EXTRACTING INFORMATION FROM FINANCIAL ASSET PRICES

Asset prices are an important and very timely source of information for central banks about market expectations concerning a number of fundamental macroeconomic variables. This article describes a number of tools that can be used to extract market expectations for key economic variables, mainly inflation and future economic activity, from asset prices. This list of tools is far from exhaustive, but it should provide an idea of how a central bank can use in practice the information contained in financial asset prices as an input for pursuing its goal of price stability.

Regarding the bond market, the yield spread between comparable conventional bonds and inflation-linked bonds –often referred to as the 'break-even inflation rate"–provides a timely indicator of market participants' inflation expectations for the euro area. Long-term index-linked bond yields can provide information about long-term economic growth expectations and option prices can be used to obtain the distribution of market participants' expectations of bond yields over the very short term. Finally, comparing long-term nominal bond yields with alternative measures of long-term nominal growth expectations may provide some insights into developments in bond market risk premia.

With regard to the stock market, as expected aggregate dividends tend to be closely linked to the expected growth in economic activity, stock prices can provide useful additional information for assessing market participants' expectations for overall economic activity. Furthermore, options on stock prices can provide indications about the perceived fragility of overall stock market conditions.

In general terms, while the information derived from all the presented indicators could in principle be very useful for monetary policy purposes, it is important to bear in mind that their information content is generally based on rather strong assumptions about the link between asset prices and key economic variables, and should therefore be interpreted with caution.

1 INTRODUCTION

For a central bank, the prices of financial assets and their derivatives are an important source of information about the expectations of market participants for a number of fundamental macroeconomic variables, such as inflation and economic activity. This information content rests on the fact that financial asset prices are inherently forward-looking and thus incorporate market participants' expectations about financial and economic developments. Regular monitoring of financial market developments may therefore provide useful information for central banks and in a more timely fashion than most business cycle and inflation indicators, which are usually published with relatively long lags.

Despite these advantages, the interpretation of indicators based on financial asset prices is often not straightforward, and it is important to bear in mind some caveats. Although the general information content of asset prices regarding market expectations is rarely questioned on theoretical grounds, from a more practical point of view the methods for extracting those expectations are critical. In particular, the information extracted from financial asset prices often rests on rather restrictive but nonetheless necessary assumptions about the links between the asset price concerned and macroeconomic fundamentals. In addition, asset prices can also be influenced by factors other than macroeconomic ones such as institutional features of the market or temporary shifts in supply and demand for the underlying asset not related to macroeconomic fundamentals. For this reason, it is important to carefully assess all potential factors in order to conduct a rigorous analysis of market expectations.

This article presents a number of tools and indicators to extract information from financial instruments and to monitor developments in financial markets in the euro area. The structure of the article is as follows. Section 2 focuses on the bond market. Indicators of inflation expectations extracted from government bonds, the information content of government bond yields regarding market expectations for economic activity and some measures of uncertainty are analysed. Section 3 shows how developments in stock prices can be used to extract expectations of macroeconomic fundamentals and investors' risk appetite and risk perceptions. Conclusions are drawn in Section 4.

2 ANALYSIS OF BOND MARKET DEVELOPMENTS

Long-term government bond yields reflect investors' expectations about inflation and economic activity, mainly over medium to long-term horizons, as well as expectations of monetary policy rates over shorter horizons. In addition, investors require risk premia to hold those long-term bonds which are also reflected in the levels of bond yields. These risk premia can be thought of as a compensation for bearing the uncertainty related to those expectations and consequently can be expected to vary over time.

Although extracting all that information is not straightforward, some tools are available which allow plausible conclusions to be drawn. For instance, monitoring bond yields over long periods can help identify how expectations about fundamental variables have evolved over time. Equally importantly, the comparison of conventional nominal and inflation-linked bond yields provides measures of market participants' inflation expectations, and making such comparisons at different horizons can provide a time profile of inflation expectations at a given point in time. Finally, measures of how market expectations are distributed can also be useful for monetary policy purposes.

2.1 DETERMINANTS OF LONG-TERM BOND YIELDS

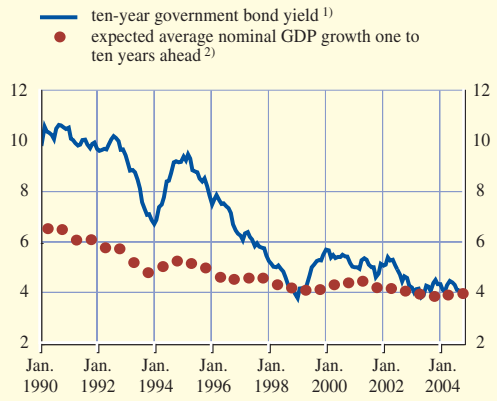
Long-term nominal bond yields can be thought of as comprising three key elements: the expected real interest rate, which is often regarded as being closely linked to expectations about economic activity, the expected rate of inflation, and risk premia. Some indication of the impact of these three elements on long-term bond yields can be obtained by comparing those yields with available survey data on long-term inflation and growth expectations.

Chart 1 plots ten-year government bond yields in the euro area and comparable nominal GDP growth expectations (constructed by summing consumer price inflation expectations and real GDP growth expectations from Consensus Economics) over long horizons. Two notable features emerge from the chart. First, over the sample under consideration, bond yields and nominal growth expectations generally displayed similar movements, which suggests that long-term expectations about macroeconomic fundamentals have played an important role in the determination of bond yields.[1] Second, the gap between long-term nominal bond yields and long-term nominal growth expectations narrowed considerably in the last decade. Long-term bond yields in the euro area stood well above long-term nominal growth expectations during the first half of the 1990s. This may be partly related to the relatively high uncertainty at that time about future developments in inflation, economic growth and real interest rates. Since the late 1990s, however, the gap between the two has narrowed mirroring the reduction in risk premia requested by investors as a result of a more stable macroeconomic environment, including progressive exchange rate stability. This

1 Structural factors such as lower productivity and population growth may have also contributed to the decline in bond yields over the 1990s. For a further discussion, see the article entitled "The natural real interest rate in the euro area" in the May 2004 issue of the Monthly Bulletin.

