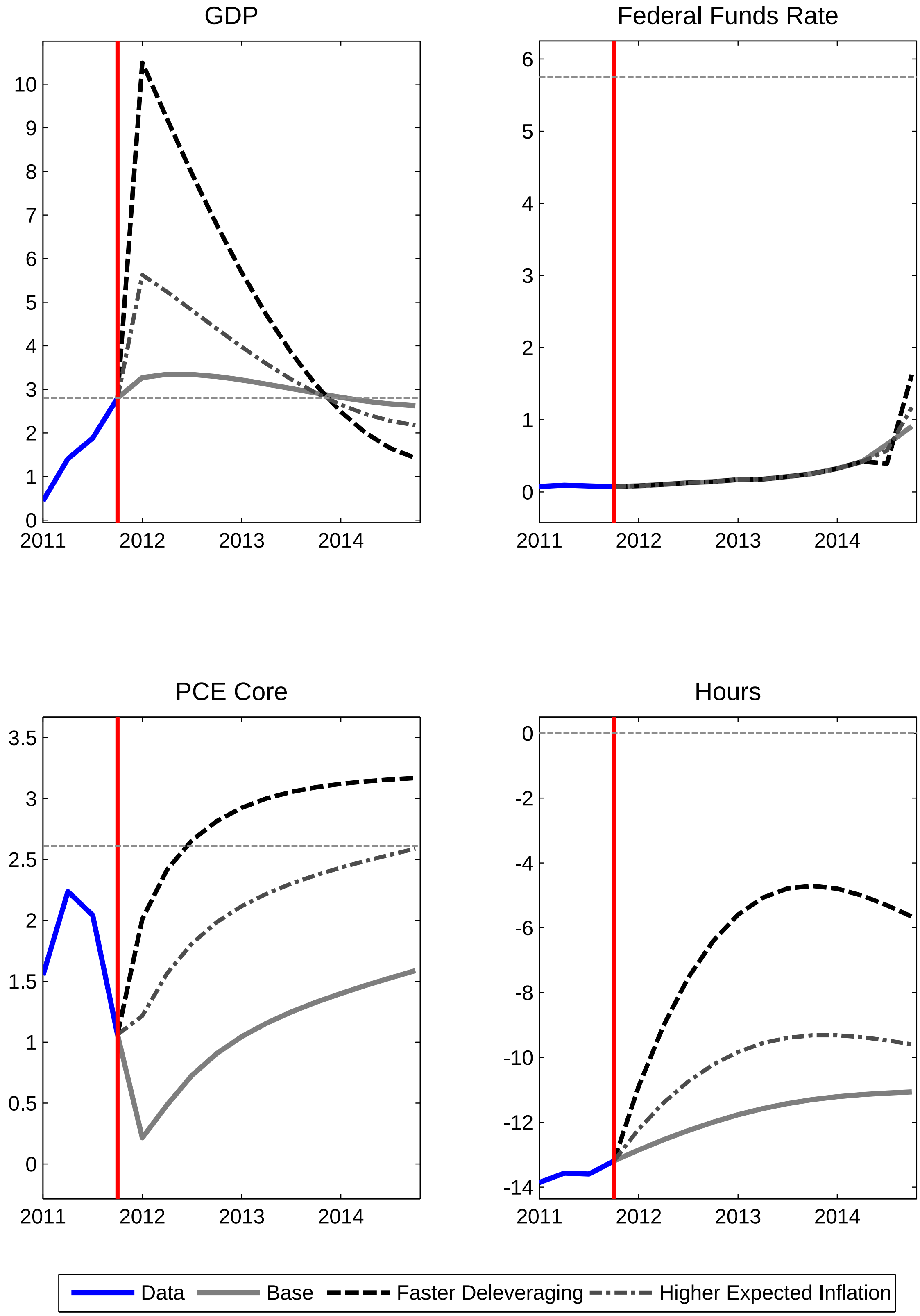
Figure 6 displays the baseline forecast along with those corresponding to the two alternative scenarios described below. GDP growth, the federal funds rate and Core PCE inflation are reported in annual rates and hours is in logs. The horizontal line in each plot indicates

