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Inflation expectation indicators based on financial instrument prices

Alberto Fuertes and Ricardo Gimeno

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This article shows how indicators of agents' inflation expectations can be derived from the prices of various financial instruments and presents the estimates obtained for the euro area and the United States. The results show that these metrics have reacted to economic and monetary decisions made in recent years, and that, on average, expected inflation is lower and less volatile in the euro area than in the United States.

Moreover, since end-2016 there has been a marked rise in the probability of observing long-term inflation rates above 2% in the United States, coinciding with the likely change in the country's economic policy stance. Changes in the indicators for the euro area have been less pronounced over this period, although a marked drop in the probability of low or negative inflation rates has been observed.

INFLATION EXPECTATION INDICATORS BASED ON FINANCIAL INSTRUMENT PRICES

The authors of this article are Alberto Fuertes and Ricardo Gimeno, of the Directorate General Economics, Statistics and Research.

Introduction

Agents' inflation expectations are decisive when studying changes in many of the variables shaping households' and firms' decision-making. As well as the average value of expectations, the probability agents assign to extreme inflation scenarios is also significant (such scenarios might include extremely high or negative inflation rates), given the impact these expectations have on the economy's growth and stability. In this connection, there are therefore various approaches to measuring agents' expectations. One approach is based on the consensus view of specialist economic forecasters, such as the surveys of professional forecasters by the European Central Bank and the Federal Reserve Bank of Philadelphia, both of which are released quarterly. Other surveys also exist, such as the University of Michigan Survey of Consumers in the United States, which elicits information from consumers rather than professional forecasters, and is produced monthly. These surveys have the drawback that they are released relatively infrequently and the information is received with something of a time lag. Moreover, they only cover a small range of time horizons (one, three and five years) and, as identified in the literature [Ang et al. (2007); Chan et al. (2013)], there is bias and inertia in the responses.

An alternative way of obtaining agents' inflation expectations is to use the prices of market-traded financial instruments employed to hedge against inflation. One advantage of this approach is that, as well as the mean distribution of expectations, it is possible to derive the whole probability function. This makes it possible to estimate the probability of the occurrence of certain extreme events or the uncertainty of future inflation, for example. Another additional advantage in comparison with surveys is that changes in expectations can be observed almost in real time. This makes it easier to identify the effect of specific events or decisions on inflation expectations.

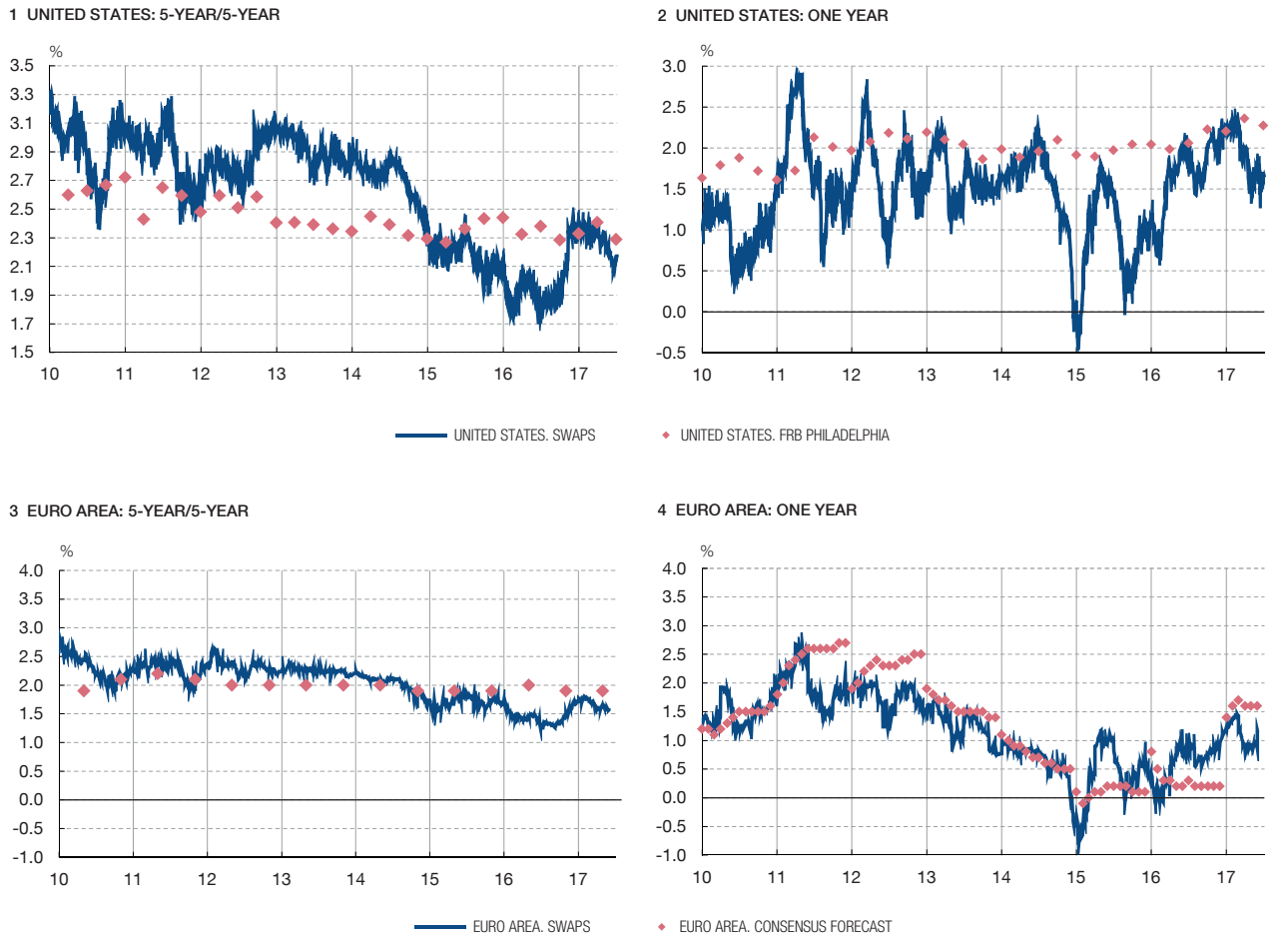
Chart 1 compares the expectations produced by a survey of analysts with those obtained from inflation swaps in each of the two areas over various intervals.[1] As can be seen, over the short term they both give very similar signals, particularly in Europe, whereas over the longer term, there is less dispersion in the information from surveys, as they react more moderately to factors such as fluctuations in commodity prices or shifts in monetary or fiscal policy. Thus, for example, the inflation expectations obtained from swaps in the United States rose considerably in the wake of the recent presidential elections, although this did not show up in the survey data.

