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AT YALE UNIVERSITY

Box 2125, Yale Station
New Haven, Connecticut 06520

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A SCORECARD FOR INDEXED GOVERNMENT DEBT

John Y. Campbell and Robert J. Shiller

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by

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Abstract

Within the last five years, Canada, Sweden and New Zealand have joined the ranks of the United Kingdom and other countries in issuing government bonds that are indexed to inflation. Some observers of the experience in these countries have argued that the United States should follow suit. This paper provides an overview of the issues surrounding debt indexation, and it tries to answer three empirical questions about indexed debt. First, how different would the returns on indexed bonds be from the returns on existing US debt instruments? Second, how would indexed bonds affect the government's average financing costs? Third, how might the Federal Reserve be able to use the information contained in the prices of indexed bonds to help formulate monetary policy? The paper concludes with a more speculative discussion of the possible consequences of increased use of indexed debt contracts by the private sector.

1. Introduction

It is natural for the principal and interest payments specified by debt contracts to be denominated in real rather than nominal terms. Payments are naturally made in terms that are meaningful to the parties to the contract, rather than in terms of money whose value, especially over long periods of time, may be very unpredictable. Government debt securities — bills, notes and bonds — that specify real payments are known as indexed or index-linked debt, since their nominal payments are linked to the value of an official price index.

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The issuance of indexed debt is not a new idea; it was proposed and implemented long ago. In 1780, the State of Massachusetts created indexed debt (Fisher, 1913). The notes specified "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 SHEEP'S WOOL, and Sixteen Pounds of SOLE LEATHER shall then cost, more or less than *One Hundred Thirty Pounds* current money, at the then current Prices of Said Articles."[1] Despite the limited number of commodities that they saw fit to include in their formula, and without using the word "index number," they indeed created indexed debt just as we define it today.

In 1822, Joseph Lowe advocated for the first time a public policy that long-term contracts should generally be settled in terms of an index number, a "tabular standard," that is based on a "table comprising articles of general consumption to each of which is affixed the probable amount of money expended on it by the public." His appears to be the first clear public advocacy of the idea that indexed debt should be the rule rather than the exception.[2] His ideas were taken up by many others in the 19th century, notably Jevons (1875), who even argued that the use of indexed debt in private contracts "might be made compulsory, in the sense that every money debt of, say, more than three months' standing, would be varied according to the tabular standard, in the absence of an express provision to the contrary."[3]

The cause of indexed debt has been taken up by many people since. The idea appears to make elementary common sense: there would seem to be little point in defining long-term contracts in terms of currency or precious metals whose value in terms of consumption goods may be very unstable. Yet the adoption of such debt by governments has been painfully slow. Even today, the governments of most of the major countries of the world have no indexed debt.

There are today, however, some grounds for optimism that indexed debt is growing in

[1]This text is from a plate (Fisher 1913, facing page 454), with a photograph of a four-year indexed note allegedly engraved by Paul Revere. The notes were issued at a difficult time during the Revolutionary War when the paper currency was very unstable. After the war, in 1786, at a time of intense public discontent about economic injustices, culminating in Shay's Rebellion, the remaining indexed debt was consolidated into non-indexed debt.

[2]At least he is thought to be the first to propose indexing of contracts by Jevons (1875) and Fisher (1934).

[3]Jevons (1875), p. 324. Jevons tried to anticipate difficulties with the scheme but could think of only a few minor ones. "It would, no doubt, introduce a certain complexity into the relations of debtors and creditors, and disputes might sometimes arise" (p. 324), but he doubted that this was a serious problem. He concluded that "The only serious difficulty which I foresee, is that of deciding upon the proper method of deducing the average [index]."

importance. There appears to be a new momentum towards the introduction of indexed bonds. Table 1 shows the dates of introduction of government bonds, indexed to consumer or wholesale prices, in various countries of the world.[4] Three countries, Canada, Sweden and New Zealand, have introduced indexed government bonds in the past five years. Note also from this table that the recent introductions of indexed debt have occurred in countries with fairly low inflation rates comparable to recent inflation rates in the United States.

Table 2 shows statistics on the importance of some of the indexed bond markets as of mid-1995. We see from these numbers that indexed bond markets are of some consequence. In Israel, indexed debt is the dominant form of government debt, reflecting a history that includes episodes of extremely high inflation. Israel has issued $25 billion of indexed bonds, over 85% of total Israeli marketable debt. The UK also has issued large quantities of indexed debt. Although indexed bonds are only 15% of total UK marketable debt, the size of UK government borrowing makes the UK indexed bond market by far the most prominent in the world, with $57 billion outstanding and an average daily turnover of over $250 million in 1994. In all of these countries except New Zealand (the most recent issuer of indexed bonds) the indexed bonds account for more than 1% of the national debt, and in all but the most recently introduced markets, New Zealand and Sweden, the turnover in these markets is substantial.

There is a history of serious interest in indexed bonds within the government of the United States, although this has never resulted in any actual issuance of government indexed bonds. Until recently, the most visible interest in creating indexed bonds came from the US Congress. Legislation mandating the issuance of indexed Treasury securities was introduced in 1985 by Senator Dan Quayle (S. 1088) and Congressman Daniel Lungren (H.R. 1773). This legislation received widespread support in testimony at hearings, although the bill suffered opposition from officials of the US Treasury. Lungren introduced his legislation again in 1987 (H.R. 1330). In 1992, John Conyers, then Chairman of the House Committee on Government Operations, submitted to Congress a report on indexed debt that argued that

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[4]The table does not consider other forms of indexed bonds whose payments are linked to a foreign currency or to the price of a precious metal. Such bonds are not equivalent to price-indexed bonds, since there may be fluctuations in the real prices of foreign currencies or precious metals. There are, however, potential advantages to these other forms of indexation, particularly for small open economies. Foreign investors may hold a substantial fraction of the debt, and they may prefer foreign-currency debt to price-indexed debt. Moreover, when inflation reaches extreme levels in a small open economy a foreign currency tends to replace the domestic currency in daily transactions. However, these arguments for other forms of indexation do not apply well to the United States.

Some of the issues of indexed bonds shown in the table (with dates we took from Page and Trollope (1974) and Jud (1978)) might have been for small amounts, and not of much importance. Diligent library work produced no confirming evidence of some of the earlier indexation dates.

government issuance of indexed debt would "contribute generally to economic efficiency, productivity, stability, and equity."[5]

More recently, the interest in indexed bonds has come from within the Clinton Administration. Darcy Bradbury, Treasury Assistant Secretary for Financial Markets, has repeatedly stated to the press since August 1994 that the Treasury is considering issuing indexed bonds, although no decision is imminent. The 1995 *Economic Report of the President* contains what seems to be cautious support for issuance of indexed bonds.[6] Laura Tyson, former Chairman of the Council of Economic Advisors, made similar statements in 1995. The US Treasury apparently has the authority to begin issuing indexed bonds without any congressional approval, but the decision whether to do so is something that would be left to the Secretary of the Treasury, Robert Rubin, who has apparently made no public statement on the issue.[7] These statements from members of the Clinton administration, coupled with the recent tendency of other countries to issue indexed bonds, make it appear that such issuance may be closer to reality in the US now than at any other time since 1780. However, the intense recent election-year discussion of the federal budget, culminating in the recent shutdown of the US government, has probably deflected the attention of national leaders from the issue of indexed bonds. We may hope that they will return to the matter in due course.

