How Flexible Can Inflation Targeting Be and Still Work?

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April 19, 2011

PRELIMINARY CONFERENCE DRAFT

1 Introduction

The widespread adoption of inflation targeting by central banks in the 1990s and 2000s was associated with the Great Moderation, and was at times given partial (or even most of the) credit for the beneficial macroeconomic outcomes seen over the period. More recently, the perceived benefits of inflation targeting as a monetary policy framework have been questioned following the global financial crisis of 2008-09, which inflation targeting was unable to prevent, and for which some would argue inflation targeting was partially (or mostly) to blame.[1] A great deal of that recent discussion has centered on whether inflation targeting kept central banks from responding sufficiently to asset price bubbles. Yet, inflation targeting was controversial in some quarters well before the crisis, for more fundamental reasons that deserve another look in light of monetary policymakers' present challenges.

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[1] See the recent opinionated contributions, pro and con, Clarida (2010), Dale, et al (2010), Issing (2011), McCallum (2009), Mishkin (2011), Nelson (2009), Orphanides (2010), Svensson (2010), and Walsh (2010).

The long-standing question about inflation targeting was whether it could actually matter for outcomes as much as, and in the way that, its advocates said it should. Proponents of inflation targeting portrayed it as a flexible monetary framework (aka a form of disciplined discretion) that would allow central banks to respond to short-term economic fluctuations in output and accommodate one-time price-shocks while maintaining medium- and long-run price stability.[2] For others, this sounded too good to be true — they expressed skepticism that such a flexible regime would offer any significant advantages over more obviously discretionary frameworks merely through the declaration of an inflation target.[3] If such announcements did confer advantages in terms of perceived commitment to price stability by inflation targeters, those improvements would have to come at the cost of greater output instability due to stricter following of a rule-based regime.[4] Either way, the challenge was that inflation targeting could not be simultaneously flexible and credible.

During the pre-crisis era, a large literature emerged which suggested that inflation targeting central banks could have their cake and eat it, too. In this view, flexible inflation targeting offered a better approximation of the optimal state contingent rule for monetary policy than pure discretion (even by a conservative central banker). Increased central bank transparency based on a public numerical inflation target would anchor inflation expectations for the long-term, allowing more short-term stabilization policy without slippage of expectations going forward.[5] The lower persistence of inflation following shocks implied by these models was then documented in a series of econometric studies looking primarily but not solely at inflation targeters.[6] A major limitation of these results, however, is that they were estimated over a period of historically low inflation and output volatility, during which few large price- or output-shocks were experienced — as a result,

[2] Bernanke *et al.* (1999) and Svensson (1997, 1999) were leading examples of advocacy based on this interpretation.

[3] Ball & Sheridan (2004), Friedman (2003), and Neumann and von Hagen (2002) were leading examples of this skeptical assessment.

[4] Friedman & Kuttner (1996) was an early exposition of this view. See also Cecchetti and Ehrman (2001), Friedman (2004), Kuttner (2004), and Mayer (2000).

[5] As argued in King (1997), Kuttner and Posen (1997), Svensson (1997), and Walsh (1994), *inter alia*.

[6] Another limitation of these studies is that they found little difference between implicit (e.g., U.S.) and explicit (e.g., U.K.) inflation targeters, and most of the strong results concerned before/after comparisons of central banks adopting inflation targeting. This does little to address the Ball & Sheridan (2004) or Friedman (2003) argument that almost all central banks, not just inflation targeters, placed greater weight on price stability over the 1990s, so showing improvements in targeting central banks' credibility proves little.

the pressures placed on inflation expectations and central bank credibility were too slight a test of the credibility of flexible inflation targets, even if the impact passed tests of statistical significance in the sample.

In this paper, we re-assess the viability of inflation targeting as a flexible monetary framework in light of the post-crisis experience, which should be a more powerful test of the anchoring of inflation expectations (albeit with few observations). Furthermore, we do so with new lenses, both theoretically and empirically. Theoretically, we outline two possible analyses of what repeated deviations of inflation outcomes from target could mean for inflation expectations: one, consistent with the majority of recent models of inflation targeting, suggests that a series of inflation overshoots for whatever reason would lead to doubts about the central bank's counter-inflationary toughness, and thus a persistent upward drift in inflation expectations; the other, drawing on a slightly older set of political economy models, suggests that the response of inflation expectations to target overshoots depends critically upon the nature and size of the shocks to which the economy is subjected, potentially leaving central bank credibility undamaged by past accommodation. Empirically, we distinguish between these two interpretations of inflation targeting by comparing pre- and post-crisis response of private-sector inflation forecasts and financial market prices to inflation outcomes. We do so by focusing on more lasting movements in inflation expectation measures than the event-study focus of the previous empirical literature.

Notably, we examine closely the differences in the response of longer-term private-sector inflation expectations to pre- and post-crisis deviations from target inflation levels in the U.K. and the U.S. For the inflation targeting skeptics' view, echoed by many recent models, the recent series of inflation overshoots in the UK is a critical test case: on this view, the credibility of the current Bank of England MPC's commitment to price stability (as measured by the perceived relative weight placed on inflation versus output stabilization) should be significantly eroding as a result of the overshoots. Some might go so far as to argue that the current US FOMC's credibility is less at risk precisely because it does not have an explicit target to fail to meet when it exercises discretionary stabilization.[7] For the inflation targeting advocates' view, in contrast, the US is a critical test case: absent an explicit inflation target, drift of expectations in response to large shocks should

[7] An extreme version of this view was offered by those in the Bank of Japan in the 1990s and early 2000s who opposed inflation targeting, saying that announcing a target only to miss it would cause harm to credibility.

be much higher than takes place in an economy under an explicit inflation targeting regime (like the U.K.). In this view, the inflation targeting framework creates a credible escape clause with respect to large or persistent shocks which would be unavailable to a less transparent central bank. The question whether flexible inflation targeting works thus comes down to whether inflation expectations are more focused on revelations of central bankers' type or on the explanations they give for policy actions when a shock hits.

2 Are Inflation Targets a Revealing Constraint or the Basis of an Escape Clause?

Economists' modeling of inflation targets is generally a simple extension of the now standard time-inconsistency models of inflation (Svensson (2011) gives a comprehensive review of this literature). In these models — and in the mindset of many market participants and central bankers — the most important variable determining macroeconomic outcomes is the relative willingness of central banks to stabilize deviations of inflation from target as opposed to fluctuations of output (or employment) around a zero output gap (natural rate). This is Svensson's famous lambda [λ] parameter, building on Rogoff's (1985) model of the degree of commitment to an intermediate monetary target by a conservative central banker. Private-sector inflation expectations map directly from agents' perceptions of the central bank's λ, and inflation outcomes are wholly determined by private-sector inflation expectations. More sophisticated versions of these models allow for multi-period games, wherein the shocks can lead to temporary deviations of inflation (and inflation expectations) from target. In the end, though, given the assumption of a vertical long-run Phillips curve and no persistent effects from shocks except through their impact on inflation expectations, the λ determines long-run outcomes.

Such models, however, do not really tell us how IT anchors expectations. Svensson (2011) makes the case that inflation forecast targeting is the nature of best practice IT, and that this can be distinguished from simpler models of IT or discretionary policy rules:

> "Therefore, flexible inflation targeting can be described as "forecast targeting": "the central bank chooses a policy-rate path so that the forecast of inflation and resource utilization stabilizes both inflation around the inflation target and resource utilization around a normal level or achieves a reasonable compromise between the two."

