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Are Long-Run Inflation Expectations Anchored More Firmly in the Euro Area than in the United States?†

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This paper compares the evolution of long-run inflation expectations in the euro area and the United States, using evidence from financial markets and surveys of professional forecasters. Survey data indicate that long-run inflation expectations are reasonably well anchored in both economies but reveal substantially greater dispersion across forecasters' long-horizon projections of US inflation. Analysis of daily data on inflation swaps and nominal-indexed bond spreads, which gauge compensation for expected inflation and inflation risk, also suggests that long-run inflation expectations are more firmly anchored in the euro area than in the United States. (*JEL* D84, E31, E37, E52, E58)

The euro area and the United States are industrial economies of comparable size and openness, and the Federal Reserve and the European Central Bank (ECB) each have a legal mandate to maintain price stability. But these two central banks have distinct approaches in formulating and communicating their policy strategies. In May 2003, the ECB clarified its commitment to maintaining euro-area consumer price inflation close to, but below, 2 percent over the medium run, whereas the Federal Reserve has not established an explicit quantitative inflation objective. No studies to date have examined the extent to which these differences in communication strategy have had significant effects on the evolution of long-run inflation expectations in the United States compared with the euro area.

In this paper, we begin by formulating a conceptual framework that clarifies the role of an explicit inflation objective in anchoring long-run inflation expectations. In particular, we define inflation expectations as being firmly anchored if private agents have a high degree of ongoing consensus regarding the central bank's long-run inflation objective. In contrast, when inflation expectations are not firmly anchored

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because the private sector is uncertain about the central bank's inflation objective, then long-run inflation expectations will be prone to revision in response to incoming news. Our conceptual framework illustrates how an explicit inflation objective can markedly reduce the variability of long-run inflation expectations and hence contribute to a substantial reduction in the volatility of actual inflation.

To evaluate how firmly long-run inflation expectations are anchored in the euro area and in the United States, we consider evidence from surveys of professional forecasters and from high-frequency financial data on inflation compensation, that is, the compensation investors require for expected inflation and inflation risk. Inflation compensation in the euro area is measured using data from the inflation-swaps market, a large and liquid market for hedging inflation exposures indexed to euro-area consumer prices, while US inflation compensation is measured as the spread between yields on nominal and indexed Treasury securities. For each economy, we measure the unconditional volatility of far-forward inflation compensation—that is, the one-year forward rate nine years ahead—as well as its sensitivity to surprises in economic news releases.

Our empirical analysis indicates that long-run inflation expectations are more firmly anchored in the euro area than in the United States. Specifically, surveys of professional forecasters indicate that long-run expectations of euro-area inflation are very stable and exhibit a high degree of consensus, whereas long-run expectations of US inflation vary more noticeably over time and are characterized by much greater disagreement across professional forecasters. In addition, far-forward inflation compensation for the United States is roughly twice as volatile as for the euro area, and our regression analysis indicates that economic news has statistically significant effects on US rates, but not on those of the euro area. Moreover, our analysis indicates that the effects of news on US far-forward inflation compensation are *not* short lived and hence do not merely reflect transitory fluctuations in market liquidity.

Our analysis is closely related to that of several other studies. In particular, Refet S. Gürkaynack, Brian Sack, and Eric Swanson (2005) examined the sensitivity of far-forward US nominal interest rates in response to economic news, while Michael Ehrmann et al. (forthcoming) documented the convergence of nominal bond yields among members of the euro area. Of course, by focusing on the behavior of far-forward inflation compensation, our study provides a more direct assessment of the extent to which economic news has significant effects on long-run inflation expectations and perceived inflation risk, as distinct from its impact on real interest rates and on risk premiums corresponding to uncertainty about the real economy.

Our approach is also similar to that of Gürkaynak, Andrew Levin, and Swanson (2006) and Gürkaynak et al. (2007), who found that long-run inflation expectations are not as firmly anchored in the United States as in several inflation targeting countries, namely, Canada, Sweden, and the United Kingdom. However, those studies left open the possibility that these results might reflect other systematic differences between small open economies versus large and relatively closed economies.

Thus, the resemblance of the euro area and the United States in terms of various indicators—such as total population, output per capita, and the share of imports and exports—makes our analysis particularly pertinent in examining the influence of an

explicit quantatitive inflation objective. Indeed, several recent empirical studies—including Lawrence Christiano, Roberto Motto, and Massimo Rostagno (2008); Jean-Guillaume Sahuc and Frank Smets (2008); and Harald Uhlig (2010)—have found that the policy actions of the ECB and the Federal Reserve are well characterized by broadly similar reaction functions; that is, the apparent disparity in the conduct of monetary policy over the past decade mainly reflects differences in the magnitude and persistence of the shocks that have buffeted each economy. As such, the contrasting behavior of long-run inflation expectations in the euro area and in the United States may well reflect alternative approaches to the communication of policy goals rather than fundamental differences in the nature of the economy or the actual conduct of stabilization policy.

The remainder of the paper is structured as follows. Section I outlines the conceptual framework underlying our analysis. Section II provides some evidence about long-run inflation expectations from surveys of professional forecasters. Section III offers an overview of our financial data, our macroeconomic news variables and the empirical methodology for the analysis. Section IV looks at the evidence that far-forward inflation compensation brings to bear on the anchoring of inflation expectations by examining unconditional volatilities and the conditional reaction of inflation compensation to news. Section V addresses whether the results reflect transitory liquidity effects or long-lived adjustments of market expectations. Section VI offers some concluding remarks.

I. Conceptual Framework

We begin by formulating a conceptual framework that clarifies how the establishment of an explicit inflation objective can influence the behavior of long-run inflation expectations and the volatility of the macroeconomy. Specifically, using stochastic simulations of the imperfect-knowledge model of Athanasios Orphanides and John C. Williams (2004, 2007), we construct summary statistics that serve as useful benchmarks for our empirical analysis.

The model consists of a stylized macroeconomy in which private agents lack information about the structure and parameters of key economic relationships. For simplicity, the central bank is assumed to enjoy full knowledge of the economy's macroeconomic relationships and its own policy preferences and objectives. It can choose, however, whether to communicate its long-run inflation objective which may be constant or time varying.

The model consists of an aggregate supply curve (1) with forward and backward-looking dependence on inflation, and a simple aggregate demand curve (2),

$$\pi_{t+1} = \phi\pi_{t+1/t} + (1 - \phi)\pi_t + \alpha y_{t+1} + e_{t+1},\ e \sim \text{iid}(0, \sigma_e^2) \tag{1}$$

$$y_{t+1} = -\xi(r_t - r^*) + u_{t+1},\ u \sim \text{iid}(0, \sigma_u^2), \tag{2}$$

where π_t is the annual rate of inflation at time t; $\pi_{t+j/t}$ is its j-period ahead forecast; y_t is the output gap; r_t is the real rate of interest; and r^* its long-run value. The inflation

shock, e_t, and aggregate demand shock, u_t, are white noise errors. The model is closed by a simple policy reaction function,

$$r_t - r^* = \frac{\theta}{\xi}(\pi_t - \pi^*) + k_t,\ k \sim \text{iid}(0, \sigma_k^2), \tag{3}$$

that emerges as the solution to the minimization of a standard quadratic loss function over the output gap and the deviation of inflation from the inflation objective, π^*, plus a monetary policy shock, k_t.[1] The parameter θ regulates the strength of the central bank's reaction to inflation deviations, that is, the extent to which it is willing to create an output gap to restore inflation to target, and is increasing in the weight on inflation stability in the loss function. The real policy response is also mediated by the elasticity of the output gap with respect to the real rate gap, ξ. The equilibrium real interest rate, r^*, is assumed to be constant and known by all.

Given the economic structure of equations (1)–(3), the rational expectations solution for the dynamics of inflation is

$$\pi_{t+1/t} = \frac{\alpha\theta}{1 - \phi}\pi^* + \frac{1 - \phi - \alpha\theta}{1 - \phi}\pi_t. \tag{4}$$

Inflation persistence is determined by the parameters of the aggregate supply curve and the policy reaction function; the steady-state rate of inflation is the central bank's inflation objective, π^*. To form inflation forecasts, private agents need to learn the dynamics of inflation. Assume that they mimic the functional form of equation (4) and learn the reduced-form dynamics of inflation by recursive least squares:

$$\pi_t = c_{1,t} + c_{2,t}\,\pi_{t-1} + v_t \tag{5}$$

$$c_t = c_{t-1} + \kappa R_t^{-1} X_t'(\pi_t - X_t\, c_{t-1}) \tag{6}$$

$$R_t = R_{t-1} + \kappa(X_t'\, X_t - R_{t-1}). \tag{7}$$

Agents recursively update their estimates of $\hat{c}_{1,t}$ and $\hat{c}_{2,t}$ using equations (6) and (7), but never converge upon the true parameter values because of a small, positive gain parameter, κ, that represents geometric discounting of historical data. Thus, agents' estimates of the parameters of equation (5) are time-varying as new shocks enter the inflation process. Adaptive learning imparts volatility not only to the perception of the persistence of inflation, $\hat{c}_{2,t}$, but also to agents' estimate of the central bank's inflation objective, $\hat{\pi}_t^*$, estimated as the steady state of inflation in equation (5), $\hat{c}_{2,t}/(1 - \hat{c}_{1,t})$. For both of these reasons, long-run inflation expectations are frequently revised.

