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Inflation Expectations and the News

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Abstract

This paper provides new evidence on the importance of inflation expectations for variation in nominal interest rates, based on both market-based and survey-based measures of inflation expectations. Using the information in TIPS breakeven rates and inflation swap rates, I document that movements in inflation compensation are important for explaining variation in long-term nominal interest rates, both unconditionally as well as conditionally on macroeconomic data surprises. Daily changes in inflation compensation and changes in long-term nominal rates generally display a close statistical relationship. The sensitivity of inflation compensation to macroeconomic data surprises is substantial, and it explains a sizable share of the macro response of nominal rates. The paper also documents that survey expectations of inflation exhibit significant comovement with variation in nominal interest rates, as well as significant responses to macroeconomic news.

Keywords: inflation expectations, macroeconomic news, inflation compensation, TIPS, inflation swaps, survey expectations

JEL Classifications: E43, E44, E52

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1 Introduction

Are changes in expected inflation an important driver for variation in long-term nominal interest rates? To understand the driving forces behind changes in nominal rates is important to academic researchers and policy makers, since it reveals how economic agents form expectations about policy and inflation, how risk premia vary over time, and how real and nominal forces affect economic incentives. Macroeconomic data releases are an important source of volatility and lead to pronounced responses of the nominal term structure of interest rates (Balduzzi et al., 2001; Gürkaynak et al., 2005; Bauer, 2014). This paper provides new evidence, using both market-based and survey-based measures of expected inflation, that variation in inflation expectations contribute importantly to the variability in both short-term and long-term nominal interest rates.

The Taylor rule literature has demonstrated that movements in policy rates can be accurately described by a simple policy rule in which the nominal short rate is a linear function of inflation and output.[1] In estimated Taylor rules the policy response to current inflation is typically found to be very pronounced (Taylor, 1999; Clarida et al., 2000). There is a tight statistical relationship between current inflation and current short-term interest rates.[2] In light of this fact, one might expect that expectations of future nominal short rates are closely related to expectations of future inflation. This would imply that a large share of variation in nominal long-term rates is explained by variation in future inflation. However, if the policy rule is credible and satisfies the Taylor principle, i.e., exhibits a positive response of real short rates to inflation, and if inflation expectations are anchored, then shocks affecting current output and inflation will be undone by monetary policy. In that case, long-term inflation expectations will be largely unaffected by current shocks. It is ultimately an empirical question how variable inflation expectations are and how much they contribute to the variability in nominal rates. The answer to this question has implications for the effectiveness of monetary policy. Highly variable inflation expectations would indicate the lack of a credible inflation target of the central bank.

One way to address this issue is to investigate the response of inflation expectations to macroeconomic data surprises. Unfortunately, inflation expectations are not easy to measure. Several studies have used financial market data to learn about the response of inflation expectations to macro surprises. Gürkaynak et al. (2005) find that in the United States, far-ahead

[1] After Taylor's (1993) original paper there have been numerous studies on this topic, for a survey see Orphanides (2008).

[2] Additionally, the literature about the Fisher effect shows that at low frequencies both short- and long-term interest move together with actual inflation—see specifically Wallace and Warner (1993).

nominal forward rates are quite sensitive to news, and argue that variation in inflation expectations and shifts in the central bank's implicit inflation likely explain this result. Gürkaynak et al. (2010a) come to a similar conclusion based on an analysis of the sensitivity of forward inflation compensation—the difference between nominal forward rates and real forward rates from the Treasury Inflation Protected Securities (TIPS) market. In contrast, Beechey and Wright (2009), henceforth BW, estimate only small responses of forward inflation compensation to real-side macroeconomic news, and attribute most of the impact of such news on nominal rates to the response of real rates.

To shed some light on these contradicting findings, this paper revisits this evidence and carefully investigates the role of inflation compensation for explaining movements in nominal interest rates. While the studies cited above have focused on TIPS breakeven inflation (BEI) rates—the spread between nominal rates and TIPS real rates—as a measure of inflation compensation, I also include inflation swap (IS) rates in the analysis. These instruments provide additional useful information about inflation compensation, which is unobserved due to market frictions and liquidity effects. I present results for both BEI and IS rates, as well as for an additional, novel measure of inflation compensation, which incorporates information from both sources and includes a liquidity adjustment.

There is a close statistical relationship between inflation compensation and long-term nominal rates. Unconditional correlations between daily changes in inflation compensation and in nominal rates are generally quite high, independent of the sample, frequency, or measure of inflation compensation. This correlation has varied over time, and its exact magnitude slightly differs between alternative measures of inflation compensation, but the overall picture that emerges is one of a quite strong comovement. The high correlations suggests that variability in inflation compensation was important for variation in nominal interest rates. An additional point is that toward the end of the sample, correlations with nominal rates decrease significantly, which may be the result of the introduction of an explicit inflation target by the Federal Reserve and a consequently declining role for variation in inflation expectations most recently.

We are ultimately more interested in the response of interest rates to news about economic fundamentals than in unconditional correlations. I document that inflation compensation, no matter how it is measured, exhibits strong sensitivity to macroeconomic surprises, both for price-level news and real-side news. This holds true for long-term yields as well as far-ahead forward rates. Surprises about nonfarm payrolls, the most important driver of nominal interest rates, have important effects on inflation compensation. Overall, inflation compensation appears to be an important factor for explaining the high sensitivity of long-term nominal rates to macro news.

While consistent with other studies in this literature, my findings about the sensitivity of forward inflation compensation to real-side macro news stand in contrast to those of BW, who find very little such sensitivity and conclude that "the vast majority of the sensitivity is concentrated in real rates." I drill down into the reasons for the different findings, and show that focusing on intraday responses of TIPS breakeven, as BW do, may partly mask the sensitivity to real-side macro news. This is due to a slightly delayed response to the announcements. I argue that event studies using intraday changes in asset prices, while having a lot of potential to increase precision and avoid unnecessary noise, should normally be complemented by analysis using daily changes. If we find significant results using daily event windows, and do not using intradaily event windows, then we may want to carefully explore the data for potential delays in asset price responses.[3] Another reason for differences between my results and those of BW is that they include the financial crisis in their sample, a period during which TIPS BEI rates may not have reflected inflation compensation very accurately due to variations in liquidity premia in Treasury markets.

The presence of inflation risk premia is a concern, because movements and sensitivity of inflation compensation may be partly due to the behavior of such risk premia. However, there is evidence that risk premia primarily move at lower frequencies, which suggests that they would be largely differenced out in the high-frequency analysis described above. Furthermore, risk premia appear to behave in counter-cyclically, whereas the response of inflation compensation to macroeconomic news is procyclical. It is unlikely that risk premia play are a major factor responsible for these results. However, to guard against this possibility, the paper also investigates the behavior of survey-based inflation expectations.

Survey expectations of future inflation are available from different sources. In my analysis I focus on the monthly Blue Chip Economic Indicators survey, and the quarterly Survey of Professional Forecasters. In addition to near-term inflation expectations, both also include long-term expectations (although these are only semi-annual for Blue Chip). As for the market-based inflation expectations, I consider both the unconditional relationship between nominal rates and inflation expectations, as well as their behavior conditional on macroeconomic news, under the constraints that the frequency is lower and the horizons are determined by the survey designs. The correlations between changes in nominal interest rates and survey expectations of inflation are significant for short horizons, and in some cases for long horizons. The magnitudes of the correlations of nominal rates with inflation expectations are similarly

[3]Statistically significant delayed responses do not necessarily imply arbitrage opportunities, for two reasons. The response may be too small, given the presence of transaction costs, to be taken advantage of in practice. And the required trading position to profit from such a pattern may be quite risky.

high as those with inflation compensation at the same frequencies. This indicates that the comovement of inflation expectations and nominal interest rates is substantial, and that it is expectations and not risk premia that explain the comovement with inflation compensation.

The paper is the first to estimate the sensitivity of survey-based inflation expectations to macro news. To do so, I cumulate macro surprises over the monthly or quarterly observation windows. Naturally, these long windows substantially lower the precision of the estimated sensitivities, since a host of news and noise that we cannot control for also affect agents expectations over these intervals. However, the results still show significant responses, both economically and statistically, of several different survey measures of inflation expectations to macroeconomic surprises. The regression R^2 are around 20%, which is substantial given the amount of outside news during such long observation period, and they are almost as high as for the regressions of nominal interest rates on macro news. The macro surprises are jointly significant for all but one expectations measure. Several estimated coefficients are significant and sizable, and most have the expected sign. Overall, this regression-based evidence points to significant sensitivity of inflation expectations to macro news, and to an important role of inflation expectations in explaining the sensitivity of nominal rates. While the evidence is stronger for expectations at short horizons, there is also some evidence for the variability of long-term inflation expectations.

Taken together, the evidence presented in this paper strongly suggests that long-term inflation expectations display economically important variation, and that they play an important role in explaining the variability of long-term nominal interest rates, and their responses to macro news. One consequence of this conclusion is that a better anchoring of long-term inflation expectations, lowering their volatility and sensitivity to macroeconomic news, could reduce the variability of long-term interest rates. Well-anchored inflation expectations have important economic benefits in terms of reduced uncertainty, not only about future inflation, but also about movements in asset prices. This is a strong argument in favor of explicit inflation targets for the conduct of monetary policy, in order to better anchor inflation expectations. The announcement of an inflation target by the Federal Reserve in January 2012 is a major step into the right direction.

2 Market-based measures of inflation expectations

A convenient and wide-spread approach for obtaining estimates of inflation expectations is to use financial market data. The crucial concept is inflation compensation, which is the additional yield that investors require to cover expected future inflation and the riskiness due to the uncertainty of future inflation:

$$i_t^n = r_t^n + IC_t^n \tag{1}$$

$$= r_t^n + n^{-1}\sum_{i=1}^{n} E_t\pi_{t+i} + IRP_t^n. \tag{2}$$

The nominal interest rate for a zero-coupon bond of maturity n, i_t^n, is the sum of the real interest rate for the same maturity, r_t^n, and inflation compensation, IC_t^n. Despite the availability of inflation-indexed fixed income securities, such as TIPS bonds in the United States, the real interest rate and inflation compensation are not observed without error. Due to differences in liquidity premia between nominal and inflation-indexed bond markets, the difference between observed nominal and real yields will be a noisy measurement of inflation compensation. To guard against this issue, the analysis is carried out using alternative estimates of inflation compensation.