To the skeptics of IT, however, this is a distinction without a meaningful difference. As Ben-

jamin Friedman once observed when discussing a conference paper on IT:

> "[D]epiction of inflation targeting as maximizing a utility function including both an inflation term AND a term in the output gap... That's what people like me had been doing for decades... the idea that inflation targeting was how one maximized an objective function in output and inflation is what led me to suggest that, like Moliere's Monsieur Jordaine, I must have been talking inflation targeting all along without realizing it."[8]

In short, if IT is too flexible, what is it doing beyond setting a discretionary policy? Svensson (2011) unintentionally emphasizes the dilemma this presents and that we focus on in this paper by specifying:

> "two things that inflation targeting is not. First, real-world inflation targeting is not strict inflation targeting... That is, inflation targeting is not only about stabilizing inflation around the inflation target. Inflation targeting is in practice always flexible inflation targeting, in the sense that there is also weight on stabilizing the real economy... Second, real-world inflation targeting is not that the policy rate responds only to current inflation, with an instrument rule."

So it is not adherence to a rule which provides an inflation target with the anchor for inflation expectations.[9]

It must be the release of information by the inflation targeting central bank that is the basis for anchoring expectations, and thus any additional flexibility, rather than anything distinctive about the inflation targeting central bank's policy approach to stabilization in and of itself. (King (1997); Kuttner and Posen (1997)) The public inflation target comes into play by removing (or at least reducing) uncertainty about the level of inflation around which the central bank is stabilizing price movements. This should enable the public and markets to hold the central bank accountable for whether the central bank is living up to its target commitment and, assuming that, whether its λ is changing. This is consistent with inflation targeting in practice usually involving far more communications than is modeled for central banks, including publication of inflation forecasts and

[8] Email communication with Benjamin M. Friedman, April 5, 2011. The reference is to the central character in Molieres *Le Bourgeois Gentilhomme* (1670), Act II, sc. iv, stating "Par ma foi, il y a plus de quarante ans que je dis de la prose, sans que j'en susse rien." ("Good heavens! For more than forty years I have been speaking prose without knowing it.")

[9] Svensson is not alone in this characterization of IT as flexible rather than following a strict targeting rule. See, Bernanke, et al (1999) or Mishkin (2011), and many examples in between.

measures of past performance, other structures for assuring transparency and accountability, and efforts to describe publicly the shocks facing the economy.[10]

That assumption, however, is not enough to clarify the response of private-sector expectations to an ITer's policy moves. Of course, one issue is the process of private sector inflation expectations formation, ranging from adaptive backwards looking to fully rational and forward-looking, and such recently developed variants as rational inattention. Unless the private actor simply does not update her expectations beyond following a random walk, though, differences in expectations formation will be a second-order concern in terms of the anchoring of long-term inflation expectations — any process of learning will lead more or less rapid convergence on the fully forward-looking rational expectation for inflation over time, including on the central bank's perceived λ. (Brazier, et al (2008))

We would argue that the critical determinant of how ITer's policy moves and performance versus target affect long-run inflation expectations is how the public and markets think λ gets set and changed over time. Inflation targeting serves different purposes depending upon how private actors view this issue. One way to think about the determination of λ is to take it as a reflection of the individual central banker's (or policy committee membership's) preferences, in the spirit of Rogoff (1985) and of a vast majority of market commentary on interest rate decisions.[11] According to this view, which emphasizes the central banker's type as the determinant of counter-inflationary conservatism, IT helps to reveal central bankers' true toughness, which might otherwise be kept as private information. Another way is to think about central bankers' λ as the result of a political process, in the spirit of Lohmann (1992) and Posen (1995). According to this view, which emphasizes economic conditions as the determinant of political pressures on the central bank, IT helps to create an public escape clause for central banks, which otherwise would lose credibility by accommodating those pressures. These have alternative views therefore have differing implications for anchoring of inflation expectations, as we will now explain.

[10] Bernanke *et al.* (1999), Posen (2002), and Svensson (2011) discuss the operational aspects of transparency under inflation targeting. Walsh (1995) offers a different model of incentives beyond communications leading to an optimal contact for a central banker, but while insightful, this has little parallel in practice beyond structuring communications. The writing of letters to elected officials by central bank governors to explain large inflation target misses, for example, are best seen as another form of communication about shocks.

[11] Kuttner and Posen (2010) assess the important of transitions between individual central bank governors to market inflation expectations, and find these are limited in situations of lower discretion, like IT.

2.1 IT as a revealing constraint

The majority of models of monetary policy in the time-inconsistency mode treat the private-sector as suspiciously watching the central bank for signs of going soft on inflation. The game is solely between a representative agent (who is presumed to set wages and prices) and the central banker. The central bank's loss function is defined in terms of the squared deviations of inflation from target and output from zero gap, relatively weighted by λ. The central banker is effectively born with her λ or type, but that type cannot be credibly revealed, given the incentive to spring inflationary surprises (even for conservative central bankers).[12] Only policy actions can establish what private agents should believe about the central bank's toughness. When there are small deviations around the target, little is revealed, but when shocks are larger, central bankers are forced to reveal their true colors by how they respond.

What the inflation target does in this regime is make it easier for the private-sector to discern the toughness of the central banker(s). As argued in Stein (1989) and Garfinkel and Oh (1995), only tough or hawkish central bankers will want to communicate clearly about their policies, while weak or dovish central bankers will want to obscure their differences. In Faust and Svensson's (2001) version, the inflation target acts to constrain even weak central bankers into a more credible counter-inflationary policy than they would otherwise pursue. The private-sector will thus update its estimate of λ either when the central banker (or the composition of the monetary policymaking committee) changes, or when a sufficiently large shock forces weaker central bankers to be more gradual than expected in bringing inflation back to target. This will lead to a rise in inflation expectations over both the short- and the medium-to-long-term. Large economic shocks therefore should be associated with sustained increases in inflation expectations and levels on average, since it will reveal some share of central bankers to be softer' on inflation than previously expected. This effect should be more pronounced under inflation targeting regimes than under less transparent and thus more discretionary regimes because the ITer would be clearly crossing the line consistent with the target, and the less transparent central bank has no clear line to cross.[13]

[12] Cukierman and Meltzer (1986) and Faust and Svensson (2001) are particularly influential examples of this kind of model. This general approach goes back to Backus and Driffil (1985).

[13] Of course, for the rational central bank, awareness of this effect will lead even softer ITers to behave more conservatively than under discretion. But, as shown in Faust and Svensson (2001) and elsewhere, this is a only

2.2 IT as a basis for escape clauses

Alternatively, the standard time-inconsistency model of inflation determination as a game between the wage- and price-setting Lohmann (1992), for example, the elected officials can decide each period whether to overrule the central bank, at some cost for so overruling.[14] Where the divergence between the elected official's (or the median voter's) preferences for inflation and output and that of the central banker is low, the usual benefits of more time-consistent policy outweigh the costs to the politician, especially net of the direct costs of intevening, and it is not worth it to overrule the central bank. As deviations of output (or employment) from the steady state increase, however, the costs of relative foregone output stabilization to the politician (or median voter) increase with the square of the difference between the central banker's and the elected official's preferences. Beyond some size of economic shock, this cost exceeds the benefits of a more conservative policy and the direct costs to the politician of overruling the central bank.

Note that this increasing divergence between the politician and the central banker in welfare costs as a function of the size of the output shock is inherent to the Rogoff (1985) framework of appointing a conservative central banker, and all that follows from it. Yet, this fact is inherently ignored in models where the elected politician who can overrule monetary policy or change the central bank mandate is absent from the game, such as all the models of IT discussed in the previous section. The direct implication of models that include the potential for political override is that the central bank's λ varies over time as a function of the size of shock experienced by the economy. Over a range of small shocks, the central bank's λ in practice is its own preference, left to its own devices. As shocks to output become larger, the central bank accommodates those shocks (i.e., is more gradual in bringing inflation back to target) to the degree necessary to keep the elected official from overruling the central bank.[15] As a result, over some range of shock size, the central

partially offsetting incentive, not sufficient to make a soft central bank be indistinguishable from a tougher one.

[14] That cost could arise from central bank independence and associated legislative and political processes, for example, or from reputational costs to the elected officials for interfering in what is meant to be non-partisan policymaking. Other models in a similar spirit include Canzoneri (1989), Drazen and Masson (1994), and Flood and Isard (1989).