Chart 1 Long-term nominal bond yields and long-term nominal GDP growth expectations in the euro area

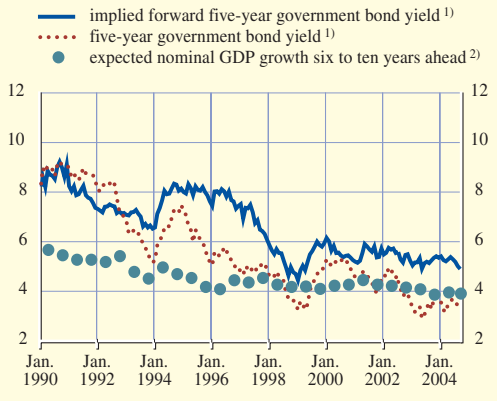
(percentages per annum)



Sources: Consensus Economics and Reuters.
1) Euro area bond yields prior to 1999 are computed as a weighted average of yields in all euro area countries using country GDP weights and PPP-based exchange rates. Thereafter outstanding amounts of bonds are used as weights for the calculation.
2) Up to October 2002, euro area expectations are computed as a GDP-weighted average of those for France, Germany, Italy, the Netherlands and Spain.

Chart 2 Five-year spot and implied forward bond yields and long-term nominal GDP growth expectations in the euro area

(percentages per annum)



Sources: Deutsche Bundesbank and Consensus Economics.
1) German (zero coupon) bond yields.
2) Expectations refer to German data prior to 1999 and to euro area data afterwards. Euro area data are computed as a GDP-weighted average of those for France, Italy, the Netherlands and Spain between April 1999 and October 2002.

narrowing may have also been a beneficial effect of a monetary policy firmly committed to maintaining price stability in the euro area as a whole.[2]

Apart from fundamental factors such as long-term growth and inflation expectations, the stance of monetary policy often also plays a role in determining long-term bond yields via the impact of this stance on short-term interest rates. This is most easily understood by thinking in terms of the expectations hypothesis of the term structure of interest rates, which states that long-term interest rates should reflect an average of current and expected short-term interest rates over the life of the long-term bond. The future path of short-term interest rates, in turn, is mainly determined by market participants' expectations about the future course of monetary policy. Abstracting from term premia, this implies that when the economy has stabilised around the expected long-run levels of economic growth and inflation, short-term and long-term interest rates should both stay at levels relatively close to nominal growth expectations. Yet, at business cycle frequencies, the economy may be hit by shocks which require monetary policy actions in order to maintain price stability over the medium term. In such circumstances, short-term interest rates may deviate for some time from "neutral" levels in line with long-term macroeconomic fundamentals reflecting the monetary policy stance, and this can also affect, via the expectations channel, longer-term bond yields.

However, monetary policy may also have an impact on long-term bond yields through other channels. In particular, the credibility of monetary policy should be reflected in low and stable long-term inflation expectations, thereby contributing to a more stable macroeconomic environment and low variability in output growth which, in turn, would tend to support a lower level of bond yields through lower risk premia. For this reason, a relatively high level of short-term

2 See the box entitled "The information content of euro area long-term forward interest rates" in the August 2004 issue of the Monthly Bulletin.

interest rates may sometimes be associated with low interest rates at the long end of the maturity spectrum.

A useful way to abstract from the short-term monetary policy influences on long-term bond yields is, for example, to decompose the ten-year bond yield into a five-year spot rate and a five-year implied forward rate five years ahead (see Chart 2). The reason for this is that shorter-term bond yields are more affected by monetary policy expectations over the short term. At the same time, the forward yield five years ahead should be much more affected by monetary policy credibility (and the related factors mentioned above).

Forward rates for the euro area are not available over a long time period, but a decomposition of long-term bond yields can instead be conducted on German bond data. Given the rather small and relatively stable spreads between government bond yields within the euro area since 1999, German bond yields can be regarded as representing interest rate developments in the euro area as a whole sufficiently well over the last few years.

Chart 2 shows that the five-year implied forward rate always stood above long-term nominal growth expectations over the period from 1990 to 2004. The two measures declined overall during the sample period, with the gap between those two measures narrowing over time probably reflecting a reduction in risk premia. However, the gap between forward bond yields and nominal growth expectations over the past couple of years has remained larger than the gap between ten-year bond yields and nominal growth expectations shown in Chart 1. This is due to the fact that the five-year spot yield fell somewhat below nominal growth expectations on several occasions including the past two years, partly reflecting a relatively accommodative monetary policy stance over these periods. Conversely, at the beginning of the 1990s, due to monetary policy responses, both the five-year spot yield and the five-year forward rate stood well above long-term growth expectations.

2.2 EXTRACTING INFORMATION ABOUT MARKET PARTICIPANTS' INFLATION EXPECTATIONS

One of the main components of long-term nominal interest rates is investors' inflation expectations. Such expectations are a fundamental piece of information for a central bank. Indeed, long-term inflation expectations are often used as a measure of the credibility of monetary policy: if the central bank's commitment to maintain price stability is credible, the private sector's long-term inflation expectations should be firmly anchored at levels consistent with the definition of price stability.

BREAK-EVEN INFLATION RATES IN THE EURO AREA

In the last few years a number of countries in the euro area have issued government bonds whose coupon and principal at redemption are indexed to the euro area HICP excluding tobacco (see Box 1). The yield spread between comparable conventional bonds and index-linked bonds should reflect, among other things, market participants' inflation expectations for the euro area over the residual maturity of the bond. This yield spread is therefore often referred to as the "break-even inflation rate" because it provides an estimate of the level of expected inflation at which, under certain assumptions, an investor would be indifferent as to which of the two types of bond to hold.

