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Inflation Indexed Bonds and Monetary Policy

Chiho Kim

This paper introduces the concept of inflation indexed government bonds, and surveys the literature and main features of the indexed bonds markets of the major industrialized countries. It details methods for extracting market expectations of inflation and real interest from the nominal and inflation indexed bonds yields, and shows how such informations are utilized in the conduct of monetary policy in the United Kingdom.

Ⅰ. Introduction

Inflation indexed bonds are financial instruments designed to protect the bond's purchasing power by tying interest and principal payments to an index of price changes. Indexed bonds include two types of compensation, a real rate of return plus a compensation for the erosion of purchasing power due to inflation. Traditional nominal bonds include a single nominal component of return, which is fixed at the time of purchase. The return on a nominal bond implicitly comprises an expected or required real rate of return, plus an estimate of inflation over the life of the bond. On an indexed bond, the real return is fixed *ex-ante*, and the nominal return is calculated *ex-post* ; at the

Senior Economist, Research Department, The Bank of Korea, Seoul 100-794, Korea. Work on this paper was initiated while the author was a visiting scholar at the Center for Pacific Basin Monetary and Economic Studies, Federal Reserve Bank of San Francisco, and at the University of California at Berkeley. The opinions expressed in this paper are the author's own and do not necessarily reflect the views of the Bank of Korea. An earlier version was presented at the annual conference of the Korea Money and Finance Association, June 25 1998. The author sincerely thanks Nicola Anderson, Bank of England, for arranging to obtain nominal and index-linked gilts yields data of the United Kingdom.

time of purchase the real return is certain and the nominal return is uncertain. For nominal bonds, the nominal return at the time of purchase is certain, the real return uncertain.

A long line of distinguished economists including Jevons, Fisher, Musgrave, Tobin, and Friedman have been strong proponents of indexed bonds (Collier [9], Humphrey [20]). However, the introduction of indexed bonds has to date been exceptional, save in inflationary circumstances which gave the authorities little scope to do otherwise. The main arguments in favor of indexed bonds are a cost-saving on borrowing to the government, completing long-term financial market, and strengthening the tools, credibility and commitment to monetary policy.

A number of developing countries, including Israel, Brazil, Argentina, and Chile adopted comprehensive indexation in the 1960s and 1970s. Indexation of financial markets was seen as an expedient to promote domestic savings and capital formation as well as to moderate inflation. However, by the 1980s inflation and capital market performances in those countries had largely deteriorated. Some countries, e.g. Argentina, Brasil, have since taken steps to reduce the scope of indexation (Jud [21], Baer and Beckerman [2], Price [25]).

Since the 1980s, however, another group of industrialized countries has adopted inflation indexed bonds programs. The U.K. was among the earliest, inaugurating the program in 1981, followed by Australia in 1986, and by Sweden and Canada in the early 1990s. New Zealand also joined the ranks in 1995, and the U.S. most recently started to issue such bonds in January 1997 after years of debate. In these countries, the decision was not dictated by the inflation circumstances at the time, or in a sense imposed on the government by the bond market as a last-ditch effort to preserve long-term capital formation. In contrast to the countries in the prior group, the latter countries that introduced indexed bonds had generally already established their anti-inflation credentials through credible policies that brought good inflation performance. They thus successfully integrated indexed bonds into existing debt management programs. In this group, the introduction of indexed bonds has been justified on grounds of cost-savings, complete financial markets, monetary policy credibility, and the extraction of valuable information for monetary policy deliberations. In particular, the importance of directly extracted information such as market expectations of inflation and real interest rates from the indexed bonds prices has been increased because of its usefulness for

policymakers interpreting the state of economy and expectations about the future (Shen [26], Wrase [30]).

This paper provides the methods for extracting market expectations of inflation and real interest from the inflation indexed bonds yield, and discusses its usefulness in terms of providing important insights for monetary policy. The following section reviews the literature and main features of the indexed bonds markets. The third section presents the methods used to extract market expectations on real interests and inflation, and shows how the extracted information is utilized in implementing monetary policy in the U.K. The final section rounds off the paper with some concluding remarks.

Ⅱ. Inflation Indexed Bonds : Motives for Issue and Main Features

1. Motives for Issuing Inflation Indexed Bonds

The concept of indexation of financial instruments has a long history. Distinguished economists including Jevons, Marshall, Keynes and Irving Fisher long ago pointed out that inflation indexed bonds could encourage saving, slow inflationary spending and reduce government borrowing costs. However, more comprehensive discussions about indexation and its usefulness in monetary and fiscal policies were presented by Musgrave, Tobin, Friedman, and others.[1] The merits of indexed bonds are here considered under the following three headings.

