On market-based measures of inflation expectations

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Prices of index-linked financial securities provide market-based measures of inflation expectations and attitudes to inflation risk. In the United Kingdom, 'breakeven' inflation rates derived from index-linked and conventional gilts reflect investors' forecasts of future inflation, and also act as a barometer of monetary policy credibility. Implied breakeven inflation rates are a useful alternative to surveys and econometric forecasts, and are regularly presented to the Bank's Monetary Policy Committee to inform its assessment of economic conditions. This paper outlines the technical and institutional factors that complicate the interpretation of UK breakeven inflation rates. Looking at data, we find that inflation expectations have fallen considerably since the adoption of inflation targeting and that UK monetary policy credibility is considerably stronger since the Bank of England was granted operational independence.

Introduction

Inflation-linked financial securities can be used to infer market-based measures of expectations of future inflation and investors' attitudes to inflation risk. Inflation-linked securities are a useful alternative to surveys and econometric forecasts as a source of information on inflation expectations, with the advantages of being forward-looking, timely, and frequently updated for a range of maturities.

This article discusses how inflation-linked securities are used to derive measures of market expectations of future inflation. The first section briefly outlines the history of the price indexation of financial securities, and looks at the UK inflation-linked debt and swap markets. The second section discusses why investors are concerned about inflation, and outlines suggested criteria for choosing a price index in designing an inflation-proof financial security. The third section explains the concept of 'breakeven' inflation rates. Despite technical and institutional complications, discussed in the following section, breakeven inflation rates contain useful information for policy-makers, and are regularly presented to the Bank's Monetary Policy Committee to inform its assessment of economic conditions. To gauge what incremental information can be extracted from breakeven rates, the next section compares the forecasting performance of breakeven inflation rates with that of Basix inflation surveys. Longer-term breakeven inflation forwards also provide a barometer of monetary policy credibility. We investigate five-year-ahead five-year breakeven forward rates for the United Kingdom since 1985, and find that anti-inflationary credibility is considerably stronger since the Bank was granted operational independence for monetary policy. The last section summarises and concludes.

The UK index-linked gilt market

A brief history of inflation-linked securities

Price indexation of financial contracts is not a new phenomenon. The idea of designing contracts to protect both parties from fluctuations in the price level dates back at least as far as 1780 when the state of Massachusetts issued 'Depreciation Notes' as wages to its soldiers during the American Revolution.[1]

There are four main arguments for debt indexation: to remove the uncertainty about the real cost of borrowing and return on lending (an *ex ante* benefit for both issuers and lenders); to deliver cheaper *ex ante* debt funding (benefiting the issuer); to provide an inflation hedge (expanding investors' investment opportunities

(1) The Massachusetts notes had the following terms: *'Both principal and interest to be paid in the then current Money of said State, in a greater or less sum, according as five bushels of corn, sixty-eight pounds and four-seventh parts of a pound of beef, ten pounds of sheeps wool, and sixteen pounds of sole leather shall then cost more or less than one hundred and thirty pounds current money, at the then current prices of the said articles.'*

and generating general welfare improvements); and to remove the monetary authorities' incentives to reduce the value of government debt through inflationary measures (benefiting bond investors and the general public).

In countries with high inflation, indexed debt may also improve monetary control (by increasing the flexibility of funding), and provide access to and foster the development of long-term capital markets (though it has also been argued that debt indexation can perpetuate the inflationary process by encouraging inflation-linking of other contracts). Since 1980, however, issues of indexed debt have come largely from relatively low inflation countries: the United Kingdom (1981),(1) Australia (1985), Canada (1991), Sweden (1994), the United States (1997) and France (1998).(2)

The UK index-linked gilt market

In 1980, the Chancellor of the Exchequer announced the Government's intention to issue index-linked stock. The index chosen was the general index of retail prices (RPI)—the inflation measure already used for uplifting state pensions. The first index-linked gilt was auctioned in March 1981, and, although initially restricted to pensioners and pension funds, by March 1982 access to the index-linked market was open to all investors. Since then the index-linked gilt (ILG) market has grown steadily: by the end of 2001, the inflation-uplifted amount outstanding, at £70.5 billion, was more than 25% of the size of the total outstanding debt stock (£274.9 billion). Turnover is much lower in the index-linked gilt market, however: in 2001 Q4, ILG turnover by transaction value was only £20.4 billion, around 4.2% of total gilt market turnover by gilt-edged market-makers.(3) Nevertheless, the UK ILG market is special because of its size and range of maturities. The UK market is second only to the United States in terms of absolute size, though it has the most bonds. This is a great advantage as there are enough ILGs distributed sufficiently evenly along the maturity structure to allow a reasonably well-specified yield curve to be fitted.