These divergences between the surveys and inflation swaps over the longer term are at least partly due to the fact that the latter have different risk premia, which are included in the prices of the underlying financial assets and which may also vary over time. The presence of these premia may distort the information content of these indicators as a measure of agents' inflation expectations.

Following this introduction, this article comprises two further sections. The first describes the financial instruments from which information about inflation expectations can be

1 Using the methodology explained in the following sections

INFLATION EXPECTATIONS OBTAINED FROM MARKET DATA (a) VS. FORECASTER SURVEYS (b) CHART 1



SOURCES: Banco de España, Federal Reserve Bank of Philadelphia and Consensus Forecast.

a Inflation expectations calculated using market data comprise the compensation demanded by investors for increases in the price level obtained from daily swap data for the US and euro area, using the methodology of Gimeno and Ibáñez (2017).
b The sources of the inflation expectations based on survey data are the Federal Reserve Bank of Philadelphia in the US (released quarterly) and the Consensus Forecast for the euro area (short-term forecast released monthly, long-term forecast six-monthly). Survey data refer to year-end, whereas swap data refer to 9-month inflation, such that the horizon is the same in April of each year [see Gimeno and Ortega, (2016)].

derived, and the second presents the results of applying a methodology enabling derivation of a risk-neutral probability function of agents' inflationary expectations to data for the euro area and the United States.

Financial instruments with information about inflation expectations

INFLATION-LINKED BONDS

One of the most popular metrics of inflation expectations (breakeven inflation rates) based on financial asset prices is that obtained from inflation-linked bonds. This metric is calculated by comparing the yield of a conventional bond (whose associated coupon and principal payments are fixed in nominal terms) with that of an inflation-linked bond (indexed to a price index) of the same maturity from the same issuer.

The inflation-linked bond market is particularly active in the United States, where these assets (known as Treasury inflation-protected securities or TIPS) are issued in sufficient quantity to create a liquid market in which price formation is fluid. By contrast, the situation in Europe is characterised by fragmentation due to the existence of multiple issuers (namely the treasuries of France, Italy and Germany, which are traditional issuers, and Greece, a less frequent issuer, which were joined by Spain in 2014) and the use of different consumer price indices (national and European) as their reference, which reduces liquidity

FACTORS INCLUDED IN BOND PRICES

TABLE 1

Conventional bond factors	Inflation-linked bond factors	Inflation compensation factors
Real interest rate expectations	Real interest rate expectations	
Real interest rate risk premium	Real interest rate risk premium	
Inflation expectations		Inflation expectations
Inflation risk premium		Inflation risk premium
Nominal bond liquidity premium	Inflation-linked bond liquidity premium	Liquidity premium spread

SOURCE: Banco de España.

and is an obstacle to obtaining a clear signal on the compensation demanded by investors for the expected increases in the cost of living.

An additional problem with this indicator is that it includes other components as well as investors' expectations about future price developments. Firstly, to the extent that investors are averse to inflation risk, they will demand a premium on conventional bonds that compensates them for the risk incurred, but not on inflation-linked bonds, as they are protected against this risk. For this reason, the indicator does not strictly measure the level of expectations, but the compensation for inflation investors demand. Secondly, the different level of liquidity of the two instruments used to obtain the indicator (generally higher for conventional bonds than inflation-linked ones), means the yield spread between them is also influenced by their different liquidity premiums. Table 1 summarises these components for each bond type, and for the inflation compensation indicator. As well as the inflation-related factors mentioned, conventional bonds include a component reflecting the expected future course of the real interest rate, together with its associated risk premium. Finally, it should be borne in mind that the size of the premia present in the break-even rate (inflation risk and relative liquidity) may change over time, depending on changes in investors' risk appetite, the level of inflation risk, or market liquidity conditions.

The inflation compensation metric derived from inflation-linked bonds may be temporarily affected by other factors additional to those mentioned. Thus, for instance, changes in the supply and demand for conventional bonds relative to that for inflation-linked bonds, such as those associated with quantitative easing programmes,[2] for example, may cause distortions in these indicators. Given all these drawbacks, an extensive academic literature has developed seeking to isolate the various different components of the inflation expectation indicators obtained from inflation-linked bonds.[3]

INFLATION-LINKED SWAPS

Along with inflation-linked bonds, inflation-linked swaps (ILS) are another type of financial asset containing information about agents' inflation expectations. In this derivative instrument, one of the contracting parties undertakes to pay the other a fixed sum on a future date in exchange for a payment linked to the future level of a price index. For example, in the case of a one-year ILS, the fixed-rate party could agree to pay 2% of €1 million in consideration for receiving the fraction of this nominal €1 million equivalent to the increase

2 Only conventional government bonds were purchased in the Federal Reserve Board's first quantitative easing programme. During the Federal Reserve Board's second quantitative easing programme (QE II), a total of $600 billion-worth of government securities was purchased, of which $26 billion was in the form of inflation-linked bonds. The fact that more conventional bonds are being bought than inflation-linked bonds could push down their relative yield, and therefore depress the inflation expectations indicator in a way that is due to a mismatch in the supply and demand for bonds used to calculate the indicator rather than to agents' forecasts of future consumer price trends.

