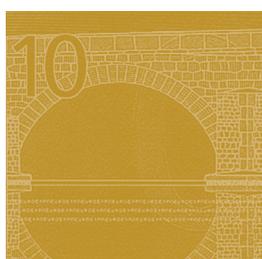




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ECONOMIC SURPRISES AND INFLATION EXPECTATIONS HAS ANCHORING OF EXPECTATIONS SURVIVED THE CRISIS?

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Abstract

This paper analyses price formation in medium- to longer-term maturity segments of euro area and US inflation-linked and nominal bond markets around the releases of important economic indicators. We compare the pre-crisis and crisis periods, controlling for liquidity effects observed in financial markets. The results allow us to draw conclusions about the anchoring of inflation expectations in the two currency areas before and during the crisis. We find a somewhat stronger anchoring of inflation expectations in the euro area than in the United States. During the crisis, the degree of anchoring of inflation expectations did not change in the euro area, but it decreased to some extent in the United States.

Keywords: inflation expectations; inflation markets; break-even inflation rates; macroeconomic announcements; nominal and real bond yields;
JEL classification: E44; G12; G01

Non-technical summary

Anchoring of inflation expectations is of key importance in conducting monetary policy. Its degree can be assessed by analysing the reactions of spot and, in particular, forward market-based measures of inflation expectations to releases of new information on inflation developments and real activity.

This paper analyses price formation in medium- to longer-term spot and forward maturity segments of euro area and US nominal and inflation-linked bond markets around the releases of important economic indicators. The results give us insights about how measures of market-based inflation expectations, namely so-called break-even inflation rates, react to various releases. We explore the differences in reactions between the pre-crisis and crisis periods, controlling explicitly for liquidity effects observed in nominal and inflation-linked bond markets. The results allow us to draw conclusions about anchoring of inflation expectations in the two currency areas before and during the crisis.

We find that, for medium- to longer-term maturities, euro area spot break-even inflation rates react to inflation data releases (flash HICP), while forward rates do not react. This effect does not change with the crisis. US spot break-even inflation rates also react to inflation data releases (e.g., CPI and PPI data), but additionally US forward numbers start to react to inflation data releases with the onset of the crisis. Furthermore, US break-even inflation rates react to real economic activity indicators, such as employment data (e.g., nonfarm payrolls). This effect strengthens somewhat during the crisis. The reaction of euro area break-even inflation rates to real activity indicators is weaker and mainly observed for the spot rates. The results also show that liquidity effects indeed influence break-even inflation rates and nominal yields, putting mostly a downward pressure on both, especially during the crisis period.

Overall we conclude that inflation expectations are anchored somewhat more firmly in the euro area than in the United States. In the euro area, the anchoring of expectations did not change during the period of financial crisis. In the United States, it decreased to some extent.

1 Introduction

Market-based measures of inflation expectation are derived from inflation-linked financial products. In contrast to indicators based on surveys, market-based measures are available at high frequency and, therefore, they can timely reflect new information available to market participants. This paper analyses price formation in euro area and US nominal and inflation-linked bond markets around releases of important economic data over the period from 2004 to 2012. The results allow us to draw conclusions about the degree of anchoring of inflation expectations in the two currency areas before and during the financial crisis.

Anchoring of inflation expectations is of key importance in conducting monetary policy (see, e.g., Trichet (2005) and Bernanke (2007)). One method to assess the degree of anchoring is by analysing the reactions of medium- to longer-term inflation expectations when new information on inflation and economic indicators is brought to the market. If they are reacting strongly to releases of conjunctural information, it suggests that economic agents do not expect the central bank to react credibly and fast to changing economic conditions. Similarly, when medium- to longer-term inflation expectations are not influenced by economic news releases, it indicates that market participants are confident that monetary policy will be adjusted to counter any risk to the inflation objective of the central bank (see, e.g., Clarida, Galí, and Gertler (2000)).

This paper studies the strength of anchoring of inflation expectations before and during the financial crisis in the euro area and the United States by evaluating the responsiveness of spot and forward market-based measures of inflation expectations to the announcements of surprises in inflation and economic data. The forward measures are particularly important to analyse, as they enable one to distinguish between effects that are related purely to current inflation developments and the expectations beyond the short-term dynamics. In contrast to previous studies on this topic, we control explicitly for the effects of safe haven flows that can influence liquidity conditions and thus the pricing of nominal and inflation-linked bonds.

Overall, the paper finds a somewhat firmer anchoring of inflation expectations in the euro area than in the United States. In the euro area, the degree of anchoring of inflation expectations did not change materially during the period of financial crisis, while in the United States it decreased somewhat. In particular, firstly, we find that euro area spot break-even inflation rates react to inflation data releases, while forward rates do not react. This effect does not change with the crisis. Secondly, while US spot break-even inflation rates react to inflation data releases already before the crisis, forward rates also start to react to such announcements with the onset of the crisis. Thirdly, US break-even inflation rates react to real activity indicators, most notably to the employment data, and the strength of the reaction appears to increase in the crisis period. The reaction of euro area break-even inflation rates to real activity indicators is weaker and mainly observed for the spot rates. Additionally, we explore the reaction of nominal bond markets and find that the most influential announcements are US labour market data as well as survey-based confidence measures such as, for example, PMIs. Finally, the results confirm that safe-haven flows influence break-even inflation rates and nominal yields, putting mostly a downward pressure on both, especially during the crisis period.

The results of this paper contribute to the literature on the anchoring of inflation expectations by exploring the differences between the pre-crisis and crisis periods, and by controlling for important liquidity effects observed in the bond markets. Recent papers on this topic also focus mainly on the market-based measures of inflation expectations, as the survey-based measures are usually available at a relatively low frequency.¹ In particular, Ehrmann, Fratzscher, Gürkaynak, and Swanson (2011) find that the anchoring of long-term inflation expectations increased substantially in the euro area countries since the EMU. On a similar note, Gürkaynak, Levin, and Swanson (2010) show that inflation expectations are more firmly anchored in an economic area where the central bank has a defined inflation target, than compared to in an area where the central bank does not have an inflation target. They show that US inflation expectations react to US

¹However, some recent research based on survey measures suggest that euro area inflation expectations remained well-anchored for longer-term horizons (see, e.g., Galati, Heemeijer, and Moessner (2011) or European Central Bank (2012)).

consumer price index releases and certain real activity indicators. Their results confirm the findings of Coffinet and Frappa (2008). Additionally, the latter paper shows that long-term measures of inflation expectations in the euro area are less responsive to economic news than short-term measures. Beechey, Johannsen, and Levin (2011) reach a consistent conclusion for the period up to the financial crisis by showing that measures of long-term forward inflation expectations are more firmly anchored in the euro area than in the United States, as they react less to economic announcements. Finally, Galati, Poelhekke, and Zhou (2011) apply structural break tests and find that the sensitivity of longer-term inflation expectations to economic news increased somewhat for the euro area, the United Kingdom and the United States when the crisis broke out. In view of these findings, our paper compares the reactions of the spot and forward inflation expectations to a set of the most important economic announcements, analysing the changes in the degree of anchoring of expectations in the four years of the financial crisis. In addition to the previous literature, we explicitly control for financial market liquidity effects in the euro area and the United States.

