Establishing Credibility:
Evolving Perceptions of the European Central Bank

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Abstract: The credibility of a central bank's anti-inflation stance, a key determinant of its success, may reflect institutional structure or, more dynamically, the history of policy decisions. The first years of the European Central Bank (ECB) provide a natural experiment for considering whether, and how, central bank credibility evolves. In this paper, we first present a model demonstrating how the high-frequency response of asset prices to news reflects market perceptions of the anti-inflation stance of a central bank. Empirical tests of this model, regressing both the change in the slope of the German yield curve and the change in the euro/dollar exchange rate on the surprise component of United States price news, suggest significant breaks in the market's perception of the policy stance of the ECB during its first five years of operation. The dates of these breaks are linked to the policies undertaken by the ECB. Similar tests on the response of the slope of the United States yield curve to price news during this period fail to find comparable breaks in market perceptions of the conduct of monetary policy by the Federal Reserve.

Keywords: Central Banking, European Central Bank, Federal Reserve, inflation, exchange rate, credibility, yield curve

JEL Classification: F3, E5, E6

[!] The views expressed in this paper are those of the individual authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System. Address correspondences to Linda S. Goldberg, Federal Reserve Bank of NY, Research Department, 33 Liberty St, New York, N.Y. 10045. email: Linda.Goldberg@ny.frb.org, or Michael W. Klein, Fletcher School, Tufts University, Medford MA 02155. email michael.klein@tufts.edu. The authors thank Dia Ganguly and Eleanor Dillon for excellent research assistance.

I. Introduction

The credibility of the anti-inflation stance of a central bank plays a key role in determining whether the goal of low inflation is attained. This point is, by now, a standard theoretical result.[1] It is also received wisdom among practitioners. In a survey of the heads of 84 central banks, as well as 52 prominent academic monetary economists, Blinder (2000) finds that credibility is considered vitally important and "helps keep inflation low."

This consensus on the importance of credibility naturally leads to the question of how it is achieved, and whether and how it evolves over time. One view is that establishing an appropriate institutional structure is the key element in attaining credibility. A second, more dynamic, view focuses on the role that actual policy conduct plays in building the reputation of a central bank. These two different views have distinct implications for the relative importance of the structure of a central bank as compared to its conduct for attaining and maintaining its credibility.

A majority of respondents to Blinder's survey believe that central bank credibility is based more its history of actions than on the construction of institutional structures that insulate a central bank from political concerns and afford it independence. Nonetheless, there is also a consensus among respondents that structure matters. This latter view is consistent with empirical research that has found, in cross sections of countries, that institutional structure is associated with economic performance, perhaps because it indicates the ability of an institution to "tie its hands" and commit to a policy that may cause short-term pain in the pursuit of longer-run gain.[2] There is less evidence, however, on whether and how the credibility of a particular central bank evolves over time in response to the conduct of policy.

The question of the achievement and the maintenance of credibility is especially relevant for a new central bank. An analysis of the experience of the European Central Band

[1] Seminal contributions on the role of credibility includes Kydland and Prescott (1977), Calvo (1978) and Barro and Gordon (1983).

[2] For example, Cukierman (1992) analyzes the charters of central banks and shows, in a cross-country panel, that average inflation is lower in countries in which laws afford central banks greater independence. Alesina and Summers (1993) also find cross-country evidence that the level of inflation, as well as its variability, is negatively associated with indicators of central bank independence, but there is no association between central bank independence and real variables. Questions have been raised, however, about whether the *de jure* structure is closely linked to the *de facto* behavior of institutions (Forder 1999).

(ECB) during its early years of operation provides a natural experiment for considering this question. The architects of the institutional structure of the ECB were mindful of lessons from economic theory concerning the importance of independence from political considerations.[3] The role of conduct was also clearly apparent. As indicated by the survey results in Blinder (2000), the directors of central banks are vitally aware that their policies are closely scrutinized for indications of general tendencies. This may be especially true with a new central bank where each policy choice can lead to a larger updating of market priors than would be the case for a long-established central bank.

In Section II, we present a framework for a novel test of the evolution of market perceptions of central bank policy. This test uses high frequency asset price data and the surprise components of economic news announcements to estimate whether the market perception of the anti-inflation credibility of a central bank changes over time.[4] The key insight from this model is that a given surprise increase in inflationary pressures will result in a greater increase in a long interest rate relative to a short interest rate, and a larger exchange rate depreciation, when a central bank is perceived as having a weaker anti-inflationary policy stance. If unvarying institutional structure is the dominant determinant of a new central bank's credibility, then one would not expect to find a change in the relationship between news and asset prices over time. But if credibility for a new central bank is earned through the conduct of its policy, one would find a significant break in the relationship between news and asset prices as credibility evolves over time.[5]

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[3] Despite these lessons, some politicians continued to try to influence policy direction. For example, Oscar Lafontaine, appointed Finance Minister of Germany in the Autumn of 1998, called for the new ECB to lower interest rates from the time of his appointment until his resignation in March 1999. In response, Wim Duisenberg, the first president of the ECB, stated in November 1998 that it was a "normal phenomenon" for politicians to offer their views on the conduct of monetary policy, but "it would be very abnormal if those suggestions were to be listened to." See "Wim Duisenberg, Banker to a New Europe," *The Economist*, November 26, 1998.

[4] Forward market information has been used in other tests of policy regime credibility. For example, Svensson (1991) shows that forward exchange rates were not within the target zone band of the European Monetary System (EMS) in the 1980s, a result he interprets as indicating that the EMS generally did not offer credible bands on its members' currencies. Svensson (1993) presents a similar set of tests to determine whether the inflation targets of Canada, New Zealand and Sweden were consistent with market yields. These tests, while informative, require the presence of an explicit target, like an exchange rate band or an inflation target, to judge credibility. Other related empirical analyses on the policy credibility of an exchange rate target zone use intervention data to estimate perceived target zone bands (Klein and Lewis 1993 and Lewis 1995).

[5] Klein, Mizrach and Murphy (1991) develop a similar type of analysis concerning differences in the responsiveness of asset prices to news as policy evolves in their study of the changing responsiveness of dollar exchange rates to news about the United States current account. They find the 1985 Plaza Accord altered perceptions of the degree to which American policy was concerned with the U.S. current account deficit.