Given the advantages of issuing index-linked debt, it is perhaps surprising that the private sector sterling index-linked market has only begun to develop in the past two or three years. The corporate and supranational sterling index-linked bond market is currently only around £6.5 billion (uplifted) nominal value in size. This was partly due to previous tax regimes which discouraged corporate issuance of index-linked securities. But another reason must be that for many private issuers, index-linked debt does not help to match liabilities to corporate earnings. Issuing long-term index-linked debt can make little sense to a company with cost and revenue streams that may not be correlated with general inflation, and could merely increase uncertainty in financial planning. One exception (at least in the United Kingdom) are the various utilities sectors whose earnings are directly linked to the RPI through the price-capping formulae used by UK regulators. Indeed, most of the recent private sector index-linked sterling issues by private non-financial companies have been by water companies, electricity generators and gas distribution companies. The non-gilt index-linked market, however, is not sufficiently developed yet to allow comparisons with same-issuer conventional bonds, from which measures of market inflation expectations might be derived.

The UK inflation swap market

In recent years, investor demand has prompted the development of structured financial derivative products designed to deliver a hedge against price inflation. One of these products is the inflation swap, which is a bilateral contractual agreement requiring one party (the 'inflation payer') to make periodic floating-rate payments linked to the RPI in exchange for predetermined fixed-rate 'coupon' payments on the same notional principal from the 'inflation receiver'. Inflation swap contracts are priced directly from the inflation forward rates implied by conventional and index-linked gilts.

Inflation payers are typically institutions with incomes linked to inflation. Examples include utility companies (whose incomes increase with inflation), private finance initiatives (with government-guaranteed cash flows linked to the RPI), and guaranteed return products (which face higher capital gains taxes on indexed gains when inflation is low). Typical inflation receivers are investors with inflation-linked liabilities, such as pension funds, and investors with liabilities on inflation-protected investment products.

(1) Admittedly not a low-inflation country in 1981.
(2) The French Trésor has recently issued a new bond (OATei 3% 25/07/2012) indexed to the eurozone harmonised index of consumer prices minus tobacco.
(3) Source: UK Debt Management Office.

Inflation swaps are generally tailored to the client's particular requirements. Despite being only a fraction of turnover in the index-linked fixed-income market, the use of inflation swaps is growing, and inflation swap activity may enhance the market's liquidity by providing a hedging facility for investors. However, market contacts report that trading is relatively infrequent, and that products are not sufficiently standardised to be able to track and interpret historical prices meaningfully.

Designing inflation-protected debt securities

Why are investors concerned about inflation risk?

Inflation affects the current value of conventional fixed-income securities in two ways. First, *anticipated inflation* determines the expected real value of a fixed nominal income stream. Second, *unanticipated inflation* may further alter the price of a conventional bond—higher-than-anticipated inflation outturns, for example, reduce the real value of a fixed nominal income stream. Hence unanticipated inflation can redistribute wealth between lenders and borrowers. So investors are concerned both about the level and the volatility of price inflation.

We would expect markets to incorporate participants' views of future inflation in prices payable today for conventional fixed-income securities. Investors are ultimately concerned about real returns, and therefore about the likely real value of an asset's payoffs and the risks surrounding those payoffs. For a conventional bond held to maturity, investors will look at the *real yield to maturity*. When the holding period is shorter than the bond's maturity, investors will be interested in *expected real holding period returns*.

If inflation were certain and stable, the nominal yield ($Y_{n,t}$) on a conventional security with a given term of n at time t can be decomposed into a real yield ($R_{n,t}$) and an average inflation component ($\pi_{n,t}$):

$$(1 + Y_{n,t}) = (1 + R_{n,t})(1 + \pi_{n,t})$$

In practice, however, both issuers and purchasers of conventional fixed-income assets are vulnerable to unexpected developments in the general price level. A financial asset that delivers an income stream of known purchasing power may offer a hedge against unpredictable inflation for risk-averse agents, helping to complete the financial markets and generate welfare improvements for both issuers and lenders.(1)

Selecting the reference price index

The choice of reference price index is critical in providing issuers and investors with real value certainty. In principle, bonds could be indexed to any of a number of variables, including price indices, commodity prices, foreign currencies or wage or earnings measures. Price (1997) suggests that the selection of a reference index should be guided by a number of criteria (though these are ideal criteria and may not be achieved in practice):

- The reference index should meet the hedging requirements of both issuer and investor, though in practice these are often unlikely to coincide. Governments, for example, may prefer indexing debt to a broad price measure that is closely correlated with taxation and spending schedules, such as the GDP deflator. Retail investors, on the other hand, may wish to purchase protection against consumer price inflation, while institutional investors (such as pension funds) might want to match liabilities to earnings growth.

- The index should be free of measurement bias. Price indices are subject to measurement and sampling errors and periodic reweighting. In the short to medium term, this may cause consumer price indices to be both an inaccurate and a sometimes upwardly biased reflection of the true cost of living. So index-linked bonds might actually (on average) *overprotect* against inflation risk. Of course, if the biases were known and stable, bond prices could be expected to fully discount for the bias, and the distortion could be negligible. But if index measurement biases were unstable, investors might demand higher real yields on index-linked bonds to compensate.