The remainder of the paper is organised as follows: Section 2 discusses the inflation-linked and nominal bond market data, as well as the announcement data for the euro area and the United States. Section 3 presents the estimation methodology and the results. Section 4 concludes.

2 Data

This section presents descriptive statistics of the data on inflation-linked and nominal bond markets. In the latter part, we present the data on economic announcements.

2.1 Market data

We use daily data for the spot and the longer-term forward break-even inflation rates (maturities of 5-year and 5-year forward 5 years ahead, respectively). Those maturities are chosen because of common use in central banks' and private sectors' analyses

of market-based inflation expectations. Taking other maturities into account does not change our conclusions materially. The data on euro area break-even inflation rates and nominal bond yields are provided by the European Central Bank. The European Central Bank estimates euro area real and nominal yield curves, and monitors break-even inflation rates (i.e. the difference between nominal and real yields) on a regular basis (see, e.g. European Central Bank (2012), European Central Bank (2011a), and European Central Bank (2011b)). For the United States, data on nominal yields are based on Thomson Reuters, and data on the break-even inflation rates are based on Federal Reserve Board staff calculations (see also Gürkaynak, Sack, and Wright (2010)).

The data sample covers the period from 1 February 2004 to 30 July 2012. In contrast to previous literature, our sample covers enough observations of announcements to consider possible crisis-related changes in the reactions to news releases. In particular, we are able to analyse both, the period of generally calm market conditions and the period characterised by the financial crisis. We divide our sample into two subperiods with a similar number of observations. The first subperiod, "the pre-crisis period", dates from 1 February 2004 to 31 December 2007 and has 1021 daily observations. The second, "the crisis period", is from 1 January 2008 to 30 July 2012 and has 1196 observations.

Table 1: Descriptive statistics of nominal and break-even inflation rates data

		Pre-crisis				Crisis			
		Med.	Std.	Min.	Max.	Med.	Std.	Min.	Max.
EA	BEIR5y	2.08	0.09	1.90	2.39	1.70	0.40	0.38	2.92
	BEIR55y	2.22	0.12	2.03	2.56	2.38	0.19	1.69	2.83
	nominal5y	3.50	0.49	2.51	4.55	2.53	0.89	0.65	4.73
	nominal55y	4.25	0.45	3.48	5.27	4.52	0.52	2.74	5.43
US	BEIR5y	2.37	0.20	1.89	2.92	1.79	0.84	-1.72	2.67
	BEIR55y	2.66	0.18	2.34	3.36	2.81	0.27	2.03	3.62
	nominal5y	4.26	0.58	2.64	5.24	2.01	0.76	0.54	3.75
	nominal55y	4.79	0.31	4.10	5.67	4.42	0.73	2.23	5.33

NOTE: This table reports descriptive statistics of nominal and break-even inflation rates data. Column labelling corresponds to: 'Med.' - median, 'Std.' - standard deviation, 'Min.' - minimum, and 'Max.' - maximum values. The sample period is 1 February 2004 to 30 July 2012. Subperiods are defined: "Pre-crisis" from 1 January 2004 to 31 December 2007 and "Crisis" from 1 January 2008 to 30 July 2012. Both periods contain a similar number of observations.

Descriptive statistics of the nominal and break-even inflation rates are presented in Table 1. The table shows that during the crisis, all analysed markets are characterised

by a higher yield dispersion, both in terms of the standard deviation and the minimum and maximum values reached throughout the period. This additionally illustrates the need to analyse the pre-crisis and crisis periods separately.

2.2 Announcement data

The data on economic announcements cover the euro area and the United States. We choose the most important real activity and inflation-related indicators, focusing in particular on the announcements which are released relatively early after the end of the reference period.² The data are based on Bloomberg and use advance or flash releases when these exist, because new information is likely to be priced by the financial markets already with the flash release. For each announcement we observe the release date, the actual release number (A) as well as the median of analyst forecasts (F). We assure specifically for each economic news indicator that its distributions of expectations are not distorted and that the survey of analysts' forecasts appears to be updated timely. We calculate the surprise for data indicator i at day t as $S_{it} = A_{it} - F_{it}$, interpreting it as a proxy for unanticipated information conveyed by a given release of the economic news indicator.³

Finally, we make sure that the chosen data releases for the United States take place in the morning when euro area markets are still actively trading, and that announcements are not systematically coincident with respect to announcement dates, which, under some conditions, could lead to problems with identification. Table 2 presents the chosen announcements, the number of observations and the number of overlapping releases, and shows that there are indeed no full overlaps of announcement days.

²See, for example, Hess and Niessen (2010) or Hess (2004) for evidence that early-released news within a certain category is more important for market participants than news being released less timely.

³This definition of surprises, in contrast to the standardised surprise measure applied, e.g., in Balduzzi, Elton, and Green (2001), allows us to interpret market reactions in basis points per actual unit of a given release.

Table 2: Number of overlapping dates of the announcement releases

			All	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Flash HICP	Ez	1	102	102	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
PPI	Ez	2	101	1	101	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Unemployment	Ez	3	102	33	17	102	.	.	.	.	.	.	.	.	.	.	.	.	.
Manufacturing PMI	Ez	4	99	3	0	18	99	.	.	.	.	.	.	.	.	.	.	.	.
ZEW	Ez	5	102	0	0	0	1	102	.	.	.	.	.	.	.	.	.	.	.
Consumer Confidence	Ez	6	98	40	4	13	9	1	98	.	.	.	.	.	.	.	.	.	.
GDP constant prices	Ez	7	64	4	8	5	6	6	3	64	.	.	.	.	.	.	.	.	.
Industrial Production	Ez	8	101	0	0	0	0	12	0	5	101	.	.	.	.	.	.	.	.
CPI	US	9	102	0	0	0	4	5	1	7	10	102	.	.	.	.	.	.	.
PPI	US	10	102	0	0	1	2	29	1	5	17	0	102	.	.	.	.	.	.
Import Prices	US	11	102	0	0	0	0	6	0	5	18	0	0	102	.	.	.	.	.
Nonfarm Payrolls	US	12	102	3	14	16	3	0	1	3	0	0	0	0	102	.	.	.	.
Initial Jobless Claims	US	13	443	16	19	13	27	0	29	16	17	20	25	34	2	443	.	.	.
Chicago PMI	US	14	102	80	0	33	0	0	45	4	0	0	0	0	0	19	102	.	.
GDP	US	15	67	22	0	12	1	0	18	2	0	0	0	0	0	20	26	67	.
Industrial Production	US	16	102	0	0	0	1	15	0	5	9	37	20	8	0	13	0	0	102

NOTE: This table reports the number of overlapping dates of the announcements. Labelling in the second column stands for: 'Ez' - Eurozone, 'US' - United States. The column labelled 'All' presents the number of all announcement releases. Euro area Flash HICP and US CPI are year over year. Euro area and US GDP are quarter over quarter. Industrial productions, PPIs and US import prices are month over month. Nonfarm payrolls and initial jobless claims are measured in 1000 persons. Euro area unemployment is in per cent. All others are in levels. The ZEW covers only Germany but is widely considered an important survey indicator for the euro area economy. The GDP announcement indicators contain the advance and the second estimates for both the United States and the euro area.