Due to the risk of changes in inflation, inflation compensation generally contains an inflation risk premium. Equation (2) is the generalized Fisher equation, expressing the nominal rate as the sum of the real rate, expected future inflation—π_t is the continuously compounded rate of inflation between $t-1$ and t— and an inflation risk premium, IRP_t^n. The ultimate goal of this paper is to learn about the importance of inflation expectations, the second term in equation (2), for variation in long-term nominal rates. To obtain evidence about inflation expectations based on an analysis using inflation compensation, one needs to either resort to a model for estimating the risk premium, as in D'Amico et al. (2010) or Christensen et al. (2010), or make additional assumptions about the behavior of this risk premium. Because estimates of the inflation risk premium are highly uncertain and model-dependent, I focus on documenting patterns in inflation compensation and do not attempt to correct for a risk premium. Empirical evidence suggests that risk premia move slowly and vary primarily at business-cycle frequencies (Harvey, 1989; Cochrane and Piazzesi, 2005; Lustig et al., 2010). Under the assumption that risk premia are slow-moving, they will be largely differenced out in the high-frequency analysis that follows. To the extent that one is willing to entertain this assumption, the results about the behavior of inflation compensation can also be taken as evidence about inflation expectations.

2.1 Measures of inflation compensation

This paper uses two sources of information about inflation compensation: spreads in yields on nominal and inflation-indexed bonds, and inflation swap rates. Absent market frictions and liquidity risk premia, the two measures should coincide. In practice, there are notable discrepancies between the two, so that it is worthwhile including both into any empirical analysis of inflation compensation.[4]

2.1.1 TIPS breakeven inflation rates

Treasury Inflation-Protected Securities (TIPS) are bonds that deliver payoffs indexed to the CPI, therefore yields correspond to real interest rates. The breakeven inflation (BEI) rate is the difference between a nominal Treasury yield and the corresponding TIPS yield of the same maturity. This is the rate of inflation that makes investments in indexed and non-indexed bonds equally profitable.

Data on nominal and TIPS zero-coupon yields is readily available. For nominal yields I use the data constructed by Gürkaynak et al. (2007). Zero-coupon TIPS yields are constructed by Gürkaynak et al. (2010b). Both data sets are available for download on the Board of Governor website. Due to low liquidity and indexation effects, TIPS yields at very short maturities are erratic and unreliable, hence the shortest maturity in the data of Gürkaynak et al. (2010b) is two years. The sample period for BEI rates used here starts in January 2, 2003, after the TIPS market had left its infancy. The data sample ends on December 31, 2013.

Generally BEI rates are not equal to inflation compensation, because they contain a liquidity risk premium which captures the differences in liquidity between the nominal Treasury and TIPS market. The effects of this liquidity premium were particularly obvious during the recent financial crisis: during 2008, flight-to-safety effects in the non-indexed Treasury market artificially compressed the spread between nominal and real yields. For some time, the distortions in BEI rates were so large that there was barely any information content about expected future inflation. There are different ways to adjust BEI rates for liquidity premia, including model-based approaches (for example, D'Amico et al., 2010) and straightforward regression-based methods (as in Gürkaynak et al., 2010b). In the analysis below, I will report results for observed, unadjusted BEI rates. In addition, I will use a liquidity-adjusted BEI rates together with adjusted inflation swap rates to filter an estimate of inflation compensation in a state-space framework.

2.1.2 Inflation swap rates

Inflation swaps are financial contracts in which one party pays a fixed interest rate, the swap rate, and the other party pays the CPI inflation rate on an underlying notional. No payments

[4]Studies that have compared these measures and investigated reasons for discrepancies include Fleckenstein et al. (2010) and Christensen and Gillan (2011).

are exchanged until the settlement date, so that one also speaks of a zero-coupon inflation swap. Studies that use data on inflation swaps include Haubrich et al. (2012), Christensen and Gillan (2011), and Fleckenstein et al. (2010).

The swap rate dataset contains end-of-day rates on U.S. zero-coupon inflation swaps for maturities from one to ten years. The data comes from by Bloomberg. Fleming and Sporn (2013) show that these end-of-day quotes are generally very close to actual transaction prices, which is comforting. The sample period is from January 2, 2005 to December 31, 2013.

Empirically, IS rates are typically higher than BEI rates, and this spread was particularly pronounced during the recent financial crisis (see Figure 1). The spread arises due to either liquidity premia in TIPS or in IS rates, or a combination of both (Christensen and Gillan, 2011). Notably, during the recent financial crisis, inflation swap rates did not show the same anomalous behavior as TIPS breakeven spreads. While liquidity premia in different markets often show commonalities (Chordia et al., 2004), the variability in the BEI-IS spread is an indication that liquidity effects in the swap market differ from those in the TIPS market. Fleckenstein et al. (2010) argue that the spread is largely due to mis-pricing in the TIPS market, which would be an argument to view IS as a better approximation of the true inflation compensation. Fleming and Sporn (2013) document that the inflation swap market is quite liquid and transparent, with modest bid-ask spreads, which also points to liquidity premia in this market likely being small.

Figure 2 shows rolling correlations of the ten-year BEI rate and the corresponding IS rate. The window length is 250 trading days, corresponding to about one year. For most of the sample period where both series are available, the correlation has been between 0.6 and 0.8. During the crisis period, this correlation dropped to as low as 0.2. This suggests that important market frictions were present during this time, and that the liquidity and risk premia in these two series had important idiosyncratic components.

In this paper I do not take a stand whether BEI or IS rates provide better estimates of the unobserved inflation compensation. I show results for both measures, as well as for a third inflation compensation measure that combines the available information. Since the results are qualitatively similar across the different measures, we can have some confidence that they are not driven by the behavior of liquidity premia.

2.1.3 Filtering inflation compensation from breakeven and swap rates

The two alternative measures of inflation compensation that we have available are presumably both imperfect, and both suffer from some variation in idiosyncratic factors related to market frictions. Therefore it appears promising to combine the information from both sources, and possibly get an improved estimate of true, unobserved inflation compensation. A state-space approach is the natural framework for this:

$$IC_t = IC_{t-1} + w_t \tag{3}$$

$$BEI_t^{adj} = IC_t + v_t^1 \tag{4}$$

$$IS_t^{adj} = IC_t + v_t^2 \tag{5}$$

Equation (3) is the transition equation for the inflation compensation, which is the latent state variable of the state-space system. In the spirit of a local-level model, the transition equation is specified as a random walk. The innovation w_t is taken to be Gaussian and homoskedastic. Equations (4) and (5) are the observation equations, linking break-even inflation and inflation swap rates to the inflation compensation and Gaussian *iid* measurement errors, which are allowed to be contemporaneously correlated.

Instead of using observed BEI and IS rates, an attempt is made to first adjust these for an estimate of the liquidity premium. One way to accomplish this is to regress the observed rates on proxies for liquidity risk. The residual from this regression then serves as a measure that is adjusted for the liquidity premium. This is the approach chosen by Gürkaynak et al. (2010b), who estimate the liquidity premium in BEI rates using as liquidity proxies the spread between Resolution Funding Corporation strips and Treasury strips, as well as the trading volume in the TIPS market relative to the entire Treasury market. For the BEI rates I use these same proxies. To estimate liquidity premia in IS rates, I use the average bid-ask spreads for inflation swaps of the same maturity (five or ten years).[5] Since this approach identifies only variation in the liquidity premium but not the level, I normalize it to be zero at the end of the sample. The estimates of liquidity-adjusted BEI and IS rates are denoted by BEI_t^{adj} and IS_t^{adj}, respectively.

To calculate the likelihood function and to filter the latent state variable, I use the Kalman filter. There are four parameters to be estimated, all pertaining to the variances and covariances of the shocks. I carry out the estimation for the five-year and ten-year inflation compensation, separately. Figure 1 shows all three measures of inflation compensation: observed BEI rates, observed IS rates, and filtered inflation compensation ("IC-new"). The filtered measure is generally quite close to the observed IS rates.

[5] I use 20-day moving averages of these bid-ask spreads.

2.2 Correlation of inflation compensation with nominal rates

A natural first step is to calculate unconditional correlations between changes in nominal rates and inflation compensation. High correlations would imply that variation in inflation compensation is an important source for variation in long-term nominal interest rates.

Table 1 reports the estimated correlations with nominal rates of the three different measures of inflation compensation, for the five-year yields, the ten-year yield, and the five-to-ten-year forward rate. The sample starts in January 2005 and ends in December 2013, a period over which observations for both BEI and IS rates are available.

The first row shows correlations for the sample including all daily changes within the sample period. The correlations with nominal rates are high for BEI rates and for the filtered inflation compensation measure, around 0.5 or higher. The correlations are somewhat smaller for IS rates but still notable. Overall, it seems that there is an important association between nominal rates and inflation compensation.

The second and third row show results for the sample that only includes days on which an employment report or CPI numbers were released. On days with employment reports, nominal interest rates typically display a high level of volatility Bauer (2014). The results show that the correlations with inflation compensation are higher on these days than over all trading days. This suggests that on employment report days, a substantial portion of interest rate volatility is explained by movements in inflation compensation. For days with a CPI report, the correlations are smaller than for the whole sample at the five-year maturity, similar at the ten-year maturity, and consequently larger than for the whole sample for five-to-ten-year forward rates. Evidently, the volatility in long-term nominal rates due to inflation news is to a large degree associated with movements in inflation compensation, while this is less pronounced for shorter maturities.

The table also reports correlations for changes at lower sample frequencies, namely, weekly, monthly, and quarterly changes. These correlations are typically larger than the correlations at the daily frequency, which points to a an even closer relationship between changes in nominal rates and inflation compensation at these frequencies. However, movements in risk premia, which arguably become more relevant at lower frequencies, may partly explain this close comovement.

The evidence in Table 1 suggests an important role for inflation compensation for explaining volatility in nominal rates. The correlations are sizable and also significantly different from zero in all but one cases.[6] Although the correlations for inflation swaps are weaker at the daily

[6]I carried out significance tests based on the usual student-t approximation for the correlation coefficient. The p-values, which are not shown, are much smaller than 5% in all cases with the exception of the five-year

frequency, overall the finding is robust across the three different measures of inflation compensation. Therefore it seems unlikely that liquidity effects in particular markets contribute a lot to these high correlations. And under the assumption that inflation risk premia are slow-moving, the evidence based on daily changes suggests that changes in inflation expectations are correlated with nominal rate changes.