[24]The discount factor is commonly used to model episodes in which the ZLB is binding. See for example Christiano et al. (2011)

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

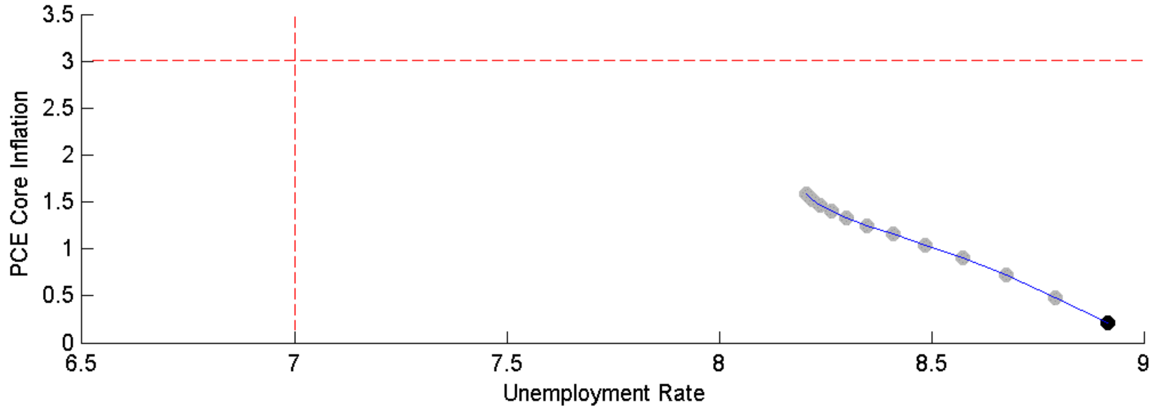
[26]We say the ZLB is binding at any given date if, when all but the forward guidance factor shocks were fed into the model to generate a conditional forecast beginning in 2008:III, the forecasted path of the federal funds rate at each date would be below zero for at least 1 period at short horizons.

Figure 6: Baseline and Alternative Projections



Note: GDP growth, the federal funds rate, and inflation are all expressed at annual rates. Hours is in logs.

Figure 7: Inflation and Unemployment in the Baseline Forecast



the long run average of the variable in question over the sample 1989:II-2007:II (log hours has a mean that is very close to zero.) The forward guidance in the baseline forecasts has been estimated to fit the federal funds rate futures path through mid-2014 after which the model predicts a mild lift-off with the funds rate about 1 percent at the end of 2014. This path is roughly in line with the January and March 2012 "late 2014" forward guidance. Corresponding to this path for the funds rate, the baseline forecast is for slightly above trend growth for 2012, returning to trend in 2013 and 2014. Growth is sufficiently tepid that per capita hours is still 10 log points below its steady state level by the end of the forecast horizon. Core-PCE inflation, after initially dropping, is forecasted to rise slowly toward its long run average.

Figure 7 shows the baseline forecast in inflation-unemployment space.[27] The black dot indicates the forecast for 2012:I with the economy's path following in sequence from that point on. The red lines indicate the thresholds of the 7/3 threshold rule. Clearly the baseline forecast is not at risk of violating the thresholds. Under this forecast the 7/3 threshold rule would prescribe maintaining the funds path at least as long as described in the last two meeting statements.

We compare two alternative scenarios with the baseline forecast. In each case we calculate the model's forecast from 2011:IV under the assumption that an unanticipated event occurs in 2012:I. The state of the economy in 2011:IV includes all prior realizations of forward guidance and agents in the model see exceptionally low interest rates through to late 2014. Our scenarios evaluate the consequences of maintaining this policy regardless of developments that might suggest the FOMC start raising the federal funds rate earlier. 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

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

this solution for the associated forecast. In both scenarios we compute a forecast starting from the same estimated state of the economy used to construct the baseline forecast. In the "sudden increase in long run inflation expectations" scenario the unanticipated event is an unusually large and persistent innovation to the inflation anchor. We assume a single innovation to the inflation anchor that generates an immediate increase in long run inflation expectations of 1 percentage point.[28] In the "rapid deleveraging" scenario we assume that the persistence of the discount rate shock drops from its calibrated level of 0.95 to its pre-crisis level of 0.75, but do not consider any shocks. In this scenario past realizations of the discount shock die out much sooner than anticipated in the baseline forecast.