Break-even inflation rates offer several important advantages as a source of information on the private sector's long-term inflation expectations. First, in terms of timeliness, they are available at very high frequency. This makes them particularly useful for detecting changes in long-term inflation expectations as they occur, which is something more difficult to detect in survey data given that surveys are only conducted a few times

per year. Second, in terms of reliability, they provide information about inflation expectations, which form the basis for market trades. Finally, as conventional and index-linked bonds are usually issued over a variety of original maturities, they in principle allow for the extraction of information about inflation expectations at a larger number of horizons than usually reported in surveys.

It should, however, be borne in mind that break-even inflation rates are only an imperfect indicator of market participants' long-term inflation expectations because the difference between comparable nominal and index-linked bond yields may be affected by purely technical and institutional market factors and may incorporate several premia, including an inflation uncertainty premium and a liquidity premium. More specifically:

– break-even inflation rates are likely to incorporate an inflation risk premium required by investors to be compensated for inflation uncertainty when holding long-maturity nominal bonds. The rationale is as follows. Future inflation erodes the payments on a nominal security but not those on an index-linked bond. Investors are therefore likely to demand a premium as compensation for holding long-term nominal securities, and, as they are typically risk-averse, such a premium is likely to vary over time with the uncertainty about future inflation. Moreover, it is natural for this inflation risk premium to rise with the maturity of the bond. This premium tends to bias the break-even inflation rate upwards. At the same time, inflation uncertainty over long horizons may also indicate the extent to which inflation expectations are anchored, which is important information for a central bank.

– as the liquidity of the index-linked bond is typically lower than that of the comparable nominal bond, this may lead to the presence of a higher liquidity premium embedded in the yields on index-linked bonds. This liquidity premium would therefore tend to bias the break-even inflation rate downwards.

– in the euro area, the break-even inflation rates refer to the HICP excluding tobacco.[3] The inflation rate measured by the overall HICP (i.e. including tobacco) has been slightly higher than for the HICP excluding tobacco over recent years. If this were to continue in the future, it would imply a negative bias in the break-even inflation rates as an indicator of expectations for (overall) HICP inflation.

– break-even inflation rates may sometimes be biased as a result of technical and institutional market factors, such as tax distortions and regulation affecting investors' tax liabilities or incentives affecting the prevailing demand for index-linked instruments, which may have little to do with changes in inflation expectations. Unfortunately, the distortionary effect of changes in legislation and market practices on break-even inflation rates is difficult to isolate and quantify, even in the case of more mature index-linked bond markets (e.g. that of the United Kingdom).[4]

Given those caveats, it is advisable to focus on changes in rather than the level of the break-even inflation rates when interpreting these rates in terms of long-term inflation expectations. However, index-linked bonds remain a very valuable source of information on inflation expectations for a central bank, and their importance is likely to grow over time with the increase in available maturities and liquidity in the market (see Box 1). In addition, as a cross-check, it is useful to compare break-even inflation rates with

3 See Box 1 for an explanation.

4 For an illustration in the case of the UK market, see the article "On market-based measures of inflation expectations" by C. Scholtes in the Spring 2002 Quarterly Bulletin of the Bank of England.

survey measures of long-term inflation expectations.

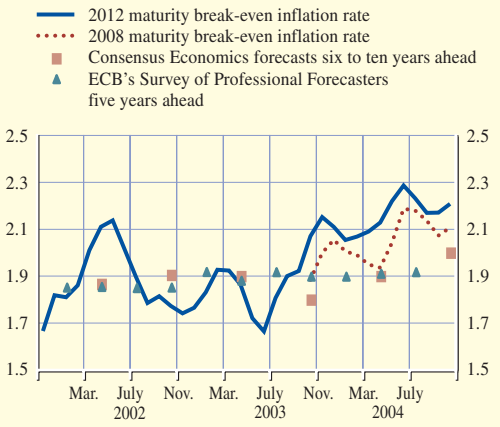
Chart 3 depicts the break-even inflation rates calculated from inflation-linked bonds of two different maturities, 2008 and 2012, issued by the Italian and the French Treasury respectively. As both bonds are indexed to the euro area HICP excluding tobacco, these break-even inflation rates can be used to gauge investors' long-term inflation expectations for the euro area. Given the still relatively limited range of maturities at which index-linked bonds are issued in the euro area, the index-linked bonds maturing in 2008 and 2012 remain the reference bonds for the calculation of the five-year and ten-year break-even inflation rates, despite the fact that their residual maturities have declined in the meantime to around four and eight years respectively.

Since the issuance of the 2012 maturity bond in November 2001, the break-even inflation rate extracted from this bond has fluctuated between 1.6% and 2.4%, and has averaged approximately 1.9%. The break-even inflation rate extracted from the 2008 maturity bond, issued in September 2003, has remained below the ten-year break-even inflation rate in the same period. This partly suggests that the inflation risk premium increases with maturity.

The growing range of maturities for which bonds indexed to the euro area HICP are available allows a comparison of average inflation expectations over different horizons. For instance, break-even inflation rates seemed to rise significantly over the second quarter of 2004. Oil price developments over that period might have not only increased short-term inflation expectations but also the uncertainty about future price developments, also possibly influenced by the ongoing recovery in global economic activity. In that context, it was important to monitor closely over which horizons inflation expectations were most affected. The break-even inflation rates over shorter horizons increased more than the ones over longer terms, with the five-year break-even inflation rate reaching the level of the ten-year break-even inflation rate by early June 2004 (see Chart 4). This indicates that inflation expectations during that period were mainly affected over shorter horizons, whereas they remained more stable over longer ones.