1) Incentives to Saving and Low Inflation

Bach and Musgrave [1] argued that inflation indexed bonds represent a non-inflationary form of saving, because the alternative to holding indexed financial assets may be real assets, especially durable goods. During periods of accelerating inflation, transfers of wealth from financial assets into real goods may intensify inflationary pressures. Indexed bonds could both encourage saving and slow inflationary spending. Corporations and institutions could use inflation indexed bonds as an alternative to

1) For a review of earlier examination and discussion concerning these issues, see Humphrey [20] and Fischer [15].

investment in commodities and real inventories, further dampening otherwise pro-cyclical behavior (Levhari [23]).

Friedman [18] and others have argued that nominal government bonds provide an enticement to the government to inflate. The idea is that nominal bonds give the government the option of reducing the real value of outstanding government bonds by engineering a surprise inflation. This amounts to an unanticipapted capital levy on lenders. Friedman concluded that indexing government bonds would remove the possibility of a surprise capital levy and reduce the incentive to inflate.

Fischer [16] pointed out that the relation between monetary policy and inflation indexed government bonds can be thought of in terms of the ability of the government to commit credibly to a low-inflation policy. At any point in time the government may find it optimal to raise revenue through an inflation-induced capital levy on nominal bonds. Lenders, however, realize that the government has this incentive, and account for this by raising their expectations of future inflation. Under a nominal bonds regime, the equilibrium inflation rate is reached when the rate of inflation is high enough to assure lenders that it is politically too costly for the government to raise inflation any higher. On these grounds, indexation of government bonds provides a method by which the government can make a commitment to a low inflation rate more credible (Hetzel [19], Shen [26]).

2) Cost-Effectiveness and Debt Management Considerations

As far back as Keynes, a number of economists have argued that indexed bonds could reduce government borrowing costs. There are two sources of saving on borrowing costs. One is the difference in the inflation expectations between investors and the government, and the other one is the inflation risk premium.

Inflation indexed bonds could provide cheaper funding than conventional nominal bonds *ex post* if inflation turns out lower than had been expected by the market in its pricing of conventionals. A government which believed that inflation would be lower than forecast by bond investors would therefore expect to save debt servicing costs through indexed bonds issuance. Although the government may not be any better at economic forecasting than the market, inflation is ultimately a variable which the authorities control, and they may have better information than the market on their anti-inflation commitment. For example, one of the reasons given for the 1994 Swedish

indexed bond issue was that the Riksbank believed that market inflation expectations were above the likely outturn for inflation (Deacon and Andrews [13]).

There is another sense in which inflation indexed bonds may prove cost-effective by eliminating an inflation risk premium that is often part of the yield on nominal bonds. A risk premium is the difference in the yields of two assets due to difference in the riskiness of the assets. Since the real return on conventional bonds is subject to inflation risk, investors in these bonds demand a risk premium in the form of a higher yield relative to an asset with no such risk. Therefore, the government typically has to pay higher yields to compensate investors for taking on the additional risk. Inflation indexed bonds, however, remove the investors' inflation risk. So by issuing indexed bonds, the government can avoid paying the inflation premium found in nominal interest rates on conventional bonds and can thereby lower its borrowing costs.[2)]

3) Indexation and Effectiveness of Monetary Policy

A comprehensive discussion on the usefulness of inflation indexed bonds for monetary policy was first given by Tobin [29]. Tobin proposed that monetary policy would operate more efficiently if open-market operations were conducted in a market for inflation indexed government bonds. In Tobin's analysis the critical idea is that indexed bonds are a closer substitute for equity than are nominal bonds. Under this assumption, control over the quantity and price of indexed bonds would allow the monetary authority to affect more directly the price of equity and thus potentially improve its stabilization policies.

Another benefit of inflation indexed bonds in the context of monetary policy implementation is that they can provide useful information to policymakers about real interest rates and inflation expectations, as well as an indication of the credibility of monetary policy. Although it is possible to obtain such information from econometric estimations or surveys, there are several critical drawbacks to these approaches (Deacon and Derry [12], Croushore [11]). Econometric estimates are imprecise, and surveys involve costs and time to process and are taken infrequently, so policymakers rarely have up-to-date measures of market expectations of inflation or of short-run changes in

2) Unfortunately, evidence on the size of the inflation risk premium on government bonds is scant and inconclusive because of the lack of data and measurement error. For more discussions and recent some empirical results, see Bodie *et al.* [5], Deacon and Derry [12], Breedon [7], and Campbell and Shiller [8].

expected inflation. Moreover in the case of surveys long-term forecasting is hardly meaningful because they are only available for a limited number of time horizons. Instead, it is possible, subject to some assumptions about risk and liquidity premia, to derive estimates of market expectations of real interest rates and inflation directly by comparing the prices of indexed and non-indexed bonds. While there are practical difficulties in estimating, information derived from the directly observed financial market data about expected inflation and real rates can be useful to monetary policymakers as well as to private economic agents. An accurate estimate of expected inflation could help in interpreting observed movements in various asset yields, since expected inflation matters for investors' decisions about asset allocations. An accurate estimate of real interest rates also help in forecasting future economic activity and inflation. Perceived real interest rates determine the real cost of capital for investment, which is an important determinant of economic activity and growth. Overall, the information provided by inflation indexed bonds would allow both policymakers and the private sector to make better economic decisions (Hetzel [19], Shen [26]).