Since there are a number of questions that arise in any serious consideration of indexed bonds, it is important at this time to review them, and give a sort of scoring of the pros and cons for indexed debt. The next section of this paper gives an overview of the issues, and we then consider three important empirical topics.

First, we consider an argument against indexed debt, that it is not really much different from something that we already have, namely, short-term debt. Short-term Treasury bills offer a considerable degree of inflation protection, since their rates adjust rapidly to changes in expected future inflation. An investor who wants inflation protection can roll over Treasury bills; but this investor is exposed to the risk of fluctuations in real interest rates. We will show evidence on the difference between indexed bond returns and the returns on nominal bills and bonds that are already issued by the US Treasury.

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[5]US Congress, Committee on Government Operations (1992), p. 15.

[6]"More direct and reliable readings of inflation expectations would be provided if one could compare rates of return on bonds whose yields are invariant to inflation with yields on conventional bonds (Box 2–5). Such inflation-indexed bonds have been issued in other countries, but not in the United States, and valuable information about inflation expectations has been obtained from their yields." *Economic Report of the President*, 1995, page 87.

[7]There is a potential problem with the national debt ceiling, which is defined in terms of the face value of the debt; with indexed debt the value of the principal is not predetermined.

Second, we consider an argument for indexed debt, that it might lower the Treasury's average financing costs. Since nominal bonds expose investors to inflation risk, their yields presumably contain an inflation risk premium. If the Treasury issues indexed bonds it can expect to save this premium, but there is surprisingly little work on the magnitude of the inflation risk premium. It is not even clear that the introduction of indexed debt would reduce borrowing costs at all. In theory, the inflation risk premium could be negative. Moreover, some Treasury officials have argued that indexed bond issuance would "balkanize" the market and reduce the liquidity of all government debt, thereby raising borrowing costs. We will provide estimates of the inflation risk premium under various assumptions, and will consider the balkanization and other issues related to borrowing costs.

Third, we consider the argument for indexed bonds that they may have some informational value because they make it easier for the monetary authority and other observers to impute the inflation expectations of bond-market investors. We will show evidence on how well existing nominal bond yields forecast inflation. Moreover, we will consider how indexed bonds have helped the monetary authority formulate policy in the UK and other countries with liquid indexed bond markets.

The conclusion of the paper considers the argument that the creation of a substantial government indexed bonds market might have a "demonstration effect," encouraging the indexation of private contracts. We discuss what private use of indexation might develop, and what might be the effects on economic welfare.

2. What Are the Issues?

Much of the political discussion of indexed debt emphasizes the consequences of indexation for average government borrowing costs. At the time of the 1985 hearings on the proposal for Treasury indexed debt, Federal Reserve Board Chairman Alan Greenspan expressed an often-stated concern: whether the issuance of such debt would really save the taxpayer money. He stated that "the real question with respect to whether indexed debt will save the taxpayer money really gets down to an evaluation of the size and persistence of the so-called inflation risk premium that is associated with the level of nominal interest rates."[8] At the same hearing, Under Secretary of the Treasury Jerome Powell argued that the securities would have to pay a high interest rate so as to attract taxable investors, and thus they might be an expensive source of government finance. He argued that the issue of securities aimed at a small segment of the market could "balkanize" the market, reducing

[8]"Inflation Indexing of Government Securities," a hearing before the Subcommittee on Trade, Productivity, and Economic Growth of the Joint Economic Committee, May 14, 1985, p. 28.

liquidity and increasing borrowing costs. He stated "We believe that the threshold question on indexed bond issuance is whether they would be a cost-effective instrument for meeting the borrowing requirements of the US government."[9]

In this paper, we do try to estimate the likely effects of debt indexation on average government borrowing costs. But we do not agree that the analysis of debt management is primarily a question of comparing the average interest costs to the government of different types of debt.

A single-minded emphasis on average interest costs is inappropriate for several reasons. First, interest costs are not real resource costs to society like the costs of the human resources used in other government activities, since the interest is really just a transfer between people. When the debt is domestic, the only direct effects of higher financing costs are higher transfers from taxpayers to bondholders who share the same government.

To illustrate this point, consider what happens when all government debt is nominal (not indexed), and inflation is lower than expected. Then the government is forced to make relatively large real payments on its nominal debt. The government in this situation is "losing" on the financing of its nominal debt, and it would be paying out less if it had used indexed debt. But of course the government is not a person, and we should not think of the government as losing money; we should think of what the situation means for real people. If the government uses taxes to make the payments on the debt, then the taxes will exactly equal the high real income that a person holding the average per capita amount of debt obtains. There is no effect of the government's high financing costs on the average person. Those individuals who hold (directly or indirectly) large amounts of government debt will gain at the expense of those who hold little government debt. Exactly the opposite occurs when inflation is higher than expected.

Some economists have argued on the basis of this logic that the form of government financing has no real effects at all. By analogy with the famous Modigliani–Miller Theorem in corporate finance, this is sometimes called a Modigliani-Miller theorem for government finance.[10] Of course, this proposition holds only under extremely restrictive assumptions, including most importantly the assumption that the government has nondistortionary sources of tax revenue. When the government must rely on distortionary taxation, then payments by taxpayers to bondholders involve deadweight losses.

Even in the presence of distortionary taxation, however, the government should not try to minimize its average borrowing costs. In efficient financial markets higher average

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[9]Hearings, p. 104. The Congressional Budget Office (1993) also emphasizes the effect of debt management on average interest costs.

[10] Sill (1994) is an accessible introduction to this idea. See also Wallace (1981).

returns (or lower average borrowing costs) can only be achieved by taking on more risk (or transferring less risk to investors). If the government really wanted to minimize its average financing costs it could borrow at the Treasury bill rate and invest the proceeds in the stock market. Such a financing strategy would earn the government the equity premium, but the risk would be unacceptably high. This illustrates the point that borrowing costs must be considered in relation to risk.

If average borrowing costs are not the key issue, what considerations are important for an assessment of indexed debt? There are several reasons to believe that creating indexed debt will have real effects: 1) creating indexed bonds may reduce the expected deadweight losses of distortionary taxation, 2) creating indexed bonds may affect incentives for the government to contain inflation, 3) creating indexed bonds may enable the market to provide important kinds of new information, and 4) creating indexed bonds may help people with different risk tolerances to share their risks better. Of these four effects, the first three can be considered from the standpoint of representative individual, as if all people are the same, while the fourth depends on heterogeneity across people. Let us consider these four effects in turn.

1. Effects on Tax Distortions. As Barro (1995) has emphasized, an important consideration in deciding the structure of government debt is that the distortionary effects of taxation should be spread as evenly as possible over time and across states of nature. This is the appropriate way for a government relying on distortionary taxation to trade off the risk and return of alternative financing strategies.

