Does Inflation Targeting Anchor Long-Run Inflation Expectations?

Evidence from Long-Term Bond Yields in the U.S., U.K., and Sweden*

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Abstract

We investigate the extent to which inflation targeting helps anchor long-run inflation expectations by comparing the behavior of daily bond yield data in the United Kingdom and Sweden—both inflation targeters—to that in the United States, a non-inflation-targeter. Using the difference between far-ahead forward rates on nominal and indexed bonds as a measure of compensation for expected inflation and inflation risk at long horizons, we examine the extent to which far-ahead forward inflation compensation moves in response to macroeconomic data releases and monetary policy announcements. In the U.S., we find that forward inflation compensation exhibits highly significant responses to economic news. In the U.K., we find a level of sensitivity similar to that in the U.S. prior to the Bank of England gaining independence in 1997, but a striking absence of such sensitivity since the central bank became independent. In Sweden, we find that inflation compensation has been insensitive to economic news over the whole period for which we have data. We show that these results are also matched by the times series behavior of far-ahead forward interest rates and inflation compensation over this period. All of our findings suggest that a known and credible inflation target significantly helps to anchor the private sector's views of the distribution of long-run inflation outcomes.

Keywords: inflation targeting, inflation compensation, forward rates, high-frequency data
JEL Codes: E31, E52, E58.

October 19, 2005

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*In compiling the data for this project, we received invaluable assistance from Jan Alsterlind, Andrew Clare, Lars Hoerngren, Michael Joyce, Peter Lildholt, and Lena Stromberg. The paper has also benefited from very helpful discussions, comments, and suggestions from Paul Beaudry, Alan Blinder, Mick Devereux, Rick Mishkin, Scott Roger, Brian Sack, Klaus Schmidt-Hebbel, Lars Svensson, Jonathan Wright, and seminar participants at the Sveriges Riksbank, the International Monetary Fund, and Johns Hopkins University. We appreciate the excellent research assistance of Andrew Marder, Claire Hausman, and Oliver Levine. The views expressed in this paper are solely the responsibility of the authors, and do not necessarily reflect the views of the Board of Governors of the Federal Reserve System, the Federal Reserve Bank of San Francisco, or any other person associated with the Federal Reserve System.

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1. Introduction

Long-term price stability is a central goal of monetary policy for essentially every modern central bank.[1] To facilitate the achievement of this objective, a number of national and supernational central banks have adopted an "inflation targeting" framework, in which a numerical objective for the level of inflation in a few years' time is explicitly stated, vigorously pursued, and clearly communicated to the public in the form of periodic, detailed reports on the current and projected future state of the economy, particularly inflation (e.g., Leiderman and Svensson, 1995, Bernanke and Mishkin, 1997, Bernanke et al., 1999, Kuttner, 2005). The adoption of inflation targeting (IT) has been encouraged by a growing body of literature that finds the framework to offer advantages in terms of the formulation and communication of monetary policy (e.g., Walsh, 1995, Persson and Tabellini, 1993, Svensson, 1997, McCallum, 1996, Bernanke et al., 1999, Svensson and Woodford, 2003). Nevertheless, empirical analysis using quarterly realizations of inflation or survey-based measures of inflation expectations has yielded at best weak support for the notion that IT significantly influences the behavior of inflation: In particular, quarterly inflation rates and short-term inflation forecasts have not behaved very differently in IT and non-IT economies, with all of the major industrial nations experiencing significant disinflation in the 1990s (Bernanke et al., 1999, Johnson, 2002, Ball and Sheridan, 2004, Gertler, 2004),[2] while analysis of longer-term inflation expectations (Castelnuovo et al., 2003, Levin and Piger, 2004) has been hampered by a scarcity of data due to the relatively recent adoption of IT in most countries and the low, typically semiannual, frequency of surveys that measure long-term expectations.

In this paper, we evaluate the influence of inflation targeting on long-term inflation expectations by comparing the behavior of daily bond yield data in the United States, the United Kingdom, and Sweden. We focus on these three countries in particular because all three have had a range of inflation-indexed government bonds outstanding for a number of years, providing us with

[1] In other periods, of course, one can find many instances in which a central bank's primary objective was to provide the government with cheap credit and seigniorage revenue.

[2] Ertürk and Özlale (2005) examine the effects of inflation targeting in emerging markets as well as in industrialized economies using a GARCH framework.

good measures of forward real as well as nominal yields.[3] Forward inflation compensation—defined as the difference between forward rates on nominal and inflation-indexed bonds—provides us with a high-frequency measure of the compensation investors demand to cover expected future inflation and the risks associated with that inflation at a given horizon.[4] Thus, if 10-year-ahead forward inflation compensation is relatively insensitive to incoming economic news, then one could infer that financial market participants have fairly stable views regarding the distribution of long-term inflation outcomes, and hence that the monetary policy framework has been reasonably successful in anchoring long-term inflation expectations.

In contrast to previous empirical studies of inflation targeting, the daily frequency of our bond yield data together with the frequent release of important macroeconomic statistics and monetary policy announcements enables us to obtain relatively precise estimates of the impact of these releases on far-ahead forward inflation compensation, even for samples that span only the past seven or eight years—the period for which inflation-indexed bonds have been traded in the U.S. and Sweden. While previous empirical work has been limited to quarterly or even semiannual data over a five- to ten-year period, we are able to bring to bear over three thousand daily observations of the response of long-term bond yields to major economic news releases in the U.S., U.K., and Sweden.

Importantly, our analysis of the inflation compensation implicit in long-term bond yields does not rely on the expectations theory of the term structure. In particular, risk premia on long-term bonds could vary widely over time and still not impact our estimates so long as that variation occurs primarily at lower, business-cycle frequencies rather than from one day to the next.

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[3] In ongoing research, we are working to extend the methods of this paper to other inflation targeting countries. However, the data limitations for other countries are often severe or prohibitive: for example, New Zealand has only one inflation-indexed bond outstanding, which makes the computation of forward rates impossible. Canada has only one inflation-indexed bond until 1996 and only two from 1996 to 2001, and even these bonds have extremely long durations (30 years) and low liquidity, making implied forward rates difficult to estimate and noisy. High-frequency data on market forecasts of macroeconomic statistical releases in Australia, New Zealand, and Finland are not available, to our knowledge. Finally, data in developing countries with inflation targets, such as South Africa and Chile, tends to be even more limited. See section 2 for more details.

[4] In contrast to yields, the use of forward rates avoids any direct influence from short-term developments, thereby permitting a sharper focus on inflation expectations at a particular horizon. See section 2, below, and Gürkaynak, Sack, and Swanson (2005) for a detailed discussion.

Empirical evidence regarding the failure of the expectations hypothesis (e.g., Fama and Bliss, 1987, Campbell and Shiller, 1994, Cochrane and Piazzesi, 2004) indeed has been primarily at these lower frequencies. (Nevertheless, we discuss the robustness of the interpretation of our results with respect to time-varying risk premia in Section 4.)

Our analysis reveals substantial cross-country differences in the sensitivity of forward nominal interest rates and inflation compensation to economic news. Reminiscent of the results in Gürkaynak, Sack, and Swanson (2005), we find that far-ahead forward nominal rates and inflation compensation in the U.S. have exhibited highly significant responses to macroeconomic data releases and monetary policy announcements. Moreover, these responses are all consistent with the view that inflation in the near term will partially pass through to inflation at very long horizons. For the United Kingdom, we find very similar results to those for the U.S. prior to the Bank of England gaining operational independence in mid-1997. However, subsequent to Bank of England independence, we find that far-ahead nominal interest rates and inflation compensation in the U.K. have been invariant with respect to economic news. Finally, far-ahead nominal rates and inflation compensation in Sweden have been unresponsive to economic news over the whole period for which we have data. Our results for the U.K. and Sweden hold both with respect to domestic economic news and news coming in from abroad—i.e., macroeconomic data releases and monetary policy announcements in the U.S. and Euro Area.

Of course, one interpretation of our findings is that it is not changes in the *mean* of the distribution of long-run inflation that are responsible so much as changes in the variance or skewness of that distribution. In fact, this story is entirely consistent with our conclusion, namely that inflation targeting helps to anchor market perceptions of the entire *distribution* of future long-run inflation outcomes.

The remainder of the paper proceeds as follows. Section 2 describes our high-frequency data and how to construct forward interest rates, inflation compensation, and the surprise components of macroeconomic data releases and monetary policy announcements. Section 3 investigates the responses of far-ahead forward interest rates and inflation compensation in the

U.S., U.K., and Sweden to economic news, both domestic and foreign. Section 4 discusses the interpretation and broader implications of our results. Section 5 concludes. An Appendix presents a detailed description of all the data used in our analysis.

2. Analytical Framework and Data

2.1 A Benchmark Model for the Response of Interest Rates to Economic News

To aid in the interpretation of our empirical findings, it is useful to have a benchmark model for comparison. We take as our benchmark a "hybrid" New Keynesian model of the form:

$$\pi_t = \mu E_t \pi_{t+1} + (1-\mu) A_\pi(L) \pi_t + \gamma y_t + \varepsilon_t^\pi \quad (2.1)$$

$$y_t = \mu E_t y_{t+1} + (1-\mu) A_y(L) y_t - \beta (i_t - E_t \pi_{t+1}) + \varepsilon_t^y \quad (2.2)$$

where π denotes the inflation rate, y the output gap, i the short-term nominal interest rate, and ε^π and ε^y are i.i.d. shocks.[5] The model is "hybrid" in that it allows for inflation and output to depend on their owns lags, which allows the model to better fit the observed degree of persistence in U.S. data (e.g., Fuhrer, 1997, Roberts, 1997, Rudebusch, 2001, Estrella and Fuhrer, 2002) and which is sometimes justified by the above authors and others on the basis of "rule-of-thumb" price-setting behavior by a fraction of firms and habit formation in consumer preferences. The parameter μ denotes the degree of forward-looking behavior in the model, and the lag polynomials govern the dynamics of any backward-looking behavior. For the purposes of generating impulse responses below, we use the parameter values estimated by Rudebusch (2001), which imply a value for μ of about 0.3.[6]

We close the model with an interest rate rule of the form:

$$i_t = (1-c)\left[(1+a)\bar{\pi}_t + b y_t\right] + c\, i_{t-1} + \varepsilon_t^i \quad (2.3)$$

[5] These variables are all normalized to have steady state values of zero.