2. The Market for Inflation Indexed Bonds : Features and Prospects

Bonds indexed to inflation have been issued over the last decade largely by industrialized countries such as the U.K., Canada, Australia, Sweden, and New Zealand. The U.S. Treasury most recent, among them, started to issue such bonds in January 1997. However, index-linked bonds issuance may be traced as far back as immediately after WWII when countries such as France and Finland issued a substantial portion of their total debt issuance in index-linked form as part of their price stabilization programmes. During the 1960s and 1970s a number of Latin American countries and Israel adopted the inflation indexed bond provisions for the purposes of economic stabilization and fostering the development of long-term capital markets. However, the performances in these countries were not largely successful. In the light of their experiences, it can be argued that comprehensive financial indexation was imposed upon them and their policy choices were limited by the inflationary circumstances at the time (Jud [21], Baer and Beckerman [2], Price [25]). Among developing countries, however, Mexico is an exceptional case. Mexico has issued indexed bonds as part of financial market liberalization and reforms to move government financing from direct

credit from banks to placements of public debt on the market since June 1989. They have successfully integrated the new debt provision into the existing government debt management programs, and overall performances in terms of long-term capital formation and inflation were quite satisfactory.

Among industrialized countries, the U.K. was the first to issue inflation indexed bonds. The U.K. government first issued an index-linked gilt on March 27, 1981. The authorities were concerned that issuing a large amount of high coupon, long-dated bonds in an environment of (temporarily) high inflation would significantly increase the long-term burden of funding the national debt. It was also argued that by issuing index-linked bonds, the U.K. monetary authorities would more credibly be able to signal their commitment to reducing inflation. If inflation increased further, the burden of financing the stock of existing debt through index-linked gilts would be higher than if the authorities issued conventional nominal stock. To this extent, the index-linked programme could be seen as running in conjunction with the Medium Term Financial Strategy, whose aim at the time was to reduce private-sector agents expectations about inflation. Finally, it was argued that inflation indexed bonds could assist monetary policy by providing the Bank of England with a more direct measure of inflation expectations and real interest rates. This can be evidenced by the extensive use of such data in the Bank of England's *Quarterly Inflation Reports* (Bank of England [3]). Although index-linked bonds still take a relatively small share of total outstanding gilts, the proportion of index-linked gilts to total gilt issuance has been rising in recent years.[3] It is expected that the importance of index-linked gilts will continue to grow within the overall funding programme.

Canada's first Real Return Bonds (RRBs) were issued on December 10, 1991. The Canadian indexed bonds market is still relatively small but there are signs that interest in them by domestic investors is steadily increasing (Branion [6]). Canadian RRBs are almost identical in structure to the U.K.'s index-linked gilts. Though the Canadian market is much newer and smaller in size than the U.K. market, the Government of Canada has begun more frequent issuance of RRBs in an attempt to deepen the market

3) The total face value of index-linked gilts accounted for 17.8% of the total face value of UK government debt on March 31 1996 (Bank of England [3]). In terms of market value, the indexed bonds account for about 15% of the UKs outstanding government debt. The data are taken from the bonds column in *Financial Times* on a daily basis.

and improve its liquidity.[4)]

The development of the RRB market assists the Government and the Bank of Canada in successfully meeting their inflation-control targets —1 ~ 3% core inflation through 1998 and price stability with a likely band of 0 ~ 2% thereafter — in two key aspects. The first is to underpin the credibility of the targets themselves, since the Government's costs in terms of both interest and principal are lowered by keeping inflation under control. The second benefit is to monitor the level of inflation expectations in the bond market. Policymakers are thus receiving a clear message that markets perceive an inflationary threat from the current size of public-sector deficits and/or the decline in the C$ since late-1991 (Cote *et al.* [10]).

The U.S. Department of Treasury recently started to offer a new type of marketable security, referred to as a Treasury Inflation-Protected Security (TIPS) and first auctioned in January 1997. The security is based, with some modifications, on the model of the Real Return Bonds currently issued by the Government of Canada. The first auction of inflation-protected securities, a 10-year note, was held in January 1997, and auctions have been staged quarterly.