[15] The central banker will resist being visibly overridden by the politician for a number of reasons, mostly having to do with the long-run economic implications of politicized monetary policy, including potentially the loss of central bank independence, the increase or removal of an inflation target, or even simply being replaced (forced to resign). See the discussion in Drazen and Masson (1994) and Lohmann (1992). One can model this as an increasing risk to the central banker of being overridden as a function of output shocks with no loss of generality.

bank's λ in practice is increasing until for very large shocks it is identical to that of the politician. This time-varying λ in practice will be true irrespective of the central banker in question's type, soft or tough, so long as the central banker is more conservative than the elected official (a safe assumption).

As a result, the inflation target plays a different role in the formation of inflation expectations than under the assumption of no risk of political override. The inflation target allows the central bank to announce and explain when it is deviating from the target due to large shocks it needs to accommodate. In contrast to the models of the previous section, central banks whose λ is increasing (are becoming more gradualist) when hit by a large shock will communicate more, rather than less, so as to establish it does not reflect the central bank's normal preference. The inflation target will function as the basis of an escape clause,' where the private-sector's medium-to-long-term inflation expectations will not increase as a result of the accommodative policy, even if short-term inflation expectations increase. This result depends crucially on the private-sector believing that the central bank will be held accountable by elected politicians and that large shocks can be verified, and thus understanding the underlying game. Both of these beliefs are more likely to be widely held given framework for communications of inflation targeting. Long-run inflation expectations should be more stable under IT than under discretion, even though average inflation levels should be more variable conditional on the shocks experienced.

2.3 Summary of alternative views of IT's impact on inflation expectations

The two views of IT set out here and summarized in table 1 can be captured by thinking about the paradigmatic State Trooper enforcing traffic laws on the highway. The inflation target is the posted speed limit. Under the first model of IT as binding constraint, the given Trooper has to enforce strictly the speed limit on his stretch of road — if he fails to chase down speeders, or fails to always give a ticket when catching speeders, he will get a reputation for being a soft type, even if he enforces the law most of the time. It is all the more important that he be seen enforcing the rules on those drivers who egregiously violate the speed limit by a large amount when the road is well-trafficked. Even if he is strict most of the time, if the trooper does not catch and punish the largest and most visible deviations from the target, more people will speed on average and fewer will expect to be caught. The posted speed limit exists in part to let drivers monitor whether it is

Table 1: Alternative Interpretations of Inflation Targeting

	Interpretation	
	IT as a binding constraint	IT as the basis for escape clause
Game players	Central banker and representative private agent	Central banker, elected politician, and representative private agent
Arguments of the central bank loss function	Output and inflation	Output, inflation, and the cost of being overruled by politician
Determinant of λ	Invariant central bank type	CB type, but effectively varies the size of economic shocks
Incentive to communicate	Lower when faced with a large shock	Higher when faced with a large shock
Reaction of longer-term inflation expectations to target misses	Increases with number and size of misses	Limited if large shock is verifiable — large around target
Implications for average inflation of large shocks	Rises persistently if λ is perceived to be less credible	Reversion to mean after shock passes if λ varies with shock

being enforced.

Under the second model of IT as enabling an escape clause, the given Trooper still has to enforce the speed limit most of the time. If, however, he is seen by a citizen complaint board or an elected official as enforcing the speed limit too strictly, he will have his duties taken away from him or have the speed limit raised for being deemed unreasonable. The first model does not consider this possibility, though it may well be in the head of the trooper. It is all the more important he identify those speeders who have good reason to be speeding — the paradigmatic woman in labor heading to the hospital, for example — and put on his siren to escort them safely at the higher speed to the destination. If he only uses the siren infrequently and with clear justification, other drivers seeing the trooper escorting a speeding car as no reason to speed more themselves, or to doubt that the speed limit would be enforced normally. The posted speed limit exists in part to let the trooper signal with his siren when unusual conditions require an exception.

3 *Evidence on the impact of inflation shocks on long-run expectations*

The goal of the empirical work is to determine which of the theoretical interpretations described in section 2 best describes the central bank's and private sector's responses to output or inflation shocks. The primary question is whether near-term inflation news causes the private sector to revise its expectations of the inflation target, i.e., the extent to which long-run inflation expectations are "anchored." Of particular concern are the effects of the positive inflation surprises experienced in recent years.

A related issue is if inflation expectations have remained stable in the face of recent positive inflation shocks, whether this is because of expectations of tighter monetary policy over the medium term. If not, then a reasonable inference is that the central bank was able to exercise its "escape clause" option without jeopardizing the credibility of its commitment to the inflation target.

Our work is similar in spirit to that of Gürkaynak *et al.* (2005), Gürkaynak *et al.* (2007), and Beechey *et al.* (2011), who assess the impact of data releases on long-run inflation expectations. Research in a similar vein includes the Kuttner & Posen (2010) analysis of markets' reactions to the appointment of new central bank governors, and the Hardouvelis (1984) work on the markets' response to money supply announcements. We focus in particular on the period leading up to and following the financial crisis, which has included episodes of above-target inflation even as monetary policy became highly expansionary. For this reason, the recent experience provides a good test case for the flexibility of the inflation targeting framework.[16]

3.1 *Alternative financial market gauges of expected inflation*

Our goal is to be able to say something about the way in which long-term inflation expectations respond to current inflation news requires some observable measure of long-term inflation expectations. To that end, we rounded up the usual suspects: (1) the long term bond government bond yield, (2) the long-term implied forward rate, typically the nine-year-ahead one-year rate, (3) the breakeven inflation rate implied by the spread between nominal and index-lined bonds, (4) the long-term implied forward breakeven inflation rate, calculated from the spread between nominal

[16] While there has been a great deal of work on central banks' actions as lenders of last resort, the only other work we know of that looks at inflation targeters' flexibility in the aftermath of the crisis is that of Calani *et al.* (2010), who found that targeters and non-targeters alike deviated significantly from conventionally-estimated reaction functions during the crisis.

and index-linked forward rates, and (5) the nominal exchange rate.

None of these measures is perfect. Long term interest rates embody inflation expectations, of course; but they are also affected by the expected path of the future short-term interest rate. Because a positive inflation shock would increase both of these components, it would be hard to tell whether an increase in the bond yield signaled an increase in inflation expectations or anticipations of a monetary contraction. A long-dated implied forward rate, such as the nine-year-ahead one-year rate, would minimize this problem, although there is still the possibility of contamination from changes in the real interest rate or the term premium.

Breakeven inflation rates calculated from the spread between nominal and index-linked bonds are, at least in theory, the ideal gauge of inflation expectations. The five- or even ten-year breakeven rate may of course be affected by short-term fluctuations in the inflation rate, using long-dated forward breakeven rates should be a relatively pure measure of long-run inflation expectations. The problem is risk and liquidity and risk premia, which Pflueger & Viceira (2011) have found to account for much of the variability in the yields on TIPS yields in the U.S. Consequently, these measures are likely to be unreliable indicators of expected inflation.[17]

For completeness, we also considered the nominal exchange rate as an alternative gauge of inflation expectations. However as discussed in Kuttner & Posen (2010), the effects of a change in inflation expectations have ambiguous effects on the nominal exchange rate: the near-term rise in the nominal interest rate would tend to strengthen the exchange rate, while the decline in its long-run equilibrium value would tend to weaken it. For this reason, it may be more reliable as an indicator of any changes in the central bank's degree of conservatism.

Finally, the one-year nominal interest rate is included in the analysis as a plausible gauge of near-term monetary policy expectations.

Figures 1 and 2 show how (a subset of) these variables have evolved over the 1999-2010 period for the six countries included in our analysis, along with the behavior of inflation over the same period.[18] The grey bars in figure 1 represent the difference between the realized inflation rate and

[17] Gürkaynak *et al.* (2010) extracted an estimate of expected inflation, but their estimates are conditional on the questionable assumption that long run expected inflation is nonstationary, while the liquidity premium follows an AR(1).