An explicit inflation objective simplifies the learning problem by revealing the steady state of the inflation-forecasting rule. As in Orphanides and Williams (2004, 2007), we assume that when the central bank communicates its inflation objective, it is able to do so clearly and credibly. With an explicit inflation objective, agents

[1] For complete details of the model specification, the reader is referred to Orphanides and Williams (2004).

continue to use a reduced-form representation of inflation dynamics, except that equation (5) is modified by subtracting the known steady state of inflation (π^*) from both sides of the equation, thus removing the constant term.[2]

An extension of the model described by equations (1)–(7) is to permit a time-varying inflation objective. We assume the following specification:

$$\pi_t^* = \pi^* + z_t \tag{8}$$

$$z_t = \rho z_{t-1} + \delta e_t + \eta_t, \eta \sim \text{iid}(0, \sigma_\eta^2), \tag{9}$$

where $0 < \rho < 1$. Parameter δ allows shocks to inflation arriving via the supply curve to affect the inflation objective. When $\delta > 0$, the central bank's inflation objective is influenced by supply shocks. When $\sigma_\eta^2 > 0$, exogenous shocks to the inflation objective add to variation in inflation. When $\delta = 0$ and $\sigma_\eta^2 = 0$, this formulation reverts to the baseline specification of a constant inflation objective.

The parameters of the aggregate supply and demand curves and the gain parameter are calibrated to values similar to those in Orphanides and Williams (2007). Specifically, $\phi = 0.5$, $\alpha = 0.2$, $\theta = 0.5$, $\xi = 1$, $\sigma_e^2 = \sigma_u^2 = 1$, and $\kappa = 0.025$, values which generate a stable equilibrium for the economy.[3] The parameter π^* is set to 2 percent, which is simply a normalization in the model. For the case of a time-varying inflation objective, we assume that the objective evolves slowly, parameterized as $\rho = 0.9$, $\delta = 0.15$, and $\sigma_\varepsilon^2 = 0.15$. This parameterization yields an inflation target that wanders very slowly between 1 and 3 percent with a mean of 2 percent.

Table 1 presents some simple comparative statistics of the economy simulated for three scenarios about the inflation objective: (from left to right) a constant and explicit objective; a constant but implicit objective; and a time-varying, implicit objective. The first two rows of Table 1 indicate that a constant, explicit inflation objective is associated with modest stabilization benefits, that is, smaller standard deviations of inflation and the output gap than with an implicit inflation objective.[4] More notable, though, is the pronounced reduction in volatility of inflation expectations at long horizons. The third and fourth rows show the standard deviation of quarterly revisions of one- and ten-year ahead inflation expectations. Compared to a constant, implicit inflation objective, the volatility of long-run inflation expectations is almost halved, and volatility is one-third that which prevails with the time-varying inflation objective.

The qualitative features of Table 1 extend to varying degrees of central bank aggressiveness toward inflation shocks. For a dovish central bank, that is, one that tends to react mildly to inflation disequilibria, communicating an explicit inflation objective is a powerful tool for stabilizing long-run inflation expectations. Because inflation can be

[2] Specifically, the vector c_t reduces from two elements to one and the X_t matrix, instead of consisting of $[1 \ \pi_t]$, becomes $[(\pi_t - \pi^*)]$.

[3] Positive values of θ/ξ ensure that the central bank's response to inflation gaps is stabilizing. This can be seen by rewriting the real reaction function in equation (3) as a nominal policy rule, $i_t - i^* = (1 + (\theta/\xi))(\pi_t - \pi^*) + k_t$.

[4] The output gap is slightly less variable with the time-varying inflation target because $\delta > 0$. When the central bank accommodates some of the inflation shock in its inflation objective, inflation is more variable but output stabilization is improved. For reference, when $\delta = 0$, the standard deviation of inflation and the output gap are 1.85 and 1.38 percentage points, respectively. The standard deviations of the quarterly revisions to one- and ten-year ahead inflation forecasts are 0.63 and 0.29 percentage points, respectively.

Table 1—Stochastic Simulations under Alternative Assumptions about the Stability and Transparency of the Central Bank's Inflation Objective

	Monetary policy regime		
	Explicit, constant π^*	Implicit, constant π^*	Implicit, time-varying π_t^*
Panel A. Macroeconomic volatility			
Inflation	1.74	1.79	1.98
Output gap	1.33	1.35	1.31
Panel B. Volatility of inflation expectations			
One year ahead	0.60	0.61	0.68
Ten years ahead	0.14	0.26	0.41

Notes: This table reports on the results of stochastic simulations of a small stylized model under three alternative assumptions about the stability and transparency of the central bank's inflation goal. For each monetary policy regime, panel A indicates the standard deviation (in percentage points) of the inflation rate and the output gap, and panel B indicates the standard deviation (in percentage points) of quarterly changes in short-term inflation expectations (that is, one year ahead) and long-term inflation expectations (that is, ten years ahead). These results have been computed using averages over 600 stochastic simulations, where each simulation is 1,000 periods long and the first 500 observations are discarded.

far from its steady state for long periods, an explicit objective mitigates the tendency of estimates of equation (5) to drift around with adaptive learning. For a more hawkish central bank, communicating an inflation objective reaps more modest benefits in stabilizing long-run inflation expectations, although expectations are less volatile in general. Orphanides and Williams (2007) also demonstrate that the stabilization gains of an explicit inflation objective are robust across a range of policy reaction functions, though the extent of the benefits depends on the type of policy rule in place.

Long-run inflation expectations that are firmly anchored should also be fairly insensitive to new information and shocks arriving in the economy. Using the model simulations, we can perform regressions of the term structure of inflation expectations on shocks arriving in the model economy, much like the regressions of the term structure of inflation compensation on macroeconomic news that we highlight later in the paper.[5] Figure 1 plots the response of inflation forecasts extending out ten years to the inflation shock, e_t, for the three scenarios portrayed in Table 1. In all cases, short-horizon inflation forecasts are revised up substantially in light of the inflation shock that hits the economy, owing to the reasonably persistent nature of inflation in the calibration.

With a constant, explicit inflation objective, long-run inflation expectations covary little with the shock, and the regression coefficients diminish quickly. The inflation objective serves as the focal point to which agents' inflation forecasts converge.[6] In contrast, with a constant but implicit inflation objective, long-run inflation expectations react more strongly to the inflation surprise. In the absence of an

[5] In this model, we focus only on inflation expectations and do not model the inflation risk premia that are also bound into financial-asset based measures of inflation compensation. More generally, inflation risk premia are likely to be larger when the central bank's long-run inflation objective is not communicated, but may or may not react to news.

[6] Even with knowledge of the inflation objective, agents' estimates of inflation persistence are revised in the same direction as the inflation shock, resulting in a small degree of sensitivity even at long horizons. With full knowledge of all economic relationships and parameters, the coefficients quickly decay to zero (not shown in Figure 1).

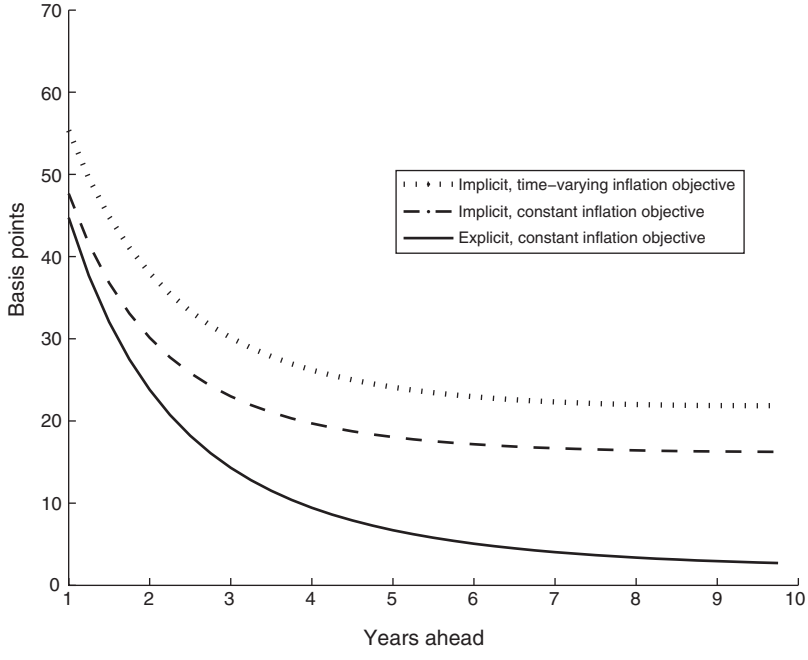

FIGURE 1. THE RESPONSE OF INFLATION EXPECTATIONS TO AN INFLATION SHOCK

Notes: The figure shows regression coefficients of the change in inflation expectations on the inflation shock to the aggregate supply curve. The scenarios correspond to those reported in Table 1. Coefficients are averaged over 600 simulations of the model economy, each simulation 1,000 periods long and the first 500 observations are discarded. The model is calibrated to the parameter assumptions stated in the text.

explicit objective, higher inflation outcomes drive agents' estimates of π^* and inflation persistence higher. When the inflation objective is not only implicit, but varies over time, long-run inflation expectations display even more sensitivity to inflation shocks. This is especially evident when the central bank partly accommodates inflation shocks in its inflation objective (the dotted line in Figure 1), but also occurs to a lesser degree when the inflation objective evolves independently of aggregate supply shocks, that is, when $\delta = 0$. Agents perceive inflation to be more persistent than in the constant-objective scenarios, so they are more prone to project higher than expected inflation today onto long-run expectations.