In Section III we apply this test to study the evolution of the credibility of the European Central Bank from the time it began its operations in January 1999 through mid-2004. We find evidence that the market's perception of the anti-inflation credibility of the ECB evolved over time and responded to its policy actions. As a benchmark for our analysis, and also to identify whether the results we found for the ECB could be attributed to changes in the economic environment rather than in specific views of its credibility, we also test for changes in the market's perception of the anti-inflation stance of the Federal Reserve over the same sample period. In contrast to our results for the ECB, we find no evidence of changing perceptions of the policy stance of the Federal Reserve, a result that is not surprising given the Fed's long-standing commitment to price stability under the chairmanship of both Alan Greenspan and Paul Volker.

II. Central Bank Policy and Market Responses to News

In this section we present a model that shows how changes in perceptions about a policy stance can alter the response of asset prices to news. This is based on a modification of the standard framework for understanding the response of an asset price to news in which $q_{t^+} - q_{t^-}$, the change in an asset price between time t^-, just before an announcement, and time t^+, just after that announcement, is a linear function of news, that is, the difference between the announced value of a variable, x_{t^+}, and the expected value of that variable at time t^-, $E_{t^-} x_{t^+}$. The standard empirical specification is

$$q_{t^+} - q_{t^-} = \alpha + \beta\left(x_{t^+} - E_{t^-} x_{t^+}\right) + \varepsilon_{t^+} \tag{1}$$

where ε_{t+} is a white-noise error term. This parsimonious specification is most appropriate when the time horizon is between t^+ and t^- is short, for example, when it is measured in minutes rather than days, and when news about the variable x does not become available at the same time (that is, within the span t^- to t^+) as announcements about some other relevant variable. The actual set of variables that constitute x depends upon the asset studied but, in general, any variable that markets construe as revealing information about current and future economic activity may be appropriate for study.

A more general version of equation (1) takes into account expectations about the policy response to news.

(2) $$q_{t^+} - q_{t^-} = \alpha + \beta\left(x_{t^+} - E_{t^-} x_{t^+}\right) + \phi\left(M_{t^+} - E_{t^-} M_{t^+}\right) + \varepsilon_{t^+}$$

In this formulation, the term $\phi\left(M_{t^+} - E_{t^-} M_{t^+}\right)$ represents the manner in which the perceived difference between actual policy path after the announcement, M_{t^+}, and its expected path before the announcement occurs, $E_{t^-} M_{t^+}$ affects the change in the price of the asset. The parameter ϕ may be positive or negative, depending upon the policy and the asset. The inclusion of $\left(M_{t^+} - E_{t^-} M_{t^+}\right)$ reflects the presence of a perceived policy reaction function in which *M* depends upon *x,* such as

(3) $$M_t = -\lambda_i (x_t - \bar{x}_i)$$

where λ_i is the response of the perceived policy path to news, $\bar{x}_i$ is a baseline value of the news variable, and the subscript *i* is included to allow for the possibility of changing policy path over time. For example, over a sample period, the perceived responsiveness of central bank policy to price shocks may change from Period A to Period B, and, therefore, the parameters in the policy reaction function may change such that $\lambda_A \neq \lambda_B$ or the baseline value of the news variable may change such that $\bar{x}_A \neq \bar{x}_B$.

If (2) is the true model, an estimate of the effect of observed news announcements on asset prices using equation (1) will yield

(4) $$q_{t^+} - q_{t^-} = \alpha + \left(\beta - \phi\lambda_i\right)\left(x_{t^+} - E_{t^-} x_{t^+}\right) + \varepsilon_{t^+}$$

and the estimated coefficient on news is $(\beta - \phi\lambda_i)$. In the case in which the perceived policy reaction function does not change over the sample period studied, there will be a constant estimated response of asset prices to news. For example, this would occur if an unvarying institutional structure determines the reaction function. But, in the case where there is a change in the perceived policy reaction function, perhaps as a consequence of the path of actual policy, there will be a corresponding change in the estimated response of asset prices to news. Therefore, we can check for changes in the market's perceptions of policy stances over a sample period by considering whether there are significant differences over time in the response of asset prices to news.

We apply this general framework to the question of whether the market perception of the anti-inflationary stance of a central bank evolves over time or remains constant. In our application, the dependent variable, $q_{t^+} - q_{t^-}$, represents the change in the slope of the yield curve over alternative asset maturities or the change in the exchange rate, reflecting the inflation outlook. For example, for 10 year and 2 year bonds, $q_t = \left(r_t^{10} - r_t^2\right) = \left(\pi_t^{10} - \pi_t^2\right)$, so that between the time before a news announcement, t^-, and the time after that announcement, t^+,

$$(r_{t^+}^{10} - r_{t^+}^2) - E_{t^-}(r_{t^+}^{10} - r_{t^+}^2) = (r_{t^+}^{10} - E_{t^-} r_{t^+}^{10}) - (r_{t^+}^2 - E_{t^-} r_{t^+}^2) = (\pi_{t^+}^{10} - E_{t^-} \pi_{t^+}^{10}) - (\pi_{t^+}^2 - E_{t^-} \pi_{t^+}^2)$$

An increase in the slope of the yield curve in response to news implies that news has a bigger impact on the change in the expected value of inflation at the 10-year horizon than on the expected value of inflation at the 2 year horizon.[6] In contrast, a flattening of the yield curve in response to economic news suggests that the effect of that news has a smaller expected effect on inflation at the longer horizon than it does on inflation at the shorter horizon.

This discussion shows how to interpret changes in the coefficients of an equation like (4) when $q_{t^+} = (r_{t^+}^{10} - r_{t^+}^2)$ and $q_{t^-} = (r_{t^-}^{10} - r_{t^-}^2)$. Consider two different market views of policy, a view that policy has a stronger anti-inflation tilt (Policy S) and a view that policy has a weaker anti-inflation tendency (Policy W). These policies are distinguished by the condition that $\lambda_S > \lambda_W$ when x in (1) represents a positive price shock. Therefore, if the perception shifted towards a view that a central bank was more committed to a strong anti-inflation policy as time went on, we would expect to find a larger value for the estimated coefficient that represents the response of the slope of that country's yield curve to inflationary news in the earlier period of the sample than in the later period since $(\beta - \phi\lambda_W) > (\beta - \phi\lambda_S)$. In contrast, if perceptions of policy were unvarying, perhaps because these perceptions were driven by the initial and unvarying institutional structure, we would

[6] News effects on equilibrium real interest rates are common to returns at all horizons along the yield curve. As a consequence, when we difference across the returns of long and short-dated bonds we abstract from the effect of news on equilibrium real returns. We also are abstracting from the effect of news on term premia or liquidity premia, which seems reasonable given the short time horizon between times t^- and t^+. In a similar vein, Fleming and Remolona (1999) argue that the effects of news on asset prices of different maturities reveals information about market participant beliefs about central bank reaction functions.

not expect to find a significantly different estimated coefficient on the response of the slope of a central bank's yield curve to price news across the sample period studied.