[18] Not all of the data are (yet) available for every country, hence the missing lines and the blank space for the Euro area in figure 2.

the target (the "miss").[19] The U.S. Federal Reserve does not have an explicit inflation target, of course, so an objective of 2 percent is used instead.[20] The upper bound of the European Central Bank's "no more than 2 percent" is used.

The graph shows just how volatile inflation has been in recent years, compared with the period prior to mid-2007. Three of the countries in our sample (the U.K., the U.S. and the Euro area) experienced unusually large positive inflation misses just prior to the financial crisis (the vertical line marks 2008Q4). Four experienced unusually large *negative* misses immediately following the crisis. Most central banks therefore have had to deal simultaneously with the challenge of stabilizing inflation while at the same time shoring up the financial system.

The policy dilemma has been particularly acute in the U.K., having significantly overshot its inflation both before *and* after the crisis. The Bank of England therefore currently faces a situation in which past and likely future inflation target overshoots, and accompanying increases in short-term household inflation expectations, suggest grounds for tightening of policy, while a forecast based primarily on movements in core inflation and on likely consumption and wage developments arguably calls for expansionary monetary policy, and the accommodation of temporary price shocks.[21] The first concern, driven by the prospect of rising inflation persistence (i.e., deanchoring of inflation expectations), raises the possibility that accommodating past target overshoots could undermine perceptions of the MPC's commitment to the inflation target, even if caused by a temporary rise in inflation due to price-level shocks. This view is consistent with the first of our theoretical interpretations set out in section 2, emphasizing the need for toughness to signal credibility. The second concern is based on the premise that monetary policy should be set with regard to the medium-term forecast for inflation, ignoring past target misses, especially when they can be attributed to observable price shocks. This view, with its implied lack of concern about the risk of deanchoring of inflation expectations during a period of large shocks, is consistent with the second of our interpretations, emphasizing the credibility of escape clauses. Analysis of the behavior of

[19] The (H)CPI is used for the calculation of the inflation rates, except for the U.K. where the RPIX is used until 2003Q4.

[20] Strictly speaking, the assumption of a 2 percent implicit target for the Federal Reserve is inappropriate, since its implicit objective is thought to refer to the PCE deflator, rather than the CPI. The fact that PCE inflation has tended to be lower than CPI inflation in recent years explains why the average "miss" has been positive. This is not an issue in the econometric work, which does not rely on any assessment of inflation relative to its target.

[21] Dale (2011) articulates the first view, while Posen (2010, 2011) sets out the second.

inflation expectations in the UK following the acute crisis and repeated inflation target overshoots therefore should give us insights into the applicability of these views (we hope).

3.2 Alternative measures of inflation news

The next issue is what to use as a proxy for new information about future inflation. As noted earlier, Gürkaynak *et al.* (2005), Gürkaynak *et al.* (2007), and Beechey *et al.* (2011) all use daily data in an event study-style analysis, as in Kuttner (2001), of the high frequency impact of macroeconomic news on inflation expectations. The advantage of this approach is that it is able to gauge the relative information content of different kinds of news (e.g., monetary policy announcements versus CPI releases), and cleanly distinguish the effect of that information from other shocks to financial indicators. One disadvantage of the event-study approach is that it maybe picking up mostly transitory effects.[22]

Our empirical strategy involves using quarterly private-sector inflation forecasts as the basis for calculating a measure of the inflation surprise. Relative to the event-study method, the main disadvantage is that it greatly reduces the number of observations available for the regression. It is also not possible to determine exactly what information is affecting inflation expectations. But the use of quarterly forecasts allows us to determine whether movements in inflation expectations are sufficiently durable to be important macroeconomically. Furthermore, since the inflationary implications of other kinds of news (e.g., employment reports) may differ across countries, the use of inflation forecasts facilitates international comparisons.

Our primary measure of inflation news is the difference between the realized 12-month inflation rate at time t and the previous quarter's forecast of the period-t inflation rate, $\pi_t - \hat{\pi}_{t|t-1}$. We also consider an alternative measure the revision from period $t-1$ to t in the forecast for period $t+k$, $\hat{\pi}^p_{t+k|t} - \hat{\pi}^p_{t+k|t-1}$. The logic is that the revision in the expectation for inflation at some fixed horizon embodies all the new information relevant to future inflation that has become available since the previous period.

The two measures are plotted together in figure 3, using $k = 1$ for the revision-based series. The two are very highly correlated, suggesting that the inflation forecast error is a major—if not the primary—source of new information about inflation, least at a one-quarter horizon. Both series

[22] Beechey *et al.* (2011) also looked at the impact of news over a slightly longer, five-day window.