Table 3: Descriptive statistics of economic announcement data

		Pre-crisis						
		All	Pos.	Neg.	Zero	Med. pos.	Med. neg.	Std.
Flash HICP	Eurozone	46	10	10	26	0.10	-0.10	0.09
PPI	Eurozone	46	12	10	24	0.10	-0.10	0.10
Unemployment	Eurozone	46	5	18	23	0.20	-0.10	0.10
Manufacturing PMI	Eurozone	43	16	26	1	0.34	-0.48	0.64
ZEW	Eurozone	47	16	31	0	5.95	-6.60	8.22
Consumer Confidence	Eurozone	44	13	14	17	1.00	-1.00	0.95
GDP constant prices	Eurozone	29	6	5	18	0.10	-0.10	0.09
Industrial Production	Eurozone	46	20	22	4	0.30	-0.50	0.47
CPI	US	47	19	17	11	0.20	-0.10	0.16
PPI	US	47	26	18	3	0.35	-0.35	0.58
Import Prices	US	47	27	18	2	0.50	-0.35	0.60
Nonfarm Payrolls	US	47	21	26	0	32.00	-59.50	77.60
Initial Jobless Claims	US	204	94	103	7	10.50	-8.00	15.70
Chicago PMI	US	47	29	18	0	3.30	-3.25	4.97
GDP	US	30	9	19	2	0.20	-0.40	0.47
Industrial Production	US	47	19	24	4	0.30	-0.30	0.33
		Crisis						
		All	Pos.	Neg.	Zero	Med. pos.	Med. neg.	Std.
Flash HICP	Eurozone	56	19	17	20	0.10	-0.10	0.15
PPI	Eurozone	55	17	23	15	0.10	-0.10	0.21
Unemployment	Eurozone	56	18	7	31	0.10	-0.10	0.10
Manufacturing PMI	Eurozone	54	26	24	4	0.85	-1.10	1.38
ZEW	Eurozone	55	27	28	0	8.00	-4.20	9.20
Consumer Confidence	Eurozone	54	21	23	10	1.10	-1.00	1.69
GDP constant prices	Eurozone	35	9	7	19	0.20	-0.10	0.15
Industrial Production	Eurozone	55	26	28	1	0.40	-0.35	0.65
CPI	US	55	19	21	15	0.20	-0.20	0.19
PPI	US	55	26	25	4	0.35	-0.30	0.45
Import Prices	US	55	27	24	4	0.50	-0.30	0.63
Nonfarm Payrolls	US	55	21	34	0	45.00	-56.00	70.56
Initial Jobless Claims	US	239	124	109	6	13.50	-10.00	20.55
Chicago PMI	US	55	36	19	0	2.95	-2.80	3.78
GDP	US	37	13	18	6	0.20	-0.35	0.51
Industrial Production	US	55	26	25	4	0.20	-0.40	0.47

NOTE: This table reports descriptive statistics of economic announcement data. Column labelling corresponds to: 'All' - number of all observations, 'Pos.' - number of positive surprises, 'Neg.' - number of negative surprises, 'Zero' - number of zero surprise releases, 'Med. pos.' - median of positive surprises, 'Med. neg.' - median of negative surprises and 'Std.' - standard deviation of surprises. The sample period is 1 February 2004 to 30 July 2012. Subperiods are defined: "Pre-crisis" from 1 January 2004 to 31 December 2007 and "Crisis" from 1 January 2008 to 30 July 2012. Both periods contain a similar number of observations.

Descriptive statistics of the announcement data are presented in Table 3. It shows that the number of releases with positive and negative surprises is relatively balanced and, for many releases, it is large in comparison to the number of releases with a zero surprise. Figure 1 presents the distributions of surprises in the pre-crisis and crisis samples for three selected economic releases. We observe that, usually, small surprises are most frequent, and that the dispersion of surprises increases visibly during the crisis.

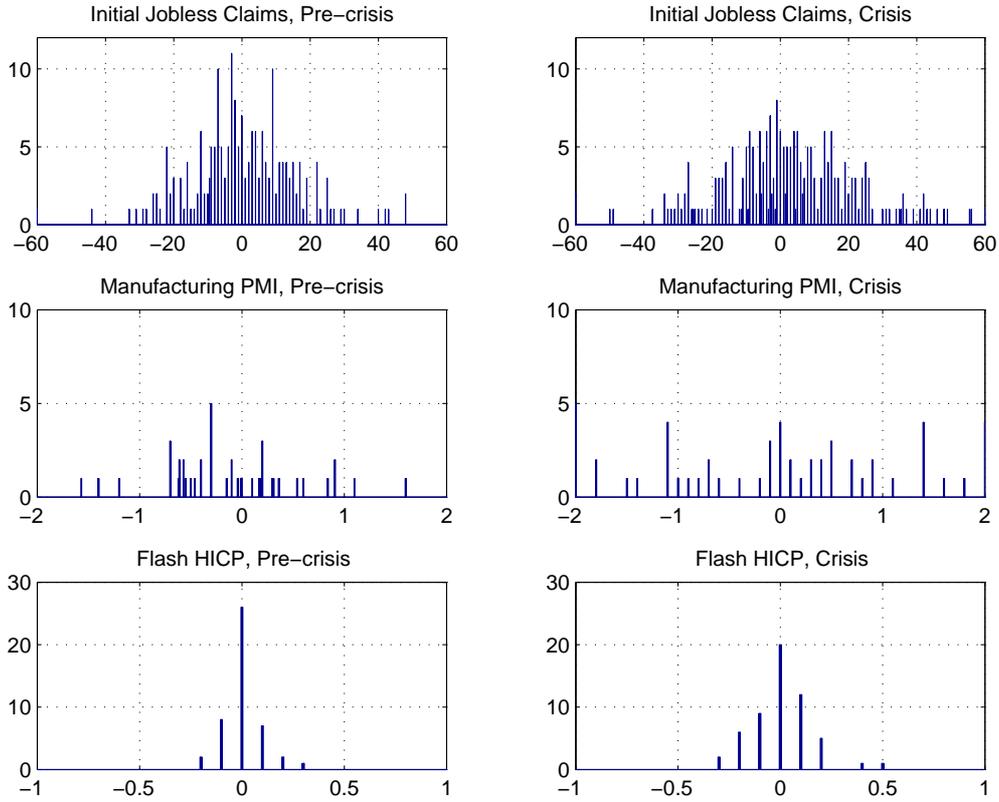


Figure 1: Distributions of surprises for selected economic announcements

NOTE: The figure shows the distributions of surprises for selected economic announcements. The sample period is 1 February 2004 to 30 July 2012. Subperiods are defined: "Pre-crisis" from 1 January 2004 to 31 December 2007 and "Crisis" from 1 January 2008 to 30 July 2012. Both periods contain a similar number of observations.