The robustness of these results can be studied by running a similar regression using, as the dependent variable, the change in the exchange rate, i.e. $q_{t^+} = s_{t^+}$ and $q_{t^-} = s_{t^-}$ where s_t is the number of units of domestic currency per unit of foreign currency. Through purchasing power parity, a nominal exchange rate evolves in accordance with the trajectories of home versus foreign inflation. The sign of the coefficient of news on s_t depends upon whether the news is expected to have a bigger effect on expected inflation in the foreign country or in the home country. This, in turn, depends upon the expected responses of the respective central banks to these inflationary pressures.

III. Evolving Perceptions of European Central Bank Policy

Based on the discussion in the previous section we test for changes in the market's perception of the policy of the ECB during its first five years by testing for a significant change in the coefficient on the surprise component of the news variable in a regression on the slope of the German yield curve or in a regression on the euro/dollar exchange rate. It is also useful, as a benchmark, to test for a significant change in responsiveness of the slope of the United States yield curve to price news. If one finds no significant change in the regressions on the United States yield curve, but a significant change in the regressions on the German yield curve and on the euro/dollar exchange rate, then this is consistent with a shift in market perceptions of the policy stance of the ECB, with no comparable shift in the market perceptions of the policy stance of the Federal Reserve. Furthermore, if the estimated coefficient on the price news variable is greater in an earlier period than in a later period, this suggests that the market is ascribing to the ECB a more anti-inflationary stance over time. The timing of breaks in slopes across periods can be compared to the evolution of actual policy to examine whether credibility evolved in response to conduct. Alternatively, if there is no evidence of a significant break in the responsiveness of news over this period, the credibility of the ECB may have been attained through the statutes that set up its institutional structure.

3.1 Empirical Methods. We implement the model presented in Section II by running regressions that take the form

$$(5) \qquad q_{t^+} - q_{t^-} = \alpha + \beta_I \left(x^I_{t^+} - E_{t^-} x^I_{t^+} \right) + \beta_{II} \left(x^{II}_{t^+} - E_{t^-} x^{II}_{t^+} \right) + \varepsilon_{t^+}$$

where $\left(x^I_{t^+} - E_{t^-} x^I_{t^+} \right)$ is the surprise component of news across announcement events in the first part of the sample period and $\left(x^{II}_{t^+} - E_{t^-} x^{II}_{t^+} \right)$ is the surprise component of news across announcement events in the second part of the sample period. A series of regressions are run, each with a successively later break point that divides the sample into its first and second parts. For a sample with *n* observations, we run *n* – 20 regressions; one in which the break point is the 10th observation and, therefore, the first period runs from observation 1 to observation 10 and the second period runs from observation 11 to observation *n*; a second regression in which the break point is the 11th observation so the first period runs from observation 1 to observation 11 while the second period runs from observation 12 to observation *n*; and so on, until the final regression, in which the break point is the *n* – 11th observation and the first period runs from observation 1 to observation $n - 11$ while the second period runs from observation $n - 10$ to observation *n*. For each of these regressions, we plot both β_I and β_{II}, and their respective confidence intervals. Also, in a separate graph, we plot the t-statistic associated with the test $\beta_I - \beta_{II} = 0$ against the dates associated with the break points. A table presents the regressions associated with break point for the first time that the test $\beta_I - \beta_{II} = 0$ is significantly different from zero at the 95 percent level of confidence, and also regressions associated with the break point that yields the maximum t-value for the test $\beta_I - \beta_{II} = 0$.

3.2 The data. We use a high frequency data base on hourly changes in sovereign debt yields for the United States and Germany, spanning the period from with from January 1999 to September 2004. The data are as reported by Reuters, for the on-the-run U.S. and German two- and ten-year notes.[7] Using this data, we construct differences between the one-hour change in 10 year bond interest rates and the one-hour change in 2 year bond interest rates

[7] Indications are captured hourly between 0:00 and 23:00 eastern standard time for these markets.

(that is, the change in the slope of the yield curve) for both German and U.S. bonds in the hour surrounding economic news announcements, that is,

$$\left(r_{t+}^{10,German} - r_{t-}^{10,German}\right) - \left(r_{t+}^{2,German} - r_{t-}^{2,German}\right)$$
$$\left(r_{t+}^{10,US} - r_{t-}^{10,US}\right) - \left(r_{t+}^{2,US} - r_{t-}^{2,US}\right)$$

where the superscripts refer to 10 year German bonds (10,German), 2 year German bonds (2,German), 10 year U.S. bonds (10,US) and 2 year U.S. bonds (2,US). We also test for changes in the effects of economic news on the euro/ dollar exchange rate,

$$(Euro/\$)_{t^+} - (Euro/\$)_{t^-}$$

The independent variable in all regressions is the surprise component of U.S. price announcements. Price news is the most direct indicator of changes in inflation. While our modeling methods also can be applied to other types of economic news variables, news about real macroeconomic variables may have more ambiguous relationships to changes in perception about the underlying inflationary environment. For example, news that real output is higher than expected may be associated with an increase in expected inflation, if the higher output is due to greater demand, or a decrease in expected inflation, if larger than expected productivity gains are the source of the increase in output. Furthermore, an investigation of changing policy responses associated with news on real macroeconomic variables can conflate perceived policy shifts of both the monetary and the fiscal authorities.

We focus on news about United States prices, rather than news about German or European prices, because of possible problems with the news content of German and European price announcements. Goldberg and Leonard (2003) and Ehrmann and Fratscher (2004) present evidence of the effect of United States macroeconomic news on American, European, and German asset prices, and the weakness or absence of an effect of German or European macroeconomic news on asset prices in both Europe or America. [8] These results, consistent with the empirical regularities found by Chinn and Frankel (2003), are strongly supportive of news effects originating in the United States and being transmitted to the euro

[8] Gadzinski and Orlandi (2004) argue that inflation persistence is comparable across the United States and the euro area.

area, without much reverse causation. The four different indicators of U.S. prices are the CPI, the PPI, the Core CPI, and the Employment Cost Index (ECI).