To assess the sub-sample stability of the results above, it is useful to consider how correlations of daily changes in nominal rates and iC have evolved over the sample period. Figure 3 shows rolling correlations for subsamples of 250 observations, that is, over about one year. The correlation series are shown for all three inflation compensation measures and for three different maturities.

The strength of the correlation has shown some degree of variation over time. This is true for all measures of inflation compensation, but particularly for IS rates and filtered inflation compensation. During the financial crisis, correlations were generally lower than at most other times in the sample. This is particularly true for the IS rates, which were basically uncorrelated with nominal rates early on in the crisis. The correlations between IS rates (and filtered inflation compensation) and nominal rates have generally been lower and more variable than for the BEI rates. After the end of the crisis until about 2012, correlations have been high and remained relatively stable, particularly for BEI rates for ten-year yields and five-to-ten-year forward rates.

Toward the end of the sample, correlations decreases significantly. For five-year BEI rates, and for IS rates at all maturities, the correlation has dropped to zero by the end of 2013. This may have been a result of the introduction of an explicit inflation target by the Fed in January 2012, which had the goal of anchoring long-term inflation expectations more firmly. This would make inflation compensation less variable, relative to real rates, and decrease the measured compensation. The evidence here suggests that the Fed's strategy has been starting to bear fruit.

The overall picture that emerges from this evidence is that for the sample as a whole, changes in nominal rates are quite closely associated with changes in inflation compensation. The strength of the comovement has varied to some degree over time, and differs slightly depending on which measure of inflation compensation is used. Taken together, however, there appears to be a significant and rather close relationship.

inflation swap rate over the CPI subsample.

2.3 Sensitivity of inflation compensation to macroeconomic news

While unconditional correlations are informative about the relationship between nominal rates and inflation compensation, they could be driven by many non-fundamental factors such as changes in liquidity and inflation risk premia, safe-haven demand flows, and others. It is preferable to study movements in asset prices that are caused by fundamental news to agents perceptions of the current economic situation. To this end, a large literature has focused on the sensitivity of asset prices to macroeconomic data surprises. In what follows, I investigate the sensitivity of inflation compensation to macro news, and assess how much it contributes to explaining the sensitivity of nominal rates.

The effects of macroeconomic announcements on asset prices can be estimated using an event study, where changes in asset prices around the time of a data release are regressed on a measure of the surprise component in this release (see e.g. Balduzzi et al., 2001):

$$\Delta p_t = \beta' s_t + \varepsilon_t, \tag{6}$$

where t indexes days with announcements, Δp_t is the change in an asset price or interest rate around the announcement, and s_t is a $k \times 1$ vector containing the surprise component for each of the k announcements – the kth element of s_t is zero if there was no release for this announcement on day t. Multivariate regression is used in order to partial out the effects of different announcements that occur on the same day. The surprise component is calculated as the difference between the released number and the consensus expectation for the release. This surprise is standardized to have unit variance for the sake of comparability of different releases. The releases I consider are the thirteen data releases that BW include in their analysis. The dependent variables are are changes, in basis points, in nominal rates, real rates, and inflation compensation. Hence each element of β has the interpretation of representing the basis point response of an interest rate to a one-standard-deviation surprise in the corresponding announcement. As in BW, I report results for the five-year yield, the ten-year yield, and the five-to-ten-year forward rate.

Table 2 shows the estimated responses for the TIPS data. The sample period is chosen to exclude the financial crisis, and extends from January 2, 2003, to July 31, 2007. The results show that both real rates and inflation compensation are very sensitive to macroeconomic news. The regression R^2 are quite similar, the surprises are highly jointly significant in both cases, and there are about as many significant coefficients for real rates as there are for inflation compensation. This holds for yields as well as forward rates.

For news about the price level, the responsiveness is concentrated in BEI rates, consistent with the findings of BW. For real-side macroeconomic news, the results here show that in most cases both real rates and BEI rates contribute significantly to the response of nominal rates. This is true for yields as well as for far-ahead forward rates. This contrasts with the conclusion of BW, who find almost no response of far-ahead forward rates to real-side news, whereas I find that real-side news matter for far-ahead forward inflation compensation. In the specific case of payroll news, which is probably the most important economic data release, the sensitivity of forward inflation compensation is only slightly smaller than the sensitivity of real forward rates, and there are a few other real-side data releases that significantly affect far-ahead forward inflation compensation. Both real-side and price-level news appear to affect inflation compensation.

Table 3 presents the same results for the inflation swap data set, based on a sample period from January 2, 2005, to December 31, 2013. For this later sample, which includes the financial crisis, the nominal rate responses look quite different than for the TIPS sample. The R^2 are much smaller, and so are several of the response coefficients, including the one for payroll news. Regarding the relative contribution of real rates and inflation compensation to the sensitivity of nominal rates, however, the same results hold. The sensitivity of IS rates is about as high or, in the case of yields, higher than for real rates, as indicated by the R^2. For price-level news, IS rates account for most of the nominal rate response. For the real-side news, the results here show significant sensitivities of inflation compensation to employment news, which contribute importantly to the sensitivity of nominal rates. Again, inflation compensation appears to respond to both price-level and real-side news.

Table 4 reports results for a decomposition of nominal rates based on filtered inflation compensation, using the same long sample period as in Table 3. The sensitivities of inflation compensation are often significant, both for real-side and price-level news. The R^2 are in fact higher for inflation compensation than for real rates for both yields and forward rates. In the case of forward rates, some key employment news only affect inflation compensation and not real rates.

The evidence across all three measures of inflation compensation is consistent in that it suggests a high sensitivity of inflation compensation to macroeconomic news, comparable to the response of real rates. Inflation compensation is sensitive to both price-level news and real-side news, and, like nominal rate and real rates, typically responds in a procyclical manner. The sensitivity is evident for both long-term yields and far-ahead forward rates. This is an important component for explaining the strong responses of nominal interest rates to macroeconomic news.

2.4 The evidence of Beechey and Wright (2009)

While these results are in line with the evidence in Gürkaynak et al. (2010a), they contrast with the conclusions of BW. Based on their analysis of daily and intradaily response of nominal, TIPS, and BEI rates to macro news, they conclude that the response of nominal rates to real-side economic data surprises is concentrated almost exclusively in real rates, and that inflation compensation does not contribute noticeably to the sensitivity of nominal rates. Here I investigate the reasons for the differences in results. There are three main factors that can possibly explain the differences in results: (i) the different sample periods, (ii) the use of smoothed vs. unsmoothed yields, and (iii) the length of the sampling windows around the announcements (daily vs. intradaily). I will discuss each of these in turn.

The first difference that drives a wedge between the TIPS results in my Table 2 and the results in BW is the sample period. BW include part of the financial crisis period in their data, which lowers the response of break-even inflation to macro news. I have carried out my analysis for the exact same sample period as in BW and generally find smaller sensitivities of inflation compensation, due to the inclusion of the financial crisis period. TIPS spreads have behaved abnormally during the crisis, due to significant flight-to-safety pressures on prices of non-indexed Treasury securities prices. The liquidity premium in the TIPS market increased markedly during the crisis period (Lehnert et al., 2009; Christensen and Gillan, 2011). I argue that using a sample period that ends before the onset of the crisis, as I do here, gives a cleaner picture of the response of inflation compensation to macroeconomic data surprises.

The second difference is that BW use unsmoothed yields, that is, yields based on quoted prices of nominal and indexed Treasury securities, whereas I use the smoothed nominal and real term structures from Gürkaynak et al. (2007) and Gürkaynak et al. (2010b). The differences in results for smoothed vs. unsmoothed yields are small, as shown by BW in their online appendix, but the sensitivity of inflation compensation to real-side news is slightly larger when using the smoothed data sample. One might argue that smoothing through the idiosyncracies of movements in individual securities promises to give more reliable estimates of shifts in the nominal and real yield curves.

The third and main difference is that I focus on regressions using daily changes, whereas BW also use intradaily changes over 30-minute windows around announcements. While in their intraday results inflation compensation is largely insensitive to real-side news, the responses are slightly larger and in some cases significant in their daily results. It is worthwhile investigating more carefully the difference between daily and intradaily sensitivities.[7]

Table 5 shows estimated sensitivities payroll surprises for nominal rates, real (TIPS) rates,

[7] I thank Meredith Beechey and Jonathan Wright for providing me with their intraday TIPS data.

and BEI rates, for the same maturities as before. The sample corresponds to the one used in BW, the only difference being that it only includes days with an employment report. The table shows the sensitivities when using a 30-minute interval around the announcement, as in BW, and the results are comparable to the ones in BW's Table 3.[8] The table also shows sensitivities for longer intraday windows, spanning four hours, and for daily windows (as in BW's Table 4). For far-ahead forward rates, which BW focus on, the sensitivity of inflation compensation is insignificant when using a short intradaily window, and becomes larger and significant when using longer sampling windows.

This difference warrants closer investigation of the adjustment over the course of the day. Figure 4 shows the response of the nominal forward rate (top row), the real forward rate (middle row), and the forward inflation compensation (bottom row) for different intra-daily windows. The left panel shows the response coefficients and 95% confidence intervals for windows that start 15 minutes before the release and end 15 minutes to four hours after the release, that is, cumulative responses (similar to BW's Figures 2 and 3). The right panel shows estimates of the responses (with 95% confidence intervals) for non-overlapping windows: the first error bar is for the 30-minute window around the release, the following ones are for the subsequent 15-minute windows. While at first sight the top left and middle left panels seem to indicate that all new information is incorporated immediately into nominal and real rates and no further adjustments occur after the first 30 minutes (the conclusion of BW), this is not the whole story. The top panels in fact show that the nominal forward rate exhibits a small but significant response in the two following 15-minute intervals. This is not the case for the real forward rate (middle panels), and thus this delayed response occurs in the forward inflation compensation, as is evident in the bottom panels: The forward inflation compensation does not respond at all during the 30-minute window around the announcement, but over the subsequent periods adjusts upward.