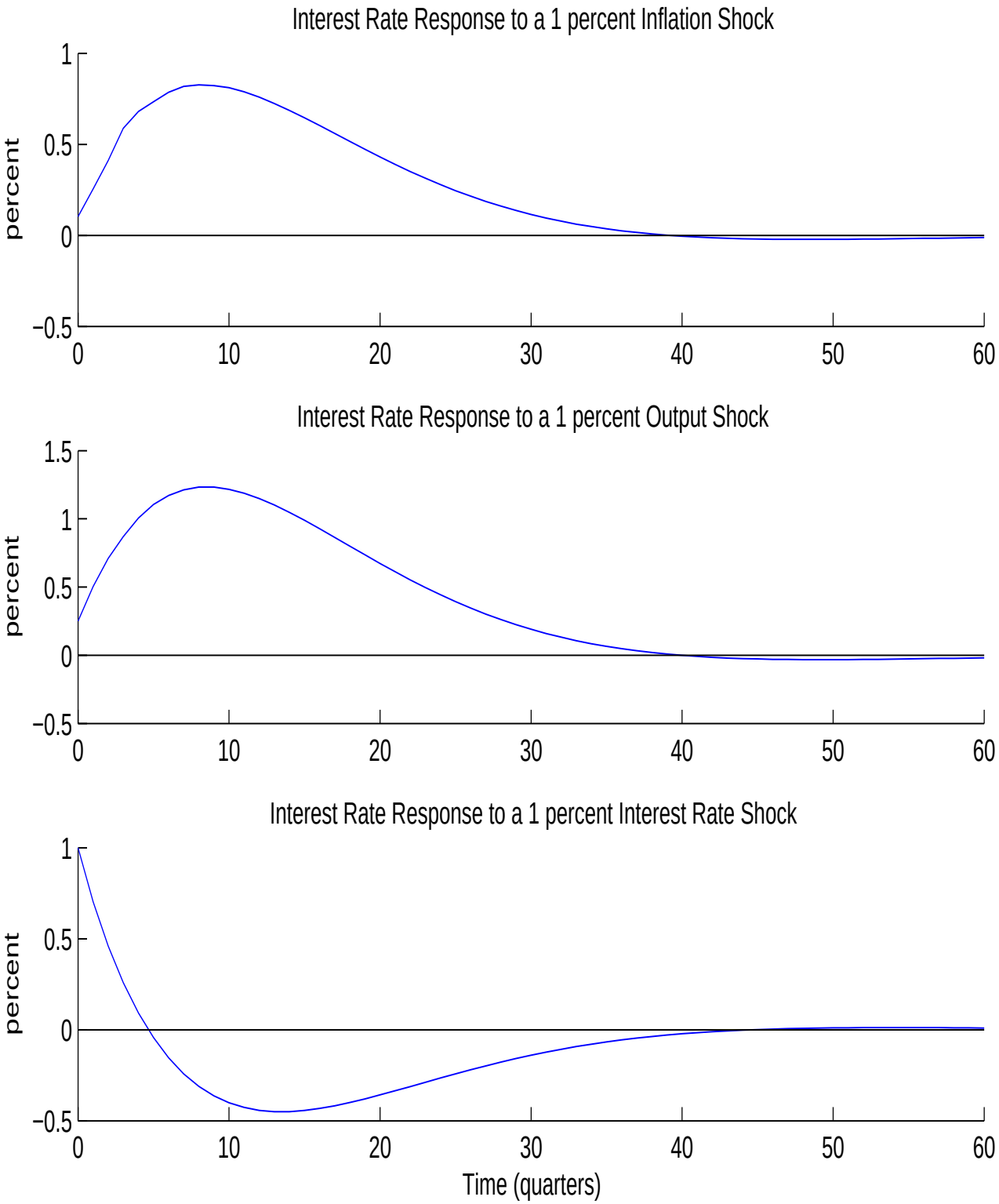
[6] Rudebusch estimates and uses a value of μ=0.29, which we use as well. There are also some minor timing differences between equations (2.1)-(2.2) and the specification of Rudebusch's model. To generate the impulse response functions in Figure 1, we use the model exactly as specified in Rudebusch (2001), but these differences in specification have no discernible effect on our results.

where $\bar{\pi}$ denotes the trailing four-quarter moving average of inflation, ε^i is an i.i.d. shock, and *a*, *b*, and *c* are the parameters of the rule.[7] Note that the policy rule is both "backward-looking," in that the interest rate responds to current values of the output gap and inflation rather than their forecasts, and "inertial," in that it includes the lagged federal funds rate. Both of these features tend to add inertia to the short rate, which generally gives the model the best possible chance of explaining the term structure evidence we find below. We include an interest rate shock, ε_t^i, for the purpose of generating impulse response functions.

In Figure 1, we plot impulse response functions for the short-term nominal interest rate in response to a one-percent shock to inflation, the output gap, and interest rates, respectively. The hump-shaped impulse response functions of the model are very standard and representative of models that match the empirical persistence in U.S. data. There are two key observations to draw from Figure 1 for the purposes of the present paper: First, short-term interest rates return much of the way to steady state within about five years after each shock, and return almost completely to steady state well within ten years after each shock. This feature is not specific to the hybrid New Keynesian model, but rather stems from the standard macroeconomic modeling assumptions that the long-run characteristics of the economy—in particular, the steady-state levels of inflation and the real interest rate—are constant over time and perfectly known by all economic agents. An implication of this assumption is that, after a macroeconomic or monetary policy shock, expectations of short-term nominal interest rates far enough in the future should remain relatively fixed. This brings us to the second key observation to draw from the model: that it is not *long-term* interest rates that should remain stable after an economic shock, but rather *far-ahead forward* interest rates that should remain stable. The *long-term* interest rate in the model is the average of short-term rates over the lifetime of the bond, and this should be expected to respond somewhat to economic shocks to the extent that the short-term rates in the near future move.

[7] We use the values of *a*, *b*, and *c* estimated by Rudebusch (2002) for the period 1987Q4 to 1999Q4: a=.53, b=.93, and c=.73.

Figure 1
Interest Rate Impulse Responses in a Benchmark Macroeconomic Model



2.2 Forward Interest Rates and Forward Inflation Compensation

As shown above, to study the extent to which inflation expectations are firmly anchored at longer horizons, we must look beyond the effects of economic news over the first few years and focus instead on the behavior of *forward* interest rates and inflation compensation several years ahead.

Forward rates are often a very useful means of interpreting the term structure of interest rates. For a bond with a maturity of *m* years, the yield $r_t^{(m)}$ represents the rate of return that an investor requires to lend money today in return for a single payment *m* years in the future (for the case of a zero-coupon bond). By comparison, the *k*-year-ahead one-year forward rate $f_t^{(k)}$ represents the rate of return from period *t+k* to period *t+k+1* that the same investor would require to commit today to a one-year loan beginning at time *t+k* and maturing at time *t+k+1*. The linkage between these concepts is simple: an *m*-year zero-coupon security can be viewed as a sequence of one-year forward agreements over the next *m* years. The *k*-year-ahead one-year forward rate $f_t^{(k)}$ can thus be obtained from the yield curve by the simple definition:

$$1+ f_t^{(k)} = \frac{(1+r_t^{(k+1)})^{k+1}}{(1+r_t^{(k)})^k} \tag{1}$$

The familiar formula in equation (1) is for zero-coupon yields compounded annually; the formula for continuously-compounded yields (which we use in this paper) is even simpler:[8]

$$f_t^{(k)} = (k+1)r_t^{(k+1)} - kr_t^{(k)} \tag{2}$$

For the U.S., we use data on nominal and real forward rates on U.S. Treasury securities produced by the Federal Reserve Board.[9] Note that U.S. inflation-indexed bonds (TIPS) were issued for the first time in January 1997 and only annually in the first few years after that date, so

[8] If we observed zero-coupon yields directly, computing forward rates would be as simple as this. In practice, however, most government bonds in the U.S. and abroad make regular coupon payments, and thus the size and timing of the coupons must be accounted for to translate observed yields into the implied zero-coupon yield curve. Gürkaynak, Sack, and Swanson (2003) investigate whether the use of U.S Treasury STRIPS (which are zero-coupon securities that thus do not require fitting a yield curve first) alters the estimated response of far-ahead forward nominal rates in the U.S., and find that the STRIPS data yield essentially identical results.

[9] The Federal Reserve Board computes implied zero-coupon yields from observed, off-the-run U.S. Treasury yields using the extension of the Nelson-Siegel (1987) method described in Svensson (1994). Details are available in Gürkaynak, Sack, and Wright (2005).

we cannot compute a far-ahead forward real rate for the U.S. until January 1998. For the U.K., we use data on nominal and real forward rates on U.K. government securities produced by the Bank of England and made available on their web site.[10] The inflation-indexed bond market in the U.K. has traditionally been the most liquid in the world, with daily data available going back to at least 1985. For Sweden, we obtained data on nominal and inflation-indexed Swedish government yields from the Swedish Riksbank. We backed out the implied zero-coupon yield curves and forward rates using the Svensson (1994) methodology (which was designed for Swedish data and is the same method employed by the Federal Reserve Board for U.S. data) and checked that these did in fact fit the Swedish bond data very well. Note that the first inflation-indexed Swedish government bond was issued in March 1994, but additional indexed bonds were not issued until May 1996 (when a range of four new maturities were issued), so our forward real rate data for Sweden begin in May 1996.

Having obtained or computed forward nominal rates and forward real rates for each country, we compute forward inflation compensation by subtracting the forward real rate from the forward nominal rate at each horizon.[11]

Given our interest in measuring long-term expectations, our analysis focuses on the longest maturity for which we have high-quality data for both real and nominal bond yields. The liquidity and breadth of the markets for government securities at and around the ten-year horizon thus suggests we focus on the one-year forward rate nine years ahead (i.e., the one-year forward rate ending in ten years). As we saw in the previous subsection, this horizon is sufficiently far out for standard macroeconomic models to largely return to their steady states, so that any movements in forward interest rates or inflation compensation at these horizons are difficult to ascribe to

[10] The Bank of England computes implied zero-coupon yields from observed U.K. government yields using a spline-based procedure. Details are available from the Bank of England's web site.