3 See, for example, D'Amico et al. (2014) and Chernov and Mueller (2012).

in the CPI over this twelve-month period. Contrary to the case of inflation-linked bonds, the ILS market is more liquid in Europe than in the United States [Gimeno and Ibáñez (2017)].

ILSs are bilaterally negotiated private contracts with no intermediary clearing house. This can create the risk of the other party failing to meet its commitment at the end of the period, such that the negotiated price incorporates the corresponding premium. Nevertheless, the absence of cash transfers until maturity reduces the size of this premium, as well as the liquidity premium, as there is no opportunity cost relative to alternative investments [Fleming and Sporn (2013)].[4]

Like inflation-linked bonds, inflation swaps contain an inflation risk premium. They therefore measure compensation for inflation as well as inflation expectations. One of the main advantages of the ILS-based indicator relative to that obtained from inflation-linked bonds is that, as it is not necessary to compare two different bonds, the distortions caused by ad hoc factors that can affect the markets asymmetrically are eliminated. In particular, these indicators would not have been directly affected by distortions linked to the implementation of central banks' asset purchase programmes.

INFLATION OPTIONS

Inflation options are contracts in which one of the parties undertakes to pay the other an amount depending on whether a price index exceeds (cap) or falls below (floor) a given threshold (the strike rate) within a given period. If the condition is met, the payment would be the difference, in absolute terms, between the index and the threshold. Unlike both inflation-linked bonds and ILSs, which give estimates of the averages only at specific points in time, options can be used to obtain additional information such as the full probability distribution of the future course of inflation or implied volatility. This gives information about risk and uncertainty around the expected average value. In particular, an increase in the implied volatility suggests that agents are more concerned and/or there is more uncertainty over the future course of price indices.

As in the case of ILSs, options are negotiated bilaterally without the intermediation of a clearing house, such that prices may include a counterparty risk premium. The majority of these derivatives are negotiated using the harmonised euro area CPI, the UK RPI (Retail Price Index) or the US CPI (Consumer Price Index), with expiries ranging from one to thirty years. The most liquid market is linked to the euro area index, followed by that of the UK [see Smith (2012)]. It should also be noted that, as in the case of the financial instruments discussed earlier, option prices also contain premiums for inflation risk, and potentially, liquidity risk.

Table 2 summarises the main differences between the inflation expectation indicators based on inflation-linked bonds, swaps and inflation-linked options. First of all, the inflation risk premium is present in all three indicators and the amount is the same. For its part, the liquidity risk premium is negative in the case of the bond-based metric, as conventional bonds are more liquid than interest-linked bonds, whereas in the ILS the sign of this premium is positive. The counterparty risk premium is only present in the case of ILSs and inflation options. Finally, the estimation error could be more significant in the case of the indicator based on inflation-linked bonds.[5]

4 https://www.newyorkfed.org/medialibrary/media/research/epr/2013/0513flem.pdf

5 Unlike ILSs, where the compensation for inflation is directly observable from the price, the bond-based indicator requires a comparison of the yields on inflation-linked bonds and conventional bonds. The differences in the features of both types of bonds, beyond the fact that in the case of inflation-linked bonds payments are linked to inflation (such as, for example, their expiry) may distort the inflation expectations indicator. The indicator is also seasonal, in a way that is linked to the behaviour of inflation. To correct for these distortions, models or adjustments are often used that are subject to potential estimation errors.

DIFFERENCES IN INFLATION EXPECTATION INDICATORS BASED ON INFLATION-LINKED BONDS AND THOSE BASED ON INFLATION SWAPS AND OPTIONS

TABLE 2

	Inflation-linked bonds vs. inflation swaps and options
Inflation risk premium	Same
Liquidity risk premium	Potentially higher in the case of inflation-linked bonds. The sign is positive for swaps and negative for bonds
Counterparty risk premium	Only in the case of inflation swaps and options
Estimation error	Estimation is more complex in the case of inflation-linked bonds as seasonal adjustment calculations are required and not all the characteristics of the nominal bonds with which they are compared are identical to those of inflation-linked bonds (particularly as regards maturities)

SOURCE: Banco de España.

Empirical results: euro area vs. the United States

This section presents the results of estimating probability distributions for the euro area and the United States using the methodology proposed by Gimeno and Ibáñez (2017). Specifically, whereas in the literature the distribution is usually estimated for each expiry independently,[6] here a single model is estimated for all the available time frames, using sufficiently liquid ILSs and options to do so. The main advantage of this approach is that calibrating a joint model reduces the risk of overparameterisation and that it is also even possible to derive values for horizons over which no instruments are traded, such as five-year inflation in five years' time (5-year/5-year inflation).[7] In the first stage, Gimeno and Ibáñez (2017) extract the average from the ILSs and then calculate the remainder of the parameters of the probability distribution using options. This reduces the sensitivity of the estimates to possible shortcomings in the data quality.[8]

Chart 2 plots average compensation for inflation over the medium term since 2010 (2-year/2-year forward inflation rates) and long term (5-year/5-year forward inflation rates) for the euro area and the United States. The first conclusion that emerges is that despite the differences in the phase of the economic cycle in each of the areas, the paths of compensation for expected price rises have been similar in both economies. In particular, a downward trend has been observed since 2013, with occasionally increments, which reversed in the second half of 2016, coinciding, *inter alia*, with a sharp rise in the oil price and heightened expectations of a change in economic policy stance in the United States. By contrast, the trend so far in 2017 has been relatively stable. It is also noteworthy that the indicator for Europe was systematically below that for the United States, where the economic cycle is further advanced than in the euro area.