One can only speculate as to the reasons for the delay of this response. It seems that a delayed adjustment should be arbitraged away, since such a predictable pattern would in principle generate a profitable trading opportunity: after observing a positive payroll surprise, a trader could enter into a long 5-to-10-year inflation compensation position, which would on average generate a positive payoff. However this is not necessarily an arbitrage opportunity for at least two reasons: First, the expected payoff might be too small to warrant the riskiness of such a trade. Second, the expected movement of about one basis point could be practically irrelevant given the prevailing bid-ask spreads in Treasury and TIPS markets – Fleming and

[8] The magnitude of the coefficients also differ from the ones in BW because the standard deviations that they use to standardize differ from mine, for an unknown reason. This, however, does not affect the relative contribution of real and break-even rates in explaining the nominal rate response.

Remolona (1999) show that after announcements the spreads in the Treasury market significantly widen. There is evidence that even in highly liquid markets delayed adjustments of prices to macroeconomic announcements is not always arbitraged away. For example Taylor (2010) shows that Federal funds futures adjust even until two hours after the announcement.

So should we be using tight intra-daily windows or daily changes to assess the impact of macro surprises? If the effect of macro news on asset prices is processed quickly, say within minutes, and no more processing takes place over the rest of the day, then "sizeable efficiency gains can be obtained from running these regressions with intra-daily data, rather than data at the daily frequency" (Beechey and Wright, 2009, p. 536). In this case the daily change is equal to the intra-daily change plus noise that is unrelated to the surprise, and tight windows around the announcements are clearly preferable. However, for certain asset prices the information processing may take longer than several minutes. Estimates based on a tight window may then miss part or all of the announcement effect, whereas estimates using longer windows recover it correctly. In general, it seems desirable to carry out event studies of announcement effects using different window lengths. This ensures that one will pick up the sensitivities to surprises, even if there is a delayed adjustment, as in the case of the response of forward BEI rates to payroll news.

3 Survey-based measures of inflation expectations

The previous section has shown that at high frequencies, inflation compensation is an important factor driving the volatility of nominal interest rates. The main concern is that this result may be partly driven by movements in the inflation risk premium. This concern can be alleviated by arguing that inflation risk premia likely move primarily at lower frequency, as discussed above. Another important point, made by Gürkaynak et al. (2010a), is that it would be difficult to attribute the procyclical response of inflation compensation to movements in risk premia, because there is ample evidence that risk premia move in a countercyclical fashion. While these arguments suggest that inflation expectations are the driving force between the evidence documented in the previous section, it is desirable to use more direct measures of inflation expectations. To this end, the analysis in this section uses inflation expectations from surveys of professional forecasters. Such survey forecasts have been found by several studies to predict future inflation quite well, and in particular better than model-based or market-based inflation forecasts.(Ang et al., 2007; Faust and Wright, 2012)

3.1 Survey data

For the analysis of survey expectations of future inflation, I use data from the Blue Chip Economic Indicators survey, as well as from the Survey of Professional Forecasters (SPF). Throughout the analysis in this section, the focus will be on *revisions* to inflation expectations, that is, changes in expectations between two successive survey observations.

3.1.1 Blue Chip Economic Indicators

Blue Chip Economic Indicators has conducted monthly surveys of business economists since 1976, which ask about respondents' price level expectations for each future quarter up until the end of the year following the survey. They survey includes questions about both the Consumer Price Index (CPI) and the GDP price index (PGDP). I focus on one-year forecasts, the longest available horizon that is available in every survey. The survey responses are collected around the turn of each month, and the results are released in the second week of each month. To line up the survey data with yields and macroeconomic news, I associate the last day of the preceding month with each survey, which closely corresponds to the actual timing of the forecasters information set.

In March and October of each year, Blue Chip also surveys respondents about their long-term inflation forecasts for the next ten years.[9] I include in the analysis the long-term forecasts of CPI and PGDP over the next five years, and over the next ten years.

3.1.2 Survey of Professional Forecasters

The Survey of Professional Forecasters (SPF) has been conducted on a quarterly basis since 1968. Since 1990 it is managed by the Federal Reserve Bank of Philadelphia. Like the Blue Chip survey, it also targets business and market economists. The survey asks about both short-term and long-term inflation forecasts. One-year-ahead forecasts are available for CPI and PGDP inflation, and ten-year forecasts are available for CPI inflation. The survey results are released early in the middle month of each quarter, and I time the SPF survey data using the last day of the first month of each quarter, a reasonably good approximation for the information set of the respondents.

[9]These long-term forecasts are available back to 1979.

3.2 Correlation of survey expectations with nominal interest rates

As in the case of inflation compensation, I first investigate unconditional correlations with nominal interest rates. Table 6 displays the correlations of changes in nominal Treasury yields with the different survey-based measures of inflation expectations. The yield maturity is matched to the horizon of the inflation forecasts. For example, the five-year yield is used to calculate the correlation with the long-term Blue Chip forecasts of inflation over the next five years. The frequency of the changes is monthly for short-term Blue Chip forecasts, semi-annual[10] for long-term Blue Chip forecasts, and quarterly for SPF forecasts. In addition to the estimated correlation coefficients, the table shows p-values based on a Student-t approximation.[11]

In the first two columns, Table 6 shows correlations between survey expectations and nominal rates over a long sample starting with the first survey in 1990 and ending with the last survey in 2013.[12] The correlations are moderately high, typically around 0.30, even for some of the long-term forecasts. The correlation coefficients are strongly significant for the one-year forecast horizon. For the long-term forecasts, only the correlations for Blue Chip CPI forecasts are (marginally) significant.

To put these numbers into perspective, the table also reports correlations of yields with survey expectations for a shorter sample, starting in July 2004, where data on inflation compensation is available. Over this shorter sample, these correlations can be compared to the correlations of nominal yields with inflation compensation, measured by BEI and IS rates. This comparison shows that the association of nominal rates with survey-based inflation expectations is, in most cases, similarly strong as the association with inflation compensation. This is certainly true for the one-year horizon, however for long-term forecasts the correlation coefficients are estimated to be insignificant over these short samples.

Overall this evidence suggests that even at these lower frequencies, a fair share of the variation in nominal yields, both at short and long maturities, is related to movements in inflation expectations. It therefore appears that the comovement of inflation compensation and nominal rates is not driven by changes in inflation risk or liquidity premia, but that movements in inflation expectations play an important role. The evidence is stronger at short forecast horizons.

[10] The long-term Blue Chip forecasts are released in March and October, so the changes are over intervals of five and seven months.

[11] Significance of the estimated correlation coefficient ρ can be tested using $t = \rho/\sqrt{(1-\rho^2)/(n-2)}$, where n is the number of observations, which approximately has a Student-t distribution with $n-2$ degrees of freedom.

[12] The long-term SPF forecasts first become available in 1991.

3.3 Sensitivity of survey expectations to macroeconomic news

A key question of this paper is whether macroeconomic data surprises systematically affect inflation expectations. Here, I address it using survey expectations of future inflation. Since surveys are conducted at monthly or lower frequencies, we cannot estimate the response of expectations over tight windows around the news announcements. Since economic agents receive a host of new information over the course of the period between surveys, many of which may affect inflation expectations. This makes the sensitivity estimates in the macro news regression imprecise, and works against finding any significant relationships. However, the results below show that in fact inflation expectations do show significant responses to macro news.[13]

In the following regressions, the dependent variable is the change in expectations over the month or quarter. The independent variables are the surprise component in each macroeconomic data release, first standardized to have unit variance, and then cumulated over the month or quarter. That is, the data surprises are constructed exactly as before, except for the fact that they are added up over longer intervals.

Table 7 shows the estimated sensitivities of Blue Chip inflation expectations to macro news, together with White standard errors. Also shown are the sensitivities of the one-year nominal yield, using monthly changes as well. These results are based on 288 monthly observations, starting in January 1990 and ending in December 2013.

Blue Chip expectations for PGDP inflation exhibit significant responses to macro news. The response coefficients are strongly jointly significant, with a p-value below 0.1%. For six out of the thirteen releases, the response coefficients are significantly different from zero, and they almost all show the expected procyclical responses. The regression R^2 of 12.4% is sizable, in light of the wide (monthly) observation intervals. Expectations of CPI inflation are much less sensitive to macro news, and in this case we cannot reject the null hypothesis that all coefficients are jointly zero. A comparison of the results for PGDP inflation expectations to those for nominal yield reveals that overall, the survey expectations show an almost similarly large response. The R^2 for survey expectations is only slightly smaller than that for the nominal yield. For nonfarm payrolls, both yield and survey expectations show a significant response, and the latter accounts for a fraction of about 0.3 of the former. For capacity utilization, the expectations response accounts for about one half of the yield response.

Table 8 reports the results for the SPF data. It shows responses for one-year inflation expectations for CPI and PGDP, and expectations for ten-year CPI inflation, together with

[13] Since the long-term Blue Chip forecasts are only released twice a year, I do not include these data in this analysis.

responses of the one-year and ten-year nominal yield. All coefficients measure the response of quarterly changes to the macro news cumulated over the course of the quarter. The sample period is from Q1-1990 to Q4-2013.

Quarterly changes in SPF inflation expectations show a close relationship with macroeconomic data surprises. This holds for both short-term and long-term expectations. For all three expectations measures, the coefficients are jointly significant at the 5% level. Several coefficients are strongly significant, and most of these have the expected sign, indicating a procyclical response. While nonfarm payroll news do not lead to a significant response of SPF inflation expectations, other real-side news do.[14] The regression R^2 are on the order of 24–28%, which comes quite close to the R^2 for the nominal yields.

To find a significant relationship between macroeconomic news and changes in inflation expectations over monthly intervals is surprising, given the host of other news that economic agents and forecasters receive which we cannot control for. It is therefore important to investigate the robustness of these results. I have estimated these regressions over different sub-samples, using different timing assumptions, and including different sets of data releases. The results are robust, and remain unchanged from my baseline specification.[15] As an example that the results are not driven by a few high-leverage observations, Figure 5 shows a scatter plot of nonfarm payroll news against changes in Blue Chip PGDP expectations. In a univariate regression, payroll news are highly significant, as in the multivariate regression, and this significant relationship is evident in the figure. Leaving out the one or two most influential observations does not change this result. I have also studied bivariate relationships in various other cases, and checked the sensitivity to outliers. The sensitivity of survey expectations to macro news is a robust finding.