- The reference price index should be understood, recognised and calculated by a body regarded as independent from the issuer (to avoid any possible conflict of interest). The bond prospectus should describe the index, allocate responsibility for its calculation, and detail the frequency and place of publication. The data behind the index should be reliable and transparent. In addition, the index

(1) A market is complete when, for any possible future state of the world, a security can be purchased that will generate a known payoff in that state and nothing in all other states.

should be free from regular revision, and, should such revisions occur, the procedures for dealing with payment calculations should be outlined in the prospectus. The prospectus should also outline provisions for the index ceasing to exist.

- The indexation lag should be short.(1) For price-indexed bonds to provide complete real value certainty, all cash flows would have to be corrected for changes in purchasing power right up to the moment at which they were due. In practice, however, unavoidable delays between actual movements in prices and adjustment to bond cash flows distort the inflation-proofing properties of indexed securities. Indexation lags produce a period at the end of a bond's life when there is no inflation-proofing, counterbalanced by a period of equal length prior to issue for which inflation compensation is paid. Since inflation in the two periods is unlikely to be the same, the real return on an indexed bond will not be fully invariant to inflation—the longer the lag and the greater the variability of inflation, the poorer the security's inflation-proofing. Because real rates are then distorted, the information content from index-linked bonds will also be affected, with short and medium-term bonds (which may be of particular interest to the monetary authorities) the worst affected.

In practice, most indexed government bonds have been linked to an index of consumer prices. Consumer price indices reflect price developments faced by many bond investors, are generally well understood, widely disseminated, broadly based, rarely revised, and issued with a short time lag (which is important for pricing and trading in the secondary market).

Calculating real interest rates and breakeven inflation rates

Real and nominal yield curves can be derived from conventional and index-linked bond markets. These nominal and real rates can then be used to calculate implied 'breakeven' inflation rates that provide a guide to market inflation expectations. This section describes how index-linked bonds are used to derive real interest rates, from which breakeven inflation rates can be calculated.

Breakeven inflation rates

If conventional and index-linked bond markets are efficient and arbitraged by investors, such that both markets incorporate the same information about real interest rates, then the difference between nominal and real interest rates should contain information about investors' expectations of future inflation. With perfect foresight and no liquidity premia, the difference between nominal and real rates should be equal to the inflation rate over the same period. In practice, however, these are unrealistic assumptions—interest rates and price inflation can be volatile and unpredictable. So implied inflation forward rates are related to, but are not equal to, investors' expectations of future inflation. Implied inflation rates calculated in this way are better referred to as *breakeven* inflation rates.

Calculating a breakeven inflation spot rate for zero-coupon bonds is straightforward.(2) The breakeven inflation zero-coupon rate is the ratio of the zero-coupon yields on two same-maturity conventional and perfectly indexed bonds. Breakeven inflation is the *average* inflation rate that would have to occur over the life of the bonds for the uplifted index-linked bond to generate the same nominal return to maturity as the conventional bond—hence the term 'breakeven'. Another way to think of breakeven inflation rates, however, is as scaling factors applied to future real payments to transform them into future nominal payments of equal present value. Looking at breakeven inflation rates in this way suggests that for coupon bonds, breakeven inflation rates should be calculated by comparing the yields to redemption on same-coupon, same-maturity index-linked and conventional bonds.

Technical complications

Investors prefer to consume wealth today, rather than in the future. Consequently, (zero-coupon) bonds, which promise wealth in the future, trade at a discount, the discount rate for each maturity being the zero-coupon

(1) The minimum indexation lag is determined by two factors: (1) reporting delays, and (2) the method used for calculating accrued interest payments (essential for trading in the secondary market). The indexation lag on US Treasury inflation-indexed securities (more commonly known as TIPS) and Canadian Real Return Bonds is three months, and accrued interest is calculated by interpolating between the three-month lagged CPI and the two-month lagged CPI value. In the United Kingdom, on the other hand, accrued interest is calculated as a linear interpolation to the next coupon payment (which must therefore be known in advance). Consequently, an eight-month lag is required: two months for reporting delays, and six months to calculate the next semi-annual coupon.

(2) A 'zero-coupon' or 'pure discount' bond is a bond that has only one cash flow—the face value (by convention £100)—which is paid at maturity. There are no intermediate cash flows (coupons). Prior to maturity, zero-coupon bonds trade at a discount to face value.

or 'spot' rates. Taken together, spot rates contain implicit forward rates—today's terms for the lending of funds between two dates in the future.(1)

The *expectations hypothesis* of the term structure states that in a world with perfect foresight, expected rates of return on different maturity bonds are equalised only when all forward rates equal expected short-term interest rates. Combined with the *efficient market hypothesis*—which has several forms, all of which require investors to use information efficiently—the pure expectations hypothesis states that market forward rates provide the best forecast of future spot rates.

Of course, in reality, investors do not have perfect foresight. But in a complete and efficient market without distortions, breakeven inflation forward rates should be determined by three factors: (i) inflation expectations; (ii) the convexity adjustments present in conventional and index-linked bonds; and (iii) inflation risk premia. This section considers how convexity biases and risk premia drive a wedge between breakeven inflation forward rates and true inflation expectations.