Figure 1: Inflation target misses and nominal interest rates

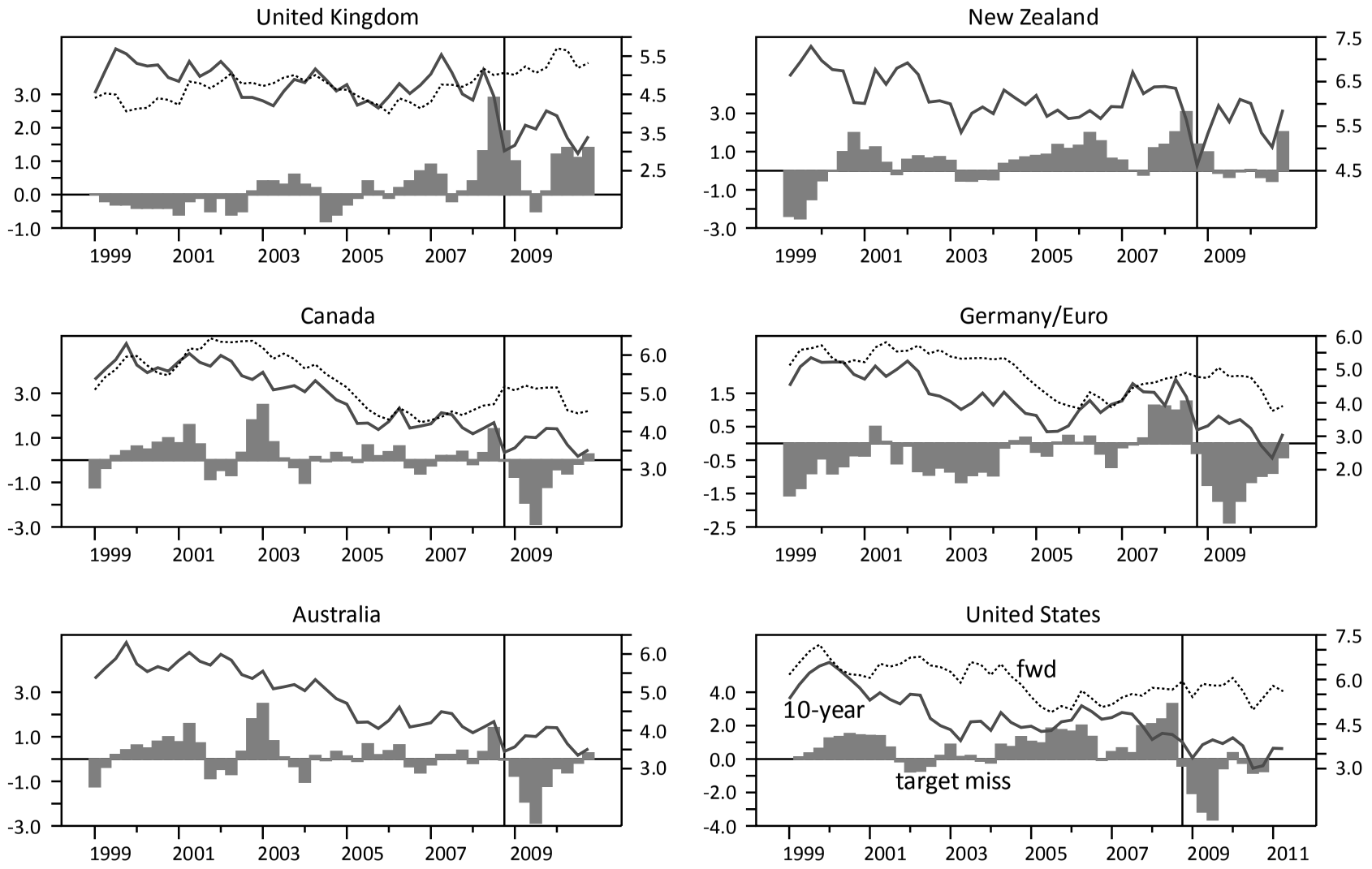


Figure 2: Inflation target misses and breakeven inflation rates

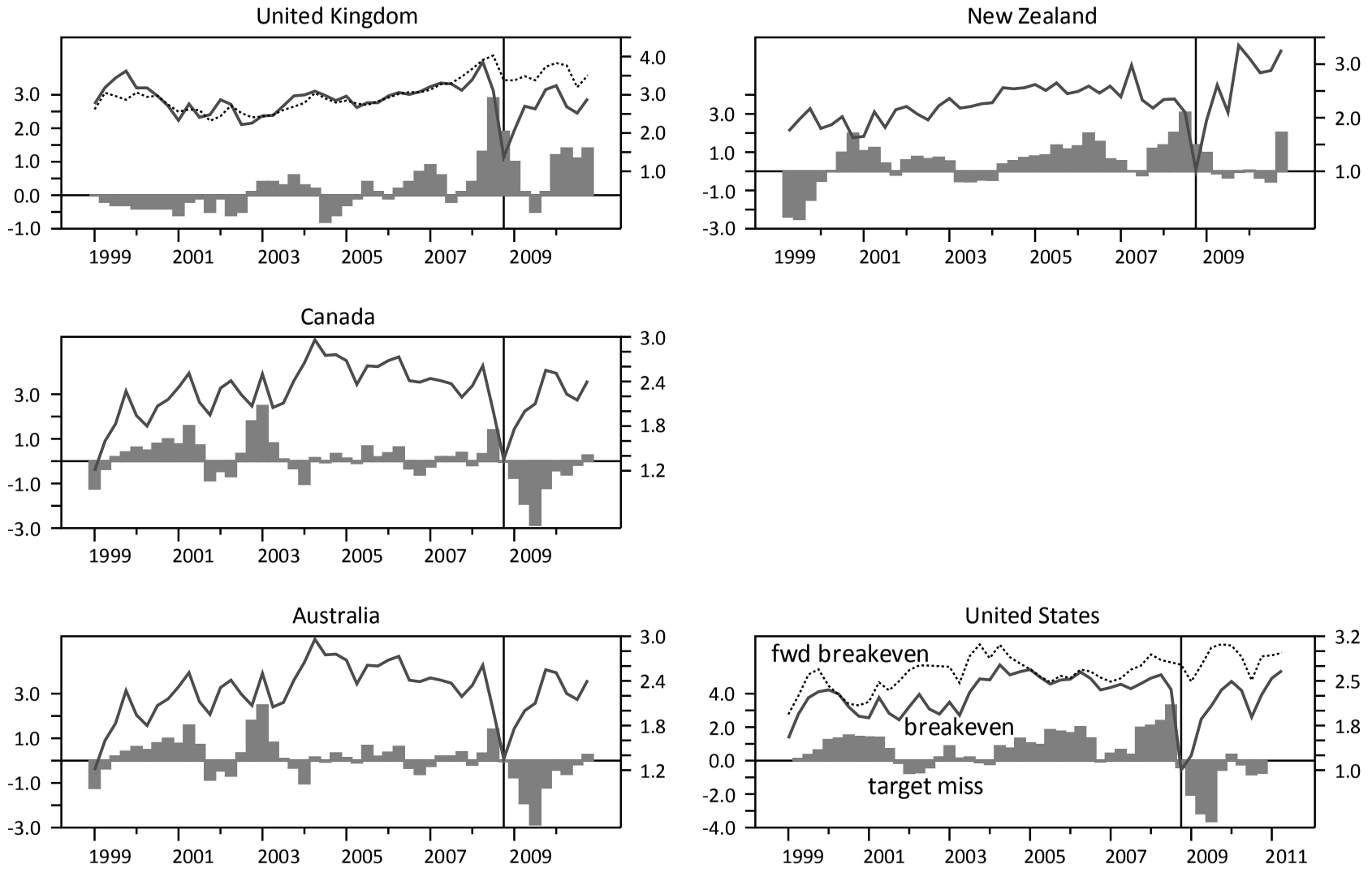
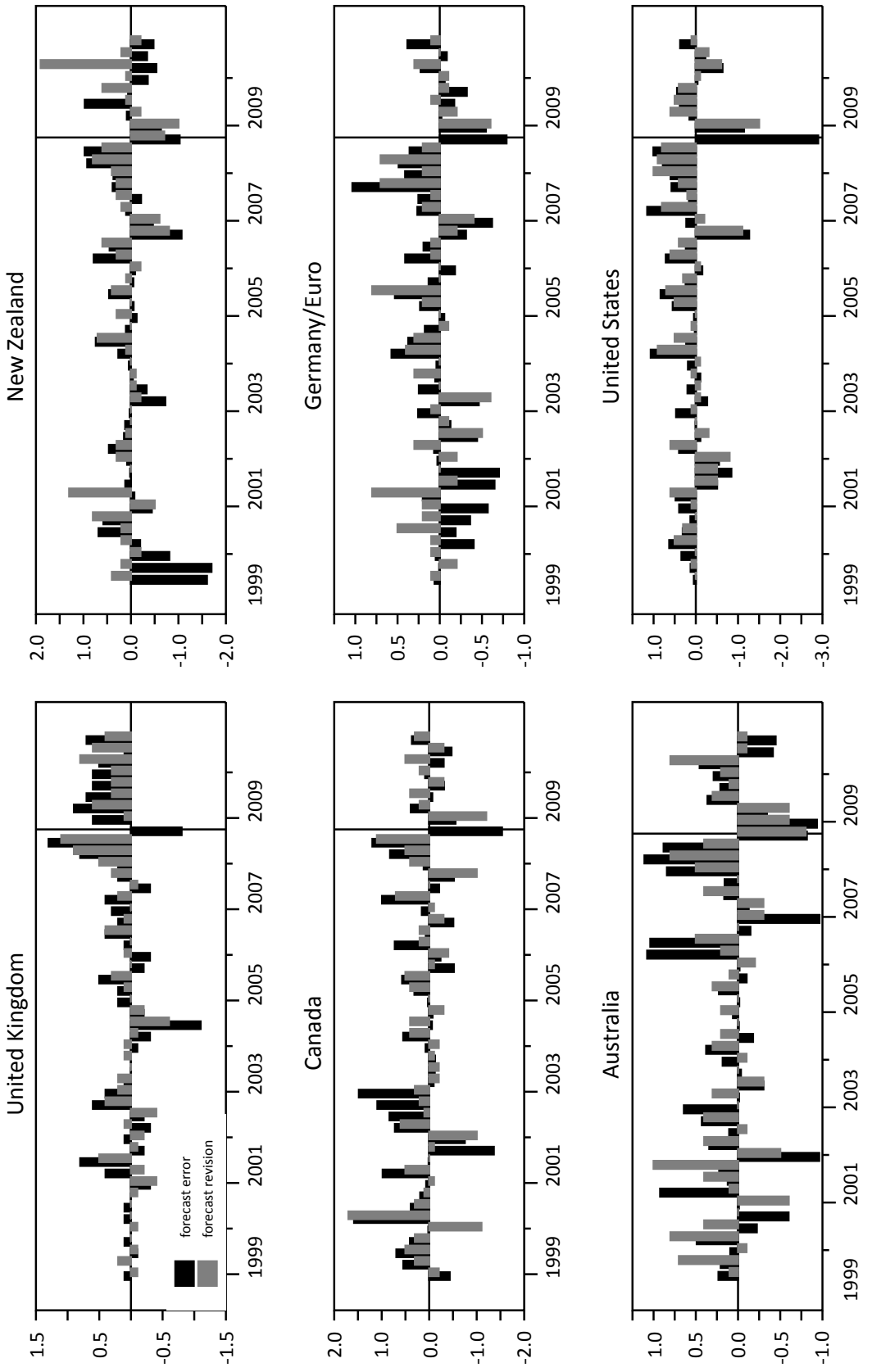


Figure 3: Inflation forecast errors and revisions



show that inflation exceeded private-sector forecasts for the three quarters leading up to the peak of the crisis, even as financial conditions were deteriorating. Unsurprisingly, private-sector forecasters in all six countries consistently revised their forecasts upwards over this period. Inflation forecasts fell sharply in 2008Q4, the quarter following the Lehman collapse. From 2009 through 2010, realized inflation remained largely in line with the forecasts in five of the six countries. The U.K. is the the exception in this regard: inflation exceeded the forecast in each of the eight quarters, and private-sector forecasts continued to rise.