As in Andersen *et al.* (2003), the *news* component of an economic data release represents the difference between the actual release and the markets' expectation of the contents of the release. Also following their approach, we obtain comparability across the four price series we use by dividing *news* for each of the series by the respective standard deviation of *news* for that series over the sample period. The expectations data that we rely on are median responses from weekly surveys of market participants conducted by Money Market Services, a division of Standard & Poor's, and more recently from Action Economics.[9]

Table 1 presents mean values of news and the associated standard errors, for each of the four separate announcements as well as for the set of the two CPI announcements and for the set of all four announcements. This table also includes the results of regressions of the value of the announcement on the expected value of the announcement. These regressions, which take the form

$$x_{t^+} = \gamma_0 + \gamma_1 E_{t^-} x_{t^+} + u_{t^+}$$

should result in $\gamma_1 = 1$ if the expectations of the announcements are unbiased forecasts.[10] The regression results show that we fail to reject the hypothesis that $\gamma_1 = 1$ at the 95 percent level of confidence for the Core CPI announcements and for set of announcements including the Core CPI and the CPI. While these results suggest that the set of the two CPI announcements is the preferred for implementing equation (5), we report, in the main body of the paper, results using all four announcement series since this provides us with more observations. But, mindful of the results presented in Table 1, in section 3.4 we present comparable results obtained with the smaller set of observations from the two CPI series only, which show the robustness of the results using all four series.

[9] Money Market Services were the source of these data through December 2003. Haver Analytics provided continuous expectations and announcement data through 2004 using data from Action Economics.

[10] Another condition is that $\gamma_0 = 0$, which is met for the Core CPI announcements and the set of Core CPI and CPI announcements.

Table 1: Statistics on News, Announcements and Expectations

		News $= \left(x_{t^+} - E_{t^-} x_{t^+}\right)$		Results of $x_{t^+} = \gamma_0 + \gamma_1 E_{t^-} x_{t^+} + u_{t^+}$				
	Obs.	Mean	s.d.	γ_0	s.e.	γ_1	s.e.	R^2
Core C.P.I.	66	-0.0045	0.0952	**0.056**	0.0640	**0.671**	0.328	0.076
C.P.I.	66	-0.0129	0.1325	-0.070	0.0309	1.256	0.116	0.693
P.P.I.	66	0.0098	0.4504	-0.186	0.0577	2.083	0.207	0.636
ECI	22	0.0182	0.2423	1.149	0.5586	-0.231	0.578	0.011
All Series	220	-0.0005	0.2718	-0.073	0.0337	1.272	0.099	0.630
All CPI Series	132	-0.0087	0.1150	-0.050	0.1066	**1.204**	0.107	0.590

Bold = $\gamma_0 = 0$ or $\gamma_1 = 1$, respectively, at 95 percent level of confidence.

3.3 Market Perceptions of Policy.

Results on the possible changes in the perceptions of policy, as embodied in a comparison of the value of the coefficients β_I and β_{II} in regressions based on specification (5), are presented in three different ways. Figures 1, 2 and 3 present the coefficients β_I and β_{II}, and their respective confidence intervals, for a set of rolling regressions in which the dates of the break points change. Table 2 presents estimates for regressions with particular break points, as well as full sample regressions with no break points. A third set of results, presented in Figure 4, plots the t-statistics for the equality of β_I and β_{II}. In each of of these three cases, the regressor is the standardized surprise component of United States price news using all four announcement series. Each of the three sets of results include estimates of the effect of this news variable on the change in the slope of the the German yield curve, the change in the slope of the United States yield curve, and the change in the value of the euro / dollar exchange rate. The overall sample period runs from February 5, 1999 to August 17, 2004, while break points are considered from observations on April 29, 1999 (corresponding to the 10^{th} observation in the data) through June 15, 2004 (corresponding to the 208^{th} observations of the data).

Figures 1, 2 and 3 show the evolution of β_I and β_{II} for each of the three regressands. In each of these graphs, the value of β_I and β_{II} for a particular date depicted on the horizontal axis represents estimated values of the respective coefficient for a regression in which the "early" period includes all observations up to and including that date, and the

"later" period consists of all observations after this date. An unvarying view of the central bank's policy stance would result in an overlap of the confidence intervals for β_I and β_{II} over the full sample period while an evolving view towards a greater anti-inflation stance is reflected in, at least initially, a significantly greater value of β_I as compared to β_{II} (that is, confidence intervals that first are distinct and later overlap).

Figure 1 shows that the estimated effect of news on the change in the slope of the German yield curve is significantly greater for the early part of the sample than for the later part of the sample when the dates defining the early part of the sample are between mid-1999 and early 2001. While $\beta_I > \beta_{II}$ for the entire sample, the confidence intervals for β_I and β_{II} overlap when the break point is either very early in the sample or after the beginning of 2001. In contrast, as shown in Figure 2, β_I and β_{II} are statistically indistinguishable for any break points when the regressand is the change in the slope of the United States yield curve. Figure 3, in which the regressand is the change in the euro / dollar exchange rate, presents a result more similar to Figure 1 than to Figure 2, since, in this case, $\beta_I > \beta_{II}$ and β_I and β_{II} are statistically distinguishable when the break point is between April 2000 and June 2003.