Our premise is that an explicit and credible long-run inflation objective, backed by appropriate monetary policy actions, fosters anchored inflation expectations by focusing private agents on the stated goal of the central bank. As a result, we expect firmly anchored long-run inflation expectations to be reasonably stable over time, to be insensitive to macroeconomic news, and to exhibit little cross-sectional dispersion across agents. These characteristics should be evident in survey measures of inflation expectations, and in financial-market derived measures of inflation compensation—the compensation received for expected inflation and taking on inflation risk. Certainly, central banks differ in the aggressiveness with which they respond to inflation disequilibria, but regardless of whether the central bank intends to return

inflation to its objective quickly or slowly, an explicit inflation objective provides a focal point for long-run inflation expectations.

II. Surveys of Long-Run Inflation Expectations

Several surveys of professional forecasters in the euro area and the United States offer insight into long-run inflation expectations.[7] This section offers some evidence from those surveys in the context of the stated policy objectives of the ECB and the Federal Reserve. The Maastricht Treaty endowed the ECB with the primary objective of achieving inflation stability. In 1998, the Governing Council of the ECB interpreted this as a directive to maintain euro area consumer price inflation at or below two percent over the medium term. This definition was subsequently clarified in a public statement in May 2003 in which the ECB declared it would aim to keep inflation *close to* but below 2 percent over the medium term. Despite its quantitative inflation objective, the ECB does not view itself as an inflation targeter.

Among its several responsibilities, the Federal Reserve has a mandate to maintain price stability. In fulfilling that mandate, the Federal Open Market Committee (FOMC) has provided a qualitative definition of price stability, but not a quantitative inflation goal. A number of individual members of the Committee have expressed personal comfort zones for inflation, but, in contrast to the Governing Council of the ECB, the FOMC as a whole has not stated a quantitative inflation objective.

Survey respondents' expectations of far-ahead inflation in the euro area have remained at or just below 2 percent since 2001. As shown in the left panel of Figure 2, the mean response of the ECB's survey of professional forecasters has been constant at 1.9 percent since 2003, while the mean response of the Consensus Economics survey has kept within a range around 1.9 percent. By comparison, survey-based measures of long-run inflation expectations for the United States have been higher and have moved over a wider range. The right panel of Figure 2 shows average responses to several professional surveys for the United States. The mean response of the Philadelphia Fed's survey of professional forecasters has cycled around 2.5 percent, as has the median response. Mean responses to the long-run inflation questions in the Consensus Economics and Blue Chip surveys have moved in a substantially wider range. Altogether, the surveys give the impression that US long-run inflation expectations are revised more often than their euro-area counterparts.

The impression of the relative stability of euro-area survey responses is reinforced by comparing measures of disagreement across forecasters in the two regions. Figure 3 shows the standard deviation of respondents' point forecasts to the ECB and Philadelphia Fed surveys. In the euro area, the standard deviation of respondents' point forecasts of five-year-ahead inflation declined steadily from 2001 to 2007 and subsequently remained low. Forecasters have grown in agreement that inflation in the

[7] The ECB solicits projections from professional forecasters of inflation five years ahead for the euro-area harmonized index of consumer prices (HICP). The Philadelphia Fed inquires about ten-year average projected inflation for the US consumer price index (CPI). These central-bank conducted surveys have a similar number of respondents and are conducted quarterly. Private-sector surveys of professional forecasters, Consensus Economics and Blue Chip, provide further information. Blue Chip asks respondents for their projection of the five-year average inflation rate seven years ahead and Consensus Economics asks for projections of inflation five to ten years ahead.

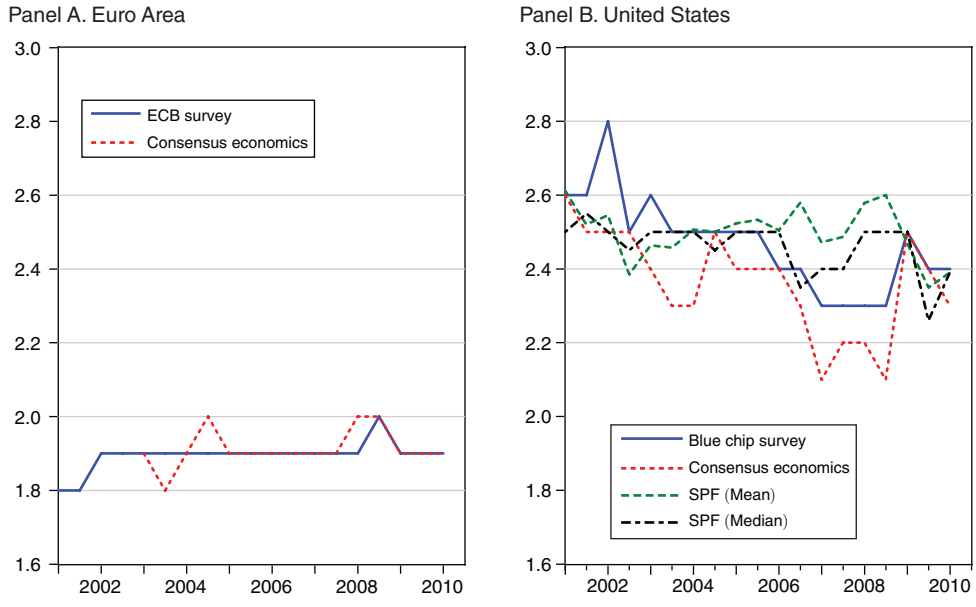

FIGURE 2. SURVEY-BASED MEASURES OF LONG-RUN INFLATION EXPECTATIONS

Notes: This figure depicts the evolution of professional forecasters' long-run inflation expectations for the euro area and the United States using survey data from 2001 through mid-2010. Panel A: For the euro area, inflation is measured in terms of the Harmonized Index of Consumer Prices (HICP). The solid line denotes the mean of individual respondents' five-year-ahead projections in the ECB's quarterly survey of professional forecasters, and the dashed line denotes the mean of individual respondents' six- to ten-year-ahead projections in semiannual surveys conducted by Consensus Economics, Inc. and published in *Consensus Forecasts*. Panel B: For the United States, inflation is measured in terms of the consumer price index (CPI). The solid line denotes the mean of individual respondents' 7- to 11-year-ahead projections in semiannual surveys conducted by Aspen Publishers, Inc., and published in *Blue Chip Economic Indicators*; the short-dashed line denotes the mean of individual respondents' six- to ten-year-ahead projections in semiannual surveys conducted by Consensus Economics, Inc., and published in *Consensus Forecasts*; and the long-dashed and dot-dashed lines denote the mean and the median, respectively, of individual respondents' ten-year-average projections in the quarterly Survey of Professional Forecasters (SPF) conducted by the Federal Reserve Bank of Philadelphia.

euro area will be close to the ECB's objective in the medium term.[8] Respondents to the Philadelphia Fed's survey disagree markedly more about their forecasts of consumer price index (CPI) inflation over the coming ten years. Moreover, the extent of disagreement has risen in recent years; notably, since 2008, the standard deviation of responses to the US survey has reached almost 0.6 percentage points.[9]

Overall, the survey data point to greater dispersion of views about long-run inflation in the United States than in the euro area, suggesting that long-run inflation expectations may not be as firmly anchored in the United States. Disagreement across

[8] Gürkaynak, Levin, and Swanson (2007) analyze the Bank of England's quarterly survey of professional forecasters and find that the cross-sectional distribution of two-year-ahead UK inflation projections is also highly concentrated.

[9] Blue Chip has recently begun publishing another measure of dispersion in long-run US inflation expectations—the average of the top and bottom 10 percent of respondents' point forecasts for consumer price inflation 7 to 12 years ahead. With only a few observations (October 2008, March 2009, and October 2009) it is difficult to form a time series. Nonetheless, the data indicate a remarkable degree of dispersion in very long-run inflation forecasts, suggesting that the recent widening of dispersion shown in Figure 3 does not simply owe to disagreement about inflation during prolonged recovery from the financial crisis.