[11] This calculation is correct as we have continuously compounded zero coupon forward rates. Note that, in general, one cannot compute long-term inflation compensation by differencing coupon-bearing long-term nominal yields and coupon-bearing long-term real yields because the coupon streams and durations of these securities are very different (see Sack and Elsasser, 2004): in particular, the real value of coupons on inflation-indexed bonds does not erode over time, so the duration of indexed securities is much longer. Thus, one cannot simply difference nominal and real coupon yields and fit a yield curve to this difference. Also, we prefer to use the officially-produced forward rate data as much as possible.

transitory responses of the economy to a shock. Finally, while not reported here, we have confirmed that our main findings are not sensitive to the use of an alternative time horizon such as the five-year-average forward rate five years ahead.

2.3 Macroeconomic Data Releases

Financial markets are forward-looking, so the expected component of macroeconomic data releases should have essentially no effect on interest rates.[12] To measure the effects of macroeconomic data releases on interest rates, then, we must first compute the unexpected, or surprise, component of each macroeconomic data release. Using the surprise components of macroeconomic data releases also removes any possible issue of endogeneity arising from interest rates feeding back to the macroeconomy, because any such effects, to the extent that they are systematic or predictable, will be incorporated into market expectations for the statistical release.

In our analysis, we consider data releases of major macroeconomic statistics for each of our three countries and also for the Euro Area. To measure the surprise component of each data release, we compute the difference between the actual release and the median forecast of that release made by professional forecasters just a few days prior to the event. For the U.S., we use data on professional forecasts of the next week's statistical releases collected and published every Friday by Money Market Services. For the U.K., Sweden, and the Euro Area, we use data on professional forecasts collected over the previous week and reported by Bloomberg Financial Services.

For the United States, we have Money Market Services data for 39 different macroeconomic data series. However, not all of these statistics have a significant impact on interest rates, even at the short end of the yield curve. Thus, to conserve space and reduce the number of exogenous variables in our regressions, we restrict attention to only those macroeconomic variables that Gürkaynak, Sack, and Swanson (2005) identified as having statistically significant effects on the one-year Treasury bill rate over the 1990-2002 period:

[12] Kuttner (2001) tests and confirms this hypothesis for the case of monetary policy announcements.

capacity utilization; consumer confidence; the core consumer price index (CPI); the employment cost index (ECI); the advance (i.e., first) release of real GDP; initial jobless claims; the National Association of Purchasing Managers (NAPM)/Institute for Supply Management (ISM) survey of manufacturing activity; new home sales; non-farm payrolls; and retail sales.[13]

For the United Kingdom and Sweden, we use all of the macroeconomic variables for which Bloomberg Financial Services compiles and publishes market projections. For the U.K., there are seven such macroeconomic series: average earnings; the preliminary (i.e., first) release of real GDP; manufacturing production; the producer price index (PPI); the retail price index (RPI); the core RPI; and retail sales. For Sweden, there are also seven such variables: the consumer price index (CPI); the core CPI; the preliminary release of real GDP; industrial production; the producer price index (PPI); retail sales; and the unemployment rate.

For many Euro Area variables, the individual country components are published several weeks prior to the release of the Euro Area aggregate, so that the Bloomberg consensus projection consistently matches the actual release. Thus, we are only able to use three Euro Area macro variables that exhibit non-trivial surprises: industrial orders; industrial production; and retail trade. Of course, because the publication of these Euro Area series was only initiated a few years ago, the impact of surprises in these variables cannot be assessed for U.K. data over the 1993-97 period.

Additional details about these macroeconomic series and the corresponding market projections are provided in the Data Appendix to this paper.

2.4 Monetary Policy Announcements

As with macroeconomic data releases, we must compute the surprise component of monetary policy announcements in each of our countries in order to measure the effects of these announcements on interest rates.

[13] In addition to these ten variables, GSS also included leading indicators, the core producer price index, and the unemployment rate in their analysis. We originally included these three variables as well, but they never entered significantly into any of our regressions at even the shortest horizon at even the 10 percent level over our sample, so we omit them from the results below to save space and reduce the number of explanatory variables. Nonetheless, our results are essentially identical whether we include these three additional variables in the regressions or not.

For the U.S., we measure monetary policy surprises using federal funds futures rates, which provide high-quality, virtually continuous measures of market expectations for the federal funds rate (Krueger and Kuttner, 1996, Rudebusch, 1998, Brunner, 2000).[14] The federal funds futures contract for a given month settles at the end of the month based on the average federal funds rate that was realized over the course of that month. Thus, daily changes in the current-month futures rate reflect revisions to the market's expectations for the federal funds rate over the remainder of the month. As explained in Kuttner (2001) and Gürkaynak, Sack, and Swanson (2002), the change in the current month's contract rate on the day of a Federal Open Market Committee (FOMC) announcement, once scaled up to account for the timing of the announcement within the month, provides a measure of the surprise component of the FOMC decision.[15] We compute the surprise component associated with every FOMC meeting and inter-meeting policy action by the FOMC over our sample.[16]

For the United Kingdom, we do not have futures data for the policy rate of the Bank of England, so we measure monetary policy surprises using the change in the spot 3-month sterling London Interbank Offer Rate (LIBOR) on the days of Bank of England monetary policy announcements. The change in the 3-month rate on these days reflects changes in financial market expectations about the current and future course of monetary policy over the subsequent 3 months. While this is not the same as the shorter horizon one would obtain from a very near-term futures contract, it is nonetheless an excellent measure of the change in the near-term monetary policy environment.

For Sweden, we likewise do not have futures data on the monetary policy instrument and instead use the change in the 3-month Swedish Government Bill rate on the days of Riksbank monetary policy announcements.

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[14] Gürkaynak et al. (2002) show that, among the many possible financial market instruments that potentially reflect expectations of monetary policy, fed funds futures are the best predictor of future policy actions.

[15] In order to avoid very large scale factors, if the monetary policy announcement occurs in the last seven days of the month, we use the next-month contract rate instead of scaling up the current-month contract rate.

[16] There is one exception in that we exclude the intermeeting 50bp easing on September 17, 2001, because financial markets were closed for several days prior to that action and because that easing was a response to a large exogenous shock to the U.S. economy, and we would have difficulty disentangling the effect of the monetary policy action from the effect of the shock itself on financial markets that day.

Finally, we also investigate the sensitivity of inflation compensation in the U.K. and Sweden to Euro Area monetary policy announcements made by the European Central Bank. To measure these surprises, we use the change in the spot 3-month Euribor rate in Frankfurt. Note that, for the Euro Area, we only include monetary policy committee meeting dates on which an interest rate decision was considered.

3. Results

We now investigate whether far-ahead forward interest rates and inflation compensation in the U.S., U.K., and Sweden respond systematically to macroeconomic data releases and monetary policy announcements. In particular, we run regressions of the form:

$$\Delta y_t = \alpha + \beta X_t + \varepsilon_t$$

where Δy_t is the change in the relevant interest rate or inflation compensation over the day, X_t is a vector of surprises and ε_t is a residual term representing other factors affecting changes in y_t that day.

3.1 Response of U.S. Forward Rates and Inflation Compensation to Domestic Economic News

Table 1 reports results for the United States over the 1998-2005 period.[17] Each column provides results from a regression of daily changes in the corresponding interest rate or in inflation compensation on the surprise component of the macroeconomic data releases and monetary policy announcements listed at the left.[18] We regress the change in interest rates on all of our macroeconomic and monetary policy surprises jointly to properly account for days on which more than one piece of economic news was released. To aid in interpreting our coefficient estimates, we normalize each macroeconomic surprise by its standard deviation, so that each coefficient in the table estimates the interest rate response in basis points per standard deviation surprise in the

[17] Recall that we can only compute far-ahead forward real rates for the U.S. beginning in January 1998.

[18] Note that, although we have almost one thousand daily observations in each of these regressions, most of the elements of any individual regressor are zero because any given macroeconomic statistic is only released once per month (or once per quarter in the case of GDP, once per week in the case of Initial Claims). We restrict attention in all our regressions to only those days on which some macroeconomic statistic was released or a monetary policy announcement was made, but our results are not sensitive to this restriction.

corresponding macroeconomic statistic—the one exception to this rule is the monetary policy surprises, which we leave in basis points, so that these coefficients represent a basis point per basis point response.

Before turning to far-ahead forward interest rates, the first column of Table 1 reports the responses of the spot one-year nominal rate to the economic releases as a benchmark for comparison. As one might expect from a Taylor-type rule or from casual observation of U.S. financial markets, interest rates at the short end of the term structure exhibit highly significant responses to surprises in macroeconomic data releases and monetary policy announcements. Moreover, these responses are generally consistent with what one would expect from a Taylor-type rule: upward surprises in inflation, output, or employment lead to increases in short-term interest rates, and upward surprises in initial jobless claims (a countercyclical economic indicator) cause short-term interest rates to fall. The magnitudes of these estimates seem reasonable, with a two-standard-deviation surprise leading to about a 3 to 9 bp change in the 1-year rate (depending on the statistic) on average over our sample. Monetary policy surprises lead to about a 1-for-3 or 1-for-2 response of the one-year yield to the federal funds rate, consistent with the view that a surprise change in the funds rate is often not a complete surprise to markets, but rather a bringing forward or pushing back of policy changes that were expected to have some chance of occurring in the future, anyway. All in all, these results are very consistent with those reported by GSS for the longer sample period (1990-2002) of their analysis.

The next three columns of Table 1 turn to the response of far-ahead forward U.S. interest rates and inflation compensation to economic news. If ten years is a sufficient amount of time for the U.S. economy to return largely to steady state following an economic shock and if long-term inflation expectations are firmly anchored in the U.S., then one would expect to see little or no response of far-ahead forward nominal rates or inflation compensation to economic news. As is clear in Table 1, this is not the case: far-ahead forward nominal rates and inflation compensation in the U.S. each respond significantly to six of the ten macroeconomic data releases we consider,

often with a very high degree of statistical significance.[19] Moreover, the signs of these coefficients are not random, but rather closely resemble the effect on short-term interest rates and the short-term inflation outlook, consistent with markets expecting some degree of pass-through of short-term inflation to the long-term inflation outlook. Furthermore, the magnitude of these effects is non-trivial, often being more than half as large as the effect on the short-term interest rate.

Finally, it is interesting to note that the response of far-ahead nominal interest rates and inflation compensation to monetary policy surprises is *negative*—indicating that a surprise monetary policy tightening leads far-ahead nominal rates and inflation compensation to *fall*—echoing the finding by GSS for their 1990-2002 and 1994-2002 samples. This result is also consistent with financial markets viewing a pass-through of the short-term inflation outlook to long-term inflation. In contrast to GSS, however, the effect here is not statistically significant, perhaps because the frequency and magnitude of such surprises has declined substantially in recent years compared with the early- and mid-1990s (Lange et al., 2004, Swanson, 2005).