The convexity adjustment

Interest rate compounding means that bond prices respond asymmetrically to changes in yield—bond prices are more sensitive to reductions in yield than to increases in yield.(2) In other words, bond prices are a convex function of yield. This combination of bond convexity and interest rate volatility raises bond prices, which pushes down forward rates. This effect is known as the convexity bias, and it grows with maturity (as compounding increases) and can vary across time (as yield volatilities change).

Differences in convexity bias between index-linked and conventional bonds mean that breakeven inflation forward rates may differ from actual inflation expectations. For example, if the convexity adjustment for the nominal forward curve was greater than for the real forward curve, perhaps because inflation uncertainty was adding to the volatility of nominal rates, then the net convexity adjustment could be expected to bias long-term breakeven inflation forward rates below actual expectations.

The inflation risk premium

The return to maturity on a conventional bond is fixed in nominal terms, but is uncertain in real terms because of inflation. Investors are interested ultimately in real returns, so may be willing to pay a premium for a security that provides real value certainty. The inflation risk premium will depend on how inflation (and hence the real returns on a conventional bond) varies with the discount factor that the market applies to real wealth in future states of the world. As with the convexity bias, these inflation risk premia may vary over time and maturity.

Fitting breakeven inflation rates

The United Kingdom has a sufficient number of index-linked government bonds to be able to fit a real yield curve.(3) When combined with a nominal yield curve, one can derive breakeven inflation yields. But the breakeven rates obtained will be influenced by the choice of curve-fitting technique, and the differences between techniques will be most pronounced when there are relatively few bond price data.

The Bank aims to use a curve-fitting technique that delivers a relatively *smooth* yield curve, since the aim is to estimate market expectations for monetary policy purposes rather than to fit prices precisely. The ideal technique should also be sufficiently *flexible* to capture movements in, and key features of, the underlying term

(1) If $z(t)$ and $z(T)$ are the annualised zero-coupon rates for t and T years maturity (where $t < T$), then the annualised forward rate at time 0 for lending between t and T is given by:

$$f\left(0,t,T\right)=\left(\frac{\left(1+z(T)\right)^{T}}{\left(1+z(t)\right)^{t}}\right)^{\frac{1}{T-t}}-1.$$

(2) For example, consider a ten-year zero-coupon bond with face value £100 and initial zero-coupon yield 5%. Its current price is £61.39—since the price at time t of a zero-coupon bond maturing at T with annually compounded yield, $y_{t,T}$, is $P_{t,T} = 1/(1 + y_{t,T})^{T-t}$. Now consider the effect of a 1 percentage point change in yield. If yield rises to 6%, the bond price falls to £55.84 (down £5.55). If yield falls to 4%, the bond price increases to £67.55 (up £6.17). So bond prices are more sensitive to falls in yield than to increases in yield, and will therefore rise as yield volatility increases.

(3) Apart from the UK Treasury, no other major government issuer currently has a sufficient number of outstanding index-linked bonds to permit estimation of a well-specified real yield curve. So for most countries it is not possible to estimate spot or forward breakeven inflation rates, and one is limited to calculating crude breakeven inflation yields from differences in redemption yields on particular conventional and index-linked bonds. However, when comparing index-linked and conventional gilts with similar coupon rates and maturities, this crude approach usually generates breakeven inflation yields that are very close to estimates derived from the difference between fitted real and nominal yields.

structure. Also the yield curves produced should be *stable*, in the sense that fitted yields at one maturity should be robust to small changes in bond data at another maturity. The Bank currently fits yield curves using both smoothed cubic spline (Anderson and Sleath (1999)) and parametric (Svensson (1995)) approaches.(1)

Institutional distortions to breakeven inflation rates

In theory, breakeven inflation rates derived from conventional and index-linked government bonds should reflect rational expectations of future inflation plus an adjustment for inflation convexity biases and risk premia. Under certain conditions, however, the breakeven inflation rates can be distorted. The first of these is the way differences in tax treatment between conventional and index-linked bonds may affect relative prices. The second is institutional factors, which may create price-inelastic demand for gilts. In practice, these technical complications and distortions may limit the usefulness of breakeven inflation rates as a measure of inflation expectations.

Taxation

Investors are concerned about real net-of-tax cash flows, so *differences in tax treatment* between conventional and index-linked bonds could influence relative prices, and therefore breakeven inflation rates. Tax authorities have to decide whether income and capital gains taxes should be applied to nominal or real cash flows—in other words, whether taxes should be levied on the inflation uplift for coupon and principal payments. However, since real value certainty is the most important characteristic of indexed bonds, a tax system that taxes the inflation uplift in effect reintroduces inflation risk. Under such a system, even if pre-tax real yields remained constant, an increase in inflation that raised the nominal yield on indexed bonds would increase the tax liability and lower the post-tax real yield. In the United Kingdom, the inflation uplift on the *principal* is considered a capital gain (and is not taxed). But the uplift on *coupon payments* is treated as income, and taxed accordingly. The implication is that the post-tax real returns on index-linked gilts are not entirely protected from erosion by high inflation, and this will be reflected in prices.