The overall picture that emerges here is that several survey-based measures of inflation expectations show significant responses to macroeconomic news. This is true for both price-level and real-side news. The magnitude of the responses to the major price and real-side news differs depending on the survey measure and horizon, but is generally comparable in magnitude to the estimates based on inflation compensation. This suggests that the sensitivity of inflation expectations likely plays an important role in explaining the sensitivity of inflation compensation to macroeconomic news. The evidence is stronger for short-term inflation expectations, but also present for long-term expectations for inflation over a ten-year

[14] Additional analysis shows that payroll news lead to significant and sizable (about four basis points) revisions of one-year SPF inflation expectations with a one-period delay.

[15] The baseline specification uses the same data releases as in Section 2, which are the ones used in BW, employs the full sample of available data, and uses straightforward and plausible timing assumptions, based on the information set of survey respondents when data is collected.

horizon. Taken together, this evidence supports the view that inflation expectations have been quite variable in the United States and played an important role in explaining movements in nominal interest rates.

4 Conclusion

This paper addresses the question how important movements in inflation expectations are for explaining variation in nominal interest rates. An analysis of market-based inflation measures documents that estimates of inflation compensation are closely related to movements in nominal rates, and that they are quite sensitive to macroeconomic data surprises. News about the price level as well as news about the real side of the economy, such as surprises in nonfarm payroll employment, causes significant responses of inflation compensation. To address the concern that this result might be driven by movements in risk premia or liquidity factors, I also investigate the behavior of survey-based inflation expectations. These are found to display significant responses to macroeconomic news as well.

Taken together, this evidence suggests that inflation expectations change in response to incoming news, and that these responses are an important source of variation for movements in long-term nominal interest rates. A possible explanation for the volatility and sensitivity of inflation expectations, in line with Gürkaynak et al. (2010a) and Beechey et al. (2011), is that inflation expectations might not have been very well anchored in the United States. For most of the sample period considered here, U.S. monetary policy did not have an explicit inflation target. Presumably, the introduction of such a target by the Federal Reserve in 2012 would reduce the variability of inflation expectations and hence of long-term nominal interest rates. This additional stability in financial markets would have potentially important economic benefits: More stable long-term interest rates would reduce the uncertainty that investors and more generally economic agents face, and in this way would have important positive welfare implications. The Federal Reserve explicitly announced an inflation target in January 2012. Whether this has started to reduce the variability of inflation expectations and consequently of nominal rates is an important question. The decreasing correlations I have reported tentatively suggest that variation in inflation expectations is starting to become less important. However, we do not yet have sufficient data on this new regime to obtain conclusive evidence to answer this question.

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Table 1: Correlations of inflation compensation with nominal rates

	Five-year yield			Ten-year yield			5-to-10-year forw.			
Sample	BEI	IS	IC*	BEI	IS	IC*	BEI	IS	IC*	N
daily, all	0.41	0.27	0.28	0.53	0.31	0.38	0.58	0.17	0.26	2134
daily, empl.	0.49	0.32	0.37	0.62	0.40	0.46	0.70	0.24	0.29	106
daily, CPI	0.28	0.11	0.22	0.50	0.28	0.37	0.66	0.34	0.41	106
weekly	0.33	0.29	0.24	0.49	0.37	0.40	0.60	0.26	0.37	439
monthly	0.37	0.39	0.32	0.51	0.36	0.40	0.74	0.30	0.45	100
quarterly	0.67	0.68	0.72	0.77	0.71	0.75	0.90	0.39	0.59	32

Unconditional correlations between rate changes in nominal rates and changes in break-even inflation for different samples. BEI is the TIPS breakeven rate. IS is the inflation swap rate. IC* is the filtered inflation compensation using information in liquidity-adjusted BEI and IS rates. Results are shown for the ten-year yield, the five-year yield, and the five-by-five-year forward rate. The last column indicates the number of observations used to calculate the correlation coefficient. The first row shows correlations for the sample including all daily changes. The second and third row show results for the sample that only includes days on which an employment report or CPI numbers were released. Rows four to six consider lower sample frequencies, using weekly, monthly, and quarterly changes, respectively. Sample starts on 1/3/2005 and ends on 12/31/2013.

Table 2: Market responses to macroeconomic news – TIPS

	Ten-year yield			Five-year yield			5-by-5y forward		
	Nominal	Real	IC	Nominal	Real	IC	Nominal	Real	IC
Capacity	0.12	0.24	-0.11	0.07	0.33	-0.26	0.20	0.14	0.06
	(0.47)	(0.39)	(0.30)	(0.54)	(0.47)	(0.38)	(0.45)	(0.40)	(0.31)
Confidence	0.47	0.11	0.36	0.62	0.37	0.25	0.33	-0.15	0.47
	(0.78)	(0.72)	(0.24)	(0.81)	(0.76)	(0.26)	(0.80)	(0.72)	(0.30)
Core CPI	1.29**	-0.42	1.71***	1.73**	-0.88	2.61***	0.82	0.06	0.76*
	(0.64)	(0.61)	(0.41)	(0.73)	(0.69)	(0.48)	(0.62)	(0.61)	(0.42)
Durable Goods	0.99	1.03	-0.04	1.33	1.68**	-0.35	0.64	0.37	0.27
	(0.77)	(0.68)	(0.37)	(0.93)	(0.82)	(0.49)	(0.63)	(0.58)	(0.31)
ECI	0.04	1.02	-0.98**	-0.03	0.89	-0.93**	0.09	1.15	-1.06*
	(1.21)	(1.04)	(0.46)	(1.19)	(1.24)	(0.42)	(1.33)	(0.92)	(0.63)
Real GDP Adv	1.77	1.15	0.62	1.50	1.76	-0.26	2.05	0.53	1.52**
	(1.47)	(1.20)	(0.45)	(1.30)	(1.29)	(0.48)	(1.73)	(1.18)	(0.77)
Initial Claims	-1.02***	-0.70***	-0.31**	-1.17***	-0.77***	-0.40**	-0.87***	-0.64**	-0.23
	(0.31)	(0.25)	(0.16)	(0.31)	(0.27)	(0.18)	(0.33)	(0.27)	(0.19)
NAPM	1.74***	1.85***	-0.11	2.06***	2.17***	-0.11	1.36***	1.55***	-0.19
	(0.48)	(0.37)	(0.44)	(0.59)	(0.47)	(0.54)	(0.52)	(0.43)	(0.41)
Nonfarm Payrolls	5.61***	3.85***	1.76***	6.91***	5.22***	1.70***	4.27***	2.46***	1.81***
	(1.46)	(1.05)	(0.46)	(1.78)	(1.34)	(0.50)	(1.16)	(0.81)	(0.47)
New Home Sales	1.13**	0.59	0.54*	1.21*	0.96*	0.25	1.06**	0.23	0.83***
	(0.57)	(0.47)	(0.31)	(0.64)	(0.57)	(0.38)	(0.54)	(0.45)	(0.29)
Core PPI	1.18**	0.19	0.99**	0.92	-0.21	1.13*	1.47***	0.60*	0.87**
	(0.51)	(0.44)	(0.42)	(0.61)	(0.62)	(0.60)	(0.49)	(0.36)	(0.41)
Retail Sales	1.12	1.31**	-0.19	1.35	1.40*	-0.05	0.90	1.22**	-0.32
	(0.92)	(0.66)	(0.36)	(1.00)	(0.84)	(0.34)	(0.89)	(0.53)	(0.49)
Unemployment	-0.50	-0.06	-0.44	-0.91	-0.54	-0.37	-0.07	0.44	-0.52
	(1.05)	(0.77)	(0.38)	(1.20)	(0.91)	(0.37)	(0.97)	(0.77)	(0.48)
R^2	0.148	0.118	0.105	0.174	0.146	0.116	0.103	0.070	0.067
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Responses to one-standard-deviation surprises in macroeconomic data releases of nominal rates, TIPS-based real rates, and BEI rates, for five- and ten-year yields and the five-by-five-year forward rate. White standard errors shown in parentheses. p-values are for the hypothesis that all coefficients are jointly zero. Sample: days with TIPS BEI rates from January 2, 2003, to July 31, 2007.

Table 3: Market responses to macroeconomic news – inflation swaps

	Ten-year yield			Five-year yield			5-by-5y forward		
	Nominal	Real	IC	Nominal	Real	IC	Nominal	Real	IC
Capacity	0.51	0.02	0.49	1.43	1.28*	0.15	-0.39	-1.22	0.83
	(0.82)	(0.63)	(0.80)	(0.96)	(0.73)	(1.08)	(0.80)	(0.85)	(0.81)
Confidence	0.59	1.22*	-0.63	0.37	1.99***	-1.62	0.79	0.42	0.37
	(0.76)	(0.69)	(0.81)	(0.69)	(0.72)	(1.02)	(0.89)	(1.14)	(1.00)
Core CPI	0.07	-1.80**	1.86*	0.04	-1.79**	1.83**	0.08	-1.81	1.89
	(0.87)	(0.88)	(0.98)	(0.82)	(0.87)	(0.80)	(1.01)	(1.15)	(1.33)
Durable Goods	0.68	0.48	0.19	0.74	1.45**	-0.71	0.62	-0.47	1.10
	(0.56)	(0.44)	(0.39)	(0.61)	(0.69)	(0.76)	(0.59)	(0.84)	(0.68)
ECI	0.35	1.57	-1.23	-0.07	0.80	-0.87	0.76	2.35	-1.58
	(1.06)	(1.23)	(0.78)	(1.08)	(1.29)	(0.77)	(1.14)	(1.58)	(1.17)
Real GDP Adv	-1.67	0.15	-1.81**	-0.67	1.64	-2.31*	-2.65*	-1.34	-1.31
	(1.16)	(1.07)	(0.82)	(0.98)	(1.12)	(1.23)	(1.38)	(1.94)	(1.46)
Initial Claims	-1.43***	-0.62	-0.81***	-1.51***	-1.03***	-0.47	-1.37***	-0.23	-1.15**
	(0.34)	(0.39)	(0.28)	(0.32)	(0.37)	(0.38)	(0.40)	(0.67)	(0.48)
NAPM	2.41***	1.70***	0.71*	2.13***	0.10	2.03***	2.67***	3.29***	-0.61
	(0.59)	(0.60)	(0.39)	(0.55)	(0.75)	(0.62)	(0.75)	(0.77)	(0.66)
Nonfarm Payrolls	2.79***	1.37	1.42**	2.89**	1.11	1.78*	2.71**	1.64	1.06*
	(1.01)	(1.27)	(0.57)	(1.21)	(1.82)	(0.96)	(1.08)	(1.09)	(0.56)
New Home Sales	0.80*	0.76	0.04	0.77	0.96	-0.19	0.84*	0.56	0.28
	(0.44)	(0.49)	(0.34)	(0.48)	(0.59)	(0.55)	(0.45)	(0.61)	(0.42)
Core PPI	1.83***	0.74**	1.09***	1.46***	0.12	1.35***	2.20***	1.37**	0.83*
	(0.52)	(0.38)	(0.37)	(0.50)	(0.43)	(0.46)	(0.64)	(0.64)	(0.49)
Retail Sales	2.28***	1.60***	0.68	2.03***	0.23	1.80***	2.54***	2.98***	-0.44
	(0.64)	(0.62)	(0.44)	(0.58)	(0.70)	(0.70)	(0.77)	(1.08)	(0.74)
Unemployment	-0.88	-0.96	0.08	-0.98	-1.68**	0.70	-0.79	-0.25	-0.54
	(0.69)	(0.67)	(0.48)	(0.73)	(0.68)	(0.62)	(0.78)	(0.95)	(0.60)
R^2	0.071	0.037	0.059	0.073	0.039	0.061	0.059	0.036	0.031
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001