With nominal debt, changes in the price level can cause changes in the real debt payments that must be financed by taxes. Barro argues that in ideal economies where there are no random fluctuations in government financing needs as would be caused by wars or other exigencies, the ideal form of government debt would be indexed consols, since even when inflation is uncertain these consols provide a uniform and perpetual stream of real payments, a stream of real payments that is maximally smoothed.[11]

2. Incentive Effects on the Government. The inflation rate itself is not exogenous but is the outcome of a political process. Indexed debt financing can matter if it changes the incentives for the government to create or tolerate inflation. Economists have identified a variety of mechanisms by which this may occur. Most obviously, the use of indexed debt removes the incentive for the government to erode the real value of its obligations by

[11] See Barro (1995). There are some potential arguments for nominal debt based on the possibility that inflation shocks are related to real shocks that individuals face, so that nominal debt can serve as an insurance medium that cushions the effects of these real shocks; see Bohn (1988). If the relation between inflation shocks and real shocks is not reliable, however, it would be better to insure directly against the real shocks; see Shiller (1993).

creating inflation. Along these lines, Margaret Thatcher argued that index-linked gilts (UK a situation in which the government would have to face a large interest expense if it ever allowed inflation to pick up.[12] On the other hand, the use of indexed debt reduces the political opposition to inflation of government bondholders, which may be a moderating influence on inflation in some countries.

3. Effects on Public Information. Possibly more relevant in the United States and other countries with moderate debt burdens and inflation rates, the existence of both nominal and indexed debt gives the monetary authority a measure of market expectations of future inflation. This can be used to fend off political pressure for excessively expansionary monetary policy during periods of temporarily low inflation. At such times the media and politicians have a tendency to proclaim that "inflation is dead" and to push for monetary stimulus of the economy; in resisting such arguments the monetary authority may find that market-based forecasts of inflation are more effective than econometric forecasts generated by its own staff economists.

4. Effects on Risk Sharing Among Heterogeneous Individuals. From the standpoint of theoretical finance, the creation of government indexed debt may fill an important gap. If the existence of government indexed debt has a demonstration effect that encourages private issuance of indexed debt as well, then a liquid market for riskfree real debt may develop, giving society a true "riskfree interest rate."

Creating a liquid market for indexed debt of course does not eliminate the fundamental risk that society faces, the risk that the economy will or will not be as productive as expected. We cannot all just invest in the riskfree rate and thereby all be completely insulated from real risk; somebody has to bear the residual risk. But riskless debt does provide a mechanism by which society can offer a riskless income to some people. If there is a market for riskless debt, then one would expect it to be priced in such a way that the expected riskless income from investing in these assets is lower than the income one could obtain if one accepted some risk, so that only the more risk averse people will choose to live with the lower income stream.

In other words, a riskfree real asset plays a central role in the risk-sharing arrangements of an ideal economy. According to the Capital Asset Pricing Model, relatively risk averse investors would hold investments in the riskfree asset and the market portfolio, while less risk-averse investors would short the riskfree asset and buy more of the market portfolio. The result of creating the riskfree asset can be a more efficient allocation of risk. In some theoretical formulations, the creation of the riskfree asset is of truly fundamental

[12] See Steve Hanke and Alan Walters, "Sleeping Policeman," *Forbes*, May 9, 1994, p. 217. Missale and Blanchard (1994) present a simple model of this effect.

significance. Shubik and Geanakoplos (1990) have shown that under certain idealized assumptions, the creation of a single market, the market for the riskfree asset will achieve full Pareto optimality even when markets are very incomplete. Even under less restrictive assumptions than are in place in their model, we would expect important welfare gains from the creation of a riskfree real asset.

This effect of the creation of indexed debt relies on there being differences across people in their concerns about risk. Some may doubt that such heterogeneity is important. For example, Barsky et al. (1995) use survey data to study individual differences in risk tolerance and relate them to differences in economic behavior; they find only rather small differences in risk tolerance that are confirmed by differences in economic behavior. But there certainly are differences across people, even if not captured by the methods of Barsky et al. that would imply that some people are very vulnerable to income fluctuations. For example, low-income retired people, or people who find it difficult to understand the issues of investing in risky assets whose prospects are very hard to define, may be more risk averse, and these people may benefit from the existence of indexed bonds. They would benefit just as some people today benefit from savings and insurance institutions that protect them from various uncertainties.

3. How Different Are Indexed Bonds?

In the US, short-term nominal bonds are similar to short-term indexed bonds, because, in most of US history, there has been little inflation uncertainty at a horizon of a month or two. Long-term nominal bond returns are primarily driven by news about future inflation, but this is not the case for short-term nominal bonds (Campbell and Ammer 1993). In fact, it is common in empirical finance to use the return on a nominal US Treasury bill as a proxy for the return on a riskless real asset. Hence, some argue, there is really no need to issue indexed government bonds because we already have short-term instruments for which inflation risk is small; the riskless real asset that is needed for effective risk-sharing already exists.

Many investors, however, have longer horizons than one or two months. An investor seeking an asset that is riskless in real terms at a long horizon can roll over short-term nominal debt, but the returns on this rollover strategy are risky because they are exposed to variations in real interest rates.

Long-term indexed bonds are different from short-term nominal or indexed bonds, because they respond differently to real interest rate shocks. Over a horizon of one month, a shock to expected future real interest rates will cause a capital loss on a long-term indexed bond (say, a 10-year zero-coupon indexed bond) but will not affect the return on a one-month Treasury bill or indexed bill. Over a horizon of 10 years, the return on a 10-year indexed bond is known in advance and will not be affected by real interest rate variation whereas the return on rolling over Treasury bills or indexed bills will be sensitive to real interest rates.

In judging the importance of indexed debt, it is vital to know how large is this difference between short-term debt and long-term indexed bonds. To address this question, we explore the historical evidence in several different ways.

3.1. Hypothetical Indexed Bonds in the United States

In the US, of course, indexed debt has not been issued in modern times. This makes it hard to know how indexed bond prices might have behaved if they had been quoted. To circumvent this difficulty, our first approach is to assume that expected real returns on indexed bonds of all maturities equal the expected real returns on short-term nominal Treasury bills plus a constant.[13] That is, we assume that the rational expectations hypothesis of the term structure would hold for indexed bonds, and that the inflation risk premium in short-term nominal bills is constant.

Note that we do not need to assume that the expectations hypothesis describes nominal bonds. Our earlier work has presented evidence against the expectations hypothesis in the nominal term structure (Shiller, Campbell, and Schoenholtz 1983, Campbell and Shiller 1991), although we have also found that nominal bond yields move closely with those predicted by the expectations hypothesis (Shiller 1972, Modigliani and Shiller 1973, Campbell and Shiller 1991). Barr and Campbell (1995) find little evidence against the expectations hypothesis in the term structure of UK indexed bond yields. The assumption of a constant inflation risk premium is harder to assess; we are disregarding the possibility that the inflation risk premium might vary systematically in response to the quantity of indexed bonds sold by the government, or that the inflation risk premium might change through time as the market for indexed bonds becomes deeper and more liquid, or that the inflation risk premium might change through time as the public becomes more familiar with indexed bonds, or just that the amount of inflation uncertainty might change through time.