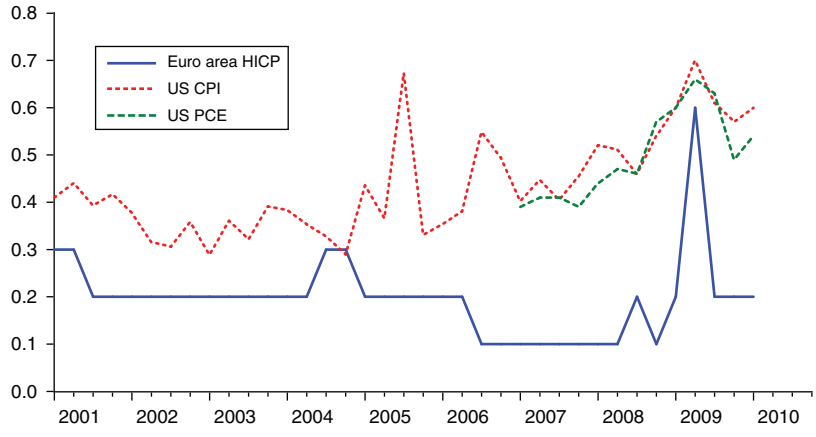

FIGURE 3. DISPERSION OF LONG-RUN INFLATION EXPECTATIONS

Notes: This figure depicts the cross-sectional dispersion of long-run inflation expectations for the euro area and the United States using survey data from 2001 through mid-2010. The solid line denotes the standard deviation of individual respondents' five-year-ahead euro area inflation projections in the ECB's quarterly survey of professional forecasters. The short-dashed line and the long-dashed line denote the ten-year-average projections for US inflation, as measured by the CPI and by the chain-weighted price index for personal consumption expenditures, respectively, in the quarterly Survey of Professional Forecasters conducted by the Federal Reserve Bank of Philadelphia.

forecasters should not be confused with inflation uncertainty, that is, the aggregate distribution of the inflation forecast. However, Paolo Giordani and Paul Söderlind (2003) demonstrate, using data from the Philadelphia Fed survey of professional forecasters, that disagreement is a reasonable proxy for inflation uncertainty. Combined with the evidence in Figure 2, that the mean responses of US surveys have varied more over time, it seems likely that the dispersion of forecasts, in part, reflects uncertainty about the distribution of future inflation outcomes in the United States.

III. Methodology for Analyzing Inflation Compensation

In this section, we move on to our financial data and empirical strategy. We discuss the markets from which we source our financial data, outline the empirical methodology we employ to estimate the reaction of forward inflation compensation to news, and give an overview of how we measure news variables and establish that they contain information for financial markets.

A. *Measuring Forward Inflation Compensation*

Euro Area.—Our financial data for the euro area stems from two markets: the inflation swaps market and the nominal interest rate swap market. Both markets are liquid and mature. The nominal interest rate swap market developed dramatically after the introduction of the euro and is the preferred market for hedging ECB interest rate movements. A nominal swap contract exchanges a fixed rate of interest for floating 6-month Euribor rates (interbank rates on unsecured euro deposits between prime banks). Euribor rates are closely linked to market expectations of the ECB's

policy rate, so the term structure of nominal swap rates provides an indication of monetary policy expectations. See Bruce Tuckman (2002) for an accessible description of the nature of interest rate swap contracts.

The euro-area inflation swaps market is a smaller volume market than that for nominal interest rate swaps, but is nonetheless the most mature and largest volume inflation swaps market in the world. Contracts are typically structured as zero-coupon instruments, which, at maturity, exchange payments of a fixed rate of inflation for a floating rate linked to euro-area consumer prices. The fixed rate, called inflation compensation, compensates the holder of the contract for expected inflation over the life of the contract plus a premium for inflation risk. There is a healthy supply of both inflation payers and receivers in the euro area; market participants include institutions with inflation-linked liabilities, particularly pension funds, and those with inflation-linked revenues, such as quasi-government utilities, as well as parties arbitraging between the indexed government debt market and the swaps market. Unlike the United States, relatively little debt linked to euro-area inflation has been issued by euro-area governments, leaving inflation swaps the major market in which to hedge inflation outcomes.[10] Data are available from mid-2003 on contracts spaced out over regular maturities from 2 to 30 years. Quotes on short-maturity contracts offers a better read on short-term inflation compensation than the outstanding set of indexed bonds.

The data for euro-area nominal and inflation swaps are gathered from Bloomberg. While it would be interesting to investigate the behavior of euro-area inflation compensation prior to the ECB's quantitative objective, data for neither inflation swaps nor European indexed bonds are available far enough back to permit such analysis. Some swaps maturities are more heavily traded than others and attract premiums that add jaggedness to the swaps curves. To retrieve smooth curves, we fit zero-coupon yield curves to the nominal and inflation-swaps data. One-year zero-coupon forward rates are then inferred from the fitted yield curves. See Appendix A for details of the curve fitting.

United States.—Forward rates of inflation compensation in the United States are calculated as the difference between nominal and real forward rates derived from fitted zero-coupon yield curves of the nominal and indexed US Treasury debt markets. The curves are estimated at the Board of Governors of the Federal Reserve. Indexed bonds in the United States (known as Treasury Inflation Protected Securities) are indexed to the headline CPI.[11] As in the inflation-swaps market, inflation compensation is comprised of expected inflation over the life of the bond and an inflation risk premium.[12]

[10] The French government has issued just five bonds indexed to euro area HICP since 2002. There are also four outstanding bonds of the Italian government and one of the Greek government. Differences in governments' credit ratings and tax conventions complicate estimation of a representative euro area inflation compensation curve, but Matthew Hurd and Jon Relleen (2006) show that on any given day, swap-based inflation compensation aligns closely with that derived from yield curves of French nominal and indexed debt.

[11] At maturity, indexed debt settles upon a two- and a half-month lagged observation of the CPI. A similar indexation lag applies to the euro-area inflation swaps market. In neither case will this have much effect on the day-to-day movements of forward rates ten years ahead.

[12] Early in the life of the US TIPS market, substantial liquidity premiums were demanded to hold indexed debt which worked to understate inflation compensation. Stefania D'Amico, Don H. Kim, and Min Wei (2008) estimate that between 1999 and 2002, the liquidity premium on TIPS averaged between 75 and 130 basis points. As issuance

A US inflation swaps market exists, but is less mature and less liquid than that in the euro area and suffers from substantial asymmetry of market participants. In particular, a shortage of market participants willing to supply the floating-rate end of inflation swap contracts creates a sizable spread over bond-market inferred inflation compensation. Despite differences in levels, movements in inflation swaps rates and bond-derived inflation compensation parallel one another and over the shorter sample for which swaps are available—from mid-2004—the two react in a similar manner to news.

B. *Regression Methodology*

The methodology used in this paper—regressing changes in interest rates on the surprise component of an event or data release—has been employed by several other researchers, including Gerald P. Dwyer, Jr. and R. W. Hafer (1989), Michael J. Fleming and Eli M. Remolona (1999), Kenneth N. Kuttner (2001), and Ehrmann and Marcel Fratzscher (2005). However, by focusing upon forward rates as dependent variables rather than yields, the approach taken here follows most closely that in Gürkaynak, Sack, and Swanson (2005), as it allows more intuitive inference about the dynamic response of inflation compensation to new information.

Forward inflation compensation at time t, $f_{n,t}$ consists of expected inflation n-years ahead, $\pi^{e}_{n,t}$, plus an inflation risk premium, $\phi_{n,t}$, that compensates investors for uncertainty about future inflation rates and other potential factors, such as liquidity and default risk. Systematic reaction of inflation compensation to news most likely owes to expected inflation or the inflation risk premium, or both. While it is difficult to disentangle these two components, we argue that sensitivity of far-forward inflation compensation to news is indicative of unanchored inflation expectations.

To investigate the response of forward rates of inflation compensation to news, we estimate the parameters of the following specification:

$$f_{n,t} - f_{n,t-1} = \alpha_n + \boldsymbol{\beta}_n \mathbf{X}_t + \varepsilon_{n,t}, \tag{10}$$

where $(f_{n,t} - f_{n,t-1})$ represents the change from period $t-1$ to t of a one-year forward rate ending n-years ahead; X_t is a vector of the surprise components of macroeconomic data released on day t; and $\varepsilon_{n,t}$ is a residual assumed to be idependently and identically distributed. The regressors consist only of the unforecastable component of data releases, which should be uncorrelated with other information already incorporated in financial markets or released on the same day.