First of all, the indicator obtained makes it possible to study whether the expected value of the compensation for inflation is wide of the price stability target set by the monetary authorities.[9] Looking at the 5-year/5-year time scale, which is the longer term here, in the US case compensation for inflation has remained above 2% throughout almost the entire analysis period. However, in the euro area this indicator was below 2% from 2015 onwards, deviating from this target in 2016 in particular. Looking at the 2-year/2-year time scale, in the euro area the expected value of compensation for inflation has been below the price

6 See, for example, Smith (2012); Kitsul and Wright (2013); Scharnagl and Stapf (2015); or Fleckenstein et al. (2017).

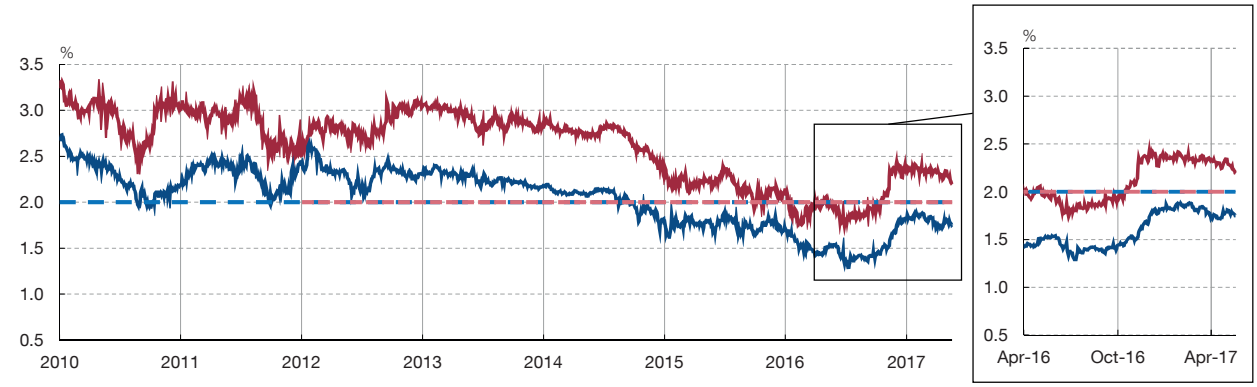
7 Five-year inflation expectations in five years' time are one of the main inflation expectation metrics used both by the ECB [Draghi (2014)] and the monetary authorities in other areas.

8 The information on inflation options is incomplete, there being various expiries and strike prices for which no data are available.

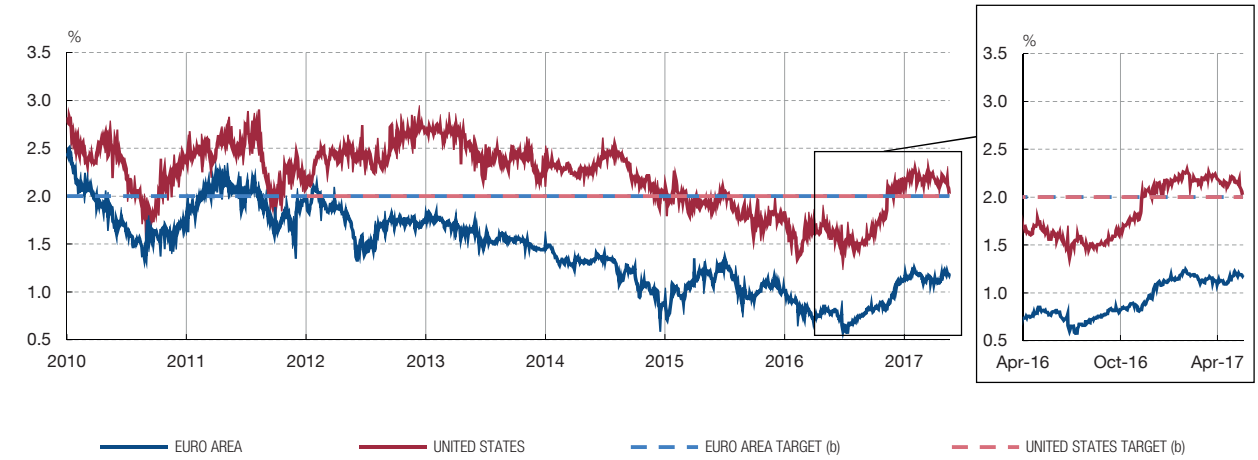
9 Although since its inception the ECB has had an inflation target of below, but close to, 2%, the Federal Reserve Board did not adopt the 2% target until January 2012. Moreover, it is worth noting that the Federal Reserve Board has a dual monetary policy mandate, whereby it targets both price stability and full employment.