Given these assumptions we can use an econometric model to estimate what the movements of the indexed yield curve would have been in historical US data. Specifically, we proceed as follows:

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[13]With all of our results reported here, returns are measured as the natural log of one plus the conventionally-defined return. This log transformation of returns is common in the empirical finance literature. It has little effect on our results, since our returns tend to be small numbers.

a. We take data on 3-month US Treasury bill rates and CPI inflation, and construct the ex post quarterly log real bill return.

b. We regress this return onto a set of forecasting variables. The fitted value of this regression is an estimate of the ex ante quarterly real interest rate. Our basic set of forecasting variables includes the lagged real bill return, the nominal bill yield at the start of the quarter, and the lagged inflation rate over the previous year; we have also considered an augmented set of variables that includes the 5-year nominal bond yield at the start of the quarter.

c. We include all these variables in a VAR system to calculate multi-period forecasts of the ex ante quarterly real interest rate. We vary the lag length of the VAR system to make sure that our results are robust to the choice of lag length; we consider 1-lag and 4-lag versions of the system.

d. We assume that the expectations hypothesis of the term structure describes log indexed bond yields, and calculate yields on hypothetical zero-coupon indexed bonds from the regression forecasts of the ex ante quarterly real interest rate. The fitted yield on a hypothetical indexed 3-month bill is just the 1-quarter forecast from the model, whereas the fitted yield on a hypothetical indexed 10-year zero-coupon bond is a simple average of these forecasts over the next 40 quarters.

   This procedure ignores differences in expected returns between nominal bills and indexed bonds, arising from inflation risk premia or risk premia in the real term structure of interest rates. If these risk premia are constant but not zero, our procedure will correctly fit the movements of the indexed yield curve but will not correctly measure the average level of the indexed yield curve. Accordingly we use our fitted yields to describe second moments but not first moments of hypothetical indexed bond returns.

e. We use our fitted indexed bond yields to calculate indexed log bond returns at short and long horizons and compare them with the returns on nominal and hypothetical indexed Treasury bills rolled over to the same horizons. If y_{kt} is the yield on a k-year indexed bond, for example, the 1-quarter return on the bond is just $(4k)y_{kt} - (4k - 1)y_{k-1,t+1}$. We compare this with the 1-quarter real return on a nominal 3-month Treasury bill and on a hypothetical indexed 3-month bill. At a horizon of k years, we compare y_{kt} with the k-year return on rolled-over nominal 3-month Treasury bills and on rolled-over hypothetical indexed 3-month bills.

We illustrate the results of this exercise in Figures 1 and 2, which are derived from the basic 1-lag VAR system. Figure 1 shows the ex post quarterly real return on nominal 3-month Treasury bills (the solid line), along with the VAR forecast of this return which is our fitted yield on a hypothetical 3-month indexed bill (the dashed line). Figure 2 shows the real yields on hypothetical indexed bonds of maturities 1 year (the solid line), 2 years (the long-dashed line), 5 years (the dotted line), and 10 years (the short-dashed line). These figures are intended to illustrate the movements of hypothetical indexed bond yields, rather than their average levels which are not identified if risk premia are nonzero.

Figure 1 shows the familiar history of quarterly US real interest rates over the past 40 years. After a period of low real interest rates in the late 1950s, real rates were comparatively stable between 1% and 2% until the mid-1970s, when they were negative or close to zero for several years. Around 1980 there was a dramatic increase in the real interest rate to almost 6%, followed by a gradual decline (briefly interrupted in the late 1980s) to levels close to zero in the early 1990s. Figure 2 shows a similar but considerably dampened pattern in the movements of longer-term indexed bond yields. The 10-year indexed bond yield, for example, hardly declines at all in the 1970s and rises by less than 2 percentage points in 1980–81. This behavior is what one would expect if much of the variation in the short-term real interest rate is transitory.

Table 3 reports summary statistics comparing the behavior of nominal 3-month Treasury bills with hypothetical indexed 3-month Treasury bills and hypothetical indexed bonds of maturities 1 year, 2 years, 5 years, and 10 years. The basic VAR system is estimated with 1 or 4 lags over the full sample period 1953–94, and with 1 lag over the subsamples 1953–73 and 1974–94. For each specification of the system, the table reports a set of standard deviations. The table does not show any means because our methodology for estimating hypothetical indexed bond yields identifies only the variation of these yields and not their average level.

The first three columns in Table 3 study the behavior of returns at a 3-month horizon. The first column gives the unconditional standard deviation of the yield on a hypothetical indexed 3-month bill. Under the assumptions we have made, this yield is the rational expectation of the real return on a nominal 3-month bill, and on a hypothetical indexed long-term bond held for 1 quarter. The second column gives the standard deviation of the unexpected real return on a nominal 3-month bill (the difference between the real return on the bill and the yield on a hypothetical indexed bill), while the third column gives the standard deviation of the unexpected real return on a hypothetical indexed long-term bond (the difference between the real bond return and the yield on a hypothetical indexed bill). All yields and returns are reported in percentage points, on an annualized basis, to match the convention for reporting nominal yields on Treasury bills, notes, and bonds. Since we are using log yields and returns, the numbers in annualized percentage points are just 400 times the numbers in natural units.

The table shows that there is some inflation risk in holding nominal 3-month bills.

Column (2) of the table shows that over the full sample period the standard deviation of the unexpected quarterly real return on these bills is about 2 percentage points on an annualized basis, or 50 basis points per quarter. This inflation risk could be entirely avoided if indexed Treasury bills were available, as indexed bills would have a known real quarterly return at the start of each quarter. (The standard deviation in column (1) of Table 3, which is also close to 2 percentage points annualized, represents unconditional variation in this expected return, not risk as measured at the start of each quarter.)

Hypothetical indexed long-term bonds also appear risky on a quarterly basis, because their returns are affected by quarterly news about future real interest rates. Column (3) shows that the standard deviation of the unexpected annualized quarterly real return on a 1-year indexed bond is 1.7 percentage points in the 1-lag VAR model (1.0 percentage point in the 4-lag model), and this rises to 6.6 percentage points (7.4 percentage points) for a 10-year indexed bond.

There is of course no uncertainty about the real return on a long-term indexed bond if it is held to maturity, for its real return will then equal its yield. Column (4) of Table 3 shows the unconditional standard deviation of this yield for 1, 2, 5, and 10-year hypothetical indexed bonds. Like the numbers in column (1), these numbers represent unconditional variation rather than risk from the perspective of an investor. As one would expect, the variability of indexed bond yields declines with maturity, from 1.2 percentage points for a 1-year bond in the 1-lag model (1.4 percentage points in the 4-lag model) to 0.4 percentage points (0.9 percentage points) for a 10-year bond.

Columns (5) and (6) of Table 3 report the standard deviations of unexpected annualized percentage returns on nominal 3-month Treasury bills and hypothetical indexed 3-month Treasury bills, respectively, rolled over for 1, 2, 5, or 10 years. Hypothetical indexed bills have return uncertainty of 60 to 100 basis points per year, depending on the investment horizon and VAR lag length, while nominal bills have return uncertainty of 120 basis points per year or more. Investors and borrowers could avoid this uncertainty if long-term indexed bonds were available.

Panels B and C of Table 3 show that there has been some change in the behavior of real and nominal interest rates over time. In the first subsample, from the early 1950s through the early 1970s, real interest rates were comparatively stable. Hence the yields and returns on hypothetical indexed bills and bonds have much smaller standard deviations in columns (1), (3), (4), and (6) of panel B. There was also somewhat less inflation uncertainty, as shown in columns (2) and (5). The second subsample, covering the last 20 years, has higher inflation uncertainty and dramatically higher variation of hypothetical bond yields at all maturities.