The variety of possible investor tax profiles also complicates the calculation of post-tax yields and breakeven inflation rates for the 'representative' marginal investor. In the United Kingdom, conventional and index-linked gilt stocks are mostly held by largely tax-exempt institutional investors. So if we assume these investors to be the marginal purchasers of gilts, then it is not unreasonable to set aside tax considerations when looking at implied breakeven rates—at least in the United Kingdom.

Other institutional considerations

UK life assurance and pension funds (LAPFs) are estimated to hold a high proportion of the outstanding gilt stock—perhaps more than a half. So the portfolio allocation decisions of these institutions could have significant effects on gilt prices. In the United Kingdom, there are a number of factors that may have helped to generate price-inelastic demand for gilts from LAPFs. In particular, pension funds have raised their holdings of gilts in response to: (i) ageing of the UK population; (ii) the introduction of Minimum Funding Requirement legislation; (iii) the need to hedge old policies with (previously unhedged) guaranteed annuity rates; and (iv) the practice of appraising pension fund and bond portfolio managers' performance against either industry peer group or gilt yield benchmarks, thereby providing an incentive to hold gilts.

In 1997, government legislation came into force designed to ensure that defined benefit pension funds would protect fund members in the event of the employer becoming insolvent. The Minimum Funding Requirement (MFR) was designed to ensure that a scheme would have sufficient assets to be able fully to protect pensions already in payment, and to provide younger members with a transfer value that would give them a reasonable expectation of replicating scheme benefits if they transferred to another pension scheme.

The MFR values a fund's assets at current prices by marking-to-market. However, to ensure that defined benefit schemes hold sufficient assets to meet their liabilities, the MFR applies a set of liability valuation rules linked to yields on a set of gilt indices.(2) Although not actually requiring pension funds to purchase gilts,

(1) For a full description of the Bank of England's yield curve fitting techniques, see Anderson and Sleath (1999) and Deacon and Derry (1994).
(2) In March 2001, the Chancellor of the Exchequer announced that the MFR would be replaced when new legislation could be formulated and passed through Parliament. Note, however, that by June 2003 a new financial reporting standard (FRS17) will come into force. FRS17 will show pension fund net assets or liabilities as an item in the balance sheet of the employer company, and will value defined benefit pension scheme liabilities using the prevailing yield on an AA-rated corporate bond of appropriate maturity.

legislation that requires the use of 15-year conventional gilt and 5-year index-linked gilt indices as discount factors for valuing liabilities also generates strong incentives for defined benefit pension funds to hold these gilts on the asset side. Matching assets and liabilities in this way, by making the same discount rates common to both, reduces the likelihood that fluctuations in financial prices will result in the fund becoming underfunded. Furthermore, work at the Bank has found evidence that the widespread use of FTSE gilt indices can also prompt gilt prices to respond to changes in the composition of the index. By influencing the demand for gilts in this way, it is possible that the MFR and the use of FTSE gilt indices may have distorted (and may continue to distort) implied breakeven inflation rates at certain points along the yield curve.

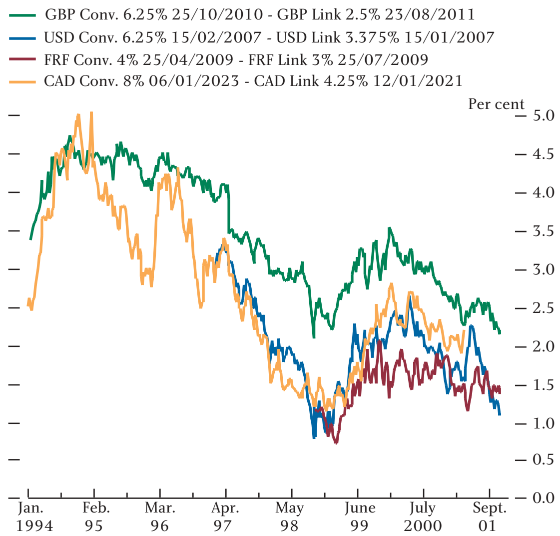
The distortionary impact of price-inelastic demand from the pension fund industry has arguably been aggravated by concerns, in recent years, about the outlook for future new supply and the outstanding stock of government debt. In the United Kingdom, net debt issuance as a percentage of GDP has been shrinking since 1996 Q1, and has been negative since 1997. A diminishing supply of UK government debt, together with a shortage of alternative high-quality long-dated fixed-income sterling securities (such as supranational or high-grade corporate paper) and a strong inelastic-demand from institutional investors may have driven prices out of line with economic fundamentals.

An indication of the impact of institutional factors may be obtained from: (i) comparisons of common currency borrowing rates on government bonds, (ii) comparisons of breakeven inflation rates in different countries, and (iii) breakeven inflation forward curve profiles for sterling.