We estimate the regressions using daily data on US and euro-area inflation compensation. The sample starts on July 1, 2003, shortly after the ECB's announcement of its quantitative inflation goal, and ends on December 31, 2007, prior to the intensification of the global financial crisis. Data beyond this date are not well suited to our analysis. The unfolding financial crisis prompted substantial flight-to-quality flows into nominal bonds and declines in liquidity in indexed-bond and

has increased and trading liquidity improved, liquidity premiums declined substantially and averaged between zero and 30 basis points over our sample starting in mid-2003. Liquidity premiums move gradually and do not seem to move systematically in the direction of data surprises.

inflation-swaps markets, causing serious distortions in the pricing of inflation compensation unrelated to the macroeconomic outlook.

The regressions are performed for one-year forward rates ending two to ten years ahead, yielding a term structure of response coefficients, β_n, for each data release. Several types of news announcements may be released on the same day, however, the number of days on which this occurs is few and the sample size is large enough to make us confident that coefficients are reasonably well identified.[13]

C. *Measuring Macroeconomic News*

We define macroeconomic news as the surprise component of a data release. The surprise is measured as the actual released value less the median survey expectation, scaled by the standard deviation of surprises over our sample. Such scaling allows the coefficients to be interpreted as the response of forward rates to a one standard deviation data surprise, facilitating comparison across news types. We use the major macroeconomic releases of the US data calendar and, for the euro area, macroeconomic announcements emanating from the three largest members of the currency bloc: Germany, France, and Italy. We focus on country-level data rather than on euro-area aggregates, which typically elicit no reaction in financial markets, because the country components have been released piecewise at earlier dates.

For European news, real-time released values and median survey expectations have been collected from Bloomberg L.P. Bloomberg's survey is based on a selection of professional economists who submit their forecasts to Bloomberg before or on the Friday prior to the data release. For US news, real-time announcements are based on data collected at the Board of Governors of the Federal Reserve and median survey expectations are recorded from the Money Market Services (MMS) survey conducted by Action Economics. This survey has the same structure as the Bloomberg survey for the euro area, recording professional economists' expectations submitted on or before the Friday prior to the data release. The US monetary policy surprise is measured in the manner proposed by Kuttner (2001), as the change in the price of the current month federal funds futures contract in a short window around FOMC policy announcements. A full listing of variables included in our regressions can be found in the regression output tables in Appendix B.

To evaluate the news content of data releases, we begin by asking whether the news variables we have marshaled have a palpable effect on expectations for monetary policy at reasonably short horizons. Specifically, we estimate equation (10) on one-year forward rates ending in two years from the euro-area nominal swaps curve and the US nominal yield curve. Because our estimation is carried out with daily data, news arriving from other time zones during the European trading day could affect

[13] While our regression analysis is conducted using daily data, each of the explanatory variables takes a nonzero value only periodically (either once a month or once a quarter, when that particular macro data release takes place). Consequently, the matrix of explanatory variables is very sparse. In that context, the analysis of Andrew Chesher and Ian Jewitt (1987) shows that conventional procedures for constructing a heteroskedasticity-consistent covariance matrix, such as that proposed by Halbert White (1980), tend to exhibit substantial downward bias that would lead to spurious significance of some regressors. Hence, all of the results in this paper are based on OLS standard errors.

identification of the response to euro-area news. Thus, we include US news surprises, typically released at about 2:30 P.M. central European time, as conditioning regressors to ensure that the estimated response coefficients to euro area news are not obscured by foreign data releases. Results for both regions are shown in Table 2.

We are confident that the data surprises have news content. Several US and some euro-area data surprises prompt changes in expectations of one- to two-year horizon policy rates, and the coefficients have the expected sign throughout. Several high profile US data releases affect policy expectations in both regions. In contrast, very few data releases emanating from the euro area elicit systematic responses in policy expectations, a finding that is broadly in line with the results of other researchers who have examined other euro-area financial markets, including money markets and bond futures markets (see Ehrmann and Fratzscher (2005) and Magnus Andersson, Lars Jul Overby, and Szabolcs Sebastyen (2009)). Various reasons have been put forward for the lack of response to euro-area data, such as the more timely nature of many US data releases, the piecewise or leaked release of some European variables, and the perception that conditions in the United States are highly influential for global growth (see Linda Goldberg and Deborah Leonard (2003)). That the two national German business confidence surveys which are released fairly early in the data calendar, IFO and ZEW (see Appendix Table B1), are the only significant euro-area variables testifies to the first reason.

IV. Evidence from Far-Forward Inflation Compensation

In this section, we analyze far-forward inflation compensation from several perspectives. We document that the unconditional volatility of inflation compensation is less in the euro area than in the United States, and argue that this is not a reflection of systematically different monetary policy. We then present results of the regressions measuring the sensitivity of inflation compensation in the two regions to macroeconomic news, and ask how inflation compensation reacts to the common shock of oil price changes.

A. *Unconditional Volatility*

Our data on far-forward inflation compensation are plotted in Figure 4. Two important features stand out. First, as in the surveys of inflation expectations, inflation compensation in the United States is, on average, about half a percentage point higher than in the euro area over the sample. The ECB's stated inflation goal is not dissimilar to the long-run inflation goal attributed by financial markets to the Federal Reserve, raising the question of why US rates of inflation compensation lie above those in the euro area.[14]

Second, far-forward inflation compensation in the two economies has traced out a similar trend over the past four years, but the US data exhibit greater month-to-month fluctuation. This trait is all the more evident when constructed for various frequencies. Shown in Table 3, movements in far-forward rates of US inflation

[14] As discussed in Section IVA, if anything, US inflation compensation is understated by the presence of modest liquidity premiums in the indexed debt market.

Table 2—Response of Policy Rate Expectations to Macroeconomic News

	Euro area	United States
US news		
Core CPI	−0.35	3.18**
	(0.63)	(0.91)
Initial jobless claims	−0.98**	−1.60**
	(0.30)	(0.44)
NAPM survey	1.83**	4.30**
	(0.60)	(0.88)
Non-farm payrolls	5.91**	11.33**
	(0.61)	(0.88)
GDP advance	2.24*	3.84**
	(1.03)	(1.49)
Retail sales	1.57*	2.46**
	(0.61)	(0.88)
Unemployment rate	−2.22**	−3.96**
	(0.61)	(0.89)
Monetary policy	−0.47	0.55
	(0.27)	(0.39)
Oil futures	−0.08	−0.10
	(0.09)	(0.14)
French news		
Business confidence	1.12	1.37
	(0.64)	(0.97)
Consumer prices	0.63	1.39
	(0.63)	(0.91)
Producer prices	−0.34	0.38
	(0.66)	(0.95)
German news		
IFO business confidence	2.66**	2.19*
	(0.61)	(0.92)
Consumer prices	0.68	1.87
	(0.71)	(1.26)
Producer prices	1.11	0.77
	(0.60)	(0.96)
Italian news		
Business confidence	−0.22	−0.08
	(0.61)	(0.88)
Consumer prices	0.07	0.13
	(0.62)	(1.10)
Producer prices	0.58	1.16
	(0.66)	(0.98)

Notes: The table shows coefficient estimates and standard errors of the response of nominal one-year forward rates ending in two years to selected macroeconomic releases. Sample period is July 1, 2003 to December 31, 2007. Comprehensive results in Appendix B, Table B1.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

compensation are more volatile than comparable euro-area rates at daily through to quarterly frequencies. At the quarterly frequency, the standard deviation for the euro area is about two-thirds that of the United States, comparable to the reduction in volatility from announcing an explicit inflation objective in our simple modeling exercise in Section I.

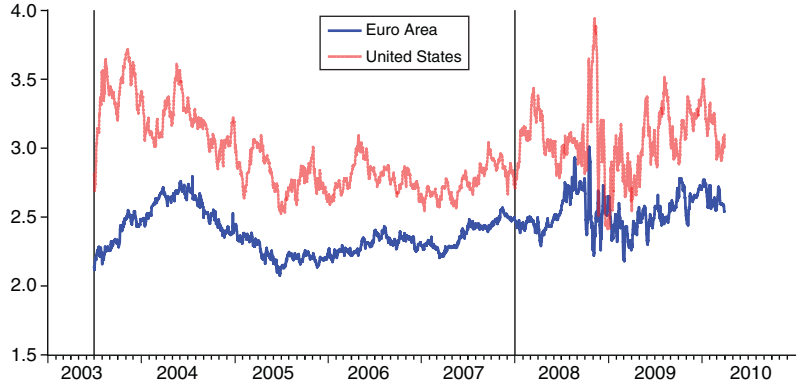

FIGURE 4. FAR-FORWARD INFLATION COMPENSATION IN THE EURO AREA AND UNITED STATES

Notes: This figure depicts the evolution of one-year forward rates of inflation compensation ending ten years ahead, using daily data for the euro area (black line) and the United States (gray line) from July 2003 to March 2010. The vertical bars denote the sample period used in our empirical analysis (July 1, 2003 through December 31, 2007), that is, the period preceding the intensification of the global financial crisis.