3.2. Indexed Bond Yields in the United Kingdom

The validity of the numbers reported in Table 3 depends critically on the assumptions we have made. In particular, the risk premia of 3-month nominal Treasury bills over 3-month indexed Treasury bills, and of long-term indexed bonds over 3-month indexed Treasury bills, must be constant. As a check on the reasonableness of these assumptions, we apply the same methodology to UK data. Since indexed bonds are traded in the UK, we can compare our hypothetical UK indexed bond yields to actual UK indexed bond yields.

Table 4 has exactly the same structure and sample period as Table 3 but is based on UK rather than US data. We use the discount rate on 91-day government bills as our 3-month interest rate (although this market is considerably less liquid than the Treasury bill market in the US), and we measure UK inflation using the Retail Price Index. The table shows that both inflation uncertainty and the variability of the real interest rate have been much higher in the UK than in the US.

Table 5 compares the hypothetical indexed bond yields constructed in Table 4 with indexed bond yields constructed from quoted prices of UK index-linked gilts over the period 1985-94.

The analysis of UK data is complicated by the fact that UK indexed bonds are not perfectly indexed, but have an 8-month indexation lag. This means that inflation in the last 8 months before each payment erodes the real value of the payment, so that UK indexed bond yields contain a nominal component. Barr and Campbell (1995) correct for this and calculate implied yields on zero-coupon nominal and perfectly indexed bonds in the UK over the period 1985-94. We use their implied indexed yields for the comparison in Table 5.

For each VAR specification, sample period, and bond maturity, Table 5 first compares the moments of hypothetical and actual indexed bond yields. The table reports the ratio of the mean hypothetical yield to the mean actual yield, the ratio of the standard deviation of the hypothetical yield to the standard deviation of the actual yield, and the correlation between the hypothetical and actual yields. Then the table reports the same moments for quarterly returns on hypothetical and actual indexed bonds.

The mean ratios tend to be greater than one at short maturities, and less than one at long maturities, indicating that our hypothetical indexed yield curve is flatter on average than the actual yield curve. This result should not be surprising, since our procedure for constructing hypothetical yields sets all term premia to zero; if there are constant positive term premia on longer-term bonds our hypothetical yield curve will tend to be too flat.

For our purposes it is more important to capture the dynamics of indexed bond yields. At horizons of 1 or 2 years our VAR model seems to do quite well; in the 1-lag VAR model estimated over the full sample the standard deviation ratio is 0.59 for 1-year bond yields and

0.68 for 2-year bond yields, while the correlation is 0.63 for 1-year bond yields and 0.46 for 2-year bond yields. These numbers indicate that the VAR model understates the variability of actual 1- and 2-year indexed bond yields. Turning to indexed bond returns, the correlations are not as high but the standard deviation ratios are closer to one. A visual impression of these results is given in Figures 3 and 4, which plot the actual and hypothetical 1-year and 2-year indexed bond yields over the 1985-94 period.

At longer horizons, the variability of both hypothetical and actual indexed bond yields decline; in the 1-lag VAR model estimated over the full sample these declines match each other so the standard deviation ratio is roughly constant. The remaining movements of the actual long-term indexed bond yield are poorly explained by our VAR model.

3.3. Tax Issues

3.3.1. The after-tax real interest rate

So far we have measured real interest rates on a pre-tax basis, and have calculated the pre-tax indexed bond yields that would equate pre-tax returns on indexed bonds of all maturities to the pre-tax return on nominal 3-month Treasury bills. But these calculations can also be done on an after-tax basis. The after-tax real interest rate is the nominal interest rate times one minus the tax rate, less the inflation rate, since nominal interest payments are fully taxable in the US. Table 6 calculates the after-tax indexed bond yields that would equate the after-tax returns on indexed bonds with the after-tax real interest rate. The table assumes a constant tax rate of 0.3. We get results that are qualitatively very similar to those in Table 3. The tax correction reduces the average level of the real interest rate and of indexed bond yields, but has only minor effects on their movements through time.[14]

3.3.2 How should indexed bonds be taxed?

It is also important to consider how indexed bonds would be taxed in the US. This is a serious practical issue that, if not handled correctly, may be an obstacle to the effective issuance of government debt that promises a stable real cash flow.[15] In the United Kingdom, the capital gain component of the return on gilts is not taxed, and so the nominal capital gains caused by the inflation adjustment of principal for index-linked gilts are not taxed. This gives index-linked gilts a tax advantage relative to nominal gilts, more of whose return

[14]Given these results, and the fact that Wilcox and Zervos (1994) find very low breakeven tax rates in the UK, we do not report after-tax results for the UK.

[15]Some former obstacles to issuance of indexed bonds in US Federal law and in the tax code have disappeared, see McCulloch (1980), Hochman and Palmon (1988), and Knoll (1991).

comes in the form of taxable coupon payments.[16] US Treasury officials have thought that, so long as our tax system is not indexed to inflation, the US must not offer such a subsidy, and should tax each year the inflation-induced increase in value of the principal as income. Note that so long as the Treasury takes such a position, then they are ruling out the issuance of bonds whose after-tax cash flow is immune from disturbances due to inflation. Should there be a dramatic inflation, then there would be dramatic tax effects on the real wealth of investors in indexed bonds. If there were unexpected very high inflation in the US, then under present US tax law, all taxable investors in indexed bonds would see a real one-year after-tax return on their investment each year equal to minus the highest tax bracket. A succession of such years would arbitrarily do great damage to the net worth of investors. If the taxation on the inflation-induced increase in principal were deferred until a later date, as would be possible for investors with tax-deferred retirement accounts, the tax effect on real values would not be so dramatic, but might still be very important if inflation becomes high. This sensitivity of after-tax returns to inflation is troubling because it undercuts the constancy of real cash flow that is the chief attraction of indexed debt.

The ideal solution to this tax problem would be to inflation-index the entire tax system, and not tax the inflation component of any returns. This ideal solution does not appear to be in the cards, however. An alternative solution would be for the government to create bonds whose adjustment of payouts to inflation more than compensates for inflation, so that the after-tax payouts are stabilized for certain tax brackets. But the easiest solution would be to follow the British example and make the inflation component of the returns tax free. There is nothing unfair to other tax payers implicit in this solution; the market would price the bonds on the date of issue higher because of the tax subsidy.[17]

Making the payouts on the bonds tax free would also solve another nuisance problem with indexed bonds whose entire payout is taxable. If the inflation-induced increase in principal of bonds were taxable each year, then there would be taxes to be paid on income that is not yet received. The taxes owed could even exceed the coupon income from the bonds, putting some bond holders in a situation where they were unable to pay their taxes without selling some of their indexed bonds, incurring transactions costs and facing difficulties to do with the lumpiness of the bonds.

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[16]This description of the UK tax regime is accurate through 1995, but changes in 1996 will alter the tax treatment of both nominal and index-linked gilts.

[17]There might be some revenue cost to the exemption if the tax bracket of the average bondholder is higher than the tax bracket of the marginal bondholder who determines the market price of the bonds.

4. How Would the Issue of Indexed Debt Affect Treasury Borrowing Costs?

4.1. Is There Public Demand for Indexed Debt?

A direct objection to the issuance of indexed debt is that the public is not interested in it except in times of hyperinflation; only economists seem to want indexed bonds. There is a popular joke that if the US Treasury is asked to issue indexed debt, then they should mail prospectuses to members of the American Economic Association. If indexed bonds are such a good idea for the general public, why haven't they taken root from private issuance of such bonds in the century and a half since they were first vigorously advocated?