It seems too early to evaluate whether the issuance of inflation indexed Treasury securities is successful. However, according to the newspapers, e.g. the *Wall Street Journal*, and most observers, there was overall agreement that the debut of inflation indexed securities was quite successful, and provided encouragement to a Treasury Department eager to gain investor acceptance for a new breed of U.S. government security designed to protect holders from inflation. However, the second and third auctions of the notes proved less successful than expected. Market participants and analysts pointed out some underlying factors : It is obvious to many bond investors why the inflation-protected bonds are not winning friends : there is little inflation to be protected from. And the markets' confidence that the Fed, under Alan Greenspans leadership, will succeed in keeping inflation under wraps makes the new bonds about as popular as an umbrella in a desert. A lack of familiarity with the securities also hampers them, despite dogged efforts by the Treasury Department to reach out to the investing

4) The average monthly (turnover) volume of RRBs during the first 6 months was C$1.45 billion (19% of outstanding stock), while the corresponding volume of nominal bonds was C$63.4 billion (100% of outstanding stock). The liquidity of RRBs is still lower than that of the nominal bonds, but it has steadily increased since the program started.

〈Table 1〉 Main features of the indexed government bonds markets of selected countries as at 31 March 1997

	Australia	Canada	Israel	Mexico	Sweden	UK	US
Total outstanding (inflation uplifted, $US bn)	3.9	5.8	27.3	10.9	14.8	84.4	7.4
Total outstanding as a percentage of total marketable debt	4.4%	1.7%	72.0%	25.0%	8.1%	17.8%	0.2%
Average daily turnover 1996 ($mn)	53.5	24.0[1]	26.7	n/a	Infrequent trading	358.9	n/a
Number of indexed bonds	7	2	200+	3	5	13	1
Longest maturity	2020	2026	2011	2000	2020	2030	2007
Coupon frequency	Quarterly	Semi-annual	Annual[2]	Quarterly	Annual	Semi-annual	Semi-annual
Frequency of inflation index publication	Quarterly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Length of lag	[3]	3 months	1 month	2 weeks	$2\frac{1}{2}$ months	8 months	3 months
Current method of issue	Multiple yield auction	Single yield auction	Multiple price auction	Multiple price auction	Yield tap	Price tap	single yield auction

1) 1995 figure.
2) Israeli fixed-rate indexed bonds pay annual coupons. Floating-rate indexed bonds pay semi-annual coupons.
3) Formula is based on the average percentage change in the CPI over the two quarters ending in the quarter which is two quarters prior to that in which the next interest payment falls.
Source : Bank of England [3], and updated by the author.

public. Despite the lack of enthusiasm by investors, and scant evidence of inflationary pressures, Treasury officials are confident a full market for the new securities will eventually materialize. It will take time before true demand for the novel securities develops. Nonetheless the decision by the U.S. Treasury to introduce inflation indexed bonds may accelerate their adoption elsewhere.

The main features of the indexed bonds markets in selected countries are summarized in 〈Table 1〉.[5]

5) For a summary history of indexed government bonds, see Bank of England [3].

Ⅲ. Extracting Market Interest Rate and Inflation Expectations

Market expectations of real interest rate and inflation can give important insights into the credibility of monetary policy directed towards achieving price stability. For that reason, central banks have carried out extensive research into the ways in which inferences about these expectations can be drawn from the market prices of financial instruments. The Bank of England's efforts are notable. This section sets out the methods for extracting information on inflation expectations and expected real interest rates from nominal and indexed bonds yields, and how such information is utilized for implementing monetary policy in the U.K..

1. Measures from Financial Markets

Measures of inflation expectations derived from financial markets, and in particular government bond markets, are based on the relationship linking real and nominal rates of interest with market expectations of future inflation. This relationship is formalized by the well-known Fisher identity which, in tis simplest form, states that the nominal interest rate on a conventional nominal bond is equal to the sum of the real interest rate plus the expected level of inflation :

$$y_t^N = \tilde{r}_t^N + E[\pi_t^N] \tag{1}$$

where y is the *observed* nominal rate of interest, $\tilde{r}$ is the *ex-ante* or *required* real rate of return on a nominal bond, and $E[\pi]$ is the *expected* rate of inflation at time t. In each case, the subscript ' t ' and the superscript ' N ' denote that these are *average* per period rates over the period t to $t+N$. When using nominal bonds, the real interest rate is assumed to satisfy certain time series properties, for example, that it is constant or mean reverting. These assumptions then allow movements in nominal interest rates to be directly related to movements in inflation expectations. This approach is simple and convenient. However, the usefulness of the approach in practice is clearly limited. In

particular, it is only possible to use the nominal term structure to extract information about inflation expectations. Moreover, even if nominal interest rates can be used to infer *changes* in inflation expectations, this approach does not provide much information about the *level* of inflation expectations, since the level of real interest rates is not known.