Chart 3 Break-even inflation rates and survey measures of long-term inflation expectations in the euro area

(percentages per annum)



Sources: Consensus Economics, Reuters and ECB calculations.

The calculation of the implied forward break-even inflation rate embodied in those spot break-even inflation rates may offer more precise information in this regard. The spot break-even inflation rates shown in Chart 3 should reflect the average inflation compensation required by investors over the residual maturity of the bond. This average expected inflation can be decomposed into the average expected inflation between 2004 and 2008 (as measured by the spot break-even inflation rate from the 2008 index-linked bond) and the average expected inflation between 2009 and 2012 (as measured by the implied forward break-even inflation rate). The implied forward break-even inflation rate should be higher than the five-year break-even inflation rate because the inflation risk premium should increase with maturity, reflecting higher inflation uncertainty at longer horizons.

The implied forward break-even inflation rate for the period 2009-2012 displays similar

Box 1

DEVELOPMENTS IN THE INDEX-LINKED BOND MARKET IN THE EURO AREA IN RECENT YEARS

The first bond with coupon payments indexed to euro area inflation was issued by the French Treasury in November 2001, with a maturity of July 2012. Although the ECB's definition of price stability in the euro area is based on the overall HICP, i.e. including tobacco, compliance with French regulations on the issuance of index-linked instruments has led to the choice of the euro area HICP index excluding tobacco. The latter reference index has become the market benchmark in the euro area since then, and all the inflation-linked bonds issued so far have been indexed to the euro area HICP excluding tobacco.

Following a relatively slow start, the market for index-linked bonds in the euro area has experienced significant growth since 2003, as two additional euro area countries, namely Greece and Italy, have decided to issue index-linked bonds (see table).[1] Moreover, a few other euro area governments have announced that they are considering the issuance of index-linked debt in 2005. The Italian and Greek bonds share most of the technical characteristics of the existing French index-linked bonds, namely they are linked to the euro area HICP excluding tobacco and also offer guaranteed redemption at par, implying deflation protection, but the bonds are not perceived by rating agencies as bearing the same credit risk.

Liquidity in the euro area index-linked bond market has been enhanced by the higher number of issuers and maturities available, and the turnover seems to have increased substantially in the last two years (see chart). In addition, over the most recent period, investors' interest in index-linked securities has increased significantly. Some changes in regulations seem to have played a major role in boosting demand for such instruments, mainly from insurance companies and pension funds, which may have led to some shortages in the market despite the growing issuance volume.[2]

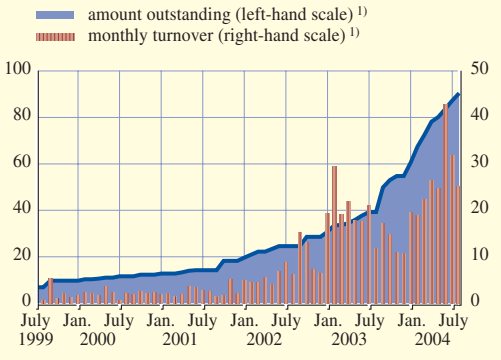
Characteristics of existing bonds linked to the euro area HICP excluding tobacco

Issuer	Maturity	Issuance date	Amount outstanding (EUR billions)
Italy	Sep. 2008	Sep. 2003	7.00
France	July 2012	Nov. 2001	11.00
France	July 2020	Jan. 2004	5.08
Italy	Sep. 2014	Feb. 2004	8.50
Greece	July 2025	Mar. 2003	1.25
France	July 2032	Oct. 2002	5.00

Sources: French, Italian and Greek Treasuries.

Monthly turnover and amount outstanding of inflation-linked bonds issued by the French Treasury

(EUR billions)



Sources: French Treasury and BNP Paribas.
1) These data refer to both debt linked to the euro area HICP excluding tobacco and to the French CPI excluding tobacco.

1 For additional details, see the box entitled "Recent developments in the market for index-linked bonds in the euro area" in the December 2003 issue of the Monthly Bulletin.

2 For instance, anecdotal evidence suggests the changes in French regulation towards an indexation of the interest rate paid on certain deposits led to a need for inflation hedging by financial institutions offering such products.

fluctuations to those of the ten-year break-even inflation rate (see Chart 4). However, it exhibits somewhat higher stability. This suggests that inflation expectations over long horizons have remained more stable, whereas those over shorter horizons have been more volatile. In addition, it is likely that the inflation risk premium is less volatile at long horizons than over shorter ones.

THE INFLATION-LINKED SWAP CURVE AND IMPLIED FORWARD INFLATION-LINKED SWAP RATES

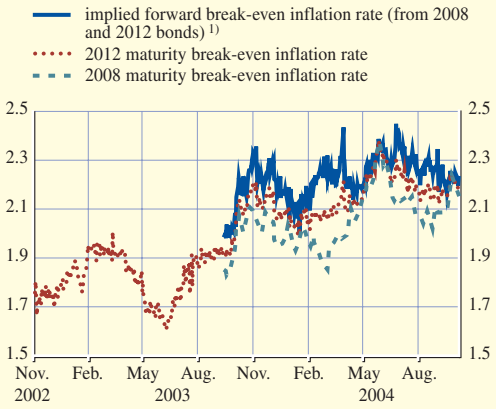
Inflation-linked swaps (I/L swaps) are an alternative source of information about the private sector's inflation expectations for the euro area. In an I/L swap agreement, an investor commits to pay to another investor a stream of payments on the basis of a fixed rate in exchange for a stream of payments linked to realised inflation over the life of the contract.[5]

The I/L swap market has grown rapidly since 2002, reflecting the increasing demand for inflation-linked instruments and the relatively limited supply of index-linked bonds in the euro area. In fact, corporations with revenues linked to inflation (e.g. utilities and retailers) can use this market to hedge against the impact of low inflation on their revenues, while corporations with liabilities linked to inflation (e.g. pension funds and life insurance corporations) can use it to hedge against the impact of high inflation on their liabilities.