The US Treasury has been alert to possible new markets as suggested by privately-created products. For example, in 1982, several investment bankers started marketing zero-coupon securities derived from coupon-bearing government bonds; these were called TIGRs (Treasury Investment Growth Receipts) by Merrill Lynch and CATS (Certificates of Accrual on Treasury Securities) by Salomon Brothers. The success of these privately-created instruments led the Treasury to issue their own zero-coupon bonds, called Treasury Strips. Thus, the Treasury followed up quickly on a new product idea whose value had been demonstrated in the private market. In contrast, there is no recent US example of private sector issuance of indexed debt for the Treasury to follow.

Even the markets for indexed debt in foreign countries are regarded by some as not obvious success stories, except for those issued in times when inflation was out of control. Some argue that the index-linked gilts issued in the UK are not evidence of the success of indexed bonds, because the UK government provides a tax subsidy in the form of zero taxation of the inflation-induced increase in the nominal principal. This gives index-linked gilts a tax advantage over conventional gilts with the same real yield. A substantial proportion of index linked gilts, especially those whose maturity is relatively short, are held by taxable investors. Because of the tax subsidy, the government is able to sell index-linked gilts successfully without having to offer a very low price and high yield. By this argument, the tax subsidy is a less visible government subsidy than high indexed bond taxable yields would be; the high yields would reveal how unsuccessful these bonds really are and so might invite criticism.

The ability of the Treasury to issue indexed debt is in some sense open to question. The issue may "fail" if there is not enough investor interest; for example, an attempted issuance of indexed bonds in Italy in 1983 was widely described as having failed; see Penati et al.

(1995).[18] What can it mean when people say that a government issue of indexed bonds has failed? The usual stories of selection bias that explain why individuals or firms may be unable to borrow at any interest rate, as for example in Stiglitz and Weiss (1981), do not seem to apply when the borrower is national government and the lenders are its people. A statement that an issue has failed apparently should be interpreted as a discovery that the real yield that would be necessary to sell the issue is very high, so that the issue can be sold only with a government subsidy that is judged as flagrantly high.

We are not inclined to use the word "success" or "failure" when describing attempts to issue new instruments. In any event, we believe that the amount of subsidy implicit in real yields and tax advantages in the UK case and in other low inflation countries has not been "flagrant." Still, there is a question why indexed bonds have not appeared privately in this country. There appears to be no clear understanding why the public is not more interested in buying indexed bonds.

One argument, advanced by Irving Fisher (1928), is that people are subject to "money illusion"; they are accustomed to thinking of money as a standard of value, and do not trust indexation schemes. There is indeed some evidence that people are vulnerable to some illusions and confusions regarding the price level, see Shafir, Diamond and Tversky (1994) or Shiller (1996). However, these public errors in thinking are probably not immutable, and if there were wider publicity given to the advantages of indexed debt, then we would expect many people to learn that investing in indexed debt is a wise thing. We proceed with this paper under the assumption that people would behave rationally in connection with these markets if they were firmly established as investment vehicles and viewed as liquid investments.

There is another interpretation of money illusion, that it occurs mostly in low inflation environments, and there because with low inflation most people do not see the benefit of taking the trouble to understand and deal with low inflation. There is plenty of evidence that when inflation becomes substantial people do take the trouble, and money illusion withers; note the prevalence of indexation in hyperinflation countries. Indeed, even in the moderately high inflation period in the United States in the late 1970s and early 1980s, there were clear signs that private indexation schemes were getting established, and one might well suspect that these would have succeeded better had the inflation continued or worsened.

In 1979, the Timbers Corp, a New York real estate development company, made inflation-indexed mortgages available in Westchester County New York, and they followed this up later in Atlanta Georgia. Shortly thereafter, the Utah State Retirement System began

[18] Contemporary news accounts blamed the failure of the Italian indexed bond issue on the choice of an obscure inflation index that was calculated only once a year and on the timing of the issue, in the slow August market.

an inflation-indexed mortgage program. In 1982, the Real Dollar Corporation sought approval from the Securities and Exchange Commission to sell indexed bonds to provide funds for indexed mortgages. At this time, the Fund for an Open Society, a nonprofit Philadelphia mortgage company, approved a plan for an indexed bond and an indexed mortgage program. In 1982 the House Subcommittee on Housing and Community Development held hearings on plans for indexed mortgages. Proponents of inflation-indexed mortgages urged Congress to pass legislation overriding state laws prohibiting negative nominal amortization in mortgages, which was an obstacle to widespread issuance of inflation-indexed mortgages. Around this time there were also some unusual schemes related to indexed bonds; for example, in 1980 the Sunshine Mining Company issued $30 million of bonds indexed to the price of silver.

All of this interest in indexed bonds dried up when the inflation rate came down dramatically, following the Fed's new restrictive monetary policy and the great recession of 1981–2. The powerful impetus to indexation caused by seeing dramatic changes in real values due to inflation was gone. The fundamental wisdom of indexed bonds remains, however, as valid as ever. With long-term bonds, there is never assurance that a high inflation episode like that of the late 70s and early 80s will not return. It should be possible now to remind people of this possibility, and rekindle the interest that was once shown in these indexed bonds.

4.1.1. Balkanization

An important argument that the US Treasury raises against issuance of government debt is that it will balkanize the Treasury bond market, and thereby increase the cost of borrowing. That the issuance of indexed debt might do this appears to be a matter of conviction to some Treasury officials, and so we should take it seriously.

It is conceivable that the market could react in a negative way to all US debt if it perceives that the Treasury will reduce the liquidity of its debt by creating too many categories of debt. By launching a single new indexed bond issue, the Treasury could engender fears that there will be many more such issues in the future, thereby creating fears of diminished future liquidity.

But we find it hard to understand why such balkanization costs are expected to be very large. The Treasury already has issued many different kinds of debt in terms of maturity and coupon, and the introduction of Treasury strips was a major innovation. In fact, there is perhaps reason to think that the balkanization costs are negative: so long as there is some clientele who are interested in indexed bonds, then the optimal thing to do, from a borrowing cost perspective, is to satisfy this clientele.[19] Even if money illusion is widespread, and accounts for widespread public disinterest in indexed bonds, there would still appear to be money to be made in issuing indexed bonds for those people who are not stymied by money illusion. Surely, there must be many people (and not just members of the American Economic Association) who are aware of the importance of inflation uncertainty in nominal contracts.[20]

4.2. How Large is the Inflation Risk Premium?

Opposing these alleged costs to the government's issuance of indexed debt, there is the possible advantage of eliminating the cost to the government of paying the inflation risk premium on its debt. Although we have noted above that we doubt that the size of the inflation risk premium should be a critical issue in deciding whether to issue indexed bonds, we will provide here some estimates of its magnitude.

There are two ways to estimate the size of the inflation risk premium, defined as the average excess return on an inflation-sensitive asset (say a nominal 5-year zero-coupon bond) that is attributable to its inflation sensitivity. First, we can assume that the average excess return on a nominal 5-year bond is entirely accounted for by its inflation risk premium, and we can compare the average return or yield on the bond with the average return or yield on a comparatively riskless asset such as a nominal 3-month Treasury bill.