Figure 1: Effect of U.S. Price Announcements on German Yield Curve
Betas for Early and Late Periods

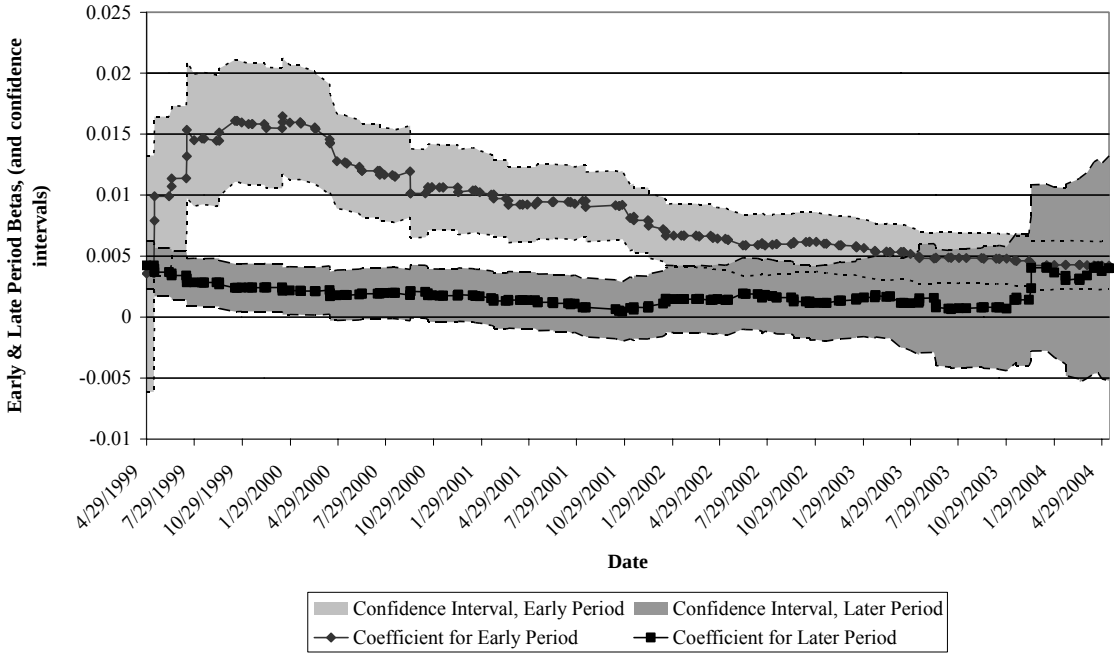


Figure 2: Effect of U.S. Price Announcements on U.S. Yield Curve
Betas for Early and Late Periods

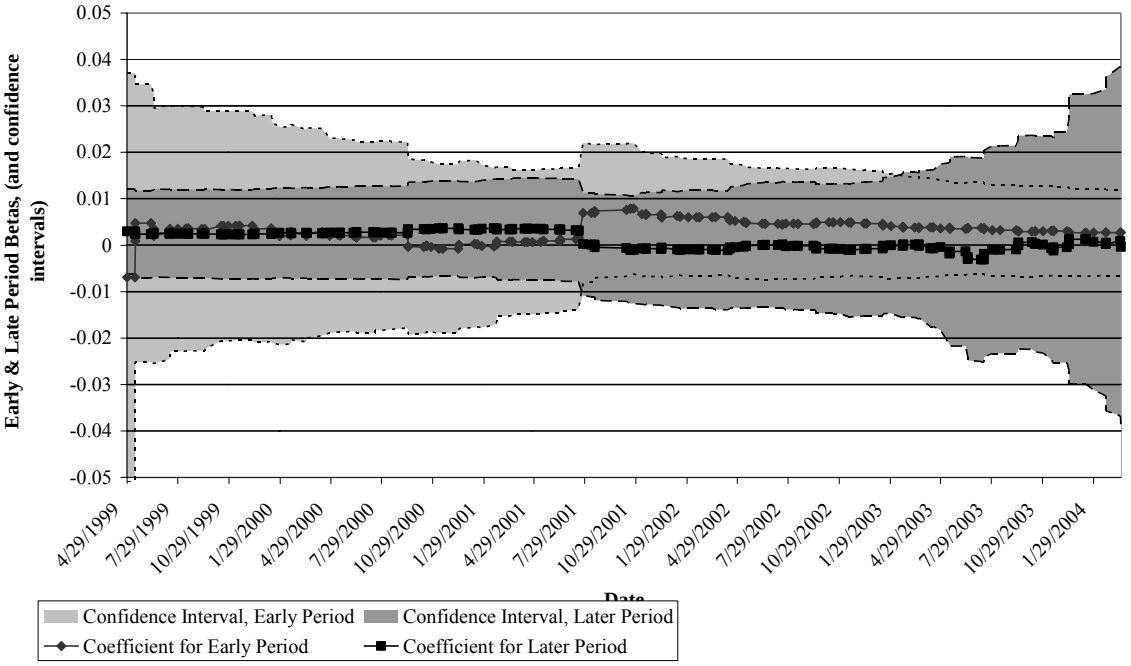
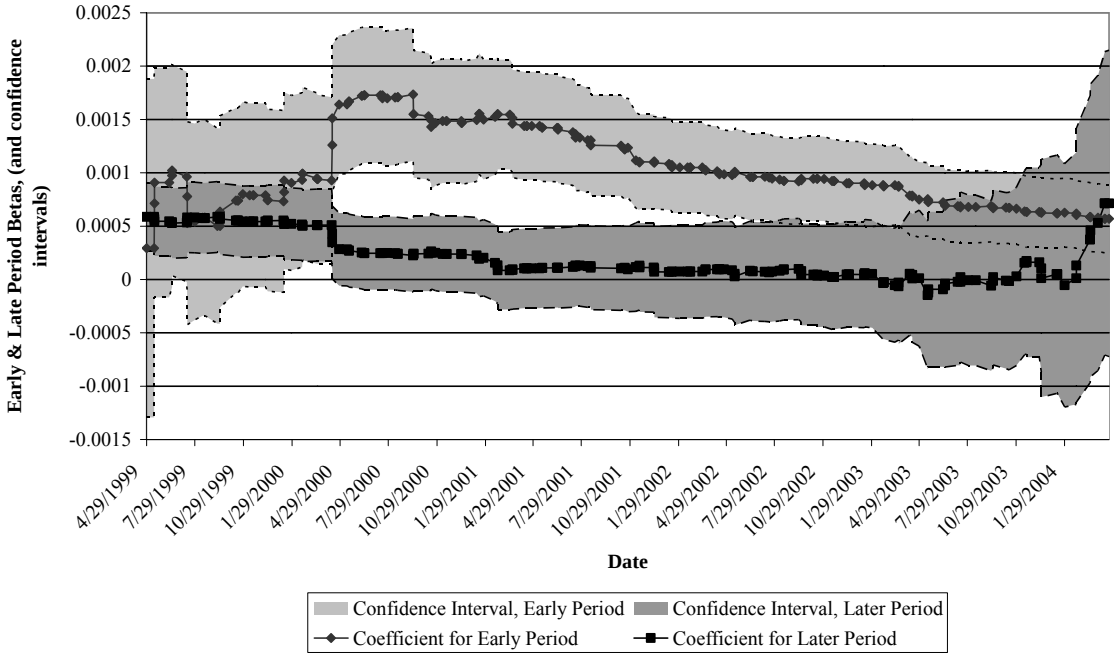


Figure 3: Effect of U.S. Price Announcements on Euro/$
Betas for Early and Late Periods



The results presented in these figures shows that the effect of the surprise component of US price announcements on the change of the slope of the German yield curve varied over the sample period, while there is no evidence of a change in the responsiveness of the slope of the US yield curve to price news announcements during this period.[11] Furthermore, the fact that the coefficients in the earlier period are significantly larger than the respective coefficients in the latter period for the regressions on change in the slope of the German yield curve is consistent with an increasing amount of credibility over time in the anti-inflation stance of the ECB.