Notes: Responses to one-standard-deviation surprises in macroeconomic data releases of nominal rates, swap-based real rates, and inflation compensation (IC) based on inflation swap rates, for five- and ten-year yields and the five-by-five-year forward rate. White standard errors shown in parentheses. p-values are for the hypothesis that all coefficients are jointly zero. Sample: days with inflation swap rates from January 2, 2005, to December 31, 2013.

Table 4: Market responses to macroeconomic news – filtered inflation compensation

	Ten-year yield			Five-year yield			5-by-5y forward		
	Nominal	Real	IC	Nominal	Real	IC	Nominal	Real	IC
Capacity	0.51	0.17	0.34	1.43	1.04	0.39	-0.39	-0.68	0.29
	(0.82)	(0.57)	(0.87)	(0.96)	(0.73)	(1.23)	(0.80)	(0.70)	(0.73)
Confidence	0.59	1.03	-0.44	0.37	1.66**	-1.29	0.79	0.38	0.41
	(0.76)	(0.65)	(0.81)	(0.69)	(0.75)	(1.05)	(0.89)	(1.01)	(0.90)
Core CPI	0.07	-1.50*	1.56*	0.04	-1.62**	1.66**	0.08	-1.38	1.46
	(0.87)	(0.80)	(0.94)	(0.82)	(0.82)	(0.80)	(1.01)	(1.06)	(1.24)
Durable Goods	0.68	0.56	0.12	0.74	1.54**	-0.80	0.62	-0.41	1.04*
	(0.56)	(0.49)	(0.38)	(0.61)	(0.69)	(0.73)	(0.59)	(0.82)	(0.61)
ECI	0.35	1.43	-1.09*	-0.07	0.39	-0.46	0.76	2.47	-1.71
	(1.06)	(1.16)	(0.66)	(1.08)	(1.22)	(0.72)	(1.14)	(1.53)	(1.10)
Real GDP Adv	-1.67	-0.17	-1.49**	-0.67	1.39	-2.06*	-2.65*	-1.72	-0.93
	(1.16)	(1.07)	(0.74)	(0.98)	(1.02)	(1.08)	(1.38)	(1.99)	(1.48)
Initial Claims	-1.43***	-0.60	-0.84***	-1.51***	-1.22***	-0.29	-1.37***	0.01	-1.39***
	(0.34)	(0.38)	(0.28)	(0.32)	(0.36)	(0.35)	(0.40)	(0.61)	(0.44)
NAPM	2.41***	1.56***	0.84**	2.13***	0.12	2.01***	2.67***	3.00***	-0.33
	(0.59)	(0.57)	(0.42)	(0.55)	(0.79)	(0.70)	(0.75)	(0.67)	(0.61)
Nonfarm Payrolls	2.79***	1.49	1.30***	2.89**	1.38	1.51*	2.71**	1.61	1.10*
	(1.01)	(1.12)	(0.47)	(1.21)	(1.64)	(0.80)	(1.08)	(0.99)	(0.61)
New Home Sales	0.80*	0.74	0.06	0.77	0.90	-0.13	0.84*	0.57	0.26
	(0.44)	(0.45)	(0.32)	(0.48)	(0.58)	(0.52)	(0.45)	(0.54)	(0.38)
Core PPI	1.83***	0.83**	1.00**	1.46***	0.48	0.98**	2.20***	1.18**	1.02**
	(0.52)	(0.37)	(0.40)	(0.50)	(0.49)	(0.48)	(0.64)	(0.54)	(0.49)
Retail Sales	2.28***	1.64***	0.64	2.03***	0.41	1.62**	2.54***	2.88***	-0.34
	(0.64)	(0.58)	(0.41)	(0.58)	(0.72)	(0.73)	(0.77)	(1.01)	(0.67)
Unemployment	-0.88	-0.98	0.10	-0.98	-1.56**	0.58	-0.79	-0.41	-0.38
	(0.69)	(0.63)	(0.43)	(0.73)	(0.73)	(0.56)	(0.78)	(0.81)	(0.52)
R^2	0.071	0.037	0.050	0.073	0.039	0.047	0.059	0.035	0.033
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001

Notes: Responses to one-standard-deviation surprises in macroeconomic data releases of nominal rates, real rates, and filtered inflation compensation (IC), for five- and ten-year yields and the five-by-five-year forward rate. White standard errors shown in parentheses. p-values are for the hypothesis that all coefficients are jointly zero. Sample: days with observations on both inflation swaps rates and TIPS break-even inflation rates, January 2, 2005, to December 31, 2013.

Table 5: Intra-daily and daily responses to nonfarm payroll surprise

Ten-year yield			Five-year yield			Five-to-ten-year forward rate		
Nom.	Real	IC	Nom.	Real	IC	Nom.	Real	IC
30-minute window								
6.61	5.18	1.43	8.58	6.27	2.31	4.02	4.03	-0.01
(0.63)	(0.46)	(0.33)	(0.79)	(0.66)	(0.42)	(0.58)	(0.52)	(0.50)
four-hour window								
6.55	4.95	1.59	7.99	6.05	1.94	4.65	3.87	0.79
(0.91)	(0.78)	(0.24)	(1.00)	(0.92)	(0.33)	(0.88)	(0.70)	(0.26)
daily window								
6.70	5.03	1.66	8.23	6.25	1.98	4.70	3.76	0.94
(0.92)	(0.80)	(0.29)	(1.02)	(0.93)	(0.37)	(0.86)	(0.78)	(0.28)

Notes: Response of nominal, real, and break-even inflation (BEI) rates to a one-standard-deviation surprise in nonfarm payrolls, using a 30-minute window around the announcement (8:15am to 8:45am), a 4-hour window (8:15am to 12:15pm), and a daily window (4pm previous day to 4pm on the announcement day). White standard errors in parentheses. Sample includes employment reports from March 2004 to June 2008.

Table 6: Correlations of survey-based inflation expectations with nominal rates

		Long sample		Short sample			
Survey	Mat.	CPI	PGDP	CPI	PGDP	BEI	IS
Blue Chip							
short-term	1y	0.13	0.28	-0.04	0.27	0.34	0.31
		[0.03]	[0.00]	[0.67]	[0.00]	[0.00]	[0.00]
long-term	5y	0.28	0.23	0.21	0.25	0.30	0.40
		[0.06]	[0.12]	[0.41]	[0.31]	[0.23]	[0.10]
long-term	10y	0.27	0.10	0.21	0.20	0.42	0.39
		[0.07]	[0.48]	[0.41]	[0.42]	[0.08]	[0.11]
SPF							
short-term	1y	0.36	0.33	0.26	0.30	0.20	0.30
		[0.00]	[0.00]	[0.11]	[0.07]	[0.23]	[0.07]
long-term	10y	0.16	—	0.17	—	0.13	0.20
		[0.14]	—	[0.33]	—	[0.44]	[0.22]

Notes: Correlations between changes in nominal Treasury yields and survey-based inflation expectations. Changes are monthly for short-term Blue Chip expectations, semi-annual for long-term Blue Chip expectations, and quarterly for SPF expectations. Also shown are correlations with changes in inflation compensation, measured by TIPS breakeven inflation (BEI) and inflation swap (IS) rates, over the same intervals. Numbers in squared brackets are p-values based on Student-t approximations. The long sample starts with the first observation in 1990 for Blue Chip and short-term SPF data, and in October 1991 for long-term SPF data. The short sample starts July 2004, when both swap and short-term breakeven data becomes available. All samples end with the last survey in 2013.

Table 7: Sensitivity of Blue Chip inflation expectations to macroeconomic news

	Yield	BC-CPI	BC-PGDP
Capacity	2.39**	0.16	1.23***
	(1.21)	(0.46)	(0.47)
Confidence	4.42***	0.46	0.57
	(1.52)	(0.54)	(0.56)
Core CPI	-0.34	1.00*	0.89*
	(1.23)	(0.52)	(0.51)
Durable Goods	0.51	0.24	0.83*
	(1.40)	(0.53)	(0.48)
ECI	1.70	0.02	1.07*
	(2.79)	(0.89)	(0.64)
Real GDP Adv	-2.12	-0.37	-1.56**
	(2.04)	(0.84)	(0.77)
Initial Claims	-1.46	-0.26	-0.32
	(0.91)	(0.28)	(0.27)
NAPM	1.88	0.66	-0.09
	(1.48)	(0.49)	(0.48)
Nonfarm Payrolls	5.52***	0.40	1.54***
	(1.27)	(0.43)	(0.39)
New Home Sales	0.59	0.69*	0.47
	(1.22)	(0.40)	(0.52)
Core PPI	-0.68	0.49	0.28
	(1.10)	(0.44)	(0.43)
Retail Sales	3.98***	-0.40	-0.08
	(1.47)	(0.59)	(0.54)
Unemployment	-3.36**	0.71	0.64
	(1.46)	(0.60)	(0.53)
R^2	0.194	0.049	0.124
p-value	0.000	0.359	0.000