Second, we can use finance theory and try to calculate the risk premium that would be justified by the covariance of the return on the nominal 5-year bond with relevant state variables. In order to isolate the inflation-related component of this risk premium, we can compare the theoretical risk premium for a nominal 5-year bond with the theoretical risk premium for a hypothetical indexed 5-year bond.

4.2.1. Direct estimates from average bond returns

To apply the first method, we use Center for Research in Security Prices (CRSP) data on nominal zero-coupon bond yields over the period 1953–94. The yields are available up

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[19] Boudoukh and Whitelaw (1993) present a formal model in which balkanization is an optimal strategy for a bond issuer. They also point out that the liquidity premium for heavily-traded issues in the US Treasury bond market is only about 10 basis points, although it is as much as 70 basis points in the Japanese government bond market. This liquidity premium is small relative to plausible estimates of the inflation risk premium.

[20] Treasury officials however stress the great cost to them, in terms of legal costs, arriving at decisions about the kinds of indexed bonds to issue, and changing of computer and administrative systems, to issuing indexed bonds. Possibly the greatest cost is the cost in terms of time and attention to high Treasury officials who have many other pressing issues to consider.

to a maturity of 5 years; they are calculated from the prices of coupon-bearing bonds using a methodology explained by Fama and Bliss (1987).[21]

Table 7 reports summary statistics on nominal bond yields of maturities 1, 2, and 5 years. Panel A covers the whole sample period, 1953–94, while panels B and C cover the two subsamples 1953–73 and 1974–94. For each bond and sample period, the table reports the average excess return over a nominal 3-month Treasury bill, the average change in the yield, and the average yield spread over a nominal 3-month Treasury bill. Standard deviations of each variable are reported in parentheses. The units for the table are again annualized percentage points.

The risk premium on a nominal bond can be computed either from its average excess return or from its average yield spread. If one assumes that changes in nominal interest rates have an unconditional mean of zero, then the unconditional mean of the excess return should equal the unconditional mean yield spread.

Over the full sample period 1953–94, the two averages are indeed quite close and suggest a risk premium of 70 to 100 basis points on 5-year nominal bonds. In finite samples, of course, these two averages can differ. The finite-sample average excess return will be a downward-biased estimate of the risk premium in a sample where there have been positive surprises in nominal interest rates on average, while the finite-sample yield spread will be an upward-biased estimate of the risk premium in a sample where there have been positive anticipated increases in nominal interest rates on average. The period 1953–73 is an example where this appears to be important; the average yield spread on nominal 5-year zero-coupon bonds exceeds the average return on these bonds by more than 80 basis points.

The instability across subsamples in Table 7 suggests that one should be cautious of empirical results generated from short samples. This point comes out even more clearly when one looks at the UK experience with indexed bonds. During the period 1983–94, Barr and Campbell (1995) show that the average returns on UK nominal bonds were almost 500 basis points above the average returns on perfectly indexed bonds. However this is not a reliable guide to the inflation risk premium because the sample is a short one — the 500 basis point excess return is not significantly different from zero at the 5% level — and an atypical one dominated by unexpected declines in inflation. When inflation unexpectedly declines, nominal bondholders enjoy windfall gains that are not available to indexed bondholders, but these should not be used to estimate the inflation risk premium.

Evidence from longer sample periods can also be informative. Siegel (1994, Tables 1-1 and 1-2) reports that long-term nominal government bonds delivered a geometric average

[21] In previous work (Campbell 1995, Campbell and Shiller 1991), we have used the zero-coupon bond yield data of McCulloch and Kwon (1993), which end in 1991. We use CRSP data here in order to include the period 1992-94 in our sample.

real return of 3.4% over the period 1802–1992, as compared with 2.9% for short-term nominal government debt and 6.7% for a broad index of common stocks. This implies a rather low risk premium on nominal bonds of only 0.5%. This finding is not driven by the inflation experience of the period since World War II, for the average long bond premium over short debt is –0.3% in the period 1802–1870, 0.5% in the period 1871–1925, and 1.2% in the period 1926–1992.

4.2.2. Indirect estimates from covariances

We now turn to our second method for estimating the inflation risk premium. We use asset pricing theory to try to judge what risk premium is implied by the covariances of bond returns with relevant state variables. We use two state variables: the return on a proxy for the market portfolio, as suggested by the traditional CAPM, and the growth rate of aggregate consumption, as suggested by the consumption CAPM.[22] While there are of course many empirical deficiencies in both forms of the CAPM, most of these concern the cross-sectional pattern of returns on stock portfolios as documented by Fama and French (1992) and others; even if the CAPM fails in this respect it may still explain the pattern of returns across broad classes of assets.

Some tricky empirical issues arise in implementing the traditional CAPM and the consumption CAPM. In the traditional CAPM, it is conventional to use a value-weighted stock index as a proxy for the market. We follow this convention in the first row of Table 8, but in the second row we also consider a broader proxy for the market portfolio constructed as 0.5 times the value-weighted stock index plus 0.5 times the return on a nominal 5-year zero-coupon bond. This weighting scheme was suggested by calculations of the ratio of corporate equity to corporate equity plus corporate bonds plus government bonds in the Federal Reserve Board of Governors Balance Sheets for the US Economy. This ratio was close to 0.5 on average in our full sample and both subsamples.

In the consumption CAPM, problems are caused by the fact that consumption is measured as a quarterly flow, so empirical researchers must decide whether to identify consumption in a given quarter as beginning-of-quarter or end-of-quarter consumption. If consumption is beginning-of-quarter, then asset returns measured over quarter t should be regressed on consumption growth from quarter t to t+1 (we call this the "lead" assumption); if consumption is end-of-quarter, then consumption growth from quarter t-1 to t should be used (we call this the "lag" assumption).

Table 8 reports the betas of nominal zero-coupon bond returns with the return on a

[22]Campbell (1996) has argued that the return on a stock index may be a good empirical proxy for the multiple factors suggested by the Merton (1973) intertemporal asset pricing model.

value-weighted stock index, the broader proxy for the market portfolio, “lagged” consumption growth, and “led” consumption growth. Correlation coefficients are also reported in parentheses. For comparison, the beta and correlation coefficients with consumption are reported for the value-weighted stock index.

The table shows that nominal bonds tend to have rather small betas on the state variables that determine risk premia. The stock market beta of a nominal 5-year zero-coupon bond in the period 1953–94 is only 0.1, implying a risk premium of 0.1 times the equity premium or about 60 basis points. The beta of the same bond on the broader market proxy is 0.4, compared with a stock beta of 1.6; this implies a risk premium of 0.4/1.6 = 0.25 times the equity premium or about 150 basis points. The “lag” consumption beta of the bond is actually negative, implying a negative risk premium, but this may merely indicate the inappropriateness of this timing assumption. The “lead” consumption beta is 0.6, as compared with a stock market “lead” consumption beta of 4.0. The implied risk premium for the bond is 0.6/4.0 = 0.15 times the equity premium or about 90 basis points. It is comforting that these risk premium estimates are fairly similar to each other and to the direct estimates in Table 7.

Interestingly, all the betas for nominal bonds are considerably higher in the last 20 years of the full sample than in the first 20 years. This may help to explain the increase in yield spreads and average excess returns on nominal bonds in the more recent period.