3 Estimation methodology and results

The following section describes the methodology and discusses estimation results and their robustness.

3.1 Estimation methodology

Bond yields, and thus also break-even inflation rates, tend to be predictable and correlated (see, e.g., Diebold and Li (2006)). Therefore, this analysis is based on first differences of daily observations of break-even inflation rates and nominal yields. Another empirical time series characteristics of yield data is heteroscedasticity of the first differences, i.e. different variance of the daily changes over time. Therefore, we apply a GARCH model, and we choose a specification of order (1,1). The results do not change materially for other specifications of the GARCH model. The innovations are modelled as being distributed according to the Student's t-distribution, which is more flexible in accounting for fat tails in comparison to the Gaussian distribution.

We control for possible distortions from changes in bond market liquidity conditions. Based on the literature on liquidity and credit risk premia in government bond markets, effects from these risk premia are sizeable, especially during turbulent market conditions (see, e.g., Beber, Brandt, and Kavajecz (2009), Krishnamurthy (2010), or Schwarz (2011)). Importantly, changes in market liquidity conditions could affect nominal and inflation-linked bond markets asymmetrically and thereby distort break-even inflation rates. Specifically, as a control variable for the euro area, we include the spread between the yields on five-year German government-guaranteed agency bonds and five-year government bonds (see Ejsing, Grothe, and Grothe (2012)). For the United States, we use the spread between ten-year on-the-run and off-the-run Treasury bonds (see, e.g., Warga (1992)).⁴ Note in this respect that main findings of this paper are also robust

⁴The choices of maturities for liquidity proxies do not influence the results materially. For the euro area we choose the five-year maturity, because our analysis of break-even inflation rates focuses on 5-year spot rates and 5-year forward 5 years ahead maturities. Using ten-year liquidity proxy gives similar results. We choose the ten-year maturity for the United States as this is the most liquid market segment for US nominal Treasuries, and so the on-the-run/off-the-run liquidity effects are most pronounced in that segment.

to the choice of the distribution for the innovations and to including control proxies for liquidity effects.

We include the surprises on all analysed announcements in the mean equation of the GARCH model, and the resulting model is:

$$dy_t = \alpha_0 + \alpha_1 liq_t + \sum_{i=1}^N \beta_i S_{it} + \varepsilon_t, \quad (1)$$

where dy_t denotes the first difference of the break-even inflation rate or the nominal yield on a given day. liq_t denotes the daily change in the liquidity premium, as defined above, S_{it} denotes the surprise of indicator i on day t , as defined in Subsection 2.2, and N is the total number of economic indicators. The innovation term is $\varepsilon_t = \sigma_t z_t$, where z_t is Student's t-distributed with the unknown number of degrees of freedom, and variance specified by

$$\sigma_t^2 = \gamma_0 + \gamma_1 \sigma_{t-1}^2 + \gamma_2 \varepsilon_{t-1}^2. \quad (2)$$

The model is estimated separately for the euro area and the United States, using in both cases the announcements from both currency areas to check for possible cross-regional reactions. For each of the two currency areas, we estimate the model for spot and forward break-even inflation rates and nominal bond yields. Spot rates are defined as 5-year rates, while forward rates are defined as 5-year forward rates 5 years ahead.⁵ To explore the crisis-related changes in the reaction to the announcements, and thus possible changes in the anchoring of monetary policy expectations, we perform the analysis separately for the pre-crisis and crisis periods described earlier. We also estimate the model for real yields and inflation swap rates, and report these results in Tables A-1 and A-2 in the Appendix.⁶ Statistical properties of all estimated models are reported in Tables A-3 and A-4 in the Appendix.

⁵These are the maturities most frequently reported by the ECB, the Federal Reserve and other international institutions. Taking other maturities into account does not change the conclusions materially.

⁶Inflation swap markets in the United States are less liquid than inflation bond markets, especially during the beginning of the sample. Therefore, the results for break-even inflation rates are more reliable. Data on inflation swaps are from Thomson Reuters.

3.2 Results

The estimated parameters of our models are reported in Table 4 for the break-even inflation rates, and in Table 5 for the nominal bond yields. The results show the following:

Euro area spot break-even inflation rates react to inflation data releases, but forward rates do not react. This result does not change with the crisis.

Euro-area break-even inflation rates react significantly to flash estimates of the euro area HICP, but mostly at the short end of the break-even inflation curve. The average reaction for the spot break-even inflation rate to a surprise of one standard deviation in the HICP flash release is relatively muted and amounts to 0.5 basis points before the crisis and 1.7 basis points during the crisis.⁷ Forward break-even inflation rates remain not significantly influenced by inflation data announcements also during the crisis. These results are in line with the notion that today's surprises to inflation are most likely transitory, and in case they were to be of a more permanent nature, a central bank that is committed to achieving its medium-term inflation target would react. Thus, today's surprises in inflation data releases should not influence longer-term forward break-even inflation rates when inflation expectations are well anchored around the central bank's target. Before the crisis, spot break-even inflation rates in the euro area seem to have reacted statistically significantly to some US inflation data releases. This does not change fully with the onset of the crisis, although the statistical significance of some of the reactions disappears.

US spot break-even inflation rates react to inflation data releases. Forward rates start to react to inflation data releases with the onset of the crisis. The reaction of US break-even inflation rates to surprises in US inflation data releases is significant for spot and, during the crisis, also for forward maturities. Before the crisis, the average reaction of spot rates amounted to 1.6 basis points to CPI surprises of 1 standard deviation.⁸ With the onset of the crisis, this reaction increases to 1.9 basis

⁷The standard deviation of HICP flash announcements is 0.09 percentage points in the pre-crisis period and 0.15 percentage points in the crisis period.

⁸The standard deviation of US CPI announcements is 0.16 percentage points in the pre-crisis period and 0.19 percentage points in the crisis period.

points, and forward rates also react significantly, namely by 0.9 basis points on average. Announcements of PPI data confirms this picture. Overall, this suggests that inflation expectations are less firmly anchored in the United States than in the euro area.

The reaction of euro area break-even inflation rates to real activity indicators is relatively weak and mainly observed for the spot rates. US break-even inflation rates react more strongly to real activity indicators, most significantly to the employment figures. This effect strengthens during the crisis.

The influence of real activity indicators on inflation expectations in the euro area is subdued, and mostly observed for the spot inflation rates, again indicating that market participants possibly expect the ECB to take measures if inflation would deviate from its target.⁹ Unexpected increases in the US employment lead to highly significant increases in US spot and forward break-even inflation rates. The reactions to a one standard deviation surprise in nonfarm payrolls is around 1.5 basis points for spot and only slightly less for forward break-even rates. Thus, also the economic significance of employment data appears high. The effects may possibly have increased slightly with the onset of the crisis. Similarly, weekly initial jobless claims releases also significantly influence spot and forward break-even inflation rates in the United States, and may have become even more important during the crisis. Higher reaction in the United States to news releases covering the real side of the economy is most probably due to the monetary policy objective of the Federal Reserve, which apart from inflation also includes employment. Finally, for both areas, the effects of survey-based economic indicators and production data (GDP and industrial production) seem non-systematic and generally have limited economic significance.