I/L swap rates provide a much wider range of maturities than index-linked bonds, in particular for short and medium-term horizons, making it possible to obtain a proper term structure of inflation swap rates. As in the case of the term structure of interest rates, the I/L swap rate curve also tends to be upward sloping, which may reflect the presence of term premia, probably closely linked to inflation uncertainty and rising with maturity. Therefore, as with break-even inflation rates, I/L swap rates are likely to be a biased and therefore imperfect indicator of inflation expectations.

Chart 4 Decomposition of ten-year break-even inflation rates into spot and forward rates

(percentages per annum)



Sources: Reuters and ECB calculations.
1) Given the limited availability of maturities for index-linked bonds in the euro area, this decomposition uses bonds issued by different Treasuries with approximately five and ten-year maturities.

There are, however, two main reasons why I/L swap quotations are likely to differ from break-even inflation rates of similar maturity. First, the most common type of I/L swaps in the euro area are zero coupon swaps, i.e. with payments taking place only once on the date of maturity of the swap, while index-linked bonds are coupon-bearing bonds with an annual payment, which may help to explain the higher I/L swap rate quotations compared with similar break-even inflation rates.[6] In addition, a counterparty risk may also be included in the measure of inflation expectations extracted from I/L swaps. This risk is usually mitigated through collateral and therefore should not be substantial but it does bias I/L swap rates upwards with respect to break-even inflation rates.

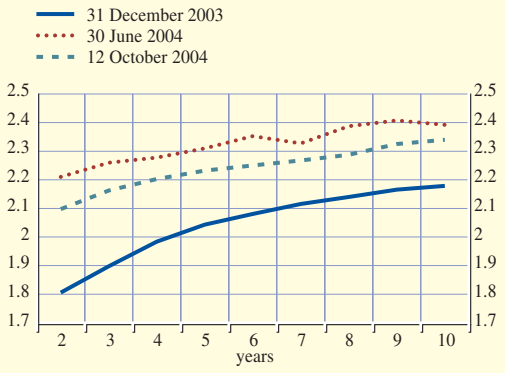
5 This section focuses on information extracted from zero coupon swaps.

6 An alternative way of comparing break-even inflation rates with I/L swap rates would be to match the duration of both financial instruments. See the box entitled "Deriving euro area inflation expectations from inflation-linked swaps" in the September 2003 issue of the Monthly Bulletin for an illustration of that approach.

Changes in inflation expectations can be analysed by monitoring shifts in the I/L swap rate curve over time. For instance, the rise in inflationary concerns in the second quarter of 2004 led to a significant upward shift of this curve in May and June 2004, followed by a gradual reversal over the summer months. As for break-even inflation rates, implied forward inflation rates can also be computed from I/L swap rates. Indeed, the wider spectrum of maturities for which I/L swap spot rates are available permits the calculation of implied forward rates for many different horizons.

Chart 5 Inflation curve derived from inflation-linked swaps in the euro area

(percentages per annum)



Source: Bloomberg.

2.3 MARKET EXPECTATIONS FOR ECONOMIC ACTIVITY

Future economic growth expectations are another fundamental determinant of long-term bond yields through their impact on the real interest rate component. The link between long-term growth prospects for the economy and the level of real interest rates goes back at least as far as Irving Fisher.[7]

In this respect, a comparison of real yields may provide useful information for central banks on how market participants perceive the long-term growth prospects of the economy. One option is to look at the yields from indexed bonds linked to the euro area HICP, but they are only available from November 2001 onwards. An alternative method is to compute ex ante real bond yields by discounting long-term nominal bond yields by measures of inflation expectations, for example from Consensus Economics, one to ten years ahead. Such a measure of ex ante real bond yields should however be treated with some caution as it also contains inflation uncertainty premia, while yields on index-linked bonds should only incorporate a premium related to real interest rate risk.

Chart 6 reveals some notable features. First, the trend is similar for the measures of long-term real yields and market participants' long-term real GDP growth expectations. This confirms that investors' long-term economic expectations play a role in the dynamics of long-term real interest rates in the euro area. Second, the ex ante measure of ten-year real bond yields (i.e. nominal bond yields discounted by inflation forecasts) and the one based on index-linked bonds moved very much in parallel. However, the level of the measure of survey-based ex ante real bond yields has decoupled somewhat from the yields offered on euro area inflation-linked bonds since around mid-2003. This deviation between the two measures might indicate an overall increase in the inflation uncertainty premium embedded in nominal bond yields, as was also reflected in the simultaneous increase observed in the ten-year break-even inflation rate.

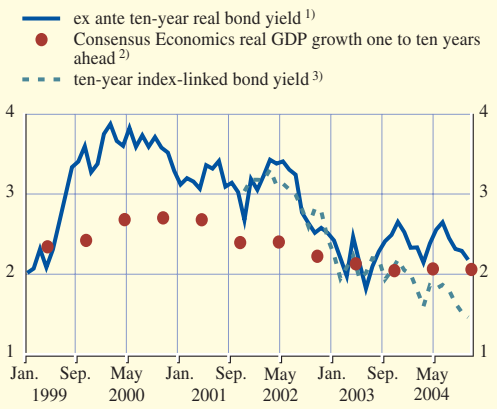
2.4 THE INFORMATION CONTENT OF BOND PRICE OPTIONS

In addition to monitoring central expectations about the future path of fundamental macroeconomic variables, it is useful to assess how widely and evenly expectations are distributed around their mean. In this respect, information contained in option prices is particularly suitable as they allow for the inference of a complete distribution of market expectations and consequently a variety of