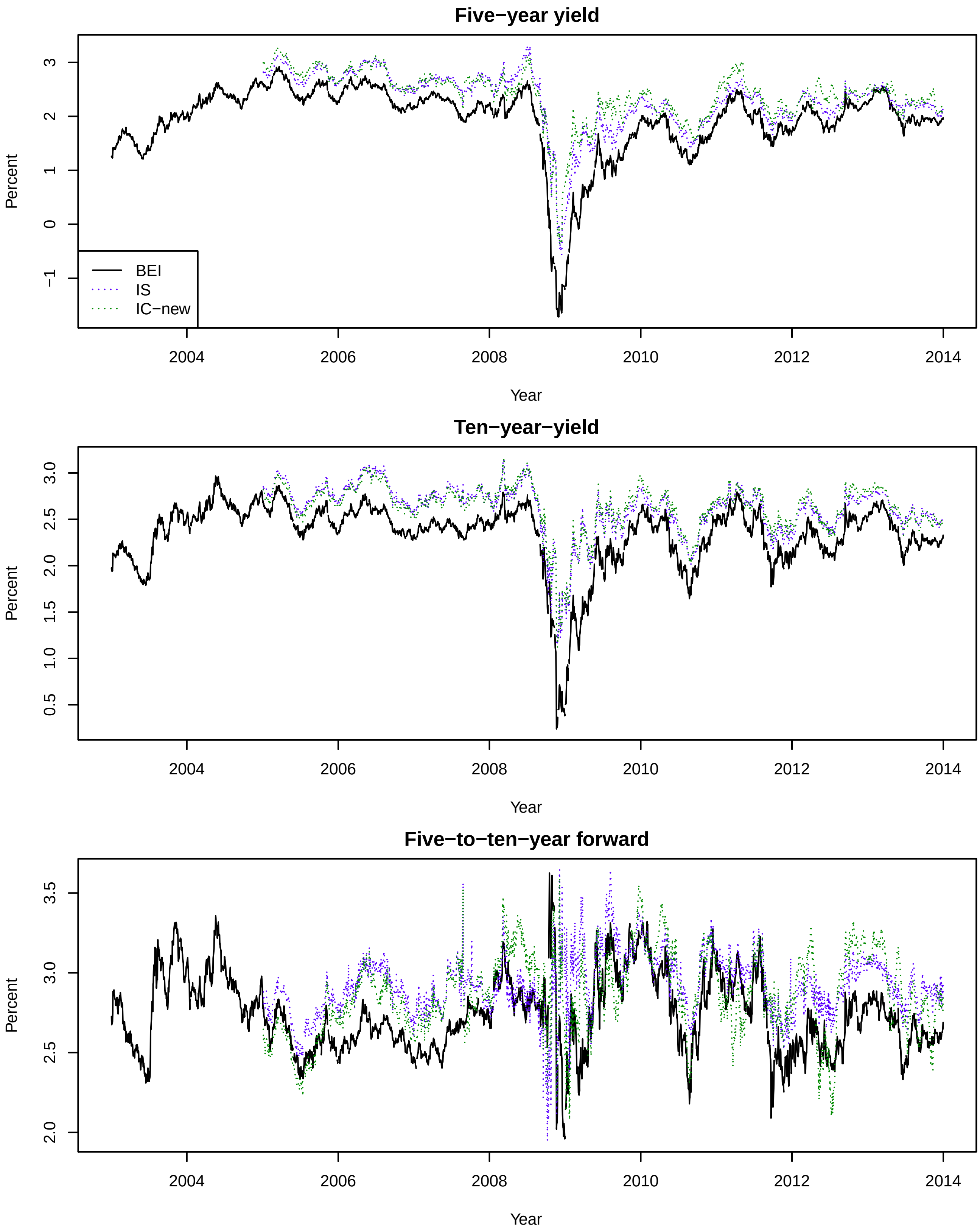
Notes: Response coefficients and White standard errors (in parentheses) for changes in the one-year nominal yield and one-year inflation expectations in CPI and PGDP from the Blue Chip Economic Indicators survey. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively. p-values are for the hypothesis that all coefficients are jointly zero. Sample: monthly observations from January 1990 to December 2013.

Table 8: Sensitivity of SPF inflation expectations to macroeconomic news

	1y Yield	1y CPI	1y PGDP	10y Yield	10y CPI
Capacity	5.51**	3.10*	3.02**	0.21	-1.87***
	(2.37)	(1.85)	(1.32)	(2.65)	(0.66)
Confidence	10.51***	3.32***	1.62	6.60**	-0.29
	(3.30)	(1.26)	(1.32)	(2.86)	(0.64)
Core CPI	-1.77	1.61**	0.54	1.53	2.02***
	(2.33)	(0.69)	(0.87)	(2.15)	(0.74)
Durable Goods	-2.93	0.15	0.38	-3.43	-1.26
	(2.86)	(1.26)	(1.31)	(3.41)	(0.89)
ECI	1.78	1.64	4.45**	-1.98	0.09
	(5.24)	(1.62)	(1.84)	(4.89)	(0.97)
Real GDP Adv	-5.55	-3.38*	-1.06	0.20	0.33
	(3.72)	(1.77)	(1.71)	(4.36)	(0.88)
Initial Claims	-1.51	-0.10	0.42	1.04	0.47
	(1.82)	(0.56)	(0.58)	(1.76)	(0.32)
NAPM	2.49	1.67	2.10	4.11*	1.66***
	(2.44)	(1.65)	(1.34)	(2.12)	(0.56)
Nonfarm Payrolls	9.86***	-1.27	0.41	9.68***	0.25
	(2.66)	(1.47)	(1.68)	(2.62)	(0.68)
New Home Sales	1.84	1.21	1.61	2.01	-0.60
	(3.05)	(0.99)	(1.23)	(2.11)	(0.40)
Core PPI	0.28	2.23**	1.26	-0.70	-1.14*
	(2.25)	(1.06)	(1.13)	(2.75)	(0.58)
Retail Sales	5.14**	0.93	-0.09	8.87***	0.83
	(2.60)	(1.42)	(1.85)	(2.70)	(0.76)
Unemployment	-0.53	-0.86	-0.77	4.26**	-0.65
	(2.04)	(1.16)	(1.15)	(2.15)	(0.69)
R^2	0.379	0.235	0.241	0.324	0.281
p-value	0.000	0.035	0.029	0.001	0.015

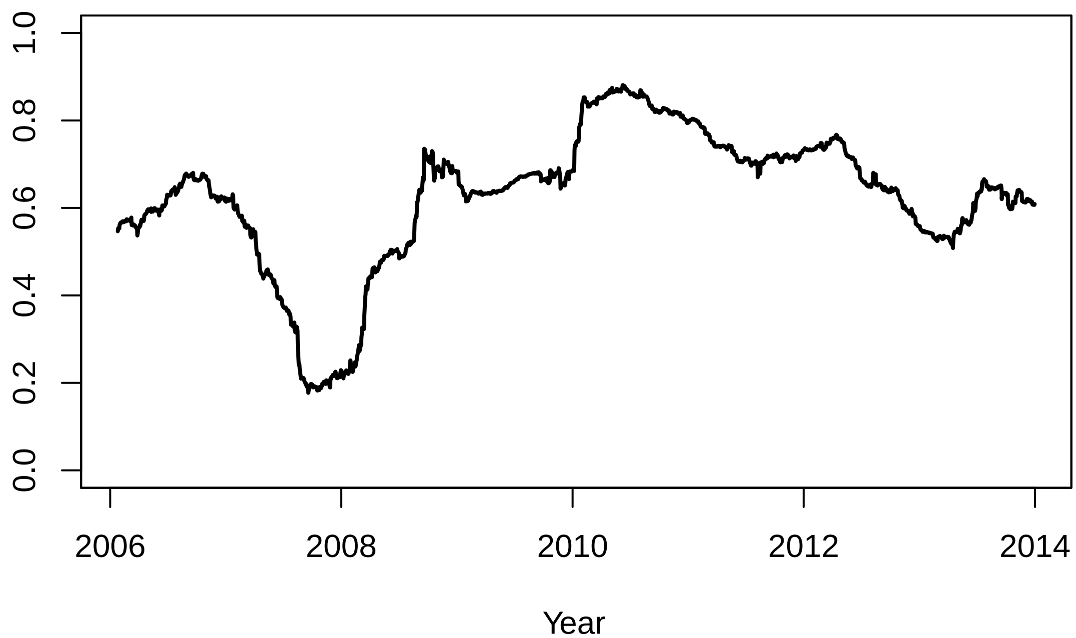
Notes: Response coefficients and White standard errors (in parentheses) for changes in nominal yields and in SPF forecasts of future CPI and PGDP inflation. Significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively. p-values are for the hypothesis that all coefficients are jointly zero. Sample: quarterly observations from from Q1-1990 to Q4-2013.