Using interest rate and currency swaps, it is possible to calculate and compare the common currency costs of borrowing for government bond issuers. For example, on 1 December 1999, the UK Treasury 9% 06/08/2012 gilt could be swapped into a bond paying sterling (GBP) 6-month Libor minus 103 basis points. The French government OAT 8.5% 26/12/2012 bond, on the other hand, could be swapped into GBP 6-month Libor minus 48 basis points. This difference in spreads to GBP 6-month Libor meant that HM Treasury was effectively able to borrow some 55 basis points more cheaply than the French Trésor. Since both issuers are almost identical in terms of credit quality, this difference must have reflected institutional factors, including MFR legislation. But note that relative funding costs also change over time—by February 2002 both the gilt and OAT swap spreads to GBP Libor had narrowed considerably, and the United Kingdom's funding cost advantage had shrunk to around 18 basis points. To the extent that institutional factors have asymmetric effects on the conventional and index-linked markets, one might see an impact on breakeven inflation rates.

Chart 1 provides an international comparison of breakeven inflation rates on selected index-linked government bonds from 1994 to 2001. Given the small absolute size of the differentials, the sterling breakeven inflation yield for the 2011 index-linked gilt was not obviously out of line with breakeven rates for other economies at similar maturities. Furthermore, any divergence could be attributed to economic fundamentals and investor preferences rather than to institutional distortions.

Chart 1
International breakeven inflation yields

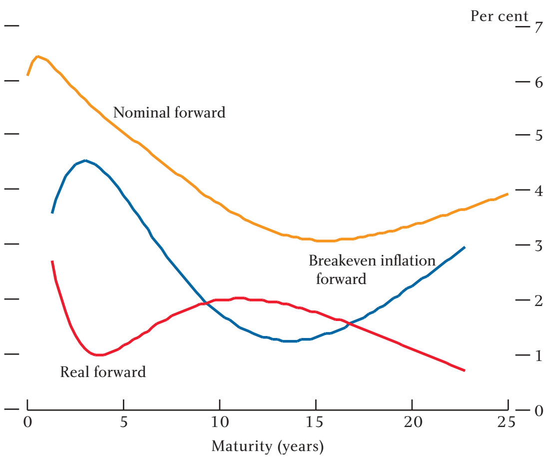


Source: Bloomberg.

However, it is also worth looking at the profile of breakeven inflation forward curves. During the period covered by the MFR, one might expect to see conventional gilts at and around 15 years' maturity trading at relatively expensive levels, driving down nominal spot and forward rates. At the same time, one might also observe episodes with price discontinuities between index-linked gilts either side of the 5-year maturity mark, translating into 'humped' real forward curves. So nominal and real interest rate and breakeven inflation forward profiles such as for 20 December 1999 (see Chart 2) suggest that the MFR was affecting the conventional and index-linked markets.

Chart 2 raises the question of whether investors could really have had sufficient information to foresee inflation following the path indicated. Can we really believe that investors anticipated inflation 15 years ahead to be lower than in 25 years' time? Arguably, breakeven inflation forward curves such as the one shown in Chart 2, taken during a period of low and stable inflation, are difficult to reconcile with investor rationality. More likely, inflation forward profiles such as that for 20 December 1999 reflect the various distortions in the gilt markets, and provide a salutary lesson for those wishing to extract inflation expectations from breakeven inflation rates. The reality is that it is difficult to isolate and quantify the distortions that can affect breakeven inflation rates.

Chart 2
UK forward curves for 20 December 1999



Note: Breakeven inflation, nominal and real one-year forward curves are calculated using the Bank of England's variable roughness penalty spline-based technique (see Anderson and Sleath (1999, 2001)).

Extracting information from breakeven inflation rates

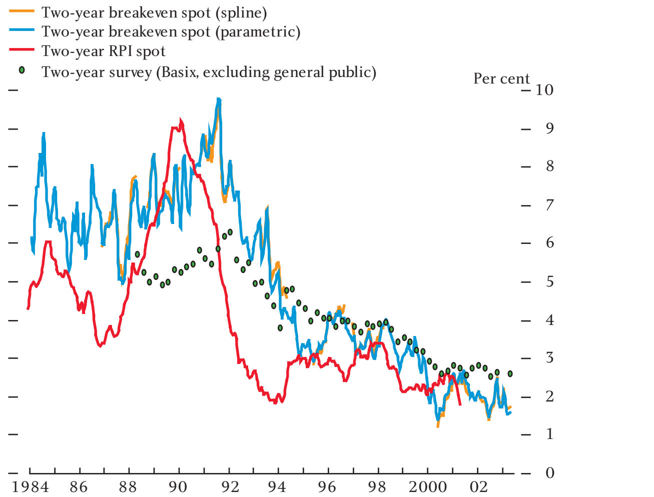
Breakeven inflation rates as forecasts of inflation

Breakeven inflation rates are useful in providing an indication of investors' views of the longer-term inflation outlook that is unavailable elsewhere. But monetary policy makers are also interested in inflation over the short-to-medium term. So it is interesting to compare the forecasting performance of breakeven inflation rates with survey-based measures of inflation expectations.