3.3 Estimation strategy

Following Gürkaynak *et al.* (2005), our approach to assessing the response of long-run inflation expectations to near-term inflation news is to regress the change in one of the financial indicators enumerated above on one of our two measures of inflation news. One regression uses the private-sector forecast error,

$$\Delta y_t = \beta_0 + \beta_1(\pi_t - \hat{\pi}_{t|t-1}) \ , \tag{1}$$

where Δy_t is the change from period $t-1$ in the financial indicator and $\hat{\pi}^p_{t|t-1}$ represents the private-sector forecast for the inflation rate at time t made at time $t-1$. The other uses the quarter-to-quarter revision in the forecast,

$$\Delta y_t = \beta_0 + \beta_1(\hat{\pi}_{t+k|t} - \hat{\pi}_{t+k|t-1}) \ . \tag{2}$$

where $\hat{\pi}_{t+k|t}$ is the private-sector forecast of inflation at time $t+k$ made at time t.

An important empirical issue concerns the choice of the sample period for the analysis. The 1999 to 2010 period for which we have data includes three distinct periods, during which bond yields may have behaved quite differently. The first period runs from the beginning of the sample to the onset of the crisis, marked by the collapse of Bear Stearns in March 2008. The second is the period of the crisis itself. Although there is well-defined endpoint, it is reasonable to assume that financial markets had more or less stabilized by the second quarter of 2009. Financial markets were of course extremely volatile during these five quarters, and bond yields were surely driven by a variety of factors, particularly risk and liquidity premia, that were unrelated to inflation expec-

tations. The effects of these factors probably began to wane after 2009Q2 although "quantitative easing" policies may have affected bonds' liquidity and term premia. Importantly, this is also a period in which central banks' interest were pegged at near-zero levels, where they were expected to remain for some time.

The choice of sample period therefore presents a dilemma. Since the largest inflation target misses occurred after mid-2007, ending the sample in 2007Q4 would eliminate most of the interesting variance in inflation expectations. But at the same time, the crisis-driven bond yield gyrations runs the risk of allowing one or two extreme observations to drive all the results. Our compromise is to include in the sample the periods prior to 2008Q1 and after 2009Q1, dropping the five-quarter crisis period from the analysis.[23] This allows us to assess the impact of some of the recent inflation instability, while avoiding the largest distortions associated with the financial crisis.

3.4 Results

Table 2 reports the estimated β_1 coefficients from the OLS estimation of equation 1 for the six countries analyzed, on a single sample encompassing the pre- and post-crisis periods.[24] For Canada, Australia, New Zealand and the Euro area, inflation forecast errors have little or no measurable impact on long-run inflation expectations, at least to the extent that they are reflected in interest rates and the exchange rate.[25] With the lone exception of one marginally significant estimate, none of the coefficients for these countries is statistically significant at conventional levels.

The U.K. and the U.S. are exceptions to this pattern. In the U.K., the nominal yield on gilts, the nine-year-ahed forward rate, and the breakeven inflation rate all display statistically significant positive responses to inflation forecast errors. The response of the bond yield and breakeven inflation rates may be explained by anticipated increases in the medium-term path of inflation and the policy rate, although the nine-year-ahead forward rate cannot. (These results turn out not to be robust with respect to the choice of regressor, however.) The five-year-ahead breakeven inflation

[23] Bond yields fluctuated wildly during the quarter that includes September 11 2001, and the one immediately following, and so those too were dropped.

[24] The unreported intercepts, which are economically uninteresting, are all close to zero and statistically insignificant.

[25] The gaps in the table are due to limited data availability for these countries.

rate does not exhibit a statistically significant response, however, contradicting implications of the behavior of the forward rate. The coefficient in the exchange rate coefficient is also insignificant, and there is no discernible reaction of the expected near-term interest rates to inflation shocks.

Statistical significance aside, the magnitudes of the estimated coefficients are relatively small. A coefficient of 0.25 implies that a 50 basis point positive forecast error would be associated with only a 12.5 basis point change in long-run inflation expectations. With a pre-crisis forecast error standard deviation of 34 basis points, the typical inflation shock would therefore have a less-than-10 basis point impact on gilt yields. But with post-crisis shocks averaging nearly 60 basis points, the cumulative impact of bad inflation news may have been nontrivial.

The United States is the only other country in which one observes a statistically significant response of interest rates, albeit only at the less robust 10% level. In the nominal bond yield and forward rate regressions, the coefficients' magnitudes are slightly over 0.25, on a par with those for the U.K., and suggestive of only a mild reaction of long-term inflation expectations to inflation news. There is no statistically significant response of the breakeven inflation rate calculated from the nominal-TIPS yield, although there is a small and marginally significant response of the five-year-ahead forward breakeven inflation rate.

Table 3 reports the results from estimating equation 2, which uses the one-quarter forecast revision, $\hat{\pi}_{t+1|t} - \hat{\pi}_{t+1|t-1}$, instead of the forecast error. Except for the U.K., the results are virtually identical to those in table 2. For the U.K., however, the financial indicators' response to inflation news is now small and statistically insignificant. While the forecast errors and revisions have a respectable correlation coefficient of 0.83, the discrepancies are sufficiently large that the use of the alternative measure tangibly alters the results. A priori, we would expect the forecast revision-based measure to be more reliable, as it should be less susceptible to transitory or one-off inflation fluctuations. Indeed, the significance of the forecast error-based results is largely a function of an unusually large negative error in 2004Q3. For these reasons, for the U.K. we regard the results in table 3 as more trustworthy than those in table 2.

As noted earlier, even with the exclusion of the financial crisis period, the 1999 to 2010 sample encompasses two distinct monetary policy regimes. Prior to 2008, inflation rates typically remained close to their targets (implicit in the case of the Federal Reserve), and policy rates were

Table 2: Financial indicators' reaction to inflation forecast errors

	Financial indicator					
Country	Bond yield	Forward rate	Breakeven inflation	5-year breakeven	Exchange rate	1-year yield
United Kingdom	0.25**	0.19***	0.25**	0.07	1.48	0.09
	(0.12)	(0.17)	(0.15)	(0.05)	(1.76)	(0.10)
Canada	0.10	0.10*	0.06		−0.67	0.10
	(0.07)	(0.06)	(0.07)		(0.81)	(0.13)
Australia	−0.04		0.06		−1.21	0.00
	(0.16)		(0.10)		(1.52)	(0.17)
New Zealand	−0.09		−0.04		1.82	−0.14
	(0.09)		(0.07)		(1.65)	(0.11)
Germany/Euro	0.18				−0.77	0.14
	(0.14)				(2.12)	(0.15)
United States	0.28*	0.27*	0.08	0.10*	−1.14	0.00
	(0.16)	(0.14)	(0.08)	(0.06)	(1.03)	(0.15)

Notes: The numbers shown are the estimated coefficients in a regression of the change in the financial indicator on the difference between the realized 12-month inflation rate and the one-quarter-ahead private-sector forecast from the previous quarter. one-quarter-ahead inflation forecast error. Asterisks denote statistical significance: *** for 1%, ** for 5%, and * for 10%. Robust standard errors are in parentheses. The sample period is 1999Q3 through 2010Q4, excluding 2001Q3 and 2001Q4 (9/11) and 2008Q4 through 2009Q1 (financial crisis). The total number of usable observations is 40.