[19] Far-ahead forward real interest rates respond significantly to four out of the ten macroeconomic data releases. We do not take a stand on why this might be so, but one possible explanation is that financial markets viewed the corresponding statistic as informative about the rate of productivity growth and thus the long-run equilibrium real rate of interest in the U.S.

Table 1 (preliminary)
U.S. Forward Rate Responses to Domestic Economic News (1998-2005)

	1-year Nominal Rate	1-year Forward Nominal Rate ending in 10 yrs	1-year Forward Real Rate ending in 10 yrs	1-year Forward Inflation Compensation ending in 10 yrs
Capacity Utilization	**1.48*** ** (0.50)	0.99 (0.68)	**0.51*** (0.29)	0.48 (0.64)
Consumer Confidence	**1.58*** ** (0.56)	0.72 (0.67)	0.25 (0.44)	0.46 (0.50)
core Consumer Price Index	0.89 (0.57)	**1.04*** (0.59)	-0.23 (0.37)	**1.27** ** (0.54)
Employment Cost Index	**2.00*** (1.10)	**1.73*** (1.02)	-0.02 (0.52)	**1.75*** (1.00)
real GDP (advance)	**2.77*** ** (0.91)	**2.23*** (1.28)	-0.07 (0.75)	**2.30** ** (1.12)
Initial Jobless Claims	**-1.15*** ** (0.33)	**-0.81*** ** (0.31)	-0.16 (0.18)	**-0.66** ** (0.27)
NAPM/ISM Manufacturing	**2.58*** ** (0.93)	**2.67*** ** (0.74)	**1.49*** ** (0.47)	**1.17** ** (0.58)
New Home Sales	0.42 (0.52)	1.02 (0.66)	-0.19 (0.41)	**1.21** ** (0.48)
Nonfarm Payrolls	**4.19*** ** (0.58)	**1.72** ** (0.81)	**1.16*** ** (0.36)	0.56 (0.63)
Retail Sales	**2.18** ** (1.02)	2.19 (1.43)	**0.98*** (0.51)	1.22 (1.16)
Monetary Policy	**0.38*** ** (0.14)	-0.09 (0.09)	0.05 (0.07)	-0.15 (0.13)
# Observations	879	879	879	879

Notes: Sample period: Jan 1998-Mar 2005. Heteroskedasticity-consistent standard errors reported in parentheses. *** indicates statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. Regressions are at daily frequency on the dates of macroeconomic and monetary policy announcements and include a constant (not reported). Macroeconomic data release surprises are normalized by their standard deviations, so that coefficients represent a basis point per standard deviation response. Monetary policy surprises are in basis points, so that those coefficients represent a basis point per basis point response. Inflation compensation is the difference between nominal rates and real rates. See text for details.

3.2 Response of U.K. Forward Rates and Inflation Compensation to Domestic Economic News

Tables 2 and 3 apply these same techniques to the United Kingdom. Although the U.K. has been an inflation targeter since October 1992, the Bank of England did not gain independence from the Treasury until about 1997 or 1998 (independence was announced on May 6, 1997, and passed into law on April 23, 1998, with an effective date of June 1, 1998). The lack of independence of the British central bank arguably led to a lack of credibility and commitment with respect to the inflation target, an idea that is supported by levels of long-term inflation expectations from surveys and bond yield data in the U.K. that were substantially higher than the official inflation target of 2.5 percent. We thus allow for a potential structural break related to Bank of England independence by splitting our sample for the U.K. into pre-independence and post-independence subsamples: January 1993 to April 1997, and June 1998 to March 2005.

Table 2 reports results for the U.K. for the earlier of these sample periods, 1993-97. The results are quite similar to those for the United States: first, the response of short-term interest rates to economic news is very similar in sign and magnitude to what we estimated for the U.S., and is highly statistically significant. Second, far-ahead forward nominal rates and inflation compensation each respond significantly to three out of the six macroeconomic data releases for which we have data in just the way one would expect if markets in the U.K. expected a partial pass-through of the short-term inflation outlook to long-term inflation. Third, we likewise estimate a negative response of far-ahead forward nominal rates and inflation compensation to monetary policy surprises, although the results for the U.K. over this period are much stronger, both in magnitude and statistical significance.

In Table 3, we investigate whether the sensitivity of long-term interest rates to economic news in the U.K. continued after the Bank of England's independence became official on June 1,

1998.[20] The results in Table 3 are strikingly different from those for the pre-independence period: although short-term interest rates continue to respond to economic news in very much the same way as they did before BoE independence, the response of far-ahead forward nominal rates and inflation compensation over this period are small and insignificant. In fact, the one coefficient for these rates that we do find to be statistically significant (on retail sales) enters with the wrong sign—one that is not consistent with a pass-through of short-term inflation to the long-term inflation outlook, and thus does not seem to suggest a change in long-term inflation expectations in response to the news. Finally, it is interesting to note that we continue to find monetary policy surprises to have a negative impact on far-ahead forward nominal rates and inflation compensation, although the effects here are much smaller than they were in the pre-independence period and are statistically significant only for inflation compensation and at only the 10 percent level. This finding suggests that the Bank of England may still have been in the process of gaining credibility with investors over at least the early part of its post-independence period—so that, for example, monetary policy tightenings in excess of financial market expectations led to revisions in the BoE's commitment to the official inflation target and a reduction in far-ahead forward inflation compensation. The hypothesis that this effect is primarily related to the early part of the post-independence period is supported by the fact that both the size and significance of this coefficient fall substantially if we begin our sample just a few months later: for example, beginning the estimation in January 1999 leads to a coefficient estimate for long-term inflation compensation on the monetary policy surprise of -.12, with a standard error of .08, and this decreases even further if we begin the sample later.

[20] In contrast to Table 2, Table 3 also includes the release of the core Retail Price Index in the U.K. We only had data on this statistic beginning in 1997, which did not provide us with enough observations to be employed in our pre-independence regressions in Table 2.

Table 2 (preliminary)
U.K. Forward Rate Responses to Domestic Economic News, pre-Bank of England Independence (1993-April 1997)

	1-year Nominal Rate	1-year Forward Nominal Rate ending in 10 yrs	1-year Forward Real Rate ending in 10 yrs	1-year Forward Inflation Compensation ending in 10 yrs
Average Earnings	**2.90***** (0.88)	0.42 (0.86)	0.48 (0.30)	-0.06 (0.77)
real GDP (preliminary)	1.67 (1.07)	**2.41**** (1.14)	0.55 (0.34)	**1.86**** (0.92)
Manufacturing Production	**1.23*** (0.75)	0.18 (1.07)	-0.36 (0.32)	0.54 (0.91)
Producer Price Index	**2.15***** (0.61)	**2.58***** (0.96)	**0.69**** (0.31)	**1.89**** (0.81)
Retail Price Index	**3.37***** (0.74)	**2.94**** (1.29)	**0.78*** (0.40)	**2.17**** (1.00)
Retail Sales	**2.68***** (0.73)	0.12 (1.03)	0.52 (0.38)	-0.40 (0.78)
Monetary Policy	**0.48***** (0.11)	**-0.36*** (0.21)	0.06 (0.04)	**-0.43**** (0.19)
# Observations	260	260	260	260

Notes: Sample period: Jan 1993-Apr 1997 (Bank of England independence announced on May 6, 1997). Heteroskedasticity-consistent standard errors reported in parentheses. *** indicates statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. Regressions are at daily frequency on the days of macroeconomic and monetary policy announcements and include a constant (not reported). Macroeconomic data release surprises are normalized by their standard deviations, so that coefficients represent a basis point per standard deviation response. Monetary policy surprises are in basis points, so that those coefficients represent a basis point per basis point response. Inflation compensation is the difference between nominal rates and real rates. See text for details.

Table 3 (preliminary)
U.K. Forward Rate Responses to Domestic Economic News, post-Bank of England Independence (June 1998-2005)

	1-year Nominal Rate	1-year Forward Nominal Rate ending in 10 yrs	1-year Forward Real Rate ending in 10 yrs	1-year Forward Inflation Compensation ending in 10 yrs
Average Earnings	**1.98*** ** (0.50)	-0.41 (0.34)	-0.06 (0.24)	-0.35 (0.29)
real GDP (preliminary)	**2.29*** ** (0.54)	-0.43 (1.24)	0.06 (0.42)	-0.49 (1.03)
Manufacturing Production	**1.30*** ** (0.41)	0.30 (0.64)	**0.76*** ** (0.25)	-0.46 (0.56)
Producer Price Index	0.08 (0.45)	0.24 (0.45)	0.42 (0.27)	-0.18 (0.36)
Retail Price Index	1.54 (1.14)	-0.01 (0.64)	0.33 (0.28)	-0.34 (0.55)
core Retail Price Index	1.26 (1.00)	-0.75 (0.61)	-0.34 (0.28)	-0.40 (0.51)
Retail Sales	**1.57*** ** (0.41)	**-1.33** ** (0.61)	0.06 (0.30)	**-1.39*** ** (0.44)
Monetary Policy	**0.59*** ** (0.11)	-0.09 (0.09)	0.06 (0.03)	**-0.15*** (0.08)
# Observations	484	484	484	484

Notes: Sample period: June 1998-Mar 2005 (Bank of England independence passed into law April 23, 1998, with effective date of June 1, 1998). Heteroskedasticity-consistent standard errors reported in parentheses. *** indicates statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. Regressions are at daily frequency on the days of macroeconomic and monetary policy announcements and include a constant (not reported). Macroeconomic data release surprises are normalized by their standard deviations, so that coefficients represent a basis point per standard deviation response. Monetary policy surprises are in basis points, so that those coefficients represent a basis point per basis point response. Inflation compensation is the difference between nominal rates and real rates. See text for details.

3.3 Response of Swedish Forward Rates and Inflation Compensation to Domestic Economic News

Table 4 repeats our analysis for Sweden. In January 1993, the Swedish Riksbank announced that it would adopt an inflation targeting framework with an official target of 2 percent that would become effective beginning in January 1995. We have real forward bond yield data for Sweden beginning in May 1996, so our sample begins with that date, which has the advantage of also giving the Riksbank a few years to gain experience and to establish some degree of credibility with respect to the new monetary policy regime.