These results support the view that the ECB gained credibility over time through its actions, not that its institutional structure garnered an unvarying level of credibility from its inception. The fact that there is no significant break in the responsiveness of the slope of the United States yield curve to United States price news over this period bolsters this result since, if there were a change in the overall economic environment, one would expect to find some consistency in the pattern of break points across countries. This interpretation is consistent as well with the pattern of significance of the regressions of surprise component of United States price news on the change in the euro/dollar exchange rate. In this case, the interpretation of the result depends upon whether the impact of an unexpectedly large increase in US prices has a bigger effect on expected inflation in the United States or in Europe, and whether the relative magnitude of these effects varies over time. The fact that $\beta_I > \beta_{II}$ for all break points, and β_I and β_{II} are statistically distinguishable when the break points are in the early part of the sample, combined with the differences in the results between the United States and German yield curve regressions, is consistent with the interpretation above of a varying perception of the anti-inflation stance of the ECB.

Figure 4 presents the t-statistics associated with the test $\beta_I - \beta_{II} = 0$ for each of the 198 possible break points in the sample, for each of the three regressands. The three lines in the figure represent tests that employ, as the regressand, the change in the slope of the United States yield curve (the line consisting of longer dashes), the change in the slope of the

[11] While numerous studies have shown the implications of such news for the U.S. yield curve, and for two or ten year bond yields, the slope of the yield curve is itself unaffected by this economic news over the period examined.

German yield curve, (the solid line), and the change in the euro/dollar exchange rate (the line consisting of shorter dashes).

Figure 4: High-Frequency Responses to U.S. Price News
t-statistic for Equality of Coefficients in 2 Periods

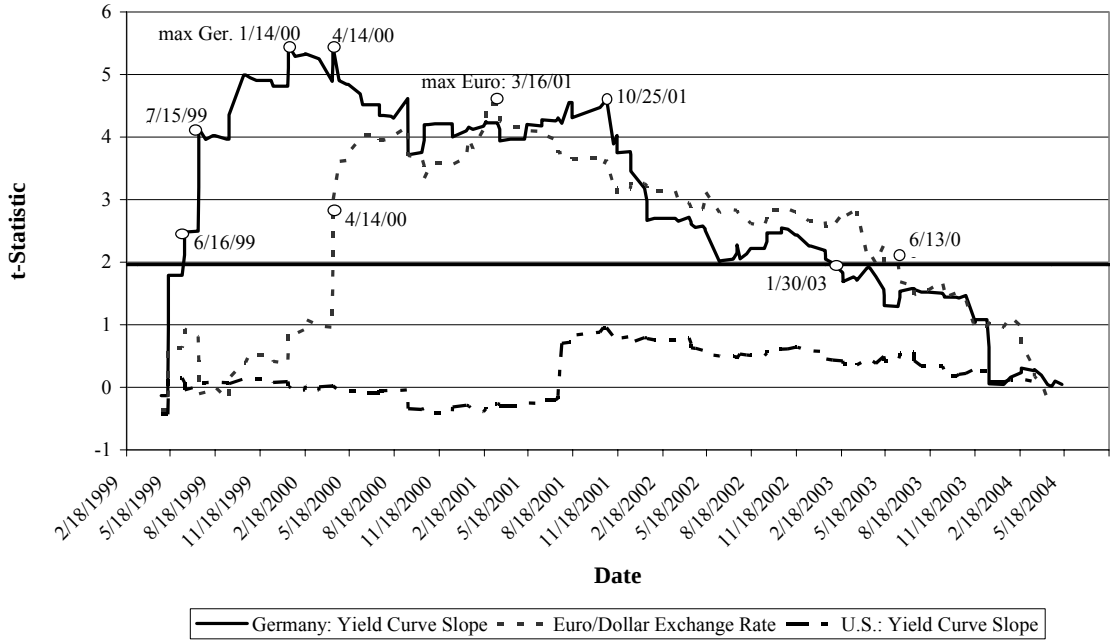


Figure 4, like Figures 1 and 3, show that the econometric tests support a range of possible break points associated with the effect of the surprise component of price news announcements on the change in the slope of the German yield curve and on the change in the euro/dollar exchange rate. Again, these results are consistent with an evolving view of the policy stance of the ECB, rather than a view of a consistent policy stance that would arise if unvarying institutional structures dominated the perception of the anti-inflation stance of the ECB. This interpretation is bolstered by the absence of a significant break point for regressions of news on the change in the slope of the United States yield curve. The absence of a significant break point in this case suggests that, in contrast to the ECB, the long and relatively stable history of Federal Reserve policy led to a consistent view of its policy stance over this sample period.

An examination of the evolution of the t-statistics with respect to dates reveals how policy actions are linked to credibility. The significance of the break point for the regression of the German yield curve on the surprise component of U.S. price news continues to rise over the first part of the sample, with the t-statistic reaching global maxima on January 14,

2000 and on April 14, 2000. On this latter date, there is also a large jump in the significance of a break point for the regression of the euro/dollar exchange rate on the surprise component of US price news from 0.96 on April 13, 2000 to 2.96 on April 14, 2000. There is no evidence of a significant break point after mid-2003.