Nominal yields react especially to real activity indicators. The most influential announcements are again US employment figures, but also survey-based indicators of economic activity seem to have an influence. We find a significant reaction of nominal spot and forward yields to some inflation and especially real activity

⁹For a broader analysis of influences of real activity indicators on euro area break-even inflation rates, see, e.g., Ciccarelli and García (2009).

Table 4: Reaction of break-even inflation rates to economic announcements

Pre-crisis					
		Eurozone		US	
		spot	forward	spot	forward
α_0		0.02	-0.02	0.00	-0.01
liq		-0.27***	-0.05	-0.09**	0.14***
Flash HICP	Eurozone	5.70***	0.50	-1.94	2.51
PPI	Eurozone	2.12	2.81	7.21**	6.97**
Unemployment	Eurozone	2.58	2.89	3.04	-2.38
Manufacturing PMI	Eurozone	0.28	0.08	0.38	-0.06
ZEW	Eurozone	0.05**	0.03	0.11**	0.05*
Consumer Confidence	Eurozone	-0.51***	-0.01	0.63*	1.09***
GDP constant prices	Eurozone	1.42	-0.82	3.65	5.17
Industrial Production	Eurozone	-0.37	-0.34	-0.48	-1.25*
CPI	US	2.97***	0.10	9.90***	-1.46
PPI	US	0.59*	0.72*	1.09**	-0.30
Import Prices	US	0.33	0.21	0.87	-0.27
Nonfarm Payrolls	US	0.01***	0.00	0.02***	0.02***
Initial Jobless Claims	US	0.01*	-0.01	-0.03***	-0.01
Chicago PMI	US	0.03	0.04	0.10*	0.10*
GDP	US	0.14	1.18**	-0.18	0.33
Industrial Production	US	0.33	0.23	0.91	0.35
Crisis					
		Eurozone		US	
		spot	forward	spot	forward
α_0		0.06	0.01	0.18*	-0.06
liq		-0.30***	-0.29***	0.10**	0.30***
Flash HICP	Eurozone	11.14***	-5.85	2.21	3.14
PPI	Eurozone	-1.65	0.14	1.27	3.70
Unemployment	Eurozone	-15.19***	-9.91*	-4.61	7.88*
Manufacturing PMI	Eurozone	-0.08	0.15	1.00**	0.29
ZEW	Eurozone	0.05	0.07	0.03	-0.05
Consumer Confidence	Eurozone	-0.22	-0.24	0.27	0.68*
GDP constant prices	Eurozone	-1.59	-0.81	-10.36**	-10.44*
Industrial Production	Eurozone	0.46	0.37	1.50	0.55
CPI	US	3.54	-1.18	10.11***	4.91**
PPI	US	1.93*	2.06*	3.53***	3.06**
Import Prices	US	-0.25	-0.28	1.25*	-0.24
Nonfarm Payrolls	US	0.01*	-0.01*	0.03***	0.02**
Initial Jobless Claims	US	-0.03**	-0.00	-0.05***	-0.02*
Chicago PMI	US	0.02	0.02	-0.12	0.04
GDP	US	-2.79**	0.07	-0.07	2.03
Industrial Production	US	2.50***	-0.55	-1.70	-0.18

NOTE: This table reports the α - and β -coefficients of GARCH models as in eq. 1 (scaled by 100; "liq" denotes α_1 in eq. 1), for euro area and US spot and forward break-even inflation rates (in first differences). Spot rates are defined as 5-year rates, while forward rates are defined as 5-year forward rates 5 years ahead. The stars report the significance of coefficients (*** at 99%, ** at 95% and * at 90% confidence levels, respectively). The subsample periods are defined as: pre-crisis sample from 1 January 2004 to 31 December 2007 and the crisis sample from 1 January 2008 to 30 July 2012. Both periods contain a similar number of observations.

Table 5: Reaction of nominal yields to economic announcements

Pre-crisis					
		Eurozone		US	
		spot	forward	spot	forward
α_0		0.16**	-0.06	0.12	0.03
liq		-2.36***	-1.02***	-1.58***	1.59***
Flash HICP	Eurozone	2.58	3.33	8.48	-3.93
PPI	Eurozone	4.62	7.36**	5.36	3.68
Unemployment	Eurozone	3.70	-1.57	8.27	-10.05
Manufacturing PMI	Eurozone	1.98***	0.16	1.94*	1.82*
ZEW	Eurozone	0.12***	0.06*	0.06	0.06
Consumer Confidence	Eurozone	-0.00	0.20	0.27	0.95
GDP constant prices	Eurozone	5.30	7.42	11.37	15.36
Industrial Production	Eurozone	-1.56**	-1.26	-2.02*	-2.73**
CPI	US	-0.60	-4.09*	-3.72	2.34
PPI	US	0.73	0.45	0.41	-0.92
Import Prices	US	0.51	0.71	1.01	2.76***
Nonfarm Payrolls	US	0.04***	0.03***	0.09***	0.07***
Initial Jobless Claims	US	-0.04***	-0.02**	-0.07***	-0.03
Chicago PMI	US	0.11	0.10	0.53***	0.16
GDP	US	2.47***	1.47*	3.30***	1.40
Industrial Production	US	1.97	0.44	-0.08	4.50*
Crisis					
		Eurozone		US	
		spot	forward	spot	forward
α_0		-0.19**	-0.10	-0.23*	-0.03
liq		-1.03***	-0.53***	-0.37***	0.43***
Flash HICP	Eurozone	-5.59	-11.64***	-0.89	0.31
PPI	Eurozone	6.60**	4.38	6.43*	8.18
Unemployment	Eurozone	-2.82	-5.15	4.76	13.53
Manufacturing PMI	Eurozone	0.65**	0.38	0.80*	1.25*
ZEW	Eurozone	0.05	0.02	-0.04	-0.08
Consumer Confidence	Eurozone	-0.23	-0.46*	0.06	-0.03
GDP constant prices	Eurozone	-4.01	-4.56	-9.04	-12.53
Industrial Production	Eurozone	0.42	0.22	0.44	-0.34
CPI	US	4.04*	1.65	4.40	6.39
PPI	US	2.59***	1.94*	2.70*	5.13**
Import Prices	US	-0.82	-0.31	0.77	-0.44
Nonfarm Payrolls	US	0.02***	0.01*	0.06***	0.05***
Initial Jobless Claims	US	-0.03***	-0.01	-0.07***	-0.09***
Chicago PMI	US	0.02	-0.11	0.07	-0.12
GDP	US	0.48	1.13	2.09	0.50
Industrial Production	US	0.31	-1.98*	0.70	1.64

NOTE: This table reports the α - and β -coefficients of GARCH models as in eq. 1 (scaled by 100; "liq" denotes α_1 in eq. 1), for euro area and US spot and forward nominal bond yields (in first differences). Spot rates are defined as 5-year rates, while forward rates are defined as 5-year forward rates 5 years ahead. The stars report the significance of coefficients (*** at 99%, ** at 95% and * at 90% confidence levels, respectively). The subsample periods are defined as: pre-crisis sample from 1 January 2004 to 31 December 2007 and the crisis sample from 1 January 2008 to 30 July 2012. Both periods contain a similar number of observations.

data. These results are in line with earlier evidence for euro area nominal markets (see, e.g. Andersson, Overby, and Sebestyén (2009)), and for US nominal bond markets (see, e.g. Andersen, Bollerslev, Diebold, and Vega (2007) or Fleming and Remolona (1999)).¹⁰ We find that these reactions continue to be highly significant and important during the crisis period.