As can be seen in Table 4, the results for Sweden are strikingly different from those for the U.S. and the pre-independence U.K., and are very similar to those for the U.K. after central bank independence. Short-term interest rates respond significantly to many of our macroeconomic data releases and monetary policy surprises with a sign and magnitude that are consistent with our estimates for the U.S. and U.K. But none of these economic surprises has an effect on far-ahead nominal forward rates or inflation compensation that is significant at the 5 percent level. Moreover, the only statistic that has an effect on inflation compensation that is significant at the 10 percent level (retail sales) has no effect on short-term interest rates in Sweden over our sample and a strong *negative* effect on forward real rates that is difficult to interpret, raising the possibility that our findings for this particular data series are simply a statistical fluke.

Table 4 (preliminary)
Swedish Forward Rate Responses to Domestic Economic News (1996-2005)

	1-year Nominal Rate	1-year Forward Nominal Rate ending in 10 yrs	1-year Forward Real Rate ending in 10 yrs	1-year Forward Inflation Compensation ending in 10 yrs
Consumer Price Index	**2.11*** ** (0.46)	0.98 (0.83)	0.22 (0.27)	0.76 (0.76)
core Consumer Price Index	**2.28*** ** (0.41)	-0.56 (1.00)	-0.51 (0.42)	-0.05 (0.88)
real GDP (preliminary)	**1.21** ** (0.58)	0.55 (0.73)	0.10 (0.45)	0.45 (0.72)
Industrial Production	-0.33 (0.65)	-0.73 (0.78)	-0.03 (0.27)	-0.70 (0.66)
Producer Price Index	**0.77*** (0.39)	-0.48 (0.47)	**-0.48*** (0.27)	-0.00 (0.45)
Retail Sales	0.18 (0.33)	0.45 (0.46)	**-0.43** ** (0.19)	**0.87*** (0.47)
Unemployment	**-0.48*** (0.28)	-0.46 (0.42)	**-0.54** ** (0.22)	0.07 (0.48)
Monetary Policy	**1.00*** ** (0.08)	0.17 (0.15)	-0.01 (0.04)	0.19 (0.15)
# Observations	443	443	443	443

Notes: Sample period: May 1996-Mar 2005. Heteroskedasticity-consistent standard errors reported in parentheses. *** indicates statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. Regressions are at daily frequency on the days of macroeconomic and monetary policy announcements and include a constant (not reported). Macroeconomic data release surprises are normalized by their standard deviations, so that coefficients represent a basis point per standard deviation response. Monetary policy surprises are in basis points, so that those coefficients represent a basis point per basis point response. Inflation compensation is the difference between nominal rates and real rates. See text for details.

3.3 Graphical Summary of Results

Figure 2 provides a graphical summary of the responses of far-ahead forward inflation compensation in the U.S., U.K., and Sweden to domestic economic news. Each graph in the figure provides a scatter plot of macroeconomic data surprises (GDP in panel a, inflation in panel b) or monetary policy surprises (panel c) along the horizontal axis against the corresponding change in far-ahead forward inflation compensation that day. The difference between the U.S. and pre-independence U.K. on the one hand vs. Sweden and the post-independence U.K. on the other, is often striking, with the scatter plots generally exhibiting a clear positive relationship for GDP and inflation in the U.S. and pre-independence U.K., and no relationship in Sweden or the U.K. post-BoE independence. For monetary policy surprises, the contrast is less stark, with the strong significance of the pre-independence U.K. driven largely by a single observation. The story behind this one observation is itself informative and supportive of our findings, however: on that day in September 1994, as reported in *The Economist* shortly after the move, chancellor of the exchequer Kenneth Clarke

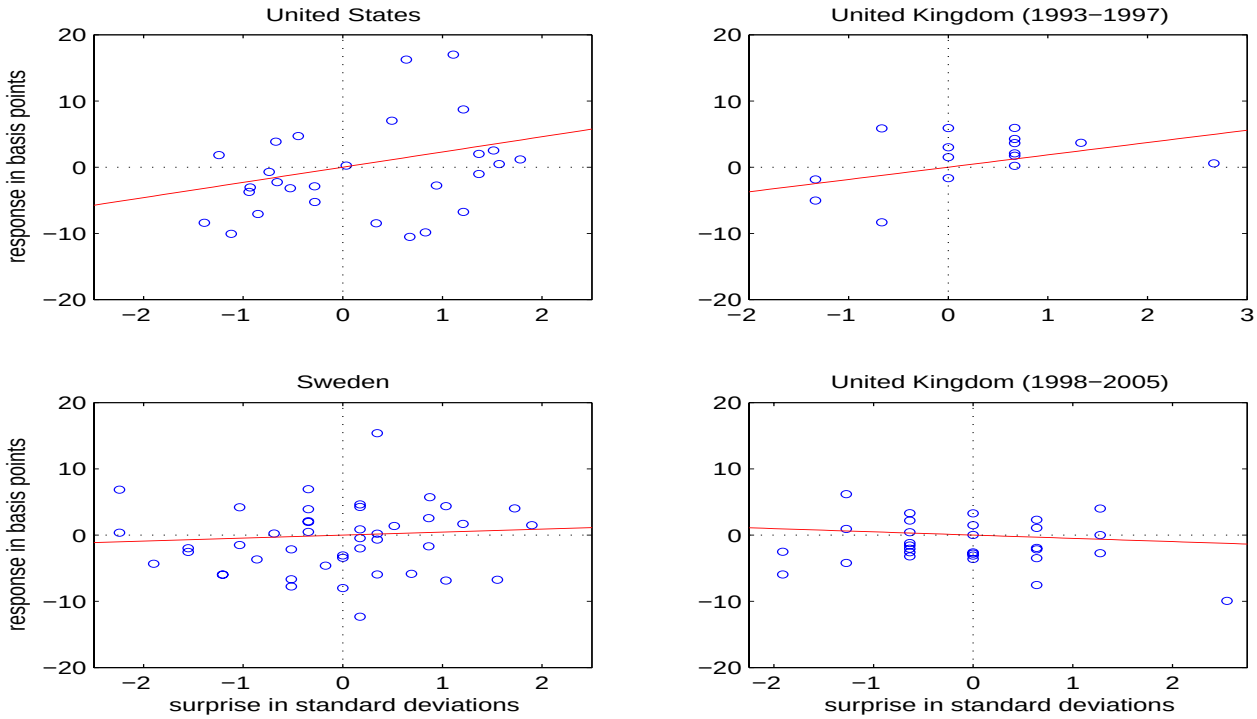
> "became the first chancellor in living memory to take the unpopular step of raising interest rates not in response to soaring prices or a sterling crisis, but as a prudent move against future inflation… Financial markets have hitherto been sceptical of the government's ability to meet its inflation target… The chancellor's display of mettle strengthened his government's credibility and, as a result, caused long-term interest rates to fall."
>
> (*The Economist*, 1994)

Several aspects of the quote are supportive of our findings: 1) the lower-rightmost point in the scatter plot for the pre-independence U.K. monetary policy surprises appears to be genuine rather than a fluke, 2) financial markets seemed to view the credibility and commitment of the Bank of England, prior to independence, with skepticism despite the official inflation target, and 3) the article directly attributes the move in U.K. long-term interest rates to the economic news released that day via changes in financial markets' long-term inflation expectations, exactly the channel that we have suggested.[21]

[21] *The Economist*'s analysis of the Bank of England's move, rather than being idiosyncratic, was echoed throughout the British press at the time. For example, *The Financial Times* reported the day after the move that: "Mr. Kenneth Clarke, the chancellor, boosted his credibility," that "the Bank of England's reputation was also enhanced," and that "the clear message is that the Bank of England has much more independence in setting monetary policy than at any time in its history" (*The Financial Times*, 1994).