2. Methods Using Inflation Indexed Bonds

The limitations of using nominal bonds can be avoided to a large extent when inflation indexed bonds yields are available. A perfectly indexed bond offers investors a guaranteed real rate of return ; this inflation risk-free real rate is denoted r. Thus, in order for risk averse investors to invest in conventional bonds, rather than indexed bonds, they are likely to require *ex ante* expected real rate of return greater than the certain rate ; as before, this *ex ante* required is denoted by $\tilde{r}$. The difference between these two rates is the inflation risk premium ρ :

$$\tilde{r}_t^N = r_t^N + \rho_t^N \tag{2}$$

The key assumption underlying equation (2) is that the only factor separating returns on conventional and inflation indexed bonds is the uncertainty over future inflation ; i.e. all other characteristics such as their maturity, default risk, liquidity, etc. are identical. Under this assumption, equation (2) describes an equilibrium condition between the two markets ; if this condition did not hold, investors would adjust their holdings of conventional and inflation indexed bonds until it did.

Using equations (1) and (2), the Fisher identity can thus be re-written in terms of the *observable* nominal rate of interest on a conventional bond, y, and the *observable* inflation risk-free real rate of return on an indexed bond, r :

$$y_t^N = r_t^N + E[\pi_t^N] + \rho_t^N \tag{3}$$

If both indexed and non-indexed securities exist, and the inflation risk premium is known, it would be possible using (3) to derive estimates of inflation expectations by comparing the prices of these instruments. In practice, the inflation risk premium, ρ, is

unobservable and hence some assumption has to be made regarding its size and behavior. The simplest (and most common) assumption is that the inflation risk premium is zero ; investors are risk neutral with respect to inflation risk. However, if investors are not risk neutral, and demand to be compensated for the additional risk of holding conventional bonds, the derived estimate of inflation expectations will clearly be biased upwards :

$$\rho_t^N > 0 \Rightarrow \hat{E}\,[\pi_t^N] > E\,[\pi_t^N]$$

where a circumflex ' ^ ' denotes the expectation derived from equation (3) under the assumption that the inflation risk premium is equal to zero, and that $E[\pi]$ denotes the 'true' market expectations. In other words, the estimate of inflation expectations from equation (3) will overestimate actual expectations.

1) Simple Measures Using Inflation Indexed Bonds

The simplest method by which to infer inflation expectations from inflation indexed bond prices is a straightforward comparison of real yields derived from these prices with nominal rates of interest on conventional nominal bonds. More precisely, the inflation expectation is given by equation (3) under the assumption of a zero inflation risk premium, i.e.

$$y_t^N = r_t^N + E\,[\pi_t^N] \qquad (4)$$

where y and r are the observed rates of interest on a conventional and indexed bond respectively, each with a term to maturity, N. The difference between these two yields is therefore interpreted as the expected average inflation rate over the period from t to $t+N$.

However, inflation indexed bonds do not offer complete real value certainty, since there will always be some form of lag in the indexation due to delays in collecting and publishing the most recent inflation data and, possibly, due to market conventions. In the U.K., for example, there is an eight-month lag in the inflation adjustment for index-linked gilts. The net effect of this lag is that returns over the last eight months of the bond are not hedged against inflation and therefore the real yield can be calculated only

by making an assumption about the marginal investor's expected level of inflation (Deacon and Derry [12]).

Thus the inflation expectation produced by the comparison of nominal and real yields depends directly upon the original inflation assumption used to calculate the real rate ; assumptions about inflation expectations are being used to derive inflation expectations. Inevitably, this procedure leads to a discrepancy between the assumed and implied rates of inflation expectations. This lack of internal consistency becomes more pronounced the longer the lag in indexation.

2) Break-even Inflation Rates [6]

The method of calculating 'break-even inflation rates' is more sophisticated than the simple yield comparison outlined above and has the advantage that it eliminates the problem of internal consistency. The method is based on the same premise that expected average rates of inflation can be inferred by comparing the yields on conventional and indexed bonds of similar maturity. However, this time, expectations are derived iteratively and, for completeness, the more accurate compound form of the Fisher identity is used :

$$1+y_t^N = (1+r_t^N)(1+E[\pi_t^N]) \tag{5}$$

Assuming investors are risk neutral, the equilibrium condition requires that conventional and indexed stocks have the same expected nominal rate of return. The required nominal yield on the indexed bonds, observed from the conventional bond, can be decomposed into its inflation and real yield components. This leaves two relationships: the bond pricing equation for an indexed bond and the Fisher identity, equation (5), to solve for the two unknowns, the expected inflation rate and the real yield. It is then straightforward to solve the equations by the use of an iterative procedure which ensures that the assumed rate of inflation used to calculate the real rate and the implied inflation expectations are consistent.