COMPENSATION FOR INFLATION. EXPECTED VALUE CHART 2

1 COMPENSATION FOR INFLATION. EXPECTED VALUE. 5-YEARS/5-YEARS (a)



2 COMPENSATION FOR INFLATION. EXPECTED VALUE. 2-YEARS/2-YEARS (a)



SOURCE: Banco de España.

a Estimates obtained using daily inflation swap and option data for the United States and the euro area, using the methodology of Gimeno and Ibáñez (2017).
b Inflation targets are 2% for the euro area and the United States (since January 2012).

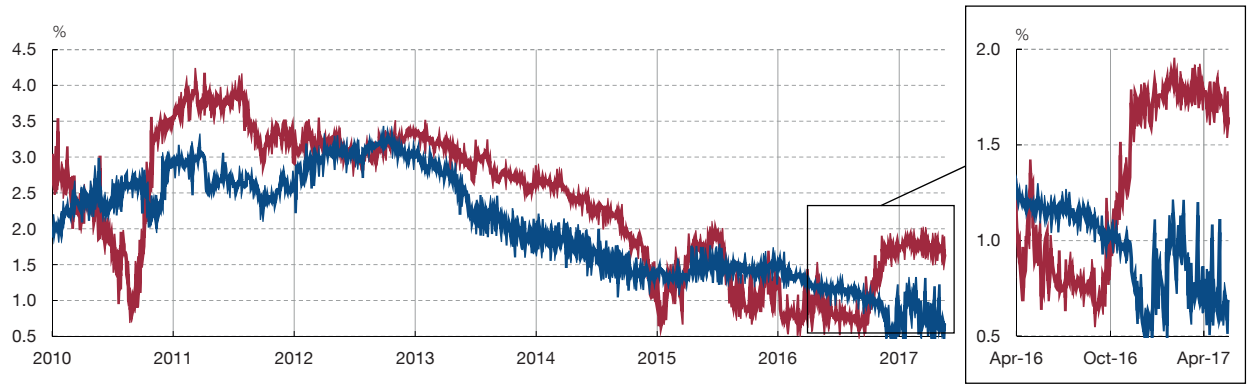
stability target throughout almost the entire period, registering levels below 1.5% since 2014. In the United States, however, the 2% level was exceeded most of the time, although it was slightly lower from 2015 until end-2016.

Chart 2 also shows how these indicators have reacted to certain monetary policy decisions, the effects being somewhat more pronounced in the case of medium-term inflation compensation than over longer horizons. Thus, for example, in the case of the United States, the announcement in September 2011 by the Federal Open Market Committee (FOMC) of an "operation twist" (Maturity Extension Program, MEP)[10] significantly raised the compensation for inflation and reversed the sharp downward trend of previous months. Specifically, the expected value of the compensation for 2-year/2-year inflation rose by 0.5 pp between the time the programme was announced and the end of its implementation,

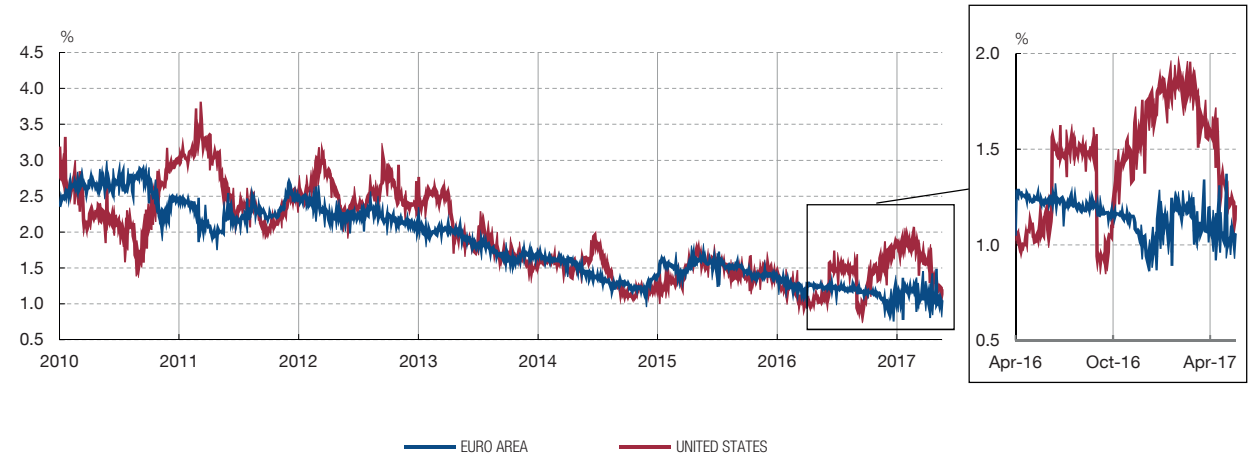
10 The aim of the programme was to extend the maturity of the Federal government debt portfolio, by replacing $400 billion of securities with residual maturities of less than three years by securities with residual maturities of between six and thirty years.

COMPENSATION FOR INFLATION. IMPLIED VOLATILITY CHART 3

1 COMPENSATION FOR INFLATION. IMPLIED VOLATILITY. 5-YEAR/5-YEAR (a)



2 COMPENSATION FOR INFLATION. IMPLIED VOLATILITY. 2-YEAR/2-YEAR (a)



SOURCE: Banco de España.