Breakeven inflation rates can be compared with the Barclays Basix survey of expectations for RPI inflation over the next two years.(1) The survey samples a number of groups, including business economists, investment analysts, academic economists, trade union secretaries and the general public. For this study, we consider only the measure that excludes the general public.(2)

Chart 3 plots the actual (monthly) RPI inflation outturn for the past two years against the zero-coupon breakeven inflation rates and (quarterly) Basix survey inflation forecasts made for those two years. The chart shows a number of interesting features: first, both the survey and breakeven series underpredicted actual RPI inflation outturns during 1989–91 but generally overpredicted inflation after 1991. Second, the two-year breakeven inflation rate tracks two-year-ahead RPI inflation better than survey forecasts. Third, breakeven inflation and survey forecasts have both been falling since 1990, though the adjustment process appears to have been lagged (and slow) compared with actual RPI inflation.(3) Fourth, two-year spot breakeven inflation and survey rates have differed, often quite considerably, during the sample period. Fifth, revisions to survey expectations have been less volatile than those of breakeven inflation rates.

Chart 3
Breakeven inflation and Basix survey two-year spot rates against RPI two-year inflation outturns

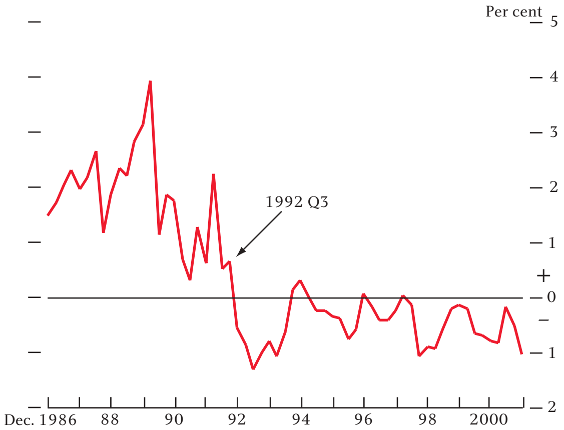


Notes: (1) The two-year annualised spot rate is the average annual rate over the past two years.
(2) Two-year breakeven inflation zero-coupon rates are calculated by the Bank of England (see Anderson and Sleath (2001) and Deacon and Derry (1998)).
(3) The two-year spline-based breakeven inflation series is broken due to occasional absence of sufficiently short index-linked bonds.

(1) Comparisons at shorter-maturity horizons are not possible because the absence of bond data points makes the real yield curve too unreliable at less than two years.
(2) We exclude the general public survey figures because of their consistent positive bias.
(3) This apparent delay in the forecast error correction process is consistent with an overlapping forecast horizon problem.

An important feature of the data is the possible structural break in the differential between the breakeven and survey inflation series—this is shown in Chart 4. The difference between surveys of two-year inflation expectations and the breakeven inflation rate implied from bond prices can be used as a proxy for the inflation risk premium. Prior to 1992 Q3, breakeven inflation rates were consistently above survey expectations (on average by 1.89 percentage points). After this date, however, this differential became negative, though smaller in absolute size (on average -0.42 percentage points), as survey respondents raised their forecasts of two-year inflation after 1992 Q3. This apparent structural break roughly coincides with sterling's exit from the European Exchange Rate Mechanism (ERM).

Chart 4
Difference between two-year breakeven and survey-based inflation expectations



Note: The differential is the two-year breakeven spot rate minus the (quarterly) two-year spot Basix survey (excluding general public).

This break in the breakeven/survey differential series also poses a puzzle, since sterling's ejection from the ERM and the associated loss of policy credibility would have been expected to drive up the inflation risk premium, and so to have widened rather than narrowed the differential, at least until the inflation-targeting framework had become established. An alternative explanation is that the United Kingdom's abandonment of exchange rate targeting in favour of an inflation-targeting policy could have been expected to lower short-term inflation volatility, and therefore to reduce immediately the short-term inflation risk premium. This argument allows for a simultaneous fall in the short-term inflation risk premium and a reduction in long-term policy credibility.

Although short-term breakeven inflation rates are not perfect forecasts of inflation (due to time-varying inflation risk premia and lags in error correction), our analysis does indicate that breakeven inflation rates are better than Basix surveys in terms of forecasting performance, and may therefore be a useful source of information on short-term inflation expectations for policy-makers.

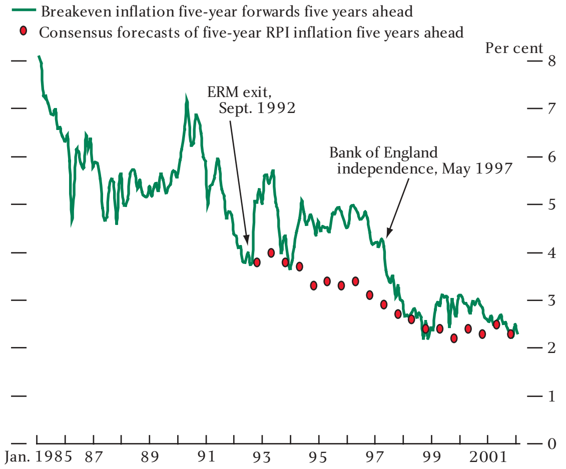
Breakeven inflation rates as a measure of central bank credibility

Investors' longer-term expectations of inflation depend on their confidence in the ability and determination of the monetary authorities to control inflation. Breakeven inflation rates may not be easily decomposed into inflation expectations and inflation risk premia, but these components are linked to investors' views and preferences about the level and volatility of future inflation. As King (1995) notes, 'both the government and private sector have subjective distributions over the possible outturns for inflation at any future date. Credibility is a measure of how close are these two distributions'. The private sector's distribution can be summarised by its mean—the expected inflation rate—and the spread of possible outturns around the mean, as proxied by the inflation risk premium. Since breakeven inflation rates capture both of these components, they are a potentially useful indicator of anti-inflationary credibility.