Analysing the market reactions from the cross-regional perspective, euro area nominal and break-even inflation rates react more significantly to news from the United States than US counterparts react to euro area news. One explanation for this could be that the importance of the United States for the global economy and inflation trends is greater than that of the euro area. However, it could also be a consequence of US data releases being more timely and therefore having a larger market impact (see, e.g. Ehrmann and Fratzscher (2004)). Finally, the results confirm also that safe-haven flows influence break-even inflation rates and nominal yields, putting mostly a downward pressure on both, especially during the crisis period.

Overall, the results provide evidence that euro area inflation expectations over the medium term, as measured by break-even inflation rates, are well anchored. Inflation expectations are somewhat less anchored in the United States than in the euro area. A strong degree of anchoring persisted also during the the period of financial crisis in the euro area, while the degree of anchoring appears to have decreased to some extent in the United States. The difference between the two currency areas may be related to the differing objectives of the corresponding monetary policy authorities.

3.3 Discussion of the robustness of results

The paper finds statistically significant reactions to various types of economic news announcements, and the estimated economic impact is often non-negligible.¹¹ As in the case of all event studies, it is important to keep in mind that releases of news are

¹⁰Also, they confirm the literature, which suggests that the US Employment Report and initial jobless claims data are some of the economic news which move not only domestic, but also international markets (see, e.g. Andersen, Bollerslev, Diebold, and Vega (2003)).

¹¹Also, in most cases, the sign of the reaction is in line with what can be expected from economic theory.

infrequent events, and that the number of observations of surprises is limited. For this reasons, we carefully choose only announcements with a sufficient number of non-zero observations in both, the pre-crisis and crisis periods. Still, in the cases when some important announcements only have relatively few non-zero observations, we make sure that we interpret the related results cautiously.

Regarding the frequency of the data, literature on announcement effects argues that important news are often priced within seconds (see, e.g. Ederington and Lee (1995) or Grothe (2010)). However, to evaluate anchoring of inflation expectations we are interested in impacts that are longer-lasting and not likely to disappear within minutes. Furthermore, it is only possible to analyse reactions of US rates to euro area news by using daily data, due to the time difference and the timing of news releases. Using daily data, as chosen in this paper, may implicate that the results are influenced by various other factors that we cannot account for, which will result in higher standard errors of estimated coefficients, i.e. possibly less significant estimates than when using data with higher frequency, as shown by Beechey and Wright (2008) for the United States.

Our analysis includes scheduled releases of economic data and does not include any political or banking sector-related news like, e.g., the bankruptcy of Lehman Brothers or the introduction of non-standard monetary policy measures. However, the choice of a GARCH model is taken to alleviate possible longer-lasting effects on the volatility in bond markets of such events. The GARCH variances confirm that break-even inflation rates were highly volatile in several periods of the crisis, and that it is therefore necessary to use a model that takes this into account (see also Figure A-1 in the Appendix).

As the main aim of the paper is to analyse the possible crisis-related changes to the degree of anchoring of inflation expectations, we cover a time period that is characterised by many extreme observations. We choose not to exclude extreme observations as outliers due to the resulting loss of valuable information. The trade-off to that decision is that the inference of announcements can be influenced by a few extreme observations (see, e.g. Booth, Thornton, and Sorokina (2013)). Therefore, we concentrate the

interpretation of results on reactions that appeared robust to the choice of analysed maturities, the model choice and inclusion of other variables.

Finally, regarding the choice of maturities and the specification of the model, we report the results for 5-year spot rates and 5-year forward rates 5 years ahead, as these are maturities mostly reported by the ECB, the Federal Reserve and other international institutions, as well as market commentators. We also run the regressions for 2- and 10-year maturities. Generally, 2-year rates react stronger, while 10-year rates react less. This is consistent with the notion that changes to current inflation are mostly transitory and that the effects therefore will gradually dissipate with the maturity of the break-even rates. The results are also not influenced materially by the choice of the order of the GARCH model, controlling for a higher order of autoregression, controlling for liquidity effects, or by the choice of the distribution for innovations.

4 Conclusion

Anchoring of inflation expectations is of key importance in conducting monetary policy and can be assessed by analysing the reactions in medium- to longer-term inflation expectations to newly released information on inflation and real activity indicators. If inflation expectations are not influenced by current news releases, it is a sign that economic agents tend to believe that as soon as there is a risk that the inflation objective of the central bank might not be met, monetary policy will be adapted. This makes inflation expectations firmly anchored.

In view of little evidence in the literature of possible crisis-related changes to the degree of anchoring, this paper analyses price formation in short- and long-term euro area and US inflation markets around the releases of important economic indicators during the pre-crisis and crisis periods separately, controlling explicitly for liquidity effects in the nominal bond and inflation markets.

We find that euro area markets react to a smaller number of macroeconomic announcements than US markets. In particular, euro area spot break-even inflation rates react

to inflation data releases, while forward rates do not react. This effect does not change with the crisis. US spot break-even inflation rates react to inflation data releases already before the crisis, but forward rates also start to react to inflation data releases with the onset of the crisis. Furthermore, US break-even inflation rates react to real activity indicators, in particular to employment data. This effect strengthens somewhat during the crisis. The reaction of euro area break-even inflation rates to real activity indicators is weaker and mainly observed for the spot rates.

In terms of anchoring of inflation expectations, we thus find a stronger anchoring in the euro area in comparison to the United States. The firm anchoring did not change during the period of financial crisis in the euro area, while in the United States, it decreased to some extent.