7 See I. Fisher (1907), "The Rate of Interest", New York, Macmillan.

Chart 6 Ex ante ten-year real bond yields, long-term index-linked bond yields and long-term real GDP growth expectations in the euro area

(percentages per annum)



Sources: Consensus Economics, Reuters and ECB calculations.
1) Euro area ten-year nominal government bond yields discounted by inflation expectations one to ten years ahead provided by Consensus Economics.
2) GDP-weighted average of the expectations for France, Germany, Italy, the Netherlands and Spain.
3) Refers to French government bonds indexed to the euro area HICP excluding tobacco.

higher moments. One popular measure derived from option prices is the implied volatility which, in theory, reveals the dispersion of expectations about the future price of the underlying asset.[8]

However, option prices can reveal information beyond that contained in the implied volatility. In fact, since the price of an option depends on the perceived probability that the price of the underlying asset will exceed the strike price of the option on the day of maturity, a set of option prices with the same maturity but with different strike prices can be used to infer the entire probability distribution of market participants' price expectations. Estimation of the complete implied option probability density function thus provides the full set of probabilities that market participants attach to the different price levels of the underlying asset at the maturity of the options. It should however be borne in mind that any effects coming from risk premia, which may potentially be large and could vary significantly over time, are not taken into account when interpreting these distributions in terms of actual expectations.

One interesting measure derived from such an implied probability density function is the degree of asymmetry measured by the skewness coefficient, which can be used to assess relative upward and downward risks affecting the underlying asset price as perceived by market participants. When this coefficient is calculated for the probability density function extracted from options on German Bund futures contracts, a positive skewness indicates that market participants attach a greater likelihood to strong increases in bond yields than to declines of the same magnitude. Chart 7 displays the monthly average skewness measure based on those options with 30 days until maturity.[9] This indicator has been positive throughout 2003 and 2004, suggesting the anticipation among market participants of net upward risks with regard to future levels of bond yields in the euro area.

3 ASSESSING DEVELOPMENTS IN STOCK MARKETS

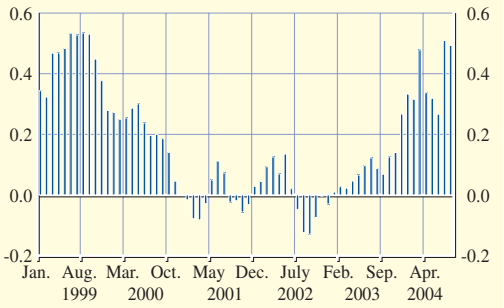
Aggregate stock prices may contain information on expectations about the future course of the economy which goes beyond that contained in bond prices. Since expected aggregate dividends tend to be closely linked to the expected growth in corporate earnings, stock market data can provide useful additional information for assessing market participants' expectations for economic activity in the economy as a whole. In addition, measures of stock market risks as perceived by investors may help in assessing the uncertainty surrounding their macroeconomic expectations and may also provide indications about the perceived fragility of overall stock market conditions.

8 See the article entitled "The information content of interest rates and their derivatives for monetary policy" in the May 2000 issue of the Monthly Bulletin.

9 As results in terms of yield to maturity may be more informative and intuitive, the estimated bond futures price distribution is transformed in Chart 7 into a bond yield distribution.

Chart 7 Option-implied skewness coefficient for long-term bond yields in the euro area

(monthly averages of daily data)



Sources: Eurex and ECB calculations.
Note: The option-implied skewness coefficient is calculated using prices of options on German government bond futures (with 30 days to maturity).

3.1 EXPLAINING STOCK PRICE DEVELOPMENTS: A MODEL-BASED DECOMPOSITION EXERCISE

In order to explain stock prices empirically, a model that relates stock prices to other observable variables which can be regarded as "fundamental" for the valuation of stocks is needed. The standard theoretical approach to valuing stocks is the dividend discount model. Assuming efficient markets, in equilibrium stock prices should just equal the present value of expected future dividends. The discount rate used to calculate the present value of future expected dividends can be broken down into a real interest rate measuring opportunity costs (i.e. the real rate of return on an alternative investment in government bonds, for example) and a corresponding equity risk premium. This equity risk premium compensates investors for bearing the typically higher risks of equities, owing to the uncertainty of future dividends, compared with interest-bearing securities. Hence, the dividend discount model identifies current and expected dividends (or corporate earnings), real interest rates and the equity risk premium as the fundamental stock price factors. This sub-section will illustrate the use of a dividend discount model to explain actual developments in euro area stock prices in terms of these fundamental macroeconomic factors (see Box 2 for details of the underlying empirical application of the model).

The equity risk premium estimated for the Dow Jones EURO STOXX index on the basis of the three-stage dividend discount model seems to be a useful indicator of market participants' perceptions of stock market risk and their degree of risk aversion. For example, as shown in Chart 8, the estimated equity risk premium co-moved quite closely with a survey-based indicator of stock market investors' risk appetite. The risk appetite indicator is shown on an inverted scale, such that a decline in this series means a higher risk appetite of investors which indeed tended to coincide with a decline in the estimated equity risk premium, for example. Moreover, the average level of the implicit equity risk premium of around 4% over the period covered appears consistent with the usual estimates of the equity risk premium.

Having calculated the equity risk premium in this way, an (approximate) decomposition of a given percentage change in stock prices into the individual contributions coming from changes in dividends, from analysts' expected real earnings growth, as well as from the real long-term interest rate and the equity risk premium can be accomplished. This is shown in Chart 9 for quarterly percentage changes in the Dow Jones EURO STOXX index from the second quarter of 2002 to the second quarter of 2004.

The chart suggests that over the past two years stock prices in the euro area have been mainly driven by changes in the equity risk premium and the real long-term interest rate. Developments in current dividends and expected earnings, by contrast, contributed much less to the explanation of stock prices on average.