It is interesting to consider these dates in light of the actions of the ECB around that time. November 4, 1999 marked the first time that the ECB raised its key interest rate since it began operations on January 1, 1999.[12] At that time, this interest rate, the rate for main refinancing operations, was raised from 2.5 percent to 3.0 percent. This was followed by another 25 basis point increase on February 3, 2000, additional 25 basis point increases on March 16 and April 27, and a 50 point basis point increase to 4.25 percent on June 9. Within our model, the spike in the significance of an estimated break point for the slope of the German yield curve in January 2000, as well as the large increase in the significance of an estimated break point for the euro/dollar exchange rate in mid-April 2000, suggest that these actions by the ECB served to alter the market's perception of its policy. In particular, the fact that the t-statistic on the test $\beta_I - \beta_{II} = 0$ is positive indicates an evolution towards the view that the ECB was becoming more strongly anti-inflationary in the wake of this round of interest rate increases in 2000.

The European Central Bank switched towards a more accommodative monetary policy on May 11, 2001 with a decrease in the minimum bid rate for the main refinancing operations by 25 basis points, to 4.50 percent.[13] As shown in Figure 4, the estimated t-statistic for the test of $\beta_I - \beta_{II} = 0$ in regressions of the euro/dollar exchange rate on the surprise component of the U.S. price news reaches its peak just before this policy shift, in mid-March 2001. After this, there is a more-or-less steady decrease in the t-statistic for an estimated break point through the end of the sample, during which time the ECB continued to lower interest rates. The decline in the t-statistic for the German yield curve regressions begins on November 9, 2001, about six months after the first indication of this policy shift,

[12] The key interest rate on fixed rate tenders was at 3.00 percent from January 1, 1999 through April 9, when it dropped by 50 basis points to 2.50 percent. On November 4, 2000 a period of monetary tightening started. For main refinancing operations, changes in the rate are effective from the first operation following the date when changes were indicated.

[13] On June 8 2000 the ECB announced that, starting June 28, 2000, the main refinancing operations of the Eurosystem would switch from fixed rate tenders to variable rate tenders. Thereafter the key interest rate set by the ECB was the minimum bid rate of the variable rate tenders for the main refinancing operations. See www.ecb.int/stats/monetary/rates.

and after three additional interest rate cuts by the ECB on August 30, 2001 (when the interest rate was cut by 25 basis points), on September 17, 2001 (when the interest rate was cut by 50 basis points), and on November 8, 2001 (when the interest rate was cut by 50 basis points). The t-statistic for a break point in the set of German yield curve regressions decreases from 4.63 for a break point on October 25, 2001, to 3.89 for a break point on the next date of a price announcement, November 9, 2001, the day after a 50 basis point cut in the key interest rate by the ECB.[14]

Figure 4 shows a more-or-less steady decline in the t-statistics for the estimated break point for both the euro/dollar exchange rate and for the German yield curve during the remainder of the sample period after November 2001. During this time, there were three more rate cuts, on December 5, 2002 (a 50 basis point cut), March 6, 2003 (a 25 basis point cut) and June 6, 2003 (a 50 basis point cut). The main refinancing interest rate remained at 2.00 percent from the time of this last rate cut until the end of the sample period in September 2004. Early in 2003 the ECB refined their "two pillar" approach, with the importance of M3 apparently reduced and the target for inflation at or slightly below two percent. This communication was a significant event. There is no evidence of a significant break point after mid-2003. An interpretation could be that, by that time, the market had established its views of the ECB and, given the experience to that point as well as the lack of more recent policy surprises, these views did not change. It is noteworthy that this stability persisted even through the time of the change of the presidency of the ECB from Wim Duisenberg to Jean-Claude Trichet on November 1, 2003.

Table 2 isolates results for regressions with particular break points and also presents regression results for the full sample under the assumption of no break point. This table includes regressions representing the earliest break point for which there is a statistically significant difference (at the 95 percent confidence interval) between β_I and β_{II}, and regressions representing in which the break point yields the largest statistical difference between β_I and β_{II}. Regressions with the separate coefficients β_I and β_{II} in which the

[14] One may be concerned that, because this period includes September 11, 2001, the effect of the terrorist attacks on that day may be responsible for the shift in the t-statistics. However, in this figure we do not observe comparable changes in the t-statistics from the regressions on the U.S. yield curve in the aftermath of the 9/11 attacks (the large change in the t-statistic for these regressions that is apparent in Figure 1 occurs in late-July 2001). As will be seen below, there is some evidence of a break point in the regressions on the slope of the US yield curve around the time of September 11, 2001 when we use only the two CPI price series announcements.

regressand is the change in the United States yield curve are not presented, however, since there is break point that generates a significant difference in β_I and β_{II} in this case.

The first day when the t-statistic for the test of the equality of the two coefficients exceeds 2.00 is June 16, 1999 for the regression on the slope of the German yield curve, and April 14, 2000 for the regression on the exchange rate. The estimates reported in Table 2 for the two regressions with these respective break points show that the coefficients on the price news for the earlier part of the subperiods are about three times larger than the coefficients for the later part of the sample in both cases. Also, the coefficients on β_I and β_{II} in each of the two regressions are significant at better than the 95 percent level of confidence. We also note that the adjusted goodness of fit improves by about 29 percent in the regression on the slope of the German yield curve and by about 24 percent in the regression on the exchange rate when comparing these regression with the respective ones with no break point.

The final set of results reported in Table 2 use, as the break point, the day that generates the maximum value of the t-statistic for the test of the equality of the two slope coefficients. This is January 14, 2000 for the regression on the slope of the German yield curve, and March 16, 2001 for the regression on the exchange rate. The adjusted R^2 statistics for these regressions are about 2.4 times larger than the adjusted R^2 statistics in the respective regressions that do not allow for different coefficients during the sample period. In the regression on the slope of the German yield curve, the estimated value of β_I is almost eight times larger than the estimated coefficient for β_{II}, and the t-statistic for the former coefficient is 6.82 while the t-statistic for the latter is 2.18. In the case of the euro/dollar exchange rate regression, the estimated coefficient in the earlier period, which has a t-statistic of 5.96, is fifteen times the size of the estimated coefficient in the latter period, which has a t-statistic of 0.38.