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Appendix

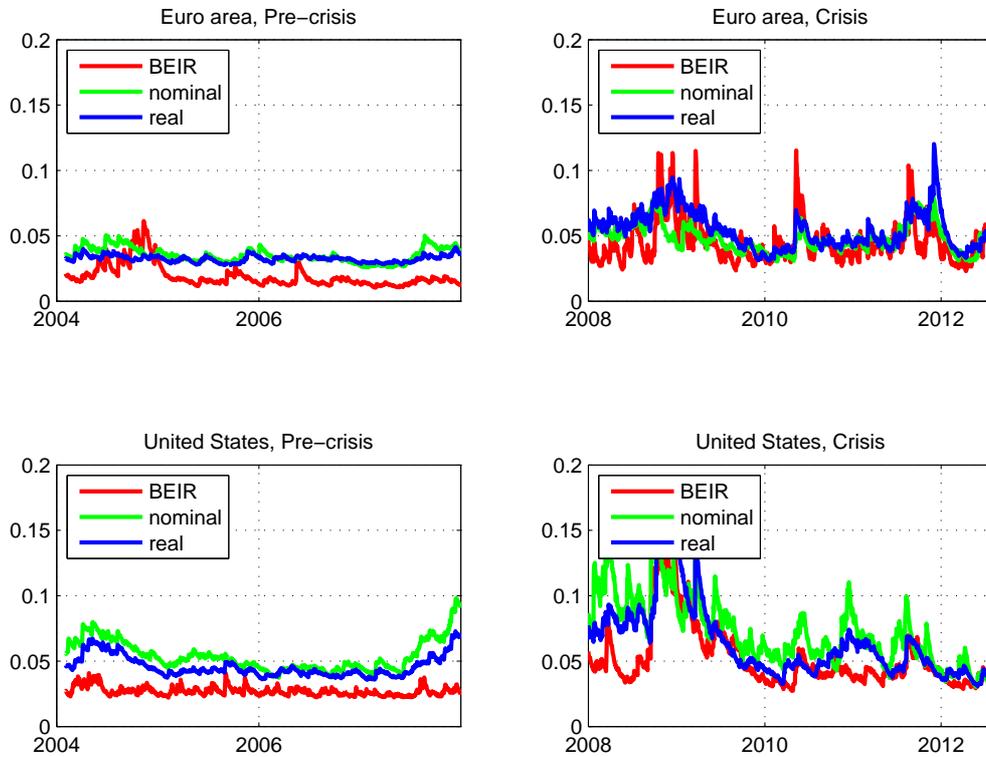


Figure A-1: Garch-volatilities of break-even inflation rates, nominal and real yields
NOTE: The figure shows the volatilities implied by GARCH(1,1) for 5-year break-even inflation rates, nominal and real yields in the euro area and US. The sample and subsample periods are defined as in Table 1.

Table A-1: Reaction of real yields to economic announcements

Pre-crisis					
		Eurozone		US	
		spot	forward	spot	forward
α_0		0.11	-0.05	0.15	-0.02
liq		-1.54***	-0.79***	-0.58***	-0.30***
Flash HICP	Eurozone	1.79	6.88*	11.59**	11.90**
PPI	Eurozone	0.93	-0.27	-4.58	1.92
Unemployment	Eurozone	2.66	-0.82	5.83	-1.08
Manufacturing PMI	Eurozone	1.09*	0.31	1.48*	0.82
ZEW	Eurozone	0.11***	0.05	-0.01	0.02
Consumer Confidence	Eurozone	0.63	0.31	0.02	-0.24
GDP constant prices	Eurozone	7.20	5.08	6.33	4.85
Industrial Production	Eurozone	-1.39*	-1.99**	-1.23	-1.30
CPI	US	-6.89***	-5.73**	-11.79***	-3.71
PPI	US	-0.51	-0.42	-0.25	0.48
Import Prices	US	0.81*	1.44**	0.02	0.30
Nonfarm Payrolls	US	0.04***	0.03***	0.06***	0.04***
Initial Jobless Claims	US	-0.04***	-0.02*	-0.04**	-0.04***
Chicago PMI	US	0.11*	0.14**	0.35***	0.20**
GDP	US	2.39**	1.04	3.71**	2.26*
Industrial Production	US	0.40	-0.95	-0.23	-0.63
Crisis					
		Eurozone		US	
		spot	forward	spot	forward
α_0		-0.16*	-0.05	-0.27**	-0.11
liq		-0.95***	-0.33***	0.10**	0.39***
Flash HICP	Eurozone	-13.05***	-7.87*	0.49	1.39
PPI	Eurozone	8.22***	1.78	4.64	6.60*
Unemployment	Eurozone	6.17	6.26	6.28	14.03**
Manufacturing PMI	Eurozone	0.77*	0.23	0.15	0.90**
ZEW	Eurozone	0.00	-0.08	-0.02	-0.02
Consumer Confidence	Eurozone	-0.30	0.07	-0.44	-0.69*
GDP constant prices	Eurozone	-5.63	-4.63	3.67	-9.05
Industrial Production	Eurozone	-0.27	-0.21	-0.86	-0.81
CPI	US	-0.83	-2.52	-14.43***	0.09
PPI	US	1.02	0.22	-1.04	1.87
Import Prices	US	-1.43*	-0.74	-0.19	0.58
Nonfarm Payrolls	US	0.02**	0.03***	0.04***	0.04***
Initial Jobless Claims	US	-0.03**	-0.03**	-0.04***	-0.07***
Chicago PMI	US	-0.06	-0.39**	0.15	0.13
GDP	US	2.72**	1.22	0.45	-1.24
Industrial Production	US	-3.03**	-1.45	3.92**	4.08**

NOTE: This table reports the α - and β -coefficients of GARCH models as in eq. 1 (scaled by 100; "liq" denotes α_1 in eq. 1), for euro area and US spot and forward real yields (in first differences). Spot rates are defined as 5-year rates, while forward rates are defined as 5-year forward rates 5 years ahead. The stars report the significance of coefficients (*** at 99%, ** at 95% and * at 90% confidence levels, respectively). The subsample periods are defined as: pre-crisis sample from 1 January 2004 to 31 December 2007 and the crisis sample from 1 January 2008 to 30 July 2012. Both periods contain a similar number of observations.