Table 3: Financial indicators' reaction to inflation forecast revisions

	Financial indicator					
Country	Bond yield	Forward rate	Breakeven inflation	5-year breakeven	Exchange rate	1-year yield
United Kingdom	0.05	0.11	0.17	0.13	0.66	−0.02
	(0.12)	(0.12)	(0.20)	(0.08)	(2.66)	(0.19)
Canada	0.08	0.01	0.04		−0.33	0.03
	(0.10)	(0.05)	(0.08)		(0.92)	(0.15)
Australia	−0.28		−0.02		−2.77	−0.10
	(0.21)		(0.12)		(3.16)	(0.21)
New Zealand	−0.32*		−0.06		−1.56	−0.04
	(0.18)		(0.14)		(3.45)	(0.21)
Germany/Euro	0.12				−3.31*	0.07
	(0.15)				(1.99)	(0.15)
United States	0.31*	0.29*	0.07	0.11*	−0.86	0.01
	(0.18)	(0.15)	(0.09)	(0.07)	(1.06)	(0.15)

Notes: The numbers shown are the estimated coefficients in a regression of the change in the financial indicator on the change from the previous to the current quarter in the forecast of the quarter-ahead 12-month inflation rate. Asterisks denote statistical significance: *** for 1%, ** for 5%, and * for 10%. Robust standard errors are in parentheses. The sample period is 1999Q3 through 2010Q4, excluding 2001Q3 and 2001Q4 (9/11) and 2008Q4 through 2009Q1 (financial crisis). The total number of usable observations is 40.

free to move according to changing economic conditions. This naturally raises the question of whether the responses estimated in tables 2 and 3 apply to both pre- and post-crisis periods.

To address this question, we re-ran the regressions interacting the slope coefficients with a pair of dummy variables: one (d_{pre}) that was set equal to 1 prior to 2008Q1, and another (d_{post}) set to one after 2009Q1,

$$\Delta y_t = \beta_0 + \beta_1 d_t^{pre}(\pi_t - \hat{\pi}_{t|t-1}) + \beta_2 d_t^{post}(\pi_t - \hat{\pi}_{t|t-1}) \ . \tag{3}$$

A common intercept is assumed for both periods.

The results from estimating equation 3 on U.S. and U.K. interest rate data appear in tables 4 (using the forecast errors as the regressor) and 5 (using the forecast revisions as the regressor). In the U.K., little changes in the forecast error regression (table 4) results when the slope coefficient is allowed to differ pre- and post-crisis. The estimates remain very close in magnitude: for the gilt yield, 0.26 before 2008Q1 and 0.24 after 2009Q1. The coefficients for the other financial indicators are also very similar. However with only seven post-crisis observations, the slope coefficient is estimated very imprecisely. The hypothesis of equal coefficients cannot be rejected at conventional levels, nor can the the hypothesis that the post-crisis coefficients are zero. In the forecast revision regressions (table 5), the inflation news variables are small and statistically insignificant in both the pre- and post-crisis subsamples.

This result is unsurprising when one examines the most recent two years of U.K. data. As shown in figure 4, over the past two years, the inflation forecast errors have been consistently positive (the black circles are all to the right of the vertical axis), ranging in magnitude from 0.1 to 0.9. At the same time, forward rates have risen and fallen, with no clear tendency to increase following the release of higher-than-expected inflation data. Breakeven inflation rates display very similar behavior.

The response of inflation expectations in the U.S. differs sharply from that in the U.K. As shown in the bottom half of table 4, the pre-crisis slope coefficients are relatively small, slightly greater than 0.1 for the nominal rates and less than 0.1 for the breakeven rates. In no case is the coefficient

statistically significant.[26] Nor is there a discernible response when the forecast revisions are used instead (table 5).

The opposite appears to be true in the post-crisis period, however. Here, the estimated slope coefficients are all positive and statistically significant. Moreover, they are quite large in economic terms, as they suggest that long-run inflation expectations are responding roughly one-for-one to one-quarter-ahead inflation forecast errors. The striking positive relationship between the inflation forecast errors and the forward rates is immediately apparent in figure 5. While no clear link between the two is evident in the pre-crisis grey squares, the post-crisis black circles line up almost perfectly along a 45-degree line running through the origin. Similar results are obtained when the forecast revision is used instead (table 5). Taken at face value, the result suggests that with the Federal funds rate pegged at zero for the foreseeable future, the Fed was expected to accommodate fluctuations in the inflation rate.

Two caveats are worth emphasizing. The most obvious is that the results are based on a very small number of observations. The comparison between the pre- and post-crises responses rely on only seven data points, not a large sample by any stretch of the imagination. Unfortunately, data limitations of this sort would be inevitable in any quantitative analysis of the effects of exercising an "escape clause," which by definition is a rare response to exceptional circumstances. A closer look at the period using higher frequency data, along the lines of Gürkaynak *et al.* (2005), would be a useful robustness check.

A second caveat is that these results do not speak to the persistence of the observed responses. Clearly, with so few observations to go on, it would be difficult to ascertain whether a positive inflation shock leads to a permanent increase in inflation expectations, as opposed to a situation in which inflationary concerns dissipated over time. At the very least, however, the results are consistent with a response that persists for at least a quarter—a short time on a macroeconomic time scale, but a very long time compared to the one- to five-day horizons used in event study-style analysis.

[26] This runs counter to the finding in Gürkaynak *et al.* (2005), and an interesting question is whether the discrepancy stems from differences in methodology, sample, or some other source.

Table 4: The reaction to inflation forecast errors in the UK and US, pre and post crisis

		Financial indicator			
Country		Bond yield	Forward rate	Breakeven inflation	5-year breakeven
United Kingdom	pre-	0.26**	0.18*	0.21**	0.04
		(0.13)	(0.10)	(0.09)	(0.07)
	post-	0.24	0.20	0.30	0.12
		(0.22)	(0.13)	(0.21)	(0.10)
United States	pre-	0.14	0.12	0.08	0.02
		(0.15)	(0.11)	(0.08)	(0.05)
	post-	1.34***	1.34***	0.87***	0.74***
		(0.36)	(0.40)	(0.18)	(0.17)

Notes: The numbers shown are the estimated coefficients in a regression of the change in the financial indicator on the difference between the realized 12-month inflation rate and the one-quarter-ahead private-sector forecast from the previous quarter, with separate regression coefficients for the pre-crisis (before 2008Q1) and post-crisis (after 2009Q1) periods. Asterisks denote statistical significance: *** for 1%, ** for 5%, and * for 10%. Robust standard errors are in parentheses. The sample period is 1999Q3 through 2010Q4, excluding 2001Q3 and 2001Q4 (9/11) and 2008Q4 through 2009Q1 (financial crisis). The total number of usable observations is 40.

Table 5: The reaction to inflation forecast revisions in the UK and US, pre and post crisis

		Financial indicator			
Country		Bond yield	Forward rate	Breakeven inflation	5-year breakeven
United Kingdom	pre-	0.06	0.02	0.21	0.17
		(0.25)	(0.25)	(0.16)	(0.10)
	post-	0.03	0.23	0.11	0.09
		(0.40)	(0.20)	(0.40)	(0.14)
United States	pre-	0.14	0.12	0.08	0.02
		(0.15)	(0.11)	(0.08)	(0.05)
	post-	1.18***	1.14***	0.75***	0.65***
		(0.40)	(0.44)	(0.20)	(0.21)

Notes: The numbers shown are the estimated coefficients in a regression of the change in the financial indicator on the change from the previous to the current quarter in the forecast of the quarter-ahead 12-month inflation rate, with separate regression coefficients for the pre-crisis (before 2008Q1) and post-crisis (after 2009Q1) periods. Asterisks denote statistical significance: *** for 1%, ** for 5%, and * for 10%. Robust standard errors are in parentheses. The sample period is 1999Q3 through 2010Q4, excluding 2001Q3 and 2001Q4 (9/11) and 2008Q4 through 2009Q1 (financial crisis). The total number of usable observations is 40.