For comparison, Table 8 also shows betas and correlations for the hypothetical indexed bond returns that were described in Table 3. The indexed bonds always have negative market and consumption betas (although the stock market betas in particular are extremely small). This implies that indexed bonds would have small negative risk premia rather than the positive risk premia found for nominal bonds.

Longer-run evidence on bond risk premia has been reported by Breeden, Gibbons, and Litzenberger (1989), who study the period 1926–82. They estimate consumption betas indirectly by calculating betas with the “maximum correlation portfolio”, the portfolio of assets that is maximally correlated with consumption growth. The consumption beta for bonds is 0.05 times the consumption beta for stocks, suggesting an inflation risk premium of only 20 or 30 basis points. Since changes in monetary policy have tended to increase inflation risk in the postwar period, it is not surprising that inflation risk premia should be smaller over the period studied by these authors.

Taken together, the results in this section suggest that there is a modest positive inflation risk premium in the returns on long-term nominal debt. A best guess might be 50 to 100 basis points for a 5-year zero-coupon nominal bond. This implies that there could be nontrivial savings to the Treasury from reducing its issuance of long-term nominal debt.

Long-term indexed debt, on the other hand, does not seem likely to have a large risk premium and might even have a negative risk premium. The main distinction between long-term indexed and short-term nominal debt has to do with return volatility at different horizons, as discussed in the previous section, rather than with the average levels of returns.

5. Indexed Bonds and Monetary Policy

Indexed bonds play an informational role by revealing the term structure of forward inflation rates. If the inflation risk premium is fairly stable, this reveals information about the market's expectations of future inflation. This can help the monetary authority judge the credibility of its anti-inflationary policy. In this section we ask how indexed bond yields might be used to help forecast inflation.

If we had both nominal and indexed bonds for all maturities out to some maximum maturity, say thirty years, then there would be, implicit in their yields, market forecasts of inflation for all forecast horizons out to the maximum, and also, forecasts of inflation for each year out to the maximum maturity. Professional forecasters do not routinely produce forecasts in such detail and for such horizons. When there is a market for both indexed and nominal debt, then there is a serious incentive for individuals to try to forecast inflation in such detail, and so we would expect that considerable effort would be expended in doing so. To the extent that markets are efficient, one would expect that the bond-market inflation forecasts might be much better than the professional forecasts we now have.

In assessing this argument it should be remembered that the profit opportunity available to traders in indexed and nominal bonds who can better forecast inflation is not a risk-free one. We are not talking about a riskless profit opportunity if the inflation expectations implicit in the yields are biased. Thus, there may be considerable play in the relation between optimal forecasts of inflation and market forecasts of inflation.

There is another concern with interpreting inflationary expectations implicit in the nominal and indexed bond yields: the spread can be influenced by considerations of tax law, both current, and expected future. The Darby–Feldstein hypothesis (Darby 1975, Feldstein 1983) asserts that nominal bond yields equal a fixed real rate plus the expected inflation rate divided by one minus the marginal tax rate. The validity of this hypothesis is somewhat clouded by the complexities of the tax system and, moreover, there are multiple tax brackets. Even if the situation were clear with regard to the current tax system, long-term bond yields would be influenced not only by the current tax system, but also by expected future tax systems. For example, it is conceivable that taxation of nominal bonds might one day exclude the inflation component of the interest; nominal bond yields ought to vary through time in response to changes in the probability of such an exclusion.

One should also worry that the inflation risk premium may not be constant through time, and thus that the implicit inflationary expectations derived by comparing nominal and indexed bond yields are invalid. The inflation risk premium might well vary through time systematically, as public attitudes towards indexed and nominal debt change, and as the public becomes more accustomed to indexed debt. Moreover, the government might be able to influence this risk premium by changing the amount of indexed bonds that it issues. For example, if the government were to issue an excessive quantity of indexed bonds it might not obtain a good price for them, and so the yield on indexed debt would rise, thereby depressing the implied inflation risk premium. What actually happens with the inflation risk premium would seem to be intimately tied up with the government's policy.[23]

To document how useful indexed bond yields might be in forecasting inflation, in the idealized world of our econometric model, we compare US nominal bond yields with hypothetical expected inflation rates (the difference between nominal bond yields and hypothetical indexed bond yields) as forecasters of inflation. We regress the annualized inflation rate at horizons of 1, 2, and 5 years on the corresponding nominal bond yield and hypothetical expected inflation rate. Table 9 reports the regression coefficients and R^2 statistics from these regressions under the heading "Levels". Under the heading "Differences," the table also reports the coefficients and R^2 statistics from regressions that subtract the inflation rate over the last year from both the regressor and the dependent variable. This transformation helps to ensure that all the variables in the regression are stationary.

We find that at every horizon and sample period, the hypothetical expected inflation rate is a better forecaster of inflation than is the nominal bond yield, in the sense that the regression coefficients are closer to their theoretical value of unity. Over the full sample period 1953–94 the R^2 statistic is also about twice as high for the hypothetical expected inflation rate, although the results are more erratic in the subsamples.

These results suggest that the Federal Reserve should not simply use nominal bond yields as forecasters of inflation, but should take other variables (specifically, the variables used in our VAR system) into account. While in principle the Federal Reserve can do this econometrically, as we have done in this paper, there would be practical and political advantages to having a market-based forecast based on nominal and indexed government bond yields. Even if the market-based forecast were subject to some of the biases we have discussed above, it may be that changes in the market-based forecast are recognized by the public as useful information about the changed outlook for inflation.

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[23]Sir Alan Walters, in discussing the UK experience with index-linked gilts, stressed that the government should be able to influence inflation expectations implicit in bond yields, in testimony before the Subcommittee on Trade, Productivity, and Economic Growth of the Joint Economic Committee, May 14, 1985, page 38.

These advantages are well illustrated by the experience of the UK. The Bank of England uses the nominal and index-linked UK government yield curves to construct a term structure of forward inflation rates; since May 1993 the Bank has reported this term structure in its *Quarterly Inflation Report*, and uses it to judge the medium- and long-term prospects for inflation.[24] This procedure gives the Governor of the Bank some independent evidence of inflation prospects to use in his regular discussions with the Chancellor of the Exchequer about the appropriate stance of monetary policy.

6. Conclusion

We conclude by considering, in a more speculative manner, some possible subsidiary benefits of creating indexed government debt. These are benefits that are caused by private sector adoption of indexed contracts spurred by the demonstration of indexing by the federal government.

It is widely acknowledged that the proper role of the government is to provide public goods, and the demonstration by example of the potential for new financial markets and instruments is really a public good. The private sector tends to undersupply new financial instruments, particularly at the retail level where marketing costs are much larger than in wholesale financial markets. Any firm which took on the public relations effort needed to first issue private indexed bonds would not be able to appropriate much of the societal benefits to doing so. If indeed there is today a slowness to adopt indexing methods, because of a general feeling that these methods have not been proven or have not met the test of time and practice, then a demonstration by the federal government of the potential for various forms of indexing may be highly productive.

If the US government were successful in creating a large, liquid market for indexed government debt today, then it would possibly become, given the leadership role this country has had in the past, a model for indexation the world over. The effect could be to help educate the public about the importance of indexing, and to stimulate many other forms of indexation.

To illustrate the importance of this, consider the effects of indexation of private retirement annuities and long-term residential mortgages. If private retirement annuities