However, this method still has a number of drawbacks. First, as the price of government bonds are typically dependent on the marginal investor's tax rate in the

6) Discussions in this and following sections are largely based on Deacon and Derry [12], Svensson [28], and Nelson and Siegel [24].

conventional and indexed bonds markets, an estimate of this tax rate has to be supplied exogenously in order to solve for the break-even inflation rate. Each market will have its own convention regarding which tax rae to employ.

Setting the tax issue aside, it will usually only be possible to find pairs of conventional and inflation indexed bonds which have approximately similar maturities. This will affect the accuracy of the implied inflation expectation. Moreover, to the extent that investors are concerned about the interest rate risk characteristics of the bonds, and hence are more concerned with their duration, rather than maturities, these measures may also be distorted. More seriously, there may not be an indexed bond maturing at or near a date of interest, thus restricting the maturities over which the break-even rates can be calculated. Furthermore, the fact that break-even inflation rates are derived from a comparison of only two bond prices means they are particularly vulnerable to distortions produced by the specific securities issues selected. For instance, when matching securities issues by maturity there may be conventionals of roughly equal maturity but, since the coupon rates on indexed bonds are typically very low, they will have widely differing coupons (and hence durations); the difference in the break-even rates this produces can be significant.

3) Term Structure Estimation Techniques

These problems using the break-even inflation rates method led to the development of a technique based on a comparison of estimated term structures for conventional and indexed bonds. Given a sufficient quantity of indexed bond prices, it is possible to estimate a term structure of real interest rates using a similar method to that used to estimate the normal yield curve. This effectively solves the maturity matching problem of the break-even methodology, since two continuous curves can be compared across all maturities. Furthermore, a term structure of implied forward rates of inflation can be constructed which, rather than giving the expected average rate of inflation over some period, shows the implied path of one-period inflation rates at each point in the future.

Having derived implied forward rate curves for both the nominal and real curves, the term structure of forward inflation rates is obtained using the Fisher identity in the form :

$$1 + {}_t y^I_{t+j} = (1 + {}_t r^I_{t+j})(1 + {}_t \pi^I_{t+j}) \qquad (6)$$

where y is the implied nominal forward rate, r is the implied real forward rate and π is the implied forward rate of inflation. The subscripts 't' and '$t+j$' and the superscript '1' denote that each measure is a one-period rate applicable to the period $t+j$ to $t+j+1$, implied by the prices of bonds at time t. Of course, in the same way as the real yield on an indexed bond depends upon an inflation assumption, the real implied forward curve will also be dependent upon this assumption. An iterative procedure, akin to that used when calculating break-even inflation rates, is therefore used to re-estimate the real yield curve until there is consistency between the assumed and implied forward inflation rates (Nelson and Siegel [24], Svensson [28]).

As with the break-even method, there are a number of problems which arise when estimating the term structure of implied forward inflation rates. For example, the relatively small size of the indexed bond market means that it is not possible to use a sophisticated method for modelling tax effects when estimating the real yield curve. In practice, tax effects appear more likely to distort the real yield curve at the shorter end of the market than at the longer end. In the U.K., this reflects evidence that high-rate income-tax payers, who are attracted to inflation indexed bonds for tax reasons, prefer short-dated securities, possibly for reasons of liquidity and reduced price volatility. In contrast, long-dated indexed bonds are favoured by pension funds, which are exempt from income tax, and life insurance companies, which have a low effective tax rate.[7]

3. Inflation Expectations and Monetary Policy Credibility

The inflation expectations data are derived from the U.K. conventional nominal and index-linked gilts yields using the inflation term structure technique described above.[8] For the purpose of assessing monetary conditions, implied forward inflation rates — term structure of inflation— offer policymakers the opportunity to assess not only the expected average rate of inflation over a particular period, but also the evolution of these expectations across time. This information is more concrete and contain more

7) The choice of yield curve model used to estimate the normal and real term structure also can have a significant effect upon the set of implied forward inflation rates. For a detailed discussion, see Deacon and Derry [12].

8) The Bank of England has routinely published the data on a daily base since May 1993. However, in this paper monthly series are derived because monthly series are enough to evaluate the monetary policy credibility.