Figure 1: Alternative measures of inflation compensation



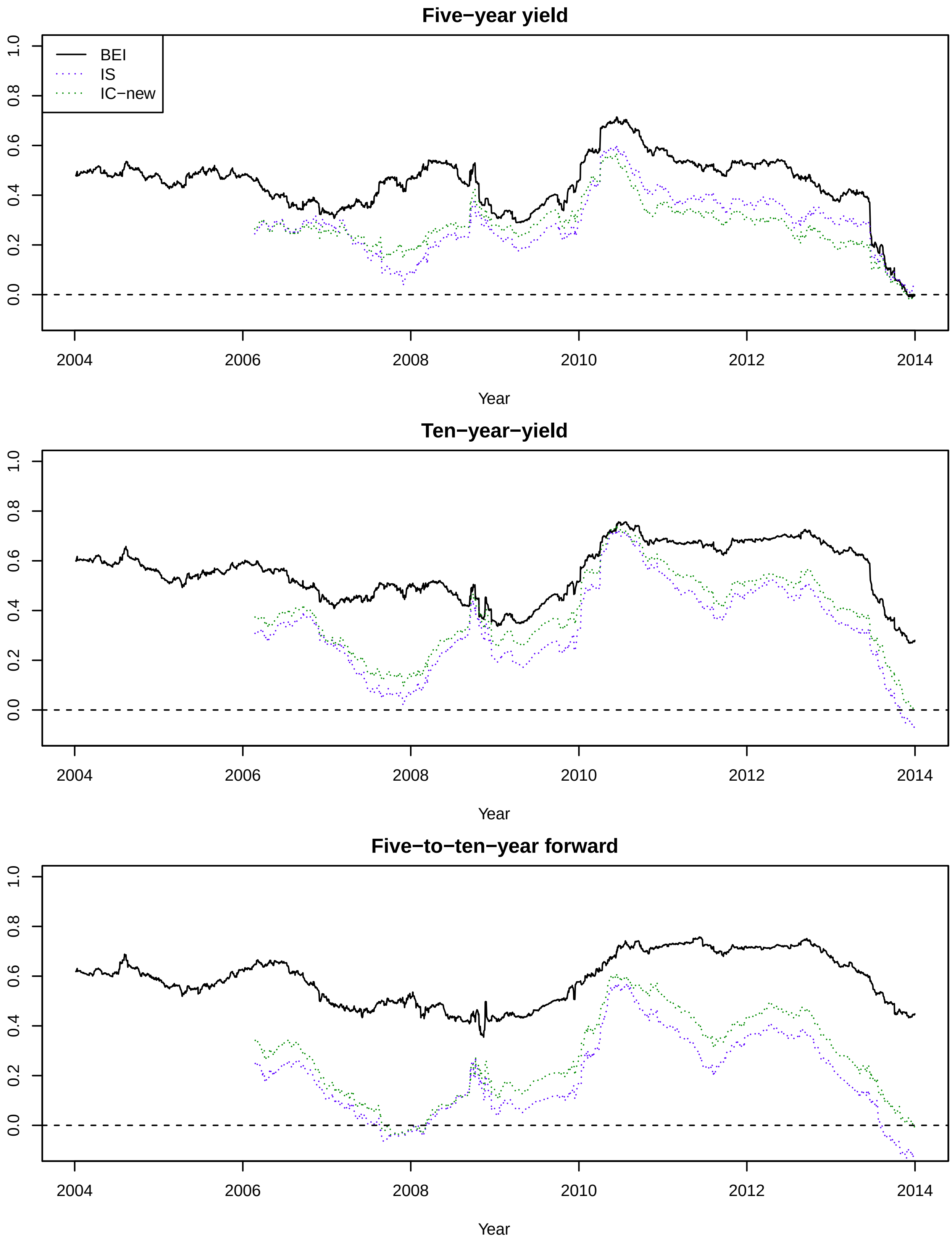
Notes: Top panel shows alternative measures of inflation compensation for the five-year maturity, middle panel for the ten-year maturity, and bottom panel for the five-to-ten-year forward maturity.

Figure 2: Correlation between ten-year TIPS breakeven and swap rate



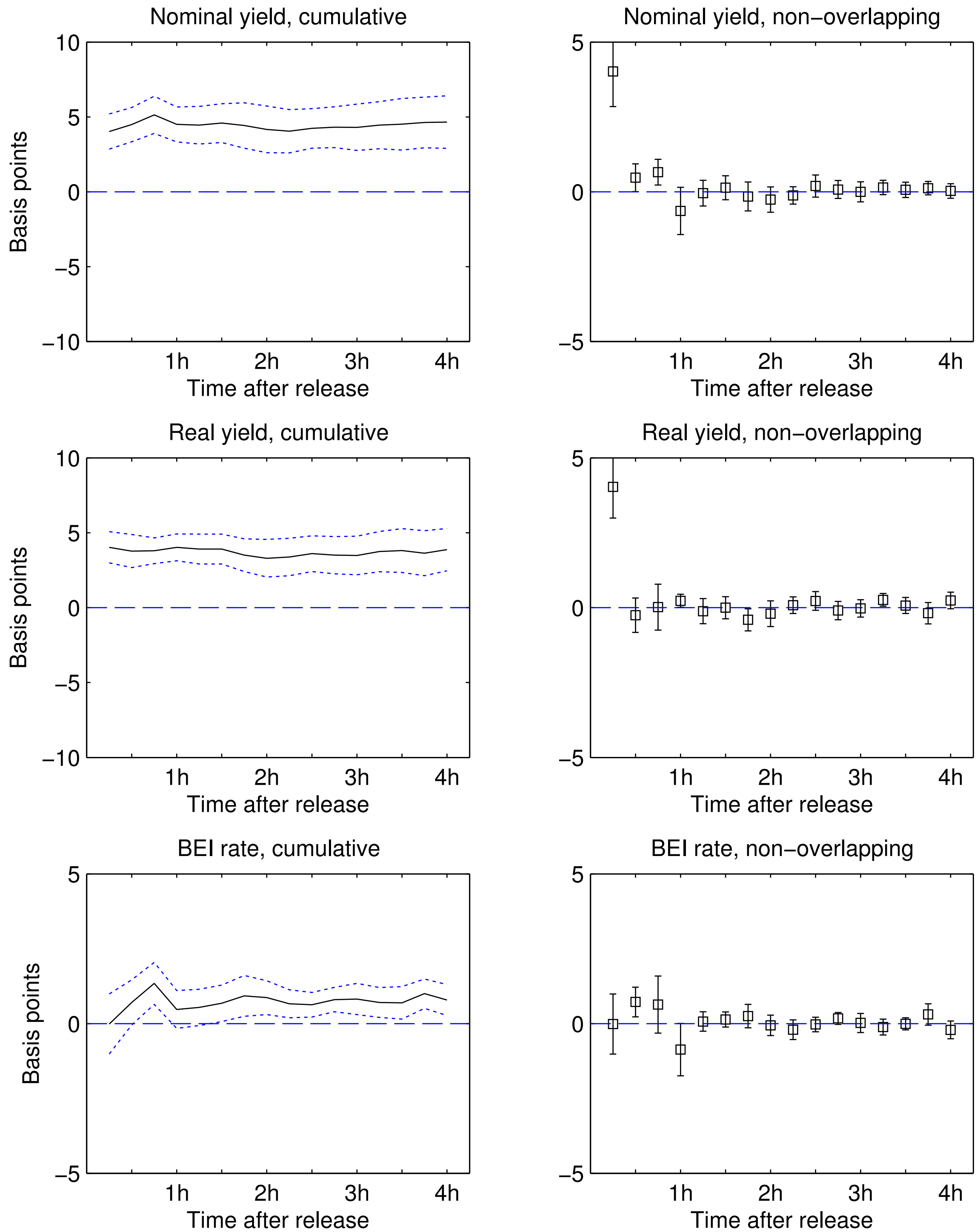
Notes: Correlation between daily changes in TIPS BEI rate and IS rate for the ten-year maturity, using rolling subsamples of 250 trading days. The indicated date is the end of the subsample window.

Figure 3: Correlations between inflation compensation and nominal rates



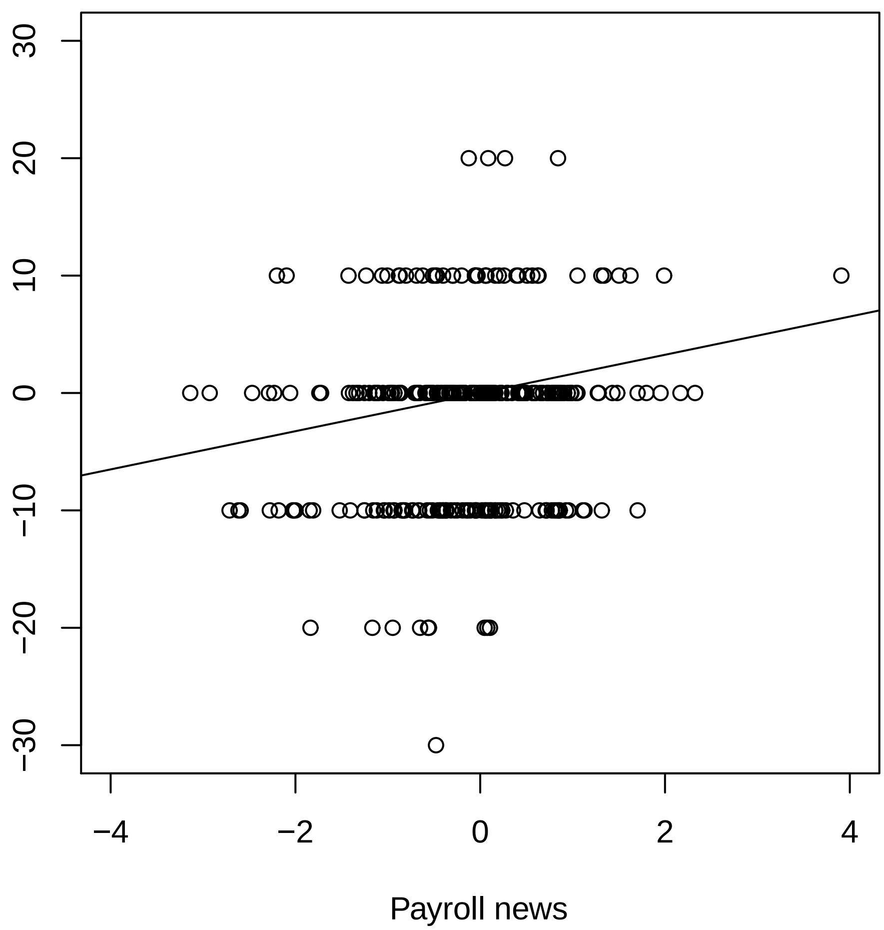
Notes: Correlation between daily changes in inflation compensation and nominal rates, using rolling subsamples of 250 trading days. The indicated date is the end of the subsample window. Top panel shows correlations for the five-year maturity, middle panel for the ten-year maturity, and bottom panel for the five-to-ten-year forward maturity.

Figure 4: Intraday responses of nominal rates, real rates and IC to payroll surprises



Notes: Left panel shows cumulative responses to one-standard-deviation surprise in nonfarm payrolls from 15 minutes before the release until 15 to 240 minutes after the release. Right panel shows responses during non-overlapping windows, the first one spanning 30 minutes around the release and the following each spanning subsequent 15-minute windows. Top row: nominal yield. Middle row: TIPS/real yield. Bottom row: breakeven inflation (BEI) rate. Also shown are 95%-confidence intervals based on White standard errors.

Figure 5: Response of inflation expectations to payroll news



Notes: Monthly changes in Blue Chip PGDP expectations, in basis points, against surprises in nonfarm payroll employment. Sample: January 1990 to December 2013. Solid line represents univariate regression equation. $R^2 = 4.1\%$.