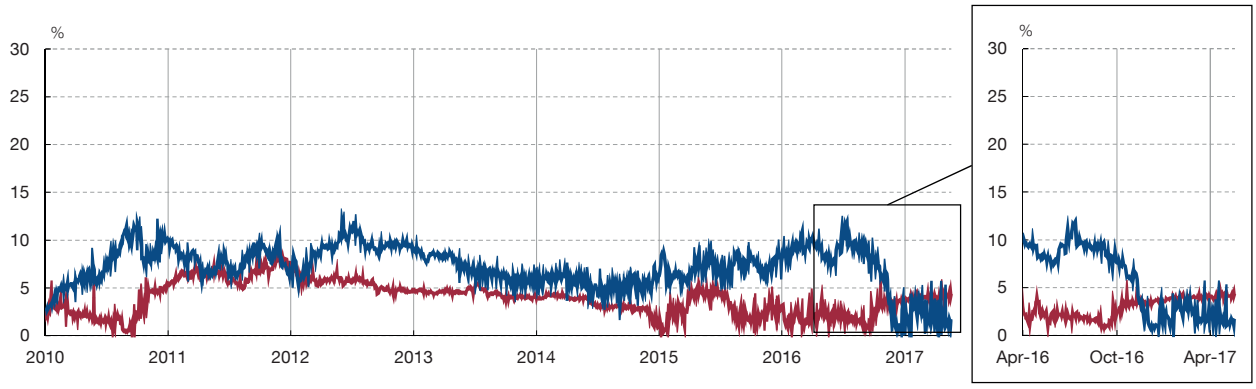
a Estimates obtained using daily inflation swap and option data for the United States and euro area using the methodology of Gimeno and Ibañez (2017).

whereas the expected value for 5-year/5-year inflation rose by 0.25 pp. The operation twist aimed to lower long-term interest rates without altering the Federal Reserve's balance sheet in the context of the uncertainty caused by the government debt ceiling crisis in the United States, successive bouts of heightened tension in international financial markets (euro area sovereign debt crisis), and the weakness of the recovery. The announcement of the public sector purchase programme (PSPP) in the euro area in early 2015, which aimed to curb the drop in inflationary expectations also seems to have managed to raise the compensation for inflation, reversing the trend observed in 2014. Thus, following the announcement of this programme on 22 January 2014, compensation for 2-year/2-year inflation had risen by 0.2 pp and that for 5-year/5-year by just 0.03 pp by the end of June.

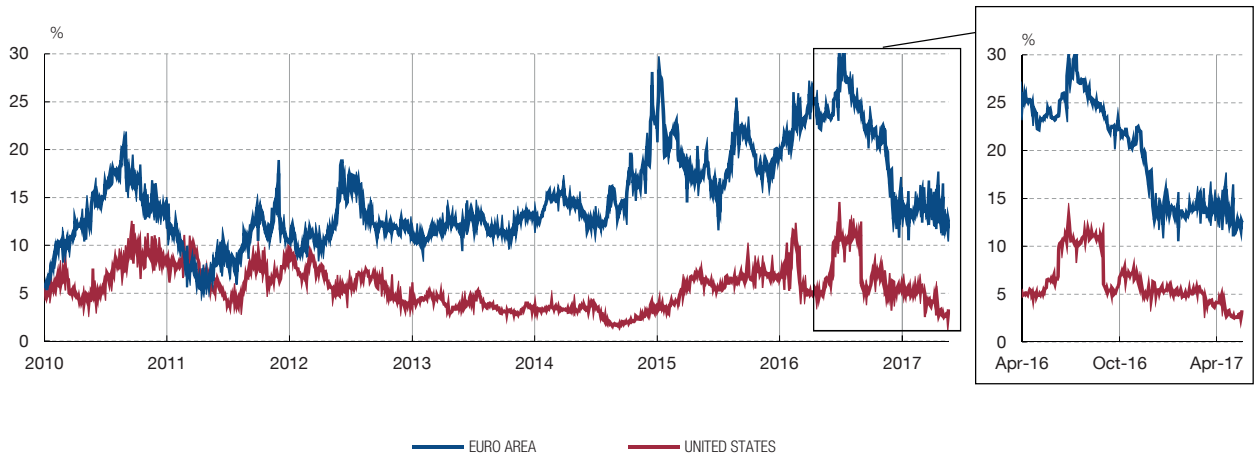
Chart 3 plots the estimated implied volatility, which gives information about market participants' level of concern or uncertainty about future inflation. Broadly, a downward trend can be seen in both areas over the period analysed. It is worth noting the upturn in volatility in the United States in the last four months of 2010, which seemed to respond to the prevailing uncertainty about the future course of monetary policy and its effects on the level of inflation. Thus, the Federal Reserve Board announced in August 2010 the

RISK-NEUTRAL PROBABILITIES OF NEGATIVE INFLATION CHART 4

1 RISK-NEUTRAL PROBABILITY OF NEGATIVE INFLATION. 5-YEAR/5-YEAR (a)



2 RISK-NEUTRAL PROBABILITY OF NEGATIVE INFLATION. 2-YEAR/2-YEAR (a)



SOURCE: Banco de España.

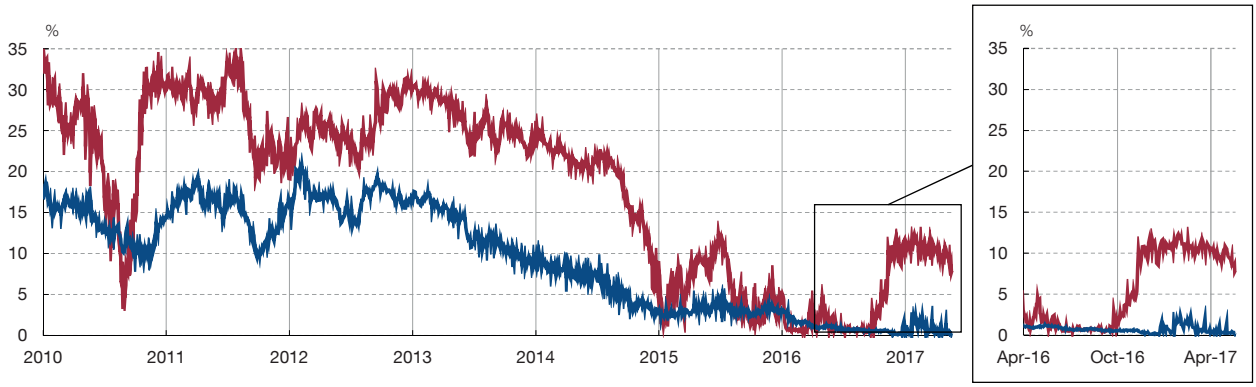
a Estimates obtained from daily inflation swap and option data for the United States and the euro area using the methodology of Gimeno and Ibáñez (2017).