While such an explanatory pattern appears highly plausible over this particular period, some of the caveats applying to the three-stage dividend discount model have to be stressed again. In particular, the equity risk premium is calculated as the residual term of the model, therefore picking up the influence of all the

Box 2

A THREE-STAGE DIVIDEND DISCOUNT MODEL FOR THE EURO AREA

This model postulates that stocks can be priced according to the present value of the expected stream of dividends over a principally infinite future. The real stock price, P, can then be expressed as:

$$P_t = \frac{D_t(1+g)}{h-g}$$

where D denotes the current level of real dividends, and g and h are respectively the expected real dividend growth rate and the discount rate, both of which are, in the simplest version, assumed constant.[1] Furthermore, assuming that dividends are a constant proportion of earnings, the expected dividend growth rate can be replaced by the expected future growth rate of earnings.

To apply the model to the Dow Jones EURO STOXX prices, we follow Fuller and Hsia (1984) and assume that real corporate earnings growth is expected to develop in three stages.[2] In the first stage (the first four years), earnings are expected to grow at a real rate g_t^{IBES}, which is set equal to I/B/E/S (Institutional Brokers Estimate System) analysts' "long-term" (three to five years ahead) earnings-per-share growth forecasts for firms in the Dow Jones EURO STOXX index,[3] less five-year-ahead Consensus Economics inflation forecasts. The second stage is an interim period (assumed to last for eight years) when real earnings growth is expected to adjust in a linear fashion to a constant long-term growth rate of real corporate earnings, g, which is assumed to prevail throughout the third infinite stage.

The equilibrium price of the Dow Jones EURO STOXX index can then be expressed as:

$$P_t = \frac{D_t\left[(1+g)+8(g_t^{IBES}-g)\right]}{h_t-g}$$

P_t, D_t and g_t^{IBES} are observable variables, and g is assumed to be constant and equal to 2.5%.[4]

The discount rate h_t can be calculated implicitly as the residual term, and broken down into a real interest rate and an equity risk premium. Hence, an estimate of the equity risk premium for the Dow Jones EURO STOXX index can be obtained by subtracting the yield on a ten-year French index-linked government bond indexed to the euro area HICP as a measure of real interest rates from the implicitly calculated discount rate. The implied equity risk premium should be interpreted with caution because there are several factors that are not properly captured by this simplistic framework.

1 For a derivation of the model, see the annex to the article entitled "The stock market and monetary policy" in the February 2002 issue of the Monthly Bulletin.

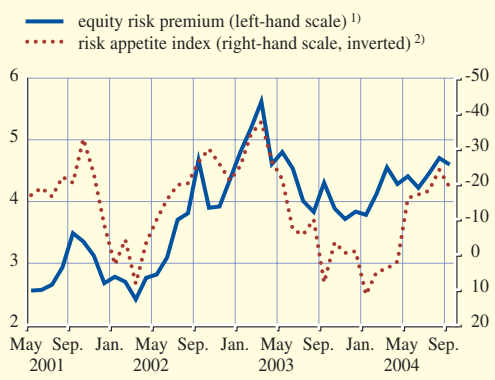
2 See R. J. Fuller and C.-C. Hsia (1984), "A simplified common stock valuation model", Financial Analysts Journal, September-October, pp. 49-56, and N. Panigirtzoglou and R. Scammell (2002), "Analysts' earnings forecasts and equity valuations", Bank of England Quarterly Bulletin, Spring, pp. 59-66.

3 Such earnings growth expectations should in any case be treated with some caution since they may not be unbiased and may not be fully representative of the market expectations. See the box entitled "What is the information content of stock market earnings expectations held by analysts?" in the March 2004 issue of the Monthly Bulletin.

4 This long-term rate of growth of real corporate earnings is chosen to be broadly consistent with private sector expectations of potential growth in the euro area.

Chart 8 Equity risk premium in the euro area and risk appetite of global investors

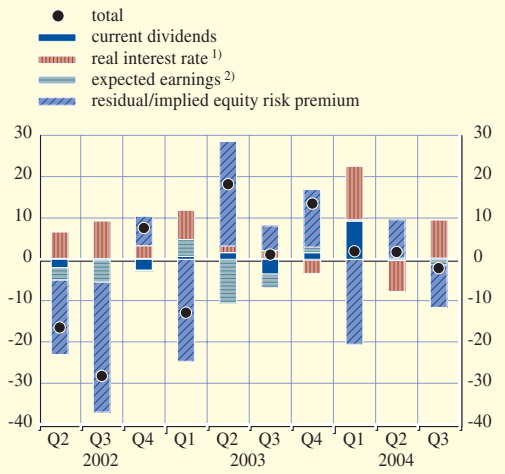
(left-hand scale in percentages per annum; right-hand scale in percentage points)



Sources: Thomson Financial Datastream, Consensus Economics, STOXX, Merrill Lynch Global Fund Manager Survey and ECB calculations.
1) Estimated on the basis of the three-stage dividend discount model described in Box 2.
2) Net percentage balance of respondents to the Merrill Lynch Global Fund Manager Survey saying that they are currently taking higher, normal or lower than normal risk in their investment strategy relative to their benchmark, where a negative number denotes net lower than normal risk-taking.

Chart 9 Decomposition of changes in the Dow Jones EURO STOXX index based on the three-stage dividend discount model

(contributions to quarterly percentage changes)



Sources: Thomson Financial Datastream, Consensus Economics and ECB calculations.
1) The real rate is the yield on ten-year French government bonds linked to the euro area HICP.
2) Analysts' long-term earnings growth expectations for the Dow Jones EURO STOXX index provided by the Institutional Brokers Estimate System.

other factors driving stock prices, which are not properly captured by the framework. Hence, the estimated equity risk premium might be more volatile than justified by investors' "true" changes in risk aversion and risk perception, implying that the decomposition tends to overstate the impact of the equity risk premium on stock prices. The influence of earnings growth expectations and real interest rates may not be properly captured either, since they are both represented by just a single indicator and not by the whole term structure of earnings growth expectations and real interest rates.