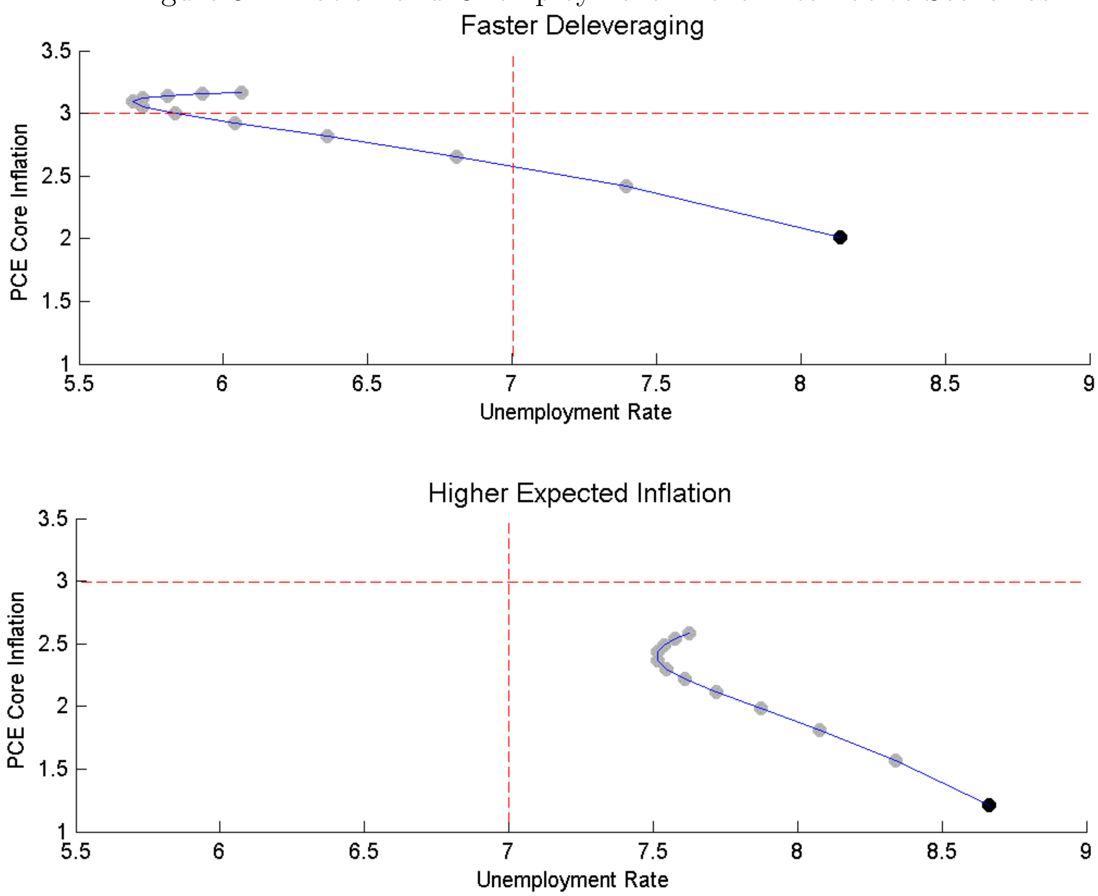
For the alternative scenarios we solve for the forward guidance that reproduces the expected funds path through 2014:II. This is accomplished by setting one of the idiosyncratic shocks to zero and then solving for the realization of the target and path factors in the first period, plus the other nine idiosyncratic shocks such that the funds path is matched exactly through 2014:II (we apply the estimated factor loadings underlying the baseline forecast to calculate the forward guidance shocks.) As Figure 6 illustrates, both alternative scenarios generate fast growth immediately: faster deleveraging through a less contractionary discount factor and higher expected inflation through lower real interest rates. Therefore, maintaining the funds rate path requires very large expansionary realizations of the path factor – essentially large expansionary forward guidance. Absent a different course for monetary policy inflation would rise above 2 percent in both scenarios, although per capita hours would remain relatively low.