reinvestment on maturity of bonds issued by the US Treasury and government sponsored enterprises (GSEs), and mortgage-backed securities (MBSs) in new federal government bonds (without altering the balance sheet). Moreover, in November that year, in the face of the deflation risks and sluggish economic recovery, it launched a fresh round of $600 billion-worth of asset purchases.

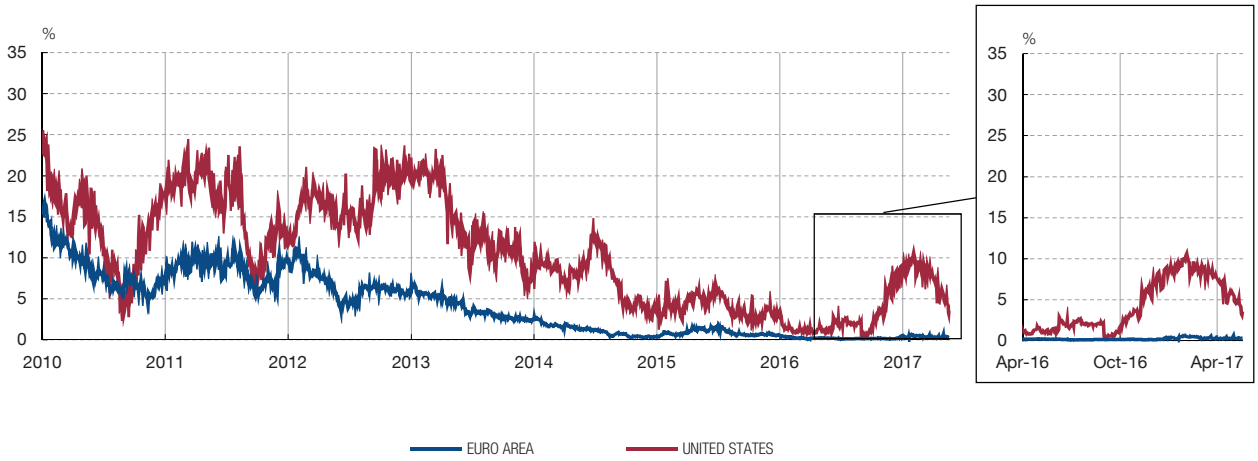
However, not all monetary policy decisions have affected volatility or the expected value of compensation for inflation equally. Thus, for example, the Federal Reserve Board's announcement in May 2013 that it might start tapering the volume of Treasury bond purchases as a result of improving labour market conditions did not significantly affect inflation compensation metrics. In this case, the rise in yields on conventional bonds following the announcement was linked more to the real interest rate expectations component and the forward premium than inflation-related factors. Another clear episode of uncertainty about future inflation occurred during last year's presidential elections in the United States, resulting in a sharp upturn in implicit volatility in late 2016. This was not seen in the euro area, and could have been a reflection of the market's doubts about the implementation and impacts of the new administration's economic policy package (financial deregulation, trade protectionism and fiscal expansion).