Table A-2: Reaction of swap rates to economic announcements

Pre-crisis					
		Eurozone		US	
		spot	forward	spot	forward
α_0		0.02	0.02	-0.06	-0.05
liq		-0.14**	-0.11*	0.09*	0.11*
Flash HICP	Eurozone	5.18***	-1.00	2.13	-1.93
PPI	Eurozone	0.75	4.90***	9.80***	10.08**
Unemployment	Eurozone	5.18***	1.90	-3.47	10.62**
Manufacturing PMI	Eurozone	-0.02	-0.62**	-0.44	1.09*
ZEW	Eurozone	0.04**	0.05**	0.05	-0.04
Consumer Confidence	Eurozone	-0.31**	-0.32*	-0.54	-0.01
GDP constant prices	Eurozone	1.01	0.20	-2.55	0.94
Industrial Production	Eurozone	-0.08	-0.02	-0.62	-0.98
CPI	US	3.90***	-1.07	6.70***	6.85***
PPI	US	0.73***	0.39	1.32**	-0.31
Import Prices	US	0.49*	1.05***	1.08*	-0.61
Nonfarm Payrolls	US	0.00	0.00	0.00	-0.00
Initial Jobless Claims	US	-0.01	-0.01	-0.01	-0.01
Chicago PMI	US	0.06**	0.11**	0.09	0.03
GDP	US	0.29	0.25	2.09**	-0.83
Industrial Production	US	-0.17	0.53	-0.13	0.82
Crisis					
		Eurozone		US	
		spot	forward	spot	forward
α_0		0.04	0.01	0.14*	-0.08
liq		-0.19***	-0.15***	0.13***	0.18***
Flash HICP	Eurozone	7.80***	2.58	2.59	-0.31
PPI	Eurozone	-1.80*	0.27	1.88	4.41**
Unemployment	Eurozone	4.13*	-5.25**	-0.62	0.07
Manufacturing PMI	Eurozone	0.24	-0.05	0.64**	-0.15
ZEW	Eurozone	0.03	0.04*	0.05	0.04
Consumer Confidence	Eurozone	-0.22	-0.02	-0.79***	0.50*
GDP constant prices	Eurozone	-2.33	0.19	1.28	-2.17
Industrial Production	Eurozone	0.18	-0.24	0.52	0.46
CPI	US	3.69**	1.22	16.69***	0.14
PPI	US	1.06**	1.05*	1.73**	1.17
Import Prices	US	-0.07	-0.31	0.62	1.05*
Nonfarm Payrolls	US	0.01*	0.01*	0.02***	0.01**
Initial Jobless Claims	US	-0.02**	-0.01*	-0.03***	-0.00
Chicago PMI	US	0.02	0.12*	-0.08	-0.13
GDP	US	-1.07	-1.20	-0.83	2.71**
Industrial Production	US	0.23	-1.01**	-1.14	-0.86

NOTE: This table reports the α - and β -coefficients of GARCH models as in eq. 1 (scaled by 100; "liq" denotes α_1 in eq. 1), for euro area and US spot and forward swap rates (in first differences). Inflation swap rates are from Thomson Reuters. Inflation swap markets in the United States are less liquid than inflation bond markets, especially during the beginning of the sample. Therefore, the results for break-even inflation rates are more reliable. Spot rates are defined as 5-year rates, while forward rates are defined as 5-year forward rates 5 years ahead. The stars report the significance of coefficients (*** at 99%, ** at 95% and * at 90% confidence levels, respectively). The subsample periods are defined as: pre-crisis sample from 1 January 2004 to 31 December 2007 and the crisis sample from 1 January 2008 to 30 July 2012. Both periods contain a similar number of observations.

Table A-3: Statistical properties of the models

<i>Break-even inflation rates</i>				
Pre-crisis				
Eurozone			US	
	spot	forward	spot	forward
γ_0	0.00***	0.00***	0.00***	0.00
γ_1	0.31***	0.34***	0.56***	0.96***
γ_2	0.29***	0.30***	0.13***	0.03***
LR test	0.00	0.65	0.00	0.00
LB test	0.00	0.00	0.20	0.25
Crisis				
Eurozone			US	
	spot	forward	spot	forward
γ_0	0.00***	0.00***	0.00**	0.00**
γ_1	0.81***	0.86***	0.93***	0.92***
γ_2	0.15***	0.09***	0.06***	0.07***
LR test	0.00	0.05	0.00	0.00
LB test	0.00	0.00	0.00	0.00
<i>Inflation swap rates</i>				
Pre-crisis				
Eurozone			US	
	spot	forward	spot	forward
γ_0	0.00*	0.00**	0.00***	0.00**
γ_1	0.96***	0.96***	0.56***	0.01
γ_2	0.03**	0.04***	0.33**	0.70**
LR test	0.00	0.01	0.17	0.18
LB test	0.05	0.00	0.00	0.00
Crisis				
Eurozone			US	
	spot	forward	spot	forward
γ_0	0.00***	0.00***	0.00***	0.00***
γ_1	0.84***	0.86***	0.77***	0.44***
γ_2	0.16***	0.12***	0.23***	0.56***
LR test	0.00	0.00	0.00	0.04
LB test	0.00	0.00	0.04	0.00

NOTE: This table reports the γ -coefficients of GARCH models as in eq. 2, for euro area and US spot and forward break-even inflation rates, nominal yields, real yields and inflation swap rates (all in first differences). The rows labelled "LR test" report the p-values of the likelihood ratio test, which compares the model in eq. 1 with the model where $\alpha_1 = 0$ and $\beta_i = 0$. The rows labelled "LB test" report the p-values of the Ljung-Box Q-Test for autocorrelation in the residual series. Spot rates are defined as 5-year rates, while forward rates are defined as 5-year forward rates 5 years ahead. The stars report the significance of coefficients (*** at 99%, ** at 95% and * at 90% confidence levels, respectively). The subsample periods are defined as: pre-crisis sample from 1 January 2004 to 31 December 2007 and the crisis sample from 1 January 2008 to 30 July 2012. Both periods contain a similar number of observations.

Table A-4: Statistical properties of the models

<i>Nominal yields</i>				
Pre-crisis				
Eurozone			US	
	spot	forward	spot	forward
γ_0	0.00	0.00*	0.00	0.00**
γ_1	0.97***	0.88***	0.97***	0.91***
γ_2	0.02**	0.05***	0.03***	0.06***
LR test	0.00	0.00	0.00	0.00
LB test	0.15	0.76	0.04	0.00
Crisis				
Eurozone			US	
	spot	forward	spot	forward
γ_0	0.00**	0.00***	0.00*	0.00***
γ_1	0.93***	0.85***	0.93***	0.89***
γ_2	0.05***	0.12***	0.06***	0.08***
LR test	0.00	0.00	0.00	0.00
LB test	0.07	0.10	0.00	0.00
<i>Real yields</i>				
Pre-crisis				
Eurozone			US	
	spot	forward	spot	forward
γ_0	0.00*	0.00	0.00	0.00
γ_1	0.03	0.88***	0.97***	0.97***
γ_2	0.05	0.03*	0.03***	0.02**
LR test	0.00	0.00	0.00	0.00
LB test	0.11	0.33	0.00	0.32
Crisis				
Eurozone			US	
	spot	forward	spot	forward
γ_0	0.00**	0.00***	0.00**	0.00***
γ_1	0.93***	0.84***	0.93***	0.91***
γ_2	0.06***	0.11***	0.06***	0.07***
LR test	0.00	0.00	0.00	0.00
LB test	0.00	0.64	0.00	0.16

NOTE: This table reports the γ -coefficients of GARCH models as in eq. 2, for euro area and US spot and forward break-even inflation rates, nominal yields, real yields and inflation swap rates (all in first differences). The rows labelled "LR test" report the p-values of the likelihood ratio test, which compares the model in eq. 1 with the model where $\alpha_1 = 0$ and $\beta_i = 0$. The rows labelled "LB test" report the p-values of the Ljung-Box Q-Test for autocorrelation in the residual series. Spot rates are defined as 5-year rates, while forward rates are defined as 5-year forward rates 5 years ahead. The stars report the significance of coefficients (*** at 99%, ** at 95% and * at 90% confidence levels, respectively). The subsample periods are defined as: pre-crisis sample from 1 January 2004 to 31 December 2007 and the crisis sample from 1 January 2008 to 30 July 2012. Both periods contain a similar number of observations.