In principle, such differences in the volatility of far-ahead inflation compensation could reflect contrasting priorities for monetary policy, that is, the relative weight that each central bank places on the stability of inflation versus the stability of real economic activity. Nevertheless, as noted at the beginning of this paper, several recent empirical studies have concluded that the policy reaction functions of the ECB and the Federal Reserve are not markedly different, and that disparities in their policy actions over the past decade have owed mainly to differences in the size and persistence of shocks.[15]

Indeed, this conclusion is bolstered by the evidence in the lower panel of Table 3, which compares the macroeconomic volatility of the euro area and the United States from 1997 to 2007. Using OECD estimates of the output gap and the unemployment gap, the volatility of real economic activity appears to be fairly similar in each economy, while the volatility of consumer price inflation is noticeably lower in the euro area. These findings are broadly consistent with the predictions of the illustrative model in Section I, namely, that the clarity of the central bank's inflation objective is associated with marked differences in the variability of long-run inflation expectations and fairly modest differences in the behavior of the macroeconomy.

[15] For example, Christiano, Motto, and Rostagno (2007) report coefficients of a policy reaction function estimated for the Federal Reserve and the ECB from 2001 to 2006. The coefficients on inflation disequilibria are 1.93 and 1.58, respectively, for the Fed and the ECB. The coefficients on the output gap do not appear to differ across the two central banks, and the ECB appears to engage in a little more interest rate smoothing. Sahuc and Smets (2008) report very similar results for a sample extending from 1985 to 2004, with median posterior coefficients on inflation disequilibria of 1.83 and 1.53, respectively, for the United States and the euro area. Euro area monetary authorities also appeared to have engaged in more interest rate smoothing over the longer sample.

Table 3—Comparison of Unconditional Volatility

	Euro area	United States
Panel A. Far-forward inflation compensation (*standard deviations in basis points*)		
Frequency		
Daily	2.1	3.6
Weekly	2.8	6.7
Monthly	4.9	12.5
Quarterly	9.5	16.4
Panel B. Key macroeconomic variables (*standard deviations in percentage points*)		
Consumer price inflation	0.9	1.5
Output gap	1.3	1.0
Unemployment gap	0.65	0.75

Notes: Panel A indicates the standard deviation of changes in the one-year forward rate of inflation compensation ending ten years ahead, where the weekly, monthly, and quarterly rates are based on period averages of daily data. Panel B indicates the standard deviation of consumer price inflation (using annualized quarterly rates of change) and of OECD estimates of the output gap and the unemployment gap, using data for the period 1997Q1 to 2007Q4.

B. *Response to Macroeconomic News*

We estimate equation (10) for far-forward rates of inflation compensation, using all available macroeconomic surprises (for both the euro area and the United States) as explanatory variables in each regression. The salient results are reported in Table 4, while a complete set of results is provided in Appendix Table B2.

For the euro area, far-forward inflation compensation does not respond significantly to any of the macro data releases—even those that exert statistically significant effects on monetary policy expectations (as shown above in Table 2). In contrast, US far-forward inflation compensation is sensitive to a variety of indicators of macroeconomic news. Indeed, for most of these variables, the reaction to a standardized data surprise falls in the range of $1/2$ to 2 basis points—not much smaller than the magnitude of the effects of these surprises on US monetary policy expectations. Moreover, US far-forward inflation compensation exhibits statistically significant responses to some of the euro area variables (such as surprises in the French CPI), indicating that investors see both domestic and international shocks as affecting the longer-term US inflation outlook.

Figure 5 displays the term structure of reaction coefficients of euro area inflation compensation to the German IFO business confidence survey and French consumer price inflation. In each case, the response of forward inflation compensation is significant at near-term maturities, but diminishes further out the term structure. Indeed, at a 10-year horizon, the reactions are indistinguishable from zero.

The term structure of reaction coefficients of US inflation compensation to two prominent macro indicators, core CPI inflation and nonfarm payrolls, are shown in Figure 6. In response to a positive data surprise, markets mark up inflation compensation at short horizons, likely because of a slightly higher expected path for inflation. The response decays somewhat by the five-year horizon, but is still positive and significant ten years ahead. Evidently, economic news has an effect on market participants' outlook for US inflation at relatively long horizons.

Table 4—Far-Forward Inflation Compensation Response to News

	Euro area	United States
US news		
Core CPI	0.08	1.28**
	(0.30)	(0.49)
Initial jobless claims	0.02	−0.33
	(0.15)	(0.24)
NAPM survey	0.27	1.22**
	(0.31)	(0.47)
Non-farm payrolls	−0.30	2.12**
	(0.30)	(0.47)
GDP advance	−0.03	1.69*
	(0.49)	(0.80)
Retail sales	0.50	0.01
	(0.31)	(0.48)
Unemployment rate	0.36	−1.69**
	(0.32)	(0.48)
Monetary policy	−0.13	−0.41*
	(0.13)	(0.21)
Oil futures	0.02	0.16*
	(0.04)	(0.07)
French news		
Business confidence	0.52	1.04*
	(0.31)	(0.52)
Consumer prices	−0.09	1.45**
	(0.30)	(0.49)
Producer prices	−0.25	−0.05
	(0.32)	(0.51)
German news		
IFO business confidence	0.33	0.73
	(0.29)	(0.49)
Consumer prices	0.05	0.48
	(0.34)	(0.68)
Producer prices	−0.03	0.34
	(0.29)	(0.52)
Italian news		
Business confidence	0.34	−0.66
	(0.29)	(0.47)
Consumer prices	0.34	0.52
	(0.30)	(0.59)
Producer prices	0.07	0.54
	(0.32)	(0.53)

Notes: The table shows coefficient estimates and standard errors of the response of one-year forward rates of inflation compensation ending in ten years to selected macroeconomic releases. Sample period is July 1, 2003 to December 31, 2007. Comprehensive results in Appendix B, Table B2.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

C. *Response to Oil Price Shocks*

We have focused our attention so far on the reaction of inflation compensation to news emerging from the United States and the euro area. US news matters for euro-area financial markets, but the size of the coefficients are difficult to compare across the two

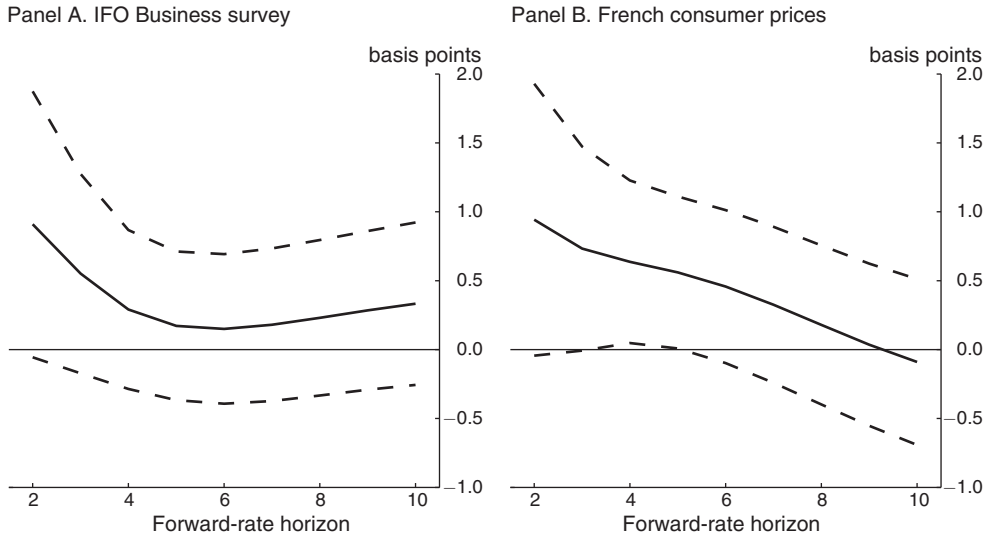

FIGURE 5. ARE LONG-RUN INFLATION EXPECTATIONS FIRMLY ANCHORED IN THE EURO AREA?

Notes: The solid lines are estimated coefficients and the dashed lines ± 2 standard error bands for regressions of one-year forward rates of euro area inflation compensation ending two- to ten-years ahead. All regressions are estimated using data from July 1, 2003 to December 31, 2007.

regions because of uncertainties about the pass through of US economic activity and inflation onto European conditions. Oil price movements are common shocks that offer a more direct comparison of the reaction in the euro area and the United States. Both regions have broadly similar energy intensities, regardless of which, the inflationary consequences of oil price shocks should be expected to die out well within ten years.

As a measure of surprises in oil prices, we employ the daily logarithmic change in the price of one-year ahead future contracts on West Texas Intermediate crude oil. The market for these contracts is highly liquid, and movements in futures prices exhibit much less transitory volatility—and hence less predictable market corrections—than the spot price of oil.