RISK-NEUTRAL PROBABILITIES OF INFLATION ABOVE 4% CHART 5

1 RISK-NEUTRAL PROBABILITY OF INFLATION ABOVE 4%. 5-YEAR/5-YEAR (a)



2 RISK-NEUTRAL PROBABILITY OF INFLATION ABOVE 4%. 2-YEAR/2-YEAR (a)



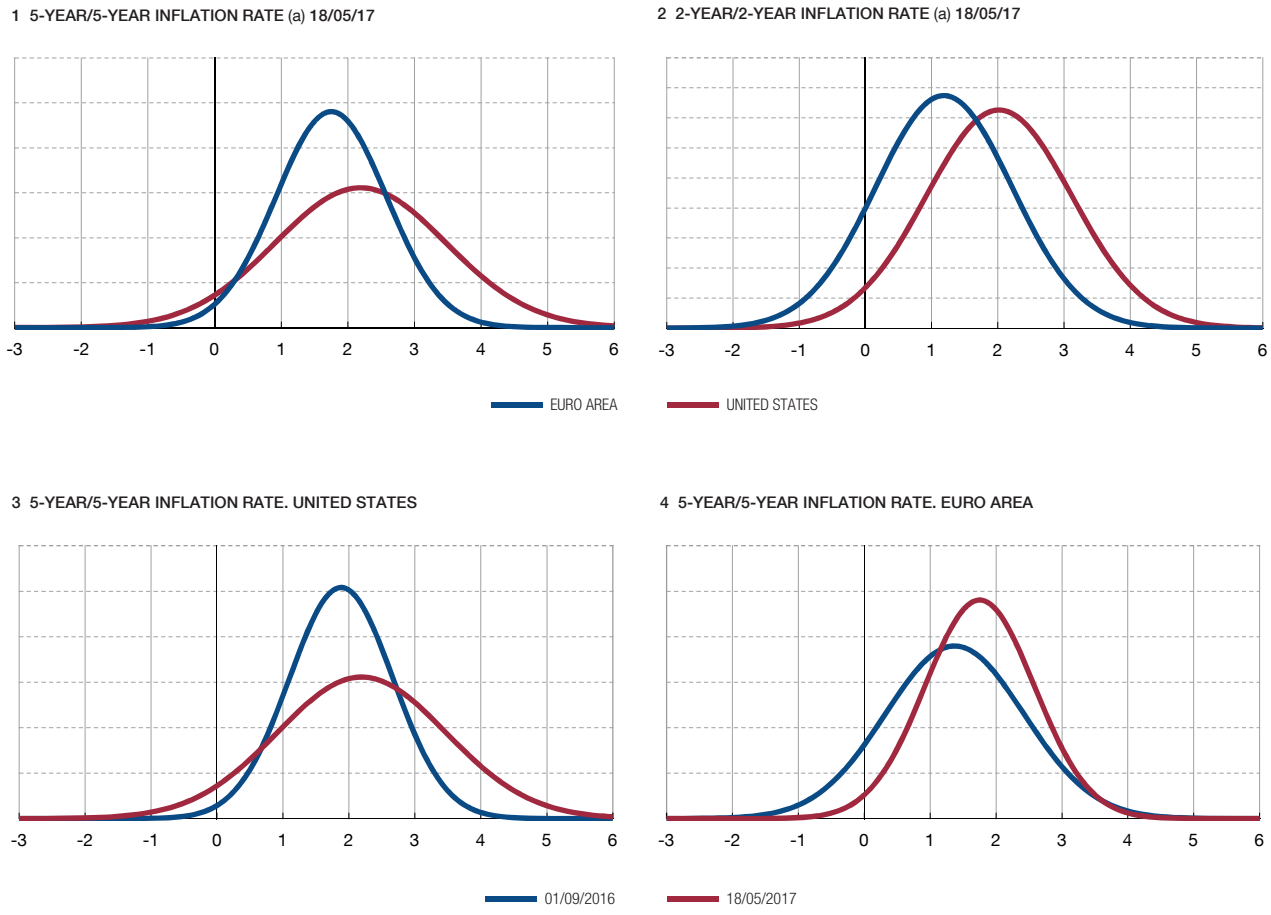
SOURCE: Banco de España.

a Estimates obtained from daily inflation swap and option data for the United States and the euro area using the methodology of Gimeno and Ibáñez (2017).

These estimates can also be used to derive the probability that the inflation rate will lie within a given interval. Thus, for instance, it is possible to calculate the probability that inflation will be below zero, providing a signal of the deflation risk. Moreover, the probability of price growth being above a certain threshold indicates the extent to which the monetary policy price stability target may be exceeded.

Chart 4 plots the probabilities of negative inflation in each of the two geographical areas studied over the alternative horizons analysed earlier. In the case of 2-year/2-year inflation a sharp rise was seen in the euro area between mid-2014 and July 2016, with a short-lived interruption in the first half of 2015 when the ECB announced the extension of its asset purchase programme. This pattern occurred at a time when inflation in the euro was extremely low, indeed at negative levels in some months during the period. This situation began to be reversed in July 2016 as oil prices rose. As might be expected, variations in the probabilities over longer horizons are more moderate in both the euro area and the United States. In the euro area, the probability of negative inflation over the 2-year/2-year horizon was 8.4% in June 2017, whereas over the 5-year/5-year horizon it was 1%, with negligible risk of a potential long-term price drop. The pattern was similar in the United

RISK-NEUTRAL INFLATION DENSITY FUNCTIONS CHART 6



SOURCES: Banco de España.

a Estimates obtained from daily inflation swap and option data for the United States and the euro area using the methodology of Gimeno and Ibáñez (2017).

States over the two-year horizon, but the changes are more pronounced and the level lower, which could be interpreted as a sign that markets are more concerned about a negative inflation scenario in the euro area than in the United States, although these fears have largely dissipated over the last few months.

Chart 5 plots the risk-neutral probabilities of inflation below 4% over the two horizons examined. These probabilities are lower in the euro area than in the United States, and have steadily declined to levels close to zero in the most recent period. The trend in the United States has also been downwards since 2013, although this reversed after the presidential elections, a change that was subsequently corrected somewhat for the two-year horizon. The recent upturn in the US economy would suggest that markets are somewhat more concerned about high inflation scenarios over the long term.

Lastly, Charts 6.1 and 6.2 plot the estimates of the risk-neutral density function in both geographical areas and for both horizons analysed up to end-June 2017. The comparison between them shows that for the longer horizon (5-year/5-year) the higher probabilities in the euro area are concentrated in the 1%-2% range, whereas the United States has higher values than in Europe for levels of inflation of over 3%. The distributions over the medium term (2-year/2-year) resemble one another more closely, although the US distribution is

shifted to the right relative to that of the euro area. This suggests that over this horizon the market foresees higher inflation rates in the United States. The probability of negative inflation is higher in the euro area, despite the significant moderation of this probability in the most recent period.

The Chart 6.3 shows how the recent US presidential elections have substantially changed the estimates of the long-term probability histogram for the US economy, going from a distribution with small tails centred on 2% in early September to one with bigger tails centred on values above 2% subsequently. This indicates that the uncertainty over future inflation, and the compensation demanded for longer maturities, has increased. During this same period, changes in the long-term density function estimated for the euro area have been more moderate (see Chart 6.4), the drop in the probability mass for low and negative values of inflation standing out, which suggests the markets are less concerned about these scenarios materialising.

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