Figure 8 shows the two alternative scenarios in inflation-unemployment space. Consider the faster deleveraging case. The figure shows unemployment crossing its 7 percent threshold within three quarters. Without any intervention by the FOMC, the forecast shows inflation crossing its 3 percent threshold within another year. The huge amount of accommodation required to maintain the funds rate path near zero clearly generates extremely vigourous macroeconomic activity putting at jeopardy the Federal Reserve's price stability mandate. However, if the 7/3 threshold rule was in force and credible, this outcome would not transpire.

Now consider the higher expected inflation scenario. Generating the increase in inflation expectations in this scenario requires a shock that is more than *four* inflation anchor innovation standard deviations as estimated in the pre-crisis sample. The resulting forecast conditioning on exceptionally low rates through at least the next ten quarters, as perceived by the market, does generate a big boom in GDP growth. However, it does not drive unemployment nor inflation near their thresholds, at least within the next 3 years. Given the

[28]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 8: Inflation and Unemployment in the Alternative Scenarios



extreme persistence of the inflation anchor, if exceptionally low rates were maintained beyond the forecast horizon it is possible that forecasts of inflation would cross its 3 percent threshold and policy would need to adjust if the 7/3 threshold rule were in force.

The higher expected inflation scenario illustrates a striking feature of estimated NK models that are calibrated to the current policy environment: very large innovations to inflation expectations do not lead to high inflation even with extraordinarily accommodative monetary policy, at least over a three year horizon. This result relies heavily on the assumed credibility of the model's policy rule and invariance of price-setting behavior to inflation expectations. If Odyssean forward guidance weakens credibility or changes price setting behavior then this kind of policy experiment might be very misleading. Nevertheless there is nothing in the experience of the last twenty-five years that suggests a destabilizing loss of credibility necessarily accompanies persistent changes in inflation expectations.

5 Conclusion

We have distinguished between two kinds of FOMC forward guidance. *Odyssean* forward guidance changes private expectations by publicly committing the FOMC to future deviations from its underlying policy rule. Circumstances will tempt the FOMC to renege on these promises precisely because the policy rule describes its preferred behavior. Hence this kind of forward guidance resembles Odysseus commanding his sailors to tie him to the ship's mast so that he can enjoy the Sirens' music. All other forward guidance is *Delphic* in the sense that it merely forecasts the future. Prominent monetary policy proposals for providing more accommodation at the zero lower bound, such as the one elucidated by Eggertsson and Woodford (2003), rely on Odyssean forward guidance. This paper has addressed the viability and impact of such policies.

Using Gürkaynak et al. (2005)'s methodology we have shown that forward guidance in monetary policy statements has had a significant affect on yields of Treasury notes and corporate bonds since the onset of the financial crisis and the attainment of the ZLB robbed the FOMC of its principal policy instrument. However, this analysis does not separate out the effects of Odyssean forward guidance which is key to implementing some of the most aggressive proposals for providing further monetary accommodation at this time. Consequently, we have developed a methodology based on a traditional interest rate policy rule that combines data on federal funds futures and market participant's expectations of future economic activity to measure Odyssean forward guidance. Our empirical evidence suggests that the public has experience with Odyssean forward guidance, so monetary policies that rely upon it may be viable. Armed with this evidence, we investigated the consequences of providing Odyssean forward guidance at this time. Our policy analysis suggests that such conditioning, if credible, could be helpful in limiting the inflationary consequences of a surge in aggregate demand arising from an early end to the post-crisis deleveraging.

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