As shown in Table 4, surprises in oil futures prices have statistically significant effects on far-forward inflation compensation for the United States, but not for the euro area. Indeed, a 1 percent increase in the oil futures price is associated with a rise of about 0.2 percent in US far-ahead inflation compensation. As emphasized above, it is difficult to discern whether inflation expectations or inflation risk premia account for this increase. Nonetheless, oil price surprises appear to prompt investors in the United States to mark up their expected path of inflation or to demand greater compensation for inflation risk far into the future in a manner that investors hedging European inflation do not require.

V. The Role of Market Liquidity

In this section, we address whether the empirical results, particularly those for the United States, represent long-lived changes in market rates or transitory responses

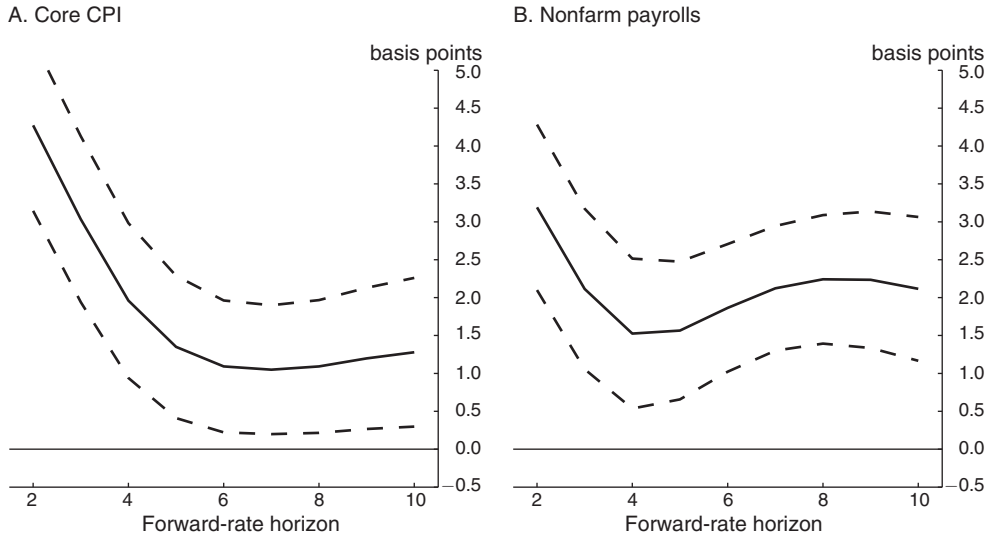

FIGURE 6. ARE LONG-RUN INFLATION EXPECTATIONS FIRMLY ANCHORED IN THE UNITED STATES?

Notes: The solid lines are estimated coefficients and the dashed lines ± 2 standard error bands for regressions of one-year forward rates of US inflation compensation ending two- to ten-years ahead. Regressions include all available US regressors and are estimated from July 1, 2003 to December 31, 2007.

of financial markets to news. The estimated reaction to news on the first day may be unwound if the immediate response owes to changes in market liquidity conditions rather than to investors' reevaluation of the outlook for inflation. We test this in two ways. First, by considering the cumulative market reaction over several days to an announcement, and second, by estimating the market reaction to announcements from prior days. We find that reactions are not unwound; rather, the magnitude of the responses generally persists for at least five days. Moreover, when there is significant market reaction on days subsequent to an announcement, the direction serves to amplify, not unwind, the initial reaction.

We estimate regressions similar to equation (10), but modify the dependent variable to be the cumulative daily change in a forward rate in order to test whether the estimated market reaction that occurs between $t-1$ and t is still present in the data five days later. That is, for forward rates ending n-years ahead, we estimate

$$f_{n,t+j} - f_{n,t-1} = \alpha_{n,j} + \beta_{n,j} X_t + \varepsilon_{n,j,t} \tag{11}$$

for $j = 0,1,2,3,4,5$. When $j = 0$, this corresponds to equation (10). If liquidity effects primarily drive the initial reaction on day t, we would expect to see most of the market reaction unwound in subsequent days and the coefficients $\beta_{n,j}$ quickly diminish to zero for higher j. In contrast, if news prompts revisions to inflation expectations and risk premia, the response should remain embodied in market rates.

Turning first to inflation compensation in the United States, we estimate this equation using the change in one-year forward rates ten years ahead and all available US regressors. Coefficient estimates and confidence intervals for two releases that

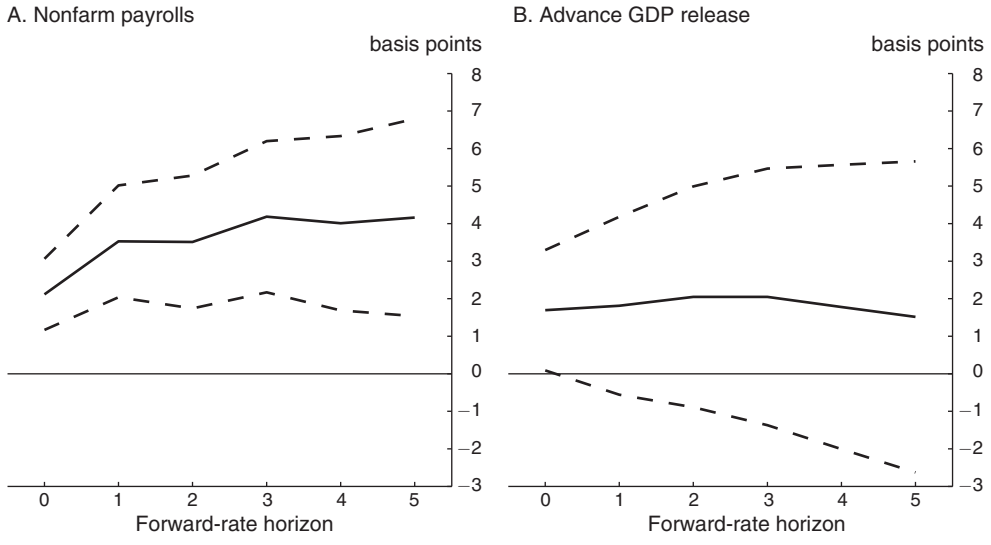

FIGURE 7. DOES MACRO NEWS HAVE PERSISTENT EFFECTS ON US FAR-FORWARD INFLATION COMPENSATION?

Notes: The solid lines plot the estimated response coefficients of the cumulative t to $t + 5$ change in the forward rate to data surprises, and the dashed lines are $\pm$ 2 standard error bands. Regressions include all available US regressors and are estimated from July 1, 2003 to December 31, 2007.

move far-forward inflation compensation are shown in Figure 7. In general, the coefficients persist through the following business week, indicating that the first day's movement is not unwound over that horizon. In the case of the nonfarm payrolls release, the coefficient estimates are large, stable, and statistically significant for the subsequent five days. For new home sales, advance GDP, and leading economic indicators, point estimates are broadly stable over the estimation window, but the standard error bands widen quickly.[16]

Because the regressions do not condition upon subsequent data releases, the relationship between the cumulative change in inflation compensation and day-t news becomes harder to identify as more days pass and more news arrives. To overcome this problem, we modify the approach to control for all incoming data. The specification we consider is as follows:

$$f_{n,t} - f_{n,t-1} = \alpha_n + \beta_n X_t + \beta_n \gamma X_{t-1} + \varepsilon_{n,t}, \tag{12}$$

which regresses the day-t change in forward rates on all contemporary and lagged regressors. As before, β_n is a vector of coefficients measuring the market response to news on the day of the release. The coefficient vector γ measures the response of day-t forward rate movements to day-$(t-1)$ news, while conditioning upon the arrival of subsequent news. This specification is estimated using nonlinear least squares.

[16] Two other data surprises move ten-year ahead inflation compensation on the release day, NAPM and the unemployment rate, but neither exhibits similarly persistent effects in the five days following release. Market revisions induced by these releases may be swamped by subsequent arriving data, at least over our short sample.

Table 5—Testing the Hypothesis that the Impact of News on US Far-Ahead Inflation Compensation Is Unwound on the Following Day

	p-value	Sign of coefficient
Capacity utilization	0.99	+
Consumer confidence	0.80	−
Core CPI	0.94	+
Industrial production	0.63	+
Initial jobless claims	0.52	−
Leading indicators	0.29	−
Monetary policy	0.32	+
NAPM survey	0.37	−
New homes	0.56	−
Nonfarm payrolls	0.03	+
Oil futures	0.61	+
Real GDP (advance)	0.69	+
Retail sales	0.99	−
Unemployment rate	0.63	−

Notes: Probability values are reported for a two-sided test of the null hypothesis that $\gamma = 0$ as estimated by equation (9). Positive values of γ indicate some amplification of the initial reaction, negative values indicate some unwinding.

This specification is parameterized in such a way to test relevant hypotheses. If $\gamma = 0$, there is no further market reaction to data beyond the release day, but if $\gamma = -1$, there is perfect unwinding of the first day's reaction to data. Additional lags of X_t could be included in the regression, but we find no evidence for further market reaction beyond the second day.