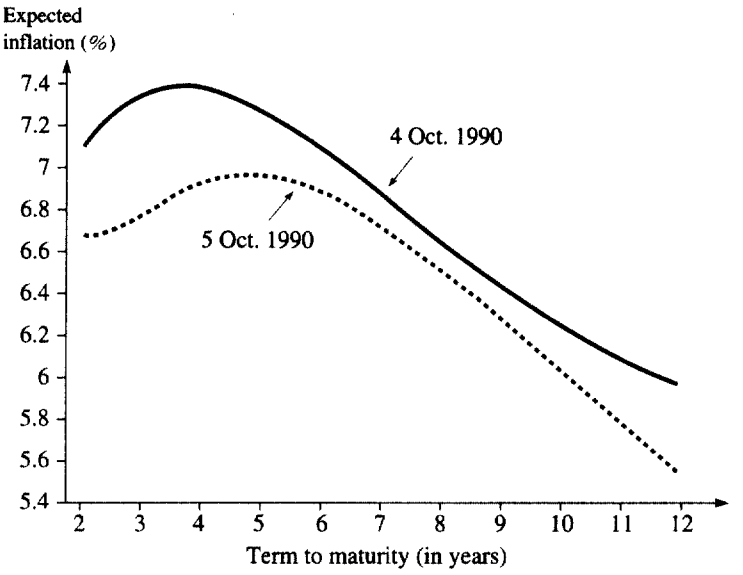
accurate insights into evaluating monetary policy deliberations than the simple comparison of nominal and indexed bonds yields as explained above.[9] Indeed, these rates make up one of the components considered when formulating monetary policy by the Bank of England.

In addition, they throw some light on changes in monetary policy credibility. As King [22] has noted, the government and private sector can be characterized as having subjective distributions over the possible outturns for inflation at any future date. Credibility is a measure of how close these distributions are. Thus, given the government's assessment of future outlook for inflation, the credibility of monetary policy can be evaluated with reference to the probability distribution held by the private sector. The expected inflation rate can be thought of as the mean of the private sector distribution, and the spread of possible outturns around the mean is proxied by the inflation risk premium. Since derived implied forward inflation rates capture both of these measures, they are a potentially useful tool for evaluating the impact of monetary policy upon credibility.

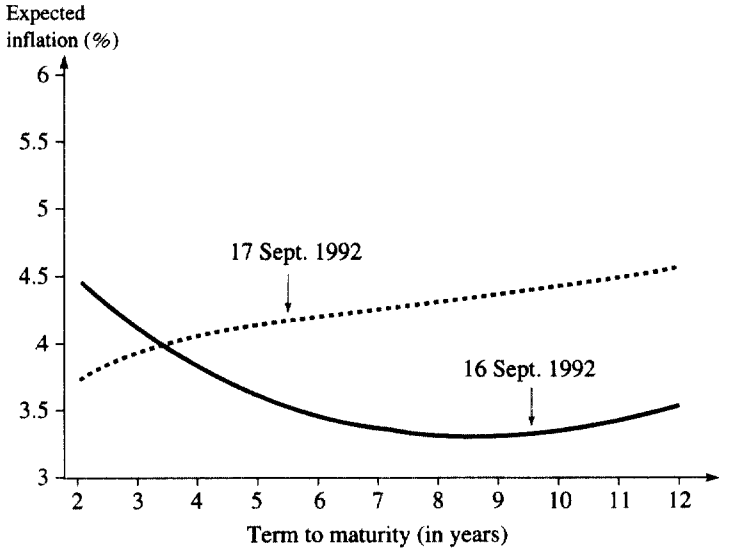
More generally, derived implied forward inflation rates can be used to examine the general reaction of the market to particular 'monetary events', such as the U.K.'s entry into and exit from the Exchange Rate Mechanism (ERM). 〈Figure 1〉 and 〈Figure 2〉 illustrate the implied forward inflation rate curves for before and after each of these events. As 〈Figure 1〉 shows, following the announcement of the U.K.'s entry into the ERM, the implied forward inflation rate curve fell over all maturities. In terms of credibility, this fall suggests that market participants drew confidence from the discipline of the ERM.[10] When the U.K. left the ERM on 16 September 1992 (Black Wednesday), market confidence in anti-inflationary discipline fell, as shown by 〈Figure 2〉.

9) With some limitations, the simple comparison also provides valuable information for the monetary policy deliberations. Shen [26] takes a good example. On April 5, 1995, the real yield of an indexed U.K. government bond maturing in 2001 was 3.95%, while the nominal yield of a conventional bond maturing in the same year was 8.40%. The difference between the two rates, 4.45%, is the sum of the average expected inflation rate over the next six years and the inflation risk premium. By June 12, both the nominal and real rates had fallen by about 0.4% points. As a result, the difference between the two rates was an almost identical 4.48%. Thus, the change in expected inflation was negligible. Without these data on the real yield, policymakers would not have been able to tell whether the 0.4% point decline in the nominal rate between April and June was due to an improved inflation outlook or to changes in the real rate — a question always facing monetary policymakers.