Figure 2
Response of Forward Inflation Compensation to Domestic Economic News

(a) GDP Surprises



(b) Inflation Surprises

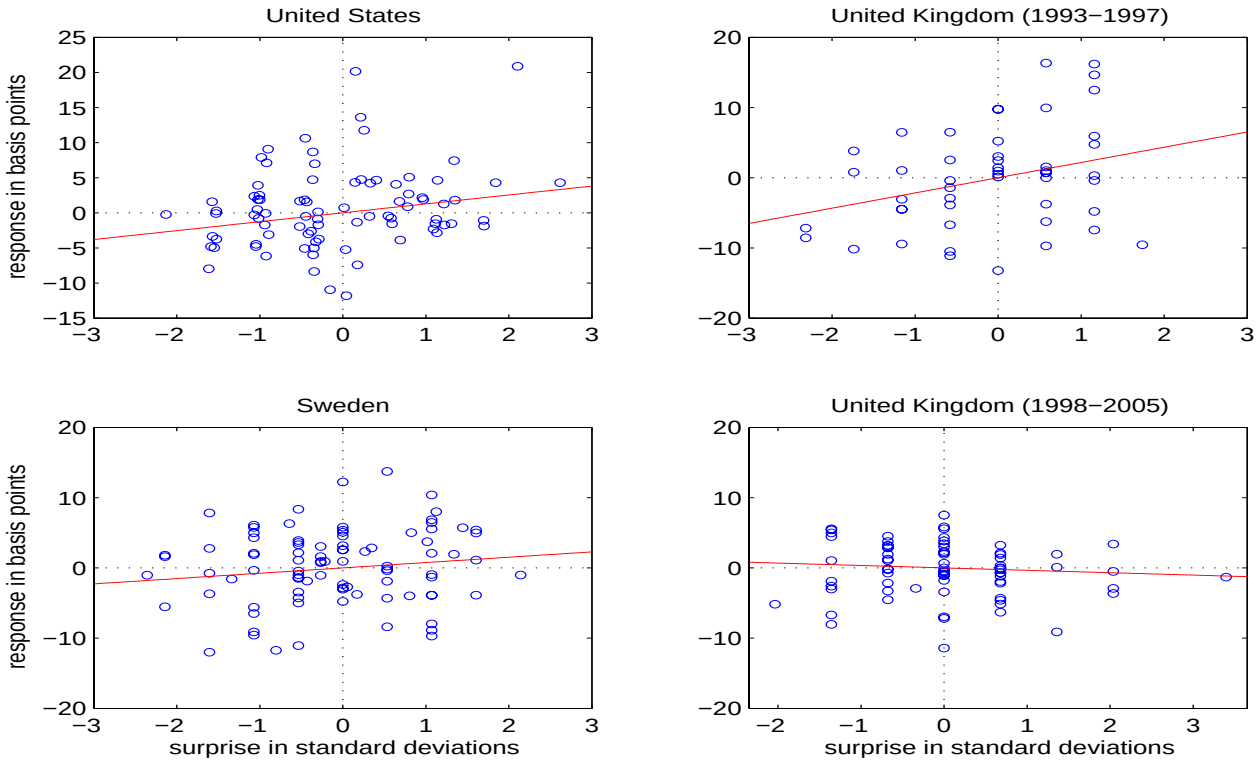
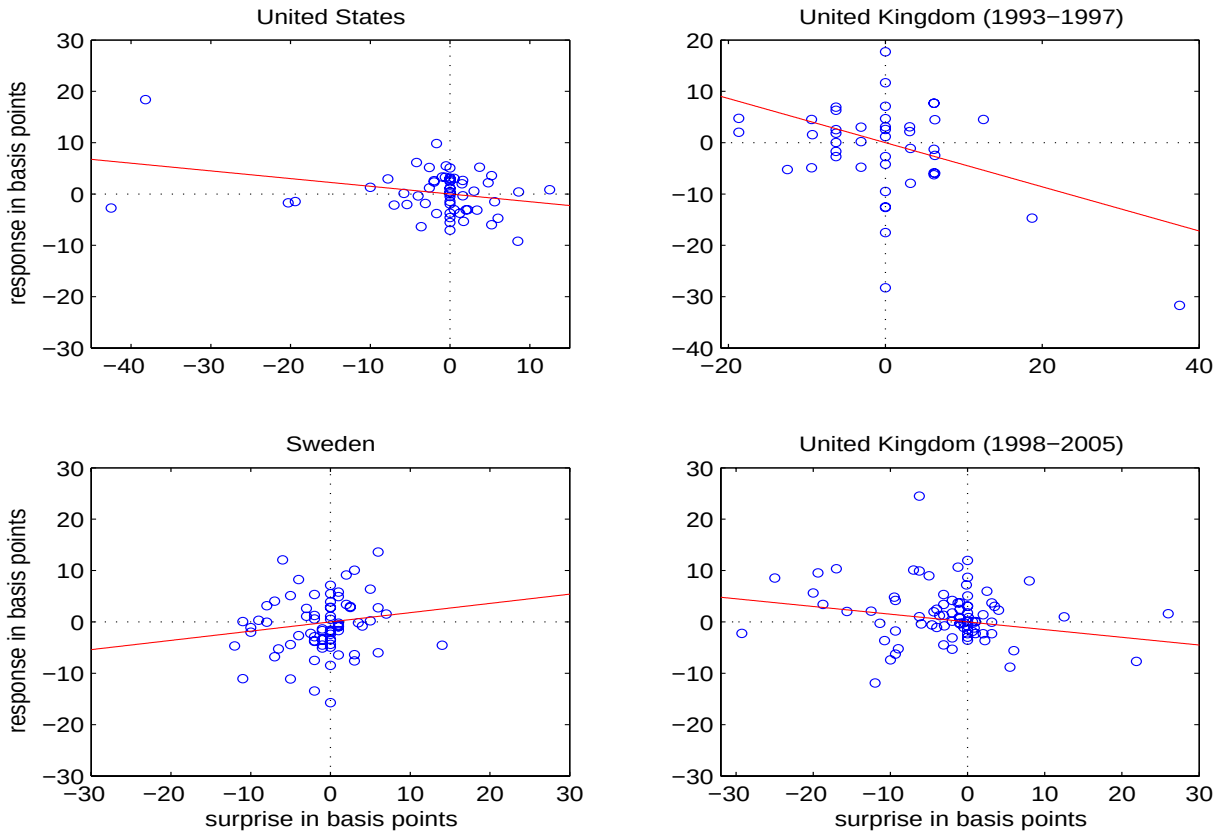


Figure 2 (continued)
Response of Forward Inflation Compensation to Domestic Economic News

(c) Monetary Policy Surprises



3.5 Response of U.K. and Swedish Forward Rates to Foreign Economic News

Our results above for the U.K. and Sweden are suggestive, but Sweden in particular is a small open economy and one might wonder whether financial markets in that country assign relatively little importance to domestic economic developments and much greater importance to news coming from the vastly larger U.S. and Euro Area economies. In theory, of course, purely nominal variables such as inflation and inflation compensation should depend entirely on domestic monetary policy, particularly at the longer horizons we are considering, even if domestic real rates are determined by global factors. Nonetheless, if U.S. and Euro Area economic news rather than domestic news is the primary driver of short-term inflation in Sweden and short-term inflation has a bearing on the long-term inflation outlook (that is, if long-term expectations in Sweden are unanchored), then we might see far-ahead forward inflation compensation in that country react significantly to news from the rest of the world despite an absence of such sensitivity to domestic releases.

The above argument is more difficult to make for the U.K.—especially given the contrast in our results pre- and post-Bank of England independence—but to the extent that the U.K. economy has become more open over time, one might wonder whether British financial markets have come to view domestic economic news as being less important than previously and attached a correspondingly greater importance to news coming from the U.S. and Euro Area. In this section, we investigate whether far-ahead forward rates and inflation compensation in the U.K. and Sweden have responded to economic news coming from these large foreign economies.

Table 5 reports results for the United Kingdom from 1998 to 2005.[22] Short-term interest rates in the U.K. respond significantly to seven of the economic news releases in the U.S., yet far-ahead forward inflation compensation responds significantly to only one (the NAPM survey). While far-ahead forward nominal rates in the U.K. respond significantly to three U.S. data releases,

[22] In the interest of space, we do not report results for the U.K. from 1993-1997, but we have verified that several of the major U.S. economic releases, as well as U.K. economic releases, cause significant movements in far-ahead forward nominal rates and inflation compensation in the U.K. over the earlier period. We did not include U.K. macroeconomic and monetary policy surprises in the regressions in Table 5, but the results in the Table are essentially identical whether we include those domestic surprises or not.

the evidence in the table is consistent with the view that these changes are largely due to changes in far-ahead forward *real* rates rather than inflation compensation, with real rates determined globally (in fact, largely in the U.S.) while U.K. inflation expectations and inflation compensation remain well anchored.

Table 6 repeats the analysis for Sweden. As in the U.K., short rates in Sweden respond significantly and with the expected signs to several economic data releases in the U.S. Again, as in the U.S. and U.K., the U.S. NAPM and nonfarm payrolls releases are associated with significant movements in far-ahead forward nominal and real interest rates in Sweden, suggesting that these releases may affect the far-ahead real rate outlook globally (due, perhaps, to information in these releases that is viewed by markets as shedding light on long-term productivity growth rate prospects). While far-ahead forward nominal rates and inflation compensation in Sweden respond significantly at the 10 percent level to the U.S. ECI and Euro Area monetary policy announcements, *short*-term rates in Sweden do not respond significantly at all to these announcements, making any interpretation of these findings as a pass-through of short-term inflation to the long-term inflation outlook suspect. Finally, the significant response of Swedish inflation compensation, like U.S. and U.K. inflation compensation, to the U.S. NAPM survey does present a puzzle and a possible interesting question for future research.

Table 5 (preliminary)
U.K. Forward Rate Responses to Foreign Economic News (1998-2005)

	1-year Nominal Rate	1-year Forward Nominal Rate ending in 10 yrs	1-year Forward Real Rate ending in 10 yrs	1-year Forward Inflation Compensation ending in 10 yrs
U.S. Capacity Utilization	**1.28***** (0.47)	0.58 (0.66)	0.11 (0.25)	0.47 (0.61)
U.S. Consumer Confidence	**0.79**** (0.33)	0.74 (0.47)	**0.55*** (0.29)	0.20 (0.34)
U.S. core Cons. Price Index	**0.88**** (0.44)	-0.01 (0.55)	0.37 (0.23)	-0.38 (0.42)
U.S. Employmnt Cost Index	0.70 (0.72)	0.69 (0.92)	0.13 (0.46)	0.56 (0.63)
U.S. real GDP (advance)	0.09 (0.74)	0.63 (0.83)	0.42 (0.42)	0.21 (0.59)
U.S. Initial Jobless Claims	**-0.44*** (0.24)	**-0.50**** (0.25)	-0.24 (0.15)	-0.26 (0.22)
U.S. NAPM/ISM Manufacturing	**1.74***** (0.48)	**2.99***** (0.62)	**1.10***** (0.27)	**1.89***** (0.55)
U.S. New Home Sales	0.26 (0.39)	-0.16 (0.62)	0.22 (0.44)	-0.38 (0.39)
U.S. Nonfarm Payrolls	**1.65***** (0.40)	**1.82***** (0.56)	**1.22***** (0.29)	0.59 (0.43)
U.S. Retail Sales	3.08 (3.38)	1.34 (1.05)	0.63 (0.65)	0.71 (0.67)
U.S. Monetary Policy	**0.13**** (0.06)	-0.09 (0.11)	0.01 (0.06)	-0.11 (0.11)
Euro Area Indust. Orders	0.00 (0.80)	-0.76 (1.25)	-0.24 (0.48)	-0.52 (0.79)
Euro Area Indust. Productn	0.48 (0.59)	0.36 (0.66)	-0.03 (0.46)	0.38 (0.49)
Euro Area Retail Trade	0.43 (0.50)	-0.13 (0.73)	0.21 (0.38)	-0.34 (0.46)
Euro Area Monetary Policy	-0.03 (0.09)	0.06 (0.08)	0.05 (0.05)	0.01 (0.05)
# Observations	881	881	881	881

Notes: The same notes as in Table 3 apply. See text for details.