The results of a two-sided test of the null hypothesis that $\gamma = 0$ are shown in Table 5, alongside an indication of the sign of the coefficient for each regressor. There is little evidence that markets continue to respond to news after the impact day, with the day-after effects mostly insignificantly different from zero. Only nonfarm payrolls continue to elicit a response the following day and the direction of the movement amplifies the initial response. Market responses to news are not systematically unwound the following day and, combined with the persistence of the point estimates using cumulative daily changes, support the view that reactions to data surprises are not an artifact of short-lived liquidity effects, but reflect revisions to beliefs about inflation expectations and inflation risk premia.

VI. Concluding Remarks

The recent history of long-run inflation expectations of professional forecasters in the United States and euro area paints a picture of reasonably well-anchored expectations in both regions. But is there scope for inflation expectations to be anchored more firmly? In this paper, we have addressed this question by taking a more detailed look at disagreement among forecasters about long-run inflation outcomes and have paired that evidence with findings from high-frequency financial market data regarding the behavior of far-ahead inflation compensation.

In the euro area, we observe that disagreement about likely long-run inflation outcomes is low and has declined over the past half decade. In contrast, disagreement among forecasters in the United States has shown no signs of diminishing and

remains above that of the euro area. From financial market data, we find that inflation compensation—the compensation required for expected inflation and inflation risk—responds differently to news in the two regions. Inflation compensation linked to long-horizon developments in euro-area consumer prices does not respond significantly to today's news, whereas compensation linked to long-horizon US consumer price inflation displays systematic sensitivity to today's data surprises. Moreover, the reaction of far-forward US inflation compensation is comparable to the revision in policy expectations at much nearer horizons.

Taken together, the evidence leads us to conclude that long-run inflation expectations are not as firmly anchored in the United States as in the euro area. These results are consistent with the hypothesis that the ECB's policy communications strategy, which includes an emphasis on the goal of price stability and a fairly specific definition of the medium-term inflation objective, has contributed to the firm anchoring of inflation expectations in the euro area.

Appendix A: Fitting Yield Curves to Euro-Area Financial Data

To replicate the curve-fitting methodology used for our US data, we fit a polynomial Svensson yield curve to each day's nominal and inflation compensation data for the euro area. We find that in the first half of the sample the estimation attributes an implausibly steep curve to the term structure of inflation compensation for maturities less than two years and exaggerates day-to-day movements in the shortest forward rate (see Table A1). Thus, prior to September 2004, we revert to the more parsimonious Nelson-Siegel parameterization. Both specifications have similar properties for longer maturities and, regardless of parameterization, the standard deviation of day-to-day changes in the fitted data is less than that in the raw data.[17] The additional volatility in the raw data, particularly at the long end, does not seem to be systematically related to macroeconomic data surprises.

Table A1—Standard Deviation of Daily Changes in Euro Area Inflation Swap Forward Rates
June 1, 2003 to December 31, 2006

	One-year forward rate ending -years ahead				Five-year forward rate ending 30-years ahead
	2[a]	3	5	10	30
Raw data	–	3.7	4.2	5.5	4.6
Fitted curves					
NS (pre Sep. 2004)	2.5	2.0	2.0	2.7	4.6
NS (post Sep. 2004)	2.2	2.6	2.5	1.7	3.7
Svensson (pre Sep. 2004)	22.3	3.4	2.6	3.5	3.7
Svensson (post Sep. 2004)	4.1	2.9	2.0	1.9	3.5
Combined fitted data	3.7	2.6	2.0	2.2	3.9

[a] The shortest maturity yield that is available is two years. Only once a smooth curve is fitted can a one-year forward rate spanning one to two years be inferred.

[17] Volatility induced at the short end by the Svensson estimation is not systematically related to our macro news variables and obscures relationships that are evident using raw forward rates or those constructed from the fitted Nelson Siegel curve.

Appendix B: Comprehensive Regression Results

Table B1—Response of Policy Rate Expectations to Macroeconomic News

	Euro area		US	
US news				
Capacity utilization	0.83	(0.87)	−1.26	(1.27)
Consumer confidence	0.87	(0.64)	−0.51	(0.92)
Core CPI	−0.35	(0.63)	3.18**	(0.91)
Industrial production	−0.45	(0.86)	0.84	(1.26)
Initial jobless claims	−0.98**	(0.30)	−1.60**	(0.44)
Leading economics indicators	0.11	(0.60)	−0.63	(0.87)
NAPM	1.83**	(0.60)	4.30**	(0.88)
New homes	0.52	(0.60)	1.82*	(0.87)
Nonfarm payrolls	5.91**	(0.61)	11.33**	(0.88)
GDP advance	2.24*	(1.03)	3.84**	(1.49)
Retail sales	1.57*	(0.61)	2.46**	(0.88)
Unemployment	−2.22**	(0.61)	−3.96**	(0.89)
US monetary policy	−0.47	(0.27)	0.55	(0.39)
Oil futures (1 year)	−0.08	(0.09)	−0.10	(0.14)
French news				
Business confidence overall	1.12	(0.64)	1.37	(0.97)
CPI	0.63	(0.63)	1.39	(0.91)
GDP	0.85	(1.07)	−1.99	(1.56)
Industrial production	0.00	(0.59)	0.32	(0.86)
Producer price index	−0.34	(0.66)	0.38	(0.95)
Unemployment rate	−0.15	(0.60)	0.38	(0.87)
German news				
Current account	0.41	(0.62)	0.67	(0.94)
HICP	0.68	(0.71)	1.87	(1.26)
IFO business climate	2.66**	(0.61)	2.19*	(0.92)
Industrial production	0.67	(0.61)	0.34	(0.89)
Producer price index	1.11	(0.60)	0.77	(0.96)
Unemployment	−0.34	(0.59)	0.14	(0.85)
ZEW growth	1.94**	(0.59)	0.96	(0.86)
Italian news				
Business confidence	−0.22	(0.61)	−0.08	(0.88)
HICP	0.07	(0.62)	0.13	(1.10)
Industrial production	1.13	(0.59)	0.63	(0.87)
Producer price index	0.58	(0.66)	1.16	(0.98)
Real GDP	0.89	(1.14)	0.27	(1.65)
Intercept	0.14	(0.13)	0.12	(0.20)
R^2	0.144		0.194	

Notes: The table shows coefficient estimates and standard errors of the response of nominal one-year forward rates ending in two years to selected macroeconomic releases. Sample period is July 1, 2003–December 31, 2007.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table B2—Response of Far-Forward Inflation Compensation to Macroeconomic News

	Euro area		US	
US news				
Capacity utilization	−0.08	(0.42)	0.02	(0.68)
Consumer confidence	0.29	(0.31)	−0.20	(0.50)
Core CPI	0.08	(0.30)	1.28**	(0.49)
Industrial production	0.12	(0.42)	−0.37	(0.68)
Initial jobless claims	0.02	(0.15)	−0.33	(0.24)
Leading economics indicators	−0.45	(0.29)	−1.66**	(0.47)
NAPM	0.27	(0.31)	1.22**	(0.47)
New homes	0.18	(0.29)	1.41**	(0.47)
Nonfarm payrolls	−0.30	(0.30)	2.11**	(0.47)
GDP advance	−0.03	(0.49)	1.69*	(0.80)
Retail sales	0.50	(0.31)	0.01	(0.48)
Unemployment	0.36	(0.32)	−1.69**	(0.48)
US monetary policy	−0.13	(0.13)	−0.41	(0.21)
Oil futures (1yr)	0.02	(0.04)	0.16*	(0.07)
French news				
Business confidence overall	0.52	(0.31)	1.04*	(0.52)
CPI	−0.09	(0.30)	1.45**	(0.49)
GDP	0.12	(0.52)	1.29	(0.84)
Industrial production	0.36	(0.29)	0.38	(0.46)
Producer price index	−0.25	(0.32)	−0.05	(0.51)
Unemployment rate	−0.18	(0.29)	-0.81	(0.47)
German news				
Current account	−0.19	(0.30)	0.40	(0.50)
HICP	0.05	(0.34)	0.48	(0.68)
IFO business climate	0.33	(0.29)	0.73	(0.49)
Industrial production	−0.01	(0.29)	-0.23	(0.48)
Producer price index	−0.03	(0.29)	0.34	(0.52)
Unemployment	−0.20	(0.28)	−0.47	(0.46)
ZEW growth	0.02	(0.30)	0.69	(0.46)
Italian news				
Business confidence	0.34	(0.29)	−0.66	(0.47)
HICP	0.34	(0.30)	0.52	(0.59)
Industrial production	−0.40	(0.30)	0.24	(0.47)
Producer price index	0.07	(0.32)	0.54	(0.53)
Real GDP	0.52	(0.54)	0.74	(0.89)
Intercept	0.01	(0.07)	−0.14	(0.10)
R^2	0.023		0.084	

Notes: The table shows coefficient estimates and standard errors of the response of one-year forward rates of inflation compensation ending in ten years to selected macroeconomic releases. Sample period is July 1, 2003–December 31, 2007.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

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