Figure 4: Inflation news and the UK nominal forward rate

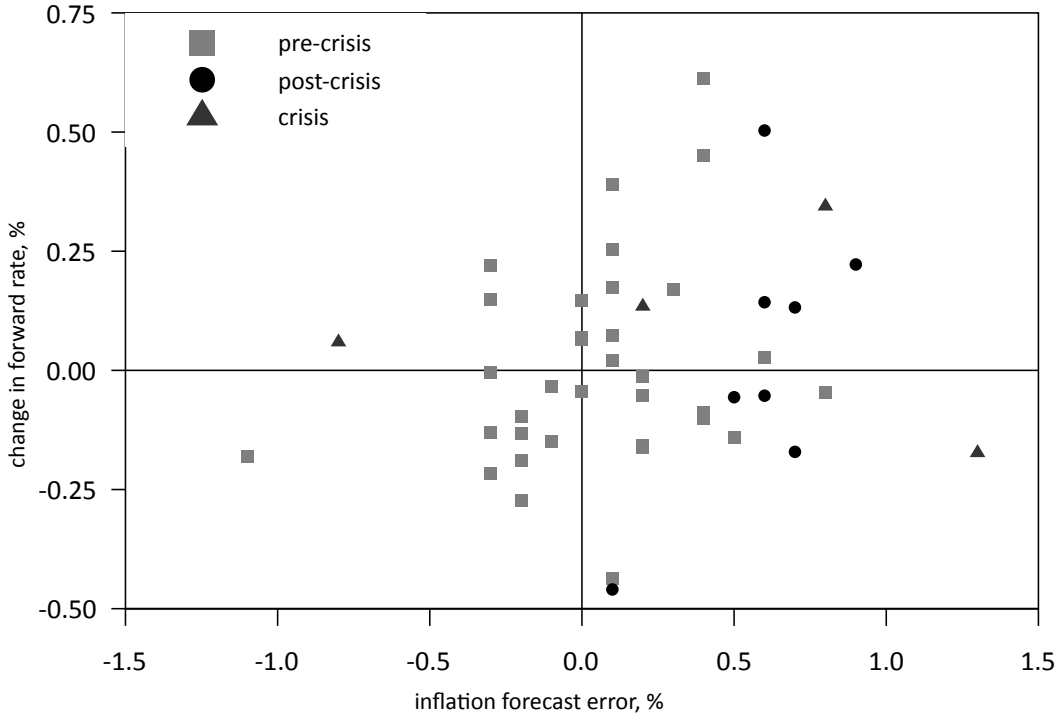
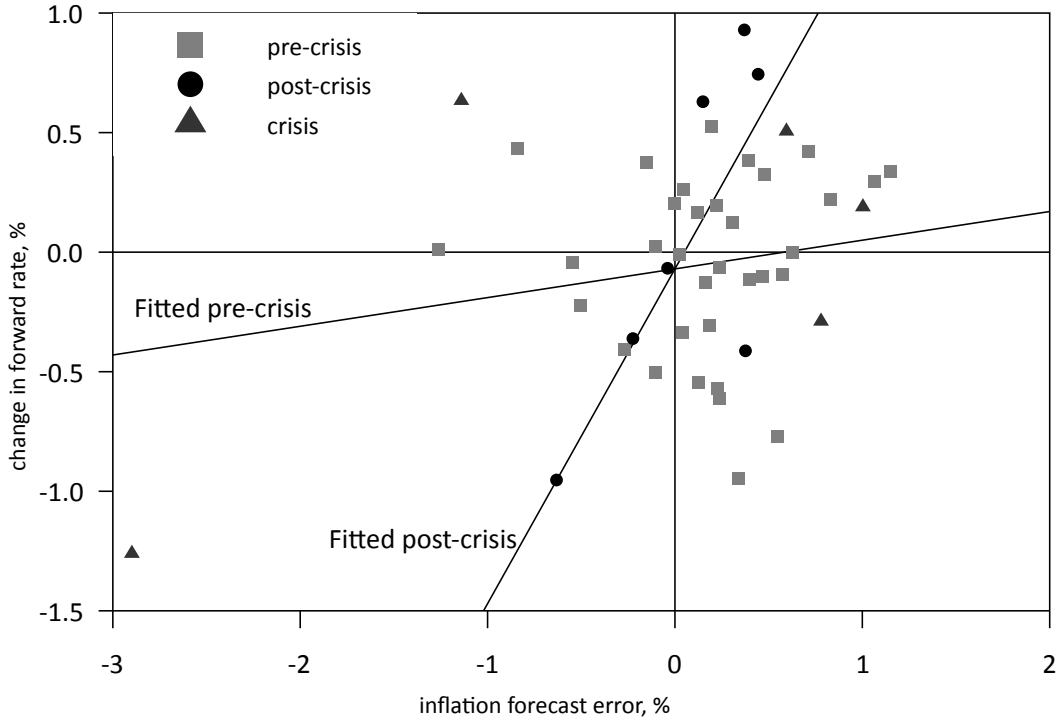


Figure 5: Inflation news and the US nominal forward rate



4 Conclusions

Under construction. . .

A *Appendix: data sources*

- *Private-sector inflation forecasts*. We use Consensus Forecasts, the arithmetic average of professional private-sector forecasters' predictions collected by Consensus Economics. The forecasts are collected four times a year and are for four-quarter headline inflation.
- *Long-term nominal bond yield*. The 10-year nominal government bond (gilt) yield data for the UK, Australia, New Zealand and Germany are from Global Financial Data. For Canada, we use the long-term government bond yield from Global Financial Data. For the US, we use the data from Gürkaynak *et al.* (2007) (series SVENY10). For all countries, the quarterly data correspond to the last day of the quarter.
- *Long-term implied forward nominal rate*. The 9-year ahead, 1-year forward rates for the UK, Canada and Germany are based on Bloomberg data and Bank of England calculations. For the US, we use the data from Gürkaynak *et al.* (2007) (series SVEN1F09). The data are not available for Australia and New Zealand.
- *Long-term nominal to index-linked gilt yield spread*. The long-term breakeven inflation rate is calcualted as the difference between the 10-year government bond yield and the 10-year inflation-indexed government bond yield (long-term yields for Canada). The data source for the 10-year government bond yield is given above. Data for the 10-year inflation-indexed government bond yield are from Global Financial Data. This applies for the UK, Australia, New Zealand and Canada. For the US, we use the data from Gürkaynak *et al.* (2010) (series BKEVENY10). For all countries, the quarterly data correspond to the last day of the quarter.
- *Long-term implied forward breakeven inflation rate*. The 5-to-10 year forward breakeven inflation rates are based on Bloomberg data and Bank of England calculations for the UK and Germany. For the UK, we use the forward RPI inflation rate implied from gilts. For Germany, we use the forward HICP inflation rate implied from swaps. For the US, we use the data from Gürkaynak *et al.* (2010) (series BKEVEN5F5). The data are not available for Australia, New Zealand and Canada.
- *Nominal bilateral exchange rate*. For all countries except the US, this corresponds to the $US to domestic currency (euro for Germany) bilateral exchange rate. For the US, we use the euro/$US exchange rate.
- *Expected path of the policy rate*. We use the 1-year nominal government note yield for the UK, US, Australia, New Zealand and Germany from Global Financial Data. For Canada, we use the 1-3-year nominal government note yield from Global Financial Data. The quarterly data correspond to the last day of the quarter.

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