In addition, the model does not explicitly account for changes in inflation as a potential driver of stock prices: the dividend discount model uses real earnings growth discounted by a real government bond yield and should therefore be principally neutral to changes in inflation expectations, apart from the impact of inflation on the level of nominal dividends. The fact that dividend yields seem to revert back to some long-term equilibrium value over time implies that nominal stock prices and nominal dividends tend to grow at the same rate in the long run. This, in turn, may suggest that, assuming that any change in the rate of inflation leads to a proportional increase in the rate of growth of nominal earnings and dividends, stocks could be used to hedge against inflation over long horizons. However, empirical evidence overall suggests that inflation tends to have a negative impact on real stock prices in general. Some explanations of this feature have been put forward. First, high and variable rates of inflation may damage the real economy and in particular the corporate sector. In this case, future expected real earnings growth may be subject to downward revisions, thereby justifying lower real stock prices in accordance with the dividend discount model. Second, the greater economic uncertainty associated with a high-inflation environment also tends to make stock market investments more risky and may put upward pressure on the equity risk premium, which, in turn, depresses real stock prices.

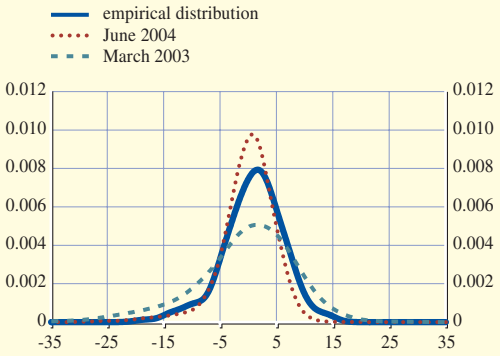
3.2 ANALYSING MARKET PARTICIPANTS' PERCEPTION OF STOCK MARKET RISK

As in the case of the bond market, information contained in option prices can also be used to gauge the whole distribution of market participants' expectations about future stock price developments. By extracting implied probability density functions from stock index options, it is possible to examine the development of market participants' perceptions of stock market uncertainty and, for example, the balances of risks they perceive with regard to future stock market returns. It should however be borne in mind that the impact of changes in risk premia, which may potentially be large and could vary significantly over time, are not taken into account when interpreting these distributions in terms of actual expectations.

The usefulness of these option-implied distributions can be illustrated on the basis of euro area data for the last two years in which the global stock market recovered strongly following three consecutive years of negative annual returns. Chart 10 displays two implied probability density functions from options on the Dow Jones EURO STOXX 50 index, each with 30 days until maturity, with the first density function extracted in March 2003 and the second one in June 2004. As the chart shows, the implied probability density function extracted in March 2003, at the height of the Iraq conflict, suggests relatively large probabilities of nearby strong downward corrections of stock prices, indicating that uncertainty regarding an imminent stock market correction was perceived to be relatively high at that time. For instance, investors perceived a likelihood of around 15% of a decline in the Dow Jones EURO STOXX 50 index of 10% or more at the time of the maturity of the options. By June 2004, this likelihood had declined to about 5%.

The empirical return distribution is based on observed monthly returns on the Dow Jones EURO STOXX 50 index from 1988 onwards. It is important to bear in mind that option-implied distributions and the empirical distribution are derived under different assumptions. The implied distribution is derived using the principle of risk-neutral valuation, according to which the price of an option can be expressed as the present value of the option's expected future pay-offs, expectations are based on the "risk-neutral probability measure", and the discount rate is the risk-free interest rate prevailing during the life of the option.[10] The empirical distribution is instead calculated using the observed stock prices and is therefore affected by changes in risk premia. The chart suggests that by June 2004 market participants perceived future stock market returns to be distributed more similarly to historical returns than in March 2003.

Chart 10 Option-based and empirical stock market return distributions for the euro area



Sources: Eurex and ECB calculations.
Note: The distributions shown for March 2003 and June 2004 are risk-neutral probability density functions calculated using the prices of options with 30 days to maturity on the Dow Jones EURO STOXX 50 index.

4 CONCLUSION

Financial asset prices can generally provide information which helps in assessing the

10 For a more detail description on how option-implied distributions are derived, see the box entitled "Estimating implied risk-neutral densities" in the article "The information content of interest rates and their derivatives for monetary policy" in the May 2000 issue of the Monthly Bulletin.

outlook for economic activity and inflation. This article has provided an illustration of how such information can be extracted from several types of financial instruments. Specifically, long-term inflation expectations for the euro area as measured by break-even inflation rates have been shown to be relatively stable over medium to long-term horizons in the last few years, although they have been much more volatile over shorter horizons. Stock market developments in the euro area appear to have mainly reflected changes in the real interest rate and the equity risk premium. In terms of investor uncertainty, short-term expectations concerning future bond yields seem to have been dominated by higher upward risks over recent years, while uncertainty regarding future stock prices appears much lower at present than about a year ago.

The overall conclusion is that financial asset prices are a very valuable source of information and provide a useful input into the monetary policy decision-making process. Despite this general usefulness, several problems arise in interpreting financial asset price movements, in particular in real time, and therefore due caution seems warranted. First of all, asset prices seem to fluctuate far more strongly than can be justified by actual and expected movements in macroeconomic fundamentals alone. This is due to the fact that many other factors – such as temporary changes in investors' risk appetite, for example – also tend to drive asset prices, at least over the short term. In addition, the methods applied to extract relevant information usually require rather restrictive assumptions about how the asset price is linked to the economic variables of interest. These caveats mean that the information extracted from asset prices has to always be put into a broader context, with cross-checking against alternative sources of information.