〈Figure 1〉 Implied forward inflation rates at U.K. entry into the ERM

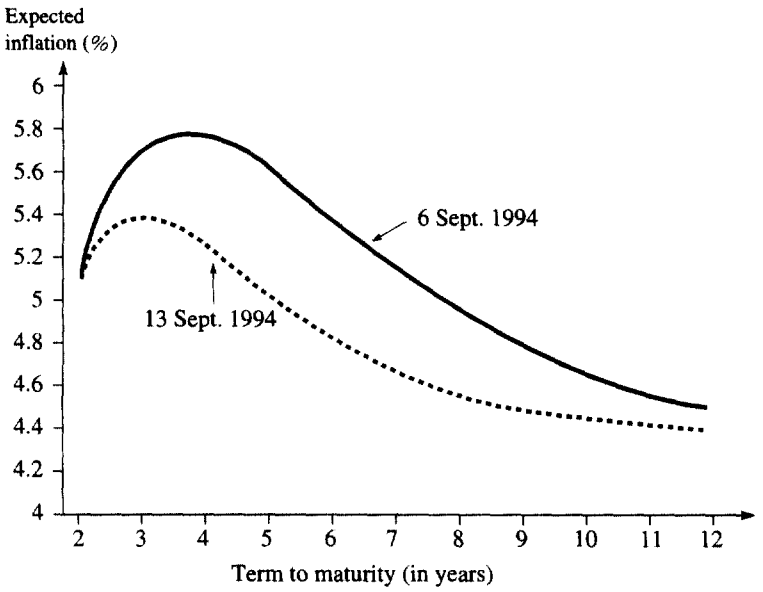


〈Figure 2〉 Implied forward inflation rates at U.K. exit from the ERM



10) The real interest rate data also can be used to examine the relative importance of different types of news in the determination of prices of index-linked and conventional gilts. Barr and Pesaran [4] found that real rate news fails significantly to influence the prices of index-linked gilts. This may reflect the belief of investors that, while real rates may fluctuate in the short-term, they will mean-revert within the life of the instrument. So we may conclude that, on the whole, unanticipated changes in the relative yields of the two types of gilts are due to revisions in inflation expectations, thus strengthening the case for their use as a measure of the credibility of monetary policy.

〈Figure 3〉 Implied forward inflation rates before and after the interestrate rises in 1994



On suspension of sterling's membership of the ERM gilts prices reacted sharply, largely reflecting changes in investor's expectations, particularly of future interest rates. These are likely to have changed significantly, since U.K. interest rates would no longer be as closely tied to the interest rates of other ERM member countries, hence giving the government more flexibility over setting rates.

A similar event study for evaluating the impact of monetary policy on credibility can be conducted from the U.K. interest rate tightenings in late 1994.[11] As 〈Figure 3〉 shows, following the rate rises the implied forward inflation rate curve fell over all maturities, implying that market participants drew confidence from the government's anti-inflationary stance.

When examining movements in the implied forward inflation curves, it is important to be aware of the significant daily volatility exhibited by the curves. An apparently significant change in the implied forward rates of inflation may simply reflect excess noise. 〈Table 2〉 shows the mean daily percentage in implied forward inflation rates and the standard deviation of these changes calculated for a number of maturities over a

11) The interest rates were raised by 0.5% points on 12 September and again 0.5% points on 7 December 1994.

〈Table 2〉 Daily volatiltty in implied forward inflation rates

	Implied inflation rate in *n* years time		
	3 years	5 years	10 years
U.K.'s entry into the ERM			
Percentage change : 4 ~ 5 Oct. 1990	−7.1	−6.8	−2.8
Mean daily % change : previous 180 days	0.1	0.1	0.2
Volatility of daily % changes : previous 180 days	3.0	2.2	3.6
U.K.'s exit from the ERM			
Percentage change : 16 ~17 Sept. 1992	−4.0	13.8	33.4
Mean % change : previous 180 days	−0.1	−0.1	−0.1
Volatility of daily % changes : previous 180 days	2.3	2.6	2.5

period of 180 days up to the dates for the U.K.'s entry to and exit from the ERM. All figures are given in percentage points. The results show that daily volatility alone cannot easily explain the episode when the U.K. withdrew from the ERM. Results for the period following the U.K.'s entry into the ERM are less convincing.

Ⅳ. Concluding Remarks

The provision of inflation indexed bonds appears to be a useful innovation in the financial market. First, it could play an important role in signalling the government's commitment to policies of low inflation in the future. The existence of indexed bonds adds to the credibility of the commitment, since the government's cost of debt financing automatically escalates in tandem with inflation. Second, it would provide an indicator of the market's assessment of the monetary authority's commitment to low inflation when indexed and nominal bonds with matching characteristics coexist, and this could be valuable in aiding short-run monetary policy deliberations. In this context, the central banks of the major industrialized countries have been strong proponents of inflation indexed bonds. Some countries, e.g. the United Kingdom, have carried out extensive research to utilize the benefits of indexed bonds. We could verify through the U.K.'s event study that the information such as the term structure of inflation extracted from

government nominal and inflation indexed bonds prices provides more accurate insights into the evaluation of monetary conditions.

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