Table 6 (preliminary)
Swedish Forward Rate Responses to Foreign Economic News (1996-2005)

	1-year Nominal Rate	1-year Forward Nominal Rate ending in 10 yrs	1-year Forward Real Rate ending in 10 yrs	1-year Forward Inflation Compensation ending in 10 yrs
U.S. Capacity Utilization	-0.02 (0.40)	0.07 (0.52)	-0.22 (0.24)	0.30 (0.53)
U.S. Consumer Confidence	**1.08** (0.54)	-0.16 (0.44)	0.15 (0.15)	-0.30 (0.45)
U.S. core Cons. Price Index	-0.08 (0.33)	0.85 (0.51)	0.09 (0.24)	0.76 (0.49)
U.S. Employmnt Cost Index	-0.15 (0.40)	**1.39*** (0.78)	-0.25 (0.42)	**1.64*** (0.86)
U.S. real GDP (advance)	-0.09 (0.56)	-0.02 (0.80)	0.19 (0.23)	-0.21 (0.82)
U.S. Initial Jobless Claims	**-0.35*** (0.18)	-0.25 (0.26)	-0.06 (0.12)	-0.19 (0.24)
U.S. NAPM/ISM Manufacturing	**1.49**** (0.72)	**2.45***** (0.63)	**0.60***** (0.23)	**1.83***** (0.59)
U.S. New Home Sales	0.53 (0.54)	0.38 (0.54)	-0.06 (0.21)	0.45 (0.50)
U.S. Nonfarm Payrolls	**0.93***** (0.38)	**1.62***** (0.61)	**0.80**** (0.36)	0.82 (0.65)
U.S. Retail Sales	1.00 (0.73)	1.20 (0.88)	0.53 (0.49)	0.67 (0.75)
U.S. Monetary Policy	**0.11*** (0.06)	-0.04 (0.11)	0.03 (0.04)	-0.07 (0.09)
Euro Area Indust. Orders	**-0.72**** (0.28)	-1.46 (1.17)	**-0.82***** (0.23)	-0.64 (1.21)
Euro Area Indust. Productn	0.48 (0.57)	0.21 (0.64)	0.09 (0.55)	0.12 (0.56)
Euro Area Retail Trade	-0.24 (0.81)	1.01 (0.89)	0.69 (0.57)	0.33 (0.90)
Euro Area Monetary Policy	0.09 (0.10)	**-0.17*** (0.10)	0.01 (0.04)	**-0.18*** (0.10)
# Observations	1086	1086	1086	1086

Notes: The same notes as in Table 4 apply. See text for details.

4. Discussion and Interpretation

A natural interpretation of the results above is that U.S. and (prior to BoE independence) British far-ahead forward interest rates and inflation compensation are not well anchored and respond to current economic news. In each of these cases there is a lack of a credible and known inflation target. In the U.K., before the central bank gained independence, the inflation target was known but this was not deemed *credible* due to the close ties between the treasury and the central bank, which apparently led markets to update their beliefs about the commitment of the central bank to the inflation target in response to surprises. On the other hand, the U.S. has one of the most credible central banks in the world, but without a *known* inflation target this credibility by itself appears insufficient to fully anchor expectations of future inflation as agents try to infer the Fed's desired inflation level from observed economic outcomes. On the other hand, far-forward interest rates and inflation compensation in our two cases that do have credible and known inflation targets, Sweden and after BoE independence England, are unaffected by current surprises, suggesting that a known and credible inflation target helps to anchor private sector expectations regarding the distribution of long-run inflation outcomes.

In this section we investigate the merits of this interpretation of our empirical findings as opposed to attributing the results to time-varying risk premia and examine the time-series behavior of far-ahead forward interest rates and inflation compensation.

4.1 Risk Premia

It should be emphasized that our results and their interpretation do not require the expectations hypothesis (EH) of the term structure to hold. According to the EH, long-term bond yields equal the expected return to rolling over a series of short-term bonds over the same horizon, plus a possibly nonzero term premium that is constant over time. While some authors have found some support for the EH in the data (e.g., Bekaert et al., 2001), a number of prominent studies (e.g., Fama and Bliss, 1987, Campbell and Shiller, 1991) have documented strong violations of the EH for a wide variety of samples and securities, suggesting that the risk, term, liquidity, and/or other

premia (often collectively referred to as "risk premia") embedded in long-term bond yields may in fact vary substantially over time.

For our analysis, however, note that so long as the variation in risk premia is small enough at the very high (i.e., daily) frequencies we consider, the *change* in bond yields over the course of the day will effectively difference out the risk premium at each point in our sample, allowing us to interpret the change in yields as being driven primarily by the change in expectations. While there is no reason *a priori* why risk premia should vary only at lower frequencies, the predictors of excess returns on bonds emphasized in the studies above generally have this feature, i.e., that the variation from one day to the next is very small, with the large variation in premia that they estimate occurring at much lower, particularly business cycle frequencies (Cochrane and Piazzesi, 2005, Piazzesi and Swanson, 2004). Thus, the failure of the expectations hypothesis is not by itself sufficient to call our analysis into question.

Nevertheless, risk premia are poorly understood, so the fact that previous estimates of time-varying risk have generally found predictability only at lower frequencies does not imply that they could not change appreciably from one day to the next. In order for changes in risk premia to explain our results, however, one would have to explain why they change for the U.S. and not for the U.K. (post-independence) or for Sweden. The Swedish bond market in particular is much smaller than that in the U.S., so one might think that liquidity or other risk premia would, if anything, be more of an issue in that market than in the U.S. To explain all of our results with changes in risk premia, one would also have to address why the behavior of those premia would have changed in the U.K. following the granting of central bank independence, and why the changes in risk premia in the U.S. and the U.K. (pre-independence) would move so systematically in the way that we document, being positively correlated with output and inflation news while moving inversely with surprises in monetary policy.

It is, of course, possible that changes in the variance or skewness of the long-run inflation distribution are responsible for our findings rather than changes in the mean of that distribution. As

noted before, this interpretation is consistent with our conclusion, namely that inflation targeting helps to anchor market perceptions of the entire *distribution* of future long-run inflation outcomes.

4.2 Time Series of Forward Nominal Rates and Inflation Compensation

While our results above suggest that the adoption of inflation targeting has helped the U.K. and Sweden to reduce the response of far-ahead interest rates and inflation compensation to economic news, it is not the case that far-ahead forward rates in these countries are constant. Figure 3 plots the daily time series of far-ahead forward nominal rates (panel a) and inflation compensation (panel b) for each of the U.S., U.K., and Sweden. There are a number of interesting features that stand out in this figure.

First, it is not the case that the far-ahead nominal rates or inflation compensation in any of the three countries is completely stable. There is clear variation both at high and low frequencies, the source of which remains an open question—possible explanations include: time-varying risk or liquidity premia;[23] variations in financial market perceptions of the credibility and commitment of the central bank to its long-run inflation objective; changes in current and expected future taxes; differences between the consumption deflator of the marginal investor and the price index that is being targeted by the central bank; market perceptions that the central bank's targeted price index might change in the future; and market perceptions that the central bank's numerical target for a given price index might change in the future.

Second, despite the fact that variation in far-ahead forward rates and inflation compensation remains in the U.K. and Sweden, the improvements that these two countries have realized in these rates is spectacular. In the first half of the 1990s, far-ahead forward rates in the U.K. and Sweden were clearly and consistently higher and arguably more volatile than in the U.S. (panel a). From the late 1990s onward, that situation had completely reversed: far-ahead forward rates in the U.K.

[23] There is somewhat of an upward trend in Swedish and U.S. inflation compensation from 1998 to 2005. This trend is often attributed to the improving liquidity of inflation-indexed securities in these countries. For example, the lack of liquidity and high transactions costs in the secondary U.S. TIPS market in its early years is generally regarded to have caused TIPS yields to be higher than they otherwise would have been (Sack and Elsasser, 2004), which in turn causes measured inflation compensation to be lower over this period. Liquidity in the secondary TIPS market has increased steadily over time and is now regarded as being quite good, suggesting that there is relatively little low-liquidity yield premium remaining in these securities at present.

and Sweden have been clearly and consistently *lower* than in the U.S., and arguably less volatile. This reversal is all the more striking in light of the facts that, first, U.S. Treasury markets are by far the largest and most liquid in the world and, second, the U.S. tends to excel in comparison to other countries by almost every economic and financial measure. The fact that the U.K. and Sweden have achieved forward rates and inflation compensation that clearly outperform those in the U.S. despite lagging the U.S. in almost every other respect—including the greatly inferior inflation expectations with which the U.K. and Sweden began the early 1990s—is truly remarkable.

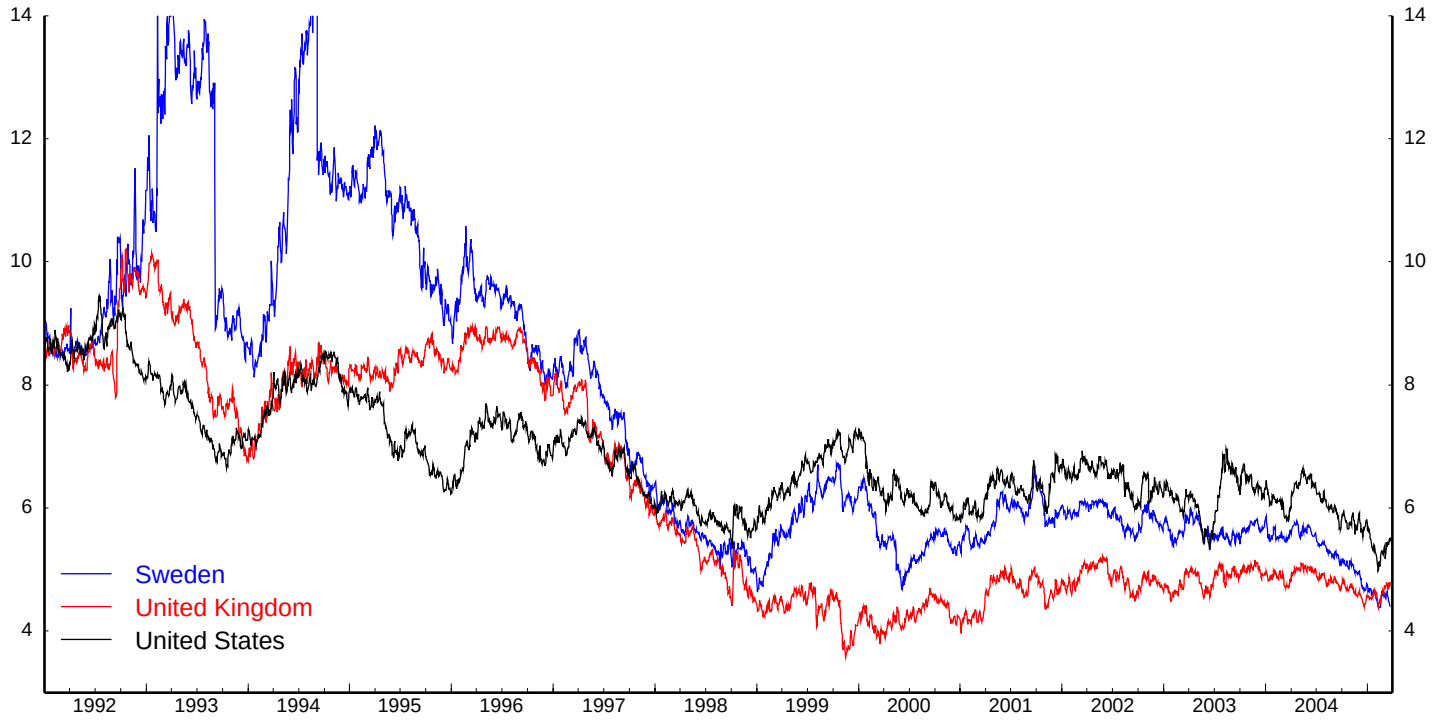
Third, inflation targeting is not a "silver bullet" that suddenly lowers and stabilizes far-ahead forward nominal rates and inflation compensation. The U.K. officially adopted inflation targeting in October 1992, but the real gains in far-ahead forward rates and inflation compensation came much later, around the time the Bank of England gained independence in 1997 and 1998, and came only gradually. Sweden officially adopted an inflation target in January 1993 with an effective date of January 1995, but far-ahead forward nominal rates and inflation compensation fell gradually throughout the mid-1990s before finally stabilizing at their current, low levels sometime in 1998. In both countries, the vast majority of gains in forward rates and inflation compensation came over time, perhaps because the initial announcement of an inflation targeting regime was regarded with some skepticism by financial markets and only gradually did the feasibility of, and the central bank's commitment to, the new targeting regime become clear.