Forward inflation rates are more informative than spot rates of inflation as an indication of monetary conditions, as they allow policy-makers to assess both the expected average rate of inflation *and* its evolution over time. Implied breakeven forward rates can be used to assess the impact of monetary policy on inflation credibility. To illustrate this, Chart 5 presents annualised breakeven inflation five-year forwards five years ahead since 1985. It is interesting to compare these forward rates with the Consensus economists' expectations of five-year annualised inflation five years ahead. The chart illustrates the impact of two major developments in monetary policy over the period: the United Kingdom's exit from the ERM in September 1992, and the establishment of the RPIX inflation target soon after, followed by the Government's concession of operational independence to the Bank of England and the formation of the Monetary Policy Committee framework in May 1997.

The breakeven inflation forward rates clearly indicate that the United Kingdom's exit from the ERM in 1992 had a dramatic impact on market confidence, driving up breakeven forwards by 125 basis points. This indicates

Chart 5
Long-term breakeven inflation forwards and Consensus expectations



Note: Breakeven inflation forward rates are derived using the Bank of England's variable roughness penalty spline-based technique (see Anderson and Sleath (1999, 2001)).

that the loss of the ERM's external discipline on policy had a serious negative impact on the credibility of UK monetary policy in the financial markets. Although the new inflation-targeting policy became established in late 1992 and early 1993 and economists began gradually to revise downwards Consensus long-term forecasts of RPI inflation, one can see that there continued to be a significant differential between the breakeven forward rates and Consensus forecasts for a number of years. This suggests that although the exchange rate target had been replaced with an inflation target, and the policy process been made more transparent and accountable through the publication of a regular *Inflation Report* by the Bank of England, there was still some 'doubt [about] the United Kingdom's willingness to remove operational decisions on interest rates from the political arena' (King (1999)). In other words, the gap between Consensus forecasts and breakeven inflation forwards was probably pointing to an inflation risk premium stemming from a policy credibility shortfall.

In May 1997, the Chancellor of the Exchequer declared that the Bank of England would be granted operational independence for the conduct of monetary policy, with a clear remit to achieve, on average, 2.5% RPIX inflation. Looking at movements in conventional and index-linked gilt prices, one finds that breakeven inflation forwards fell by 50 basis points at ten years' maturity on the day of the announcement, and by even more thereafter.(1) But credibility generally takes longer to establish than it does to lose, and as the Chancellor, Gordon Brown, stated at the time, 'the ultimate judgement of the success of this measure will not come next week, or indeed in the next year, but in the long term.' Since May 1997, the gap between long-term breakeven inflation forwards and long-term inflation expectations has narrowed considerably. Indeed, breakeven inflation five-year forwards five years ahead have fallen by around 180 basis points, and are currently close to both the Government's 2.5% RPIX inflation target and Consensus RPI inflation forecasts.

Summary and conclusions

This paper has outlined how inflation-linked securities can be used to infer market-based expectations of future inflation. Inflation-linked securities provide an alternative source of information on inflation expectations to surveys and econometric forecasting approaches, with the advantages of being available for a wide range of maturities, entirely forward-looking, timely, and updated every working day.

In the United Kingdom, market inflation expectations can be derived from a comparison of conventional and index-linked gilt prices or (with difficulty) directly from inflation swaps. By fitting real and nominal yield curves to conventional and index-linked gilts, it is possible to infer zero-coupon and forward breakeven inflation rates. These breakeven inflation rates contain information about inflation expectations, though to extract this information one has to allow for both technical complications and the possibility of institutional distortions.

Due to the near-continuous nature of gilt trading activity, breakeven inflation rates can provide policy-makers with an immediate verdict on the market's view of the impact of economic news on the anticipated path of future inflation, and investors' attitudes to inflation risk. To gauge what incremental, policy-relevant information can, in practice, be gained from a comparison of index-linked and conventional gilt prices, we compared the two-year breakeven inflation rates with two-year Basix inflation surveys. Our results indicate that, despite the possible influence of risk premia and institutional distortions, two-year breakeven inflation rates do provide information additional to that already contained in surveys of inflation expectations. Longer-term breakeven inflation rates, meanwhile,

(1) See King (1999). This speech may be found on the Bank's web site at www.bankofengland.co.uk/speeches/speech41.pdf

provide a barometer of inflation credibility. It is interesting, for example, to compare the immediate (negative) impact of September 1992 on UK monetary policy credibility in long-term breakeven forward rates with the gradual gains in credibility accumulated since Bank of England independence.

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