Table 2 Effects of Surprise Component of 4 US Price News Series on Yield Curve Slopes and Exchange Rate

		Slope of German Yield Curve		Euro/Dollar Exchange Rate		Slope of US Yield Curve	
		Coef.	s.e.	Coef.	s.e.	Coef.	s.e.
No Break Points	α	**-0.00199**	0.00097	0.00010	0.00016	-0.00476	0.00446
	β	**0.00423**	0.00097	**0.00059**	0.00016	0.00259	0.00456
	Adj. R^2	0.076		0.055		-0.003	
First Significant Break Point (6/16/1999; 4/14/2000)	A	**-0.00190**	0.00096	0.00011	0.00016		
	B_I	**0.01074**	0.00323	**0.00126**	0.00037		
	B_{II}	**0.00358**	0.00102	**0.00044**	0.00017		
	Adj. R^2	0.098		0.068			
	t-stat: $\beta_I = \beta_{II}$	2.12		2.03			
Break Point with Max. Significance (1/14/2000; 3/16/2001)	A	-0.00149	0.00091	0.00007	0.00015		
	B_I	**0.01650**	0.00242	**0.00155**	0.00026		
	B_{II}	**0.00216**	0.00099	0.00010	0.00026		
	Adj. R^2	0.186		0.132			
	t-stat: $\beta_I = \beta_{II}$	5.47		4.53			

α = intercept, β = coefficient on surprise component of US price news for full sample,
β_I, β_{II} coefficients on surprise component of US price news for 1st or 2nd part of sample, respectively.
Dates listed for First Significant Break Point and Maximum Significant Break Point are for (German Yield Curve; Euro/Dollar Exchange Rate).
Bold = significant at better than 95 percent level of confidence.
See text for definitions of regressands and surprise component of US price news.

3.4 Robustness

The results presented in Table 1 indicate that the expected values of the two CPI price announcements, the CPI itself and the Core CPI, are good predictors of the actual announcements over the sample period in that we cannot reject the hypothesis that the estimated coefficient on the expected value of the announcement is equal to 1 at the 95 percent level of confidence in a regression of the actual announcement on its expected value. As was seen in Table 1, this result does not extend to the other two price series, the PPI and the Employment Compensation Index. Therefore, as a check of the robustness of the results

presented in Figure 1, we also calculated the t-statistics associated with a break in the responsiveness of the slope of the German yield curve, the slope of the U.S. yield curve, and the euro/dollar exchange rate to news about the CPI series only. The results from this exercise, which includes 130 observations and, therefore, t-statistics for 110 possible break points from June 16, 1999 through March 17, 2004, are plotted in Appendix Figure 1.

The results from this exercise are generally consistent with those presented in regressions using the full set of four price series in constructing news. The first significant break points occur on the same dates for both the German yield curve and exchange rate regressions using either all four price series, as in Figure 1, or only the two CPI series.[15] The date on which the t-statistic associated with the break point reaches its maximum value is the same across the sets of estimates for the German yield curve, and is about six months earlier for the exchange rate when using only the two CPI series than when using all four series. The last date on which the t-statistic associated with a break point is greater than 2.00 is virtually the same in the two figures for the exchange rate series, but it is about six months later for the German yield curve estimates when only the two CPI series are used rather than all four price series.

The one striking difference between the results is that there is a significant break in the slope of the US yield curve series when only the two CPI announcement series are used. The period over which a break is significant is relatively short, and occurs between August 16, 2001 and November 16, 2001, a period that spans the terrorist attack on the World Trade Center. The largest t-statistic is associated with a break point on October 19, 2001. The regression estimate with this break point is

$$(r_{t^+}^{10,US} - r_{t^+}^{2,US}) - (r_{t^-}^{10,US} - r_{t^-}^{2,US}) = \underset{(0.0017)}{0.0013} + \underset{(0.0026)}{0.0057}(x_{t^+}^{I} - E_{t^-}x_{t^+}^{I}) - \underset{(0.0024)}{0.0027}(x_{t^+}^{II} - E_{t^-}x_{t^+}^{II})$$

with an R^2 of 0.046 and a t-statistic of 2.37 for the test $\beta_I = \beta_{II}$ (standard errors are presented in parentheses below the coefficient estimates).

According to this result, the period around the 9/11 attack may have marked a significant break point for the markets' view of the behavior of U.S. inflation. But, given the weakness of the US economy in the post 9/11 period, it can be argued that break point could

[15] The date for the break point for the German yield curve, June 16, 1999, is the first possible break point in Figure 2 because of the smaller set of observations available with only the CPI announcements.

represent a change in any of the parameters in the term $(\beta - \phi\lambda)$ of equation 4, not just a change in λ as was posited in that model. It is also noteworthy, with respect to the perceived policy of the ECB, that there was not a upward spike in the t-statistics associated with a break point for either the German yield curve or the exchange rate regressions in the period around the terrorist attack. Thus, it is likely that the change that may have occurred in β or φ with respect to the U.S. economy at that time was not matched by a comparable change in β or φ for the German economy, or for that of Europe as a whole. Therefore, the fact that there is a short period of a significant estimated break point for the responsiveness of the slope of the US yield curve to a subset of the price news announcement data set does not alter our view that the significant breaks in the regressions for the slope of the German yield curve and the exchange rate could reflect changing views about the policy stance of the European Central Bank.

IV. Conclusions

The importance of the reputation of a central bank for the success of its operations is stressed in theory and is evident from practical experience. An important question is whether a central bank gains credibility through its institutional structure or through the conduct of policy. This question is especially relevant for a newly established central bank that faces the challenge of establishing its reputation, sometimes in the face of political controversy over the appropriate conduct of monetary policy.

The evolution of the markets' perceptions of the policy stance of the European Central Bank since it began operations in January 1999 is interesting for a number of reasons. One of these reasons is the inherent interest of the economic experience of the eurozone. A second reason is that the establishment of the European Central bank provides a natural experiment for considering how the reputation of a central bank evolves over time. This episode is a particularly rich vein to mine because of the controversy surrounding the conduct of monetary policy in Europe as the ECB began its operations.

In this paper, we propose a novel test for the study of the evolution of market perceptions about the policy stance of a central bank. When we apply this test to data on the slope of the German yield curve and the euro / dollar exchange rate, we find, in fact, evidence of a steady shift towards the view that the ECB policy is geared towards keeping

inflation low. There is not a similar shift in the market's perception of the policy stance of the Federal Reserve, a period marked by the stability in its leadership, the consistency of its stated goals, and the lack of political opposition to the manner in which it conducts policy.

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Appendix

Appendix Figure 1: High-Frequency Responses to U.S. CPI Price News
t-statistic for Equality of Coefficients in 2 Periods