Finally, despite the slowness with which forward rates and inflation compensation fell in both these countries, the rapid response of financial markets to significant economic news can also be seen in Figure 3. Two dates for the U.K. stand out in particular: On the evening of September 16, 1992, the U.K. abandoned the Exchange Rate Mechanism, untying the pound from its peg to the other major European currencies, and far-ahead forward rates and inflation compensation skyrocketed 200 to 300 basis points in just a few days surrounding that announcement. Almost as dramatic a response can be seen on May 6, 1997, when chancellor of the exchequer Gordon Brown unexpectedly announced the complete independence of the Bank of England and far-ahead forward rates and inflation compensation fell 75 to 100 basis points that same day. On both dates, financial

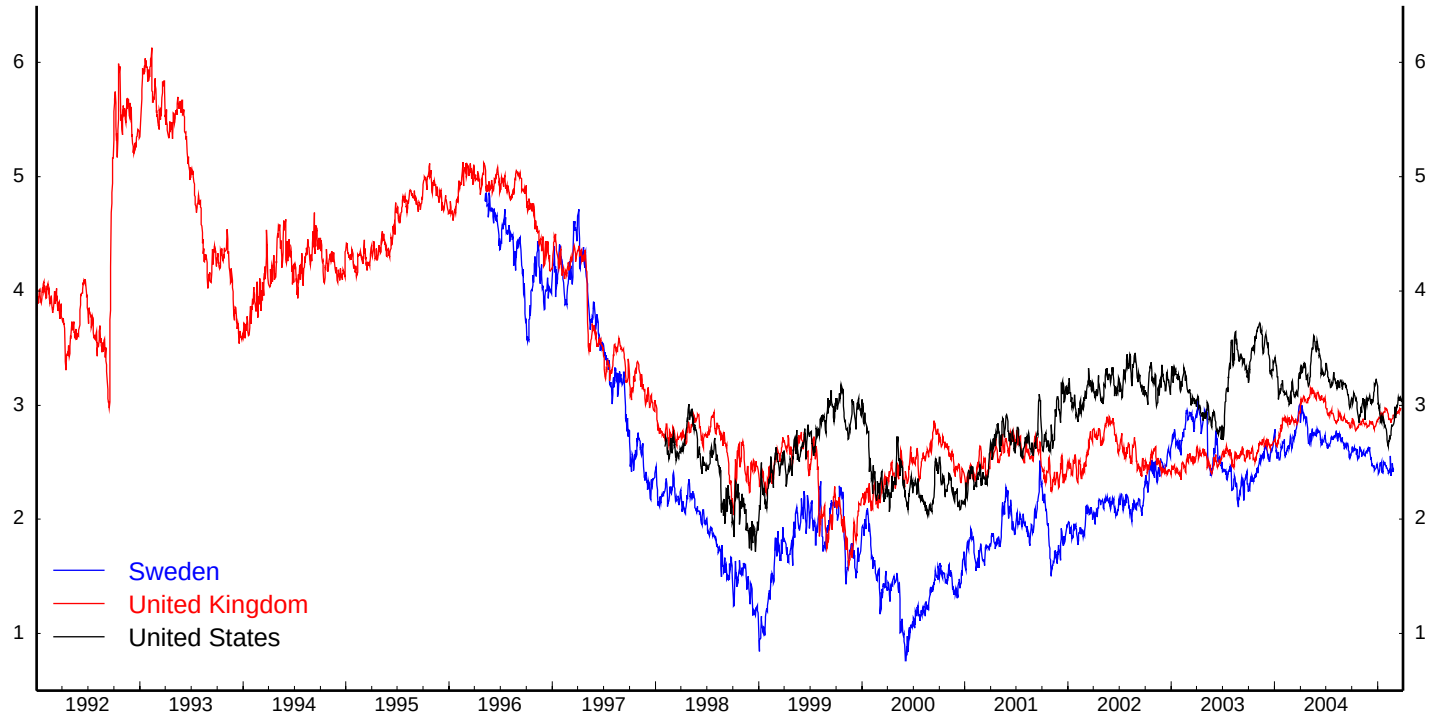
markets reacted extremely rapidly in just the way that our interpretation of far-ahead forward rate behavior would suggest that they should.

Figure 3
Time Series of Forward Nominal Rates and Inflation Compensation

(a) Far-Ahead Forward Nominal Rates



(b) Far-Ahead Forward Inflation Compensation



5. Conclusions

Does inflation targeting anchor private sector perceptions of the future distribution of long-term inflation outcomes? We find much evidence that it does. In contrast to previous studies using quarterly or even semiannual data, we have presented evidence from over three thousand daily observations of long-term bond yield responses to economic news in the U.S., U.K., and Sweden that support this conclusion. Far-ahead forward nominal rates and inflation compensation in the U.S. and the U.K. (prior to Bank of England independence) respond significantly to economic news while those in the U.K. after central bank independence and in Sweden exhibit no such sensitivity.

Our results have potentially humbling implications for the U.S. Despite the generally superb performance of the U.S. economy and U.S. monetary policy in the 1990s and 2000s, we find that the Federal Reserve's informal approach to a long-run inflation objective has failed to anchor the private sector's long-term inflation views to the extent that we see in the U.K. and Sweden, both formal inflation targeters. This performance has been all the more remarkable in light of the greatly inferior inflation expectations in the U.K. and Sweden relative to the U.S. that existed throughout the early 1990s. Although we have not shown in this paper that there any advantages, either qualitatively or quantitatively, to the stabilization of long-term nominal rates or inflation compensation, existing macroeconomic and finance theory suggests that there should be several: for example, better dynamics of inflation in the short and medium run due to firmer anchoring of expectations at the long end (Woodford, 2003, Ch. 7, Diron and Mojon, 2005); a greater ability of the central bank to control inflation in the short and medium run (ibid.); a greater stability and predictability of long-term interest rates that would improve the efficiency of investment decisions (Ingersoll and Ross, 1992, Dixit and Pindyck, 1993); and a reduced probability of a 1970's-style "expectations trap" for inflation (e.g., Albanesi et al., 2003). To the extent that these benefits are important in practice as well as in principle, there are reasons to think that with an explicit inflation objective U.S. economic performance and U.S. monetary policy could be improved even beyond the successes of the past twenty years.

Data Appendix

Data on U.S. macroeconomic statistical releases and forecasts were obtained from Money Market Services up through July 2003, when that company merged with a larger financial institution. Beginning in December 2003, the same survey was produced again by Action Economics. Both data sets can be obtained from Haver Analytics at http://www.haver.com. From August through November 2003, we fill in the holes in the MMS/AE survey data using the releases and forecasts reported by Bloomberg Financial Services. For additional details about individual macroeconomic series, see Gürkaynak, Sack, and Swanson (2003).

For the U.K. and Sweden, many of the macroeconomic data releases and forecasts in Bloomberg are stored both as month-on-month and year-on-year changes, so this presents an issue in terms of which version of each statistic to use for our analysis. Often, one version contains many more observations than the other; when that is the case, we used the version that had more observations. When the number of observations was similar across the two versions (within about five observations), we used the month-to-month changes by default, since our U.S. macro data is generally reported in month-to-month change format and because this is the version that usually receives the most attention in the U.S. financial press. The exact statistics we use, including Bloomberg mnemonics, for the U.K. and Sweden are reported in the following tables:

United Kingdom

Name	Ticker	Notes
Average Earnings	ukaenewy	3 Month Average Index, base year 2000, SA
real GDP, preliminary release	Ukgrabiy	YoY, Market prices, annual chain linking.
Industrial Production	ukipimom	Incorporates annually weighted and chained estimates of volume measures, base year T-3.
Manufacturing Production	ukmpimom	MoM, SA
Producer Price Index	Ukppiiy	YoY, Base Year 2000 = 100.
Retail Price Index	ukrpmom	MoM, Base date 13 January 1987 = 100, NSA
Retail Price Index Less Mortgage Interest Payments (core)	ukrpxmom	MoM, Base date 13 January 1987 = 100, NSA, first observation is in 1997
Retail Sales Volume	ukrvamom	MoM, Base Year 2000 = 100, SA
Unemployment Rate	Ukuer	SA

Sweden

Name	Ticker	Notes
Consumer Price Index	Swcpyoy	YoY
Consumer Price Index, underlying (core)	swcpundy	YoY
real GDP, preliminary release	swgdpwyy	YoY, Base year 2000
Industrial Production	swipnsyoy	YoY, Index 1995=100, NSA.
Producer Price Index	swppiyoy	YoY, Includes domestic sales & exports.
Retail Sales	swrsiyoy	YoY, Index, 1995=100, constant prices. Excludes motor vehicles, beverages, pharmacies and repair shops for personal and household goods.
Unemployment Rate	Swue	NSA

Notes: "Ticker" reports the mnemonic used in the Bloomberg database. NSA = not seasonally adjusted, SA = seasonally adjusted, MoM = month-on-month percentage change, YoY = year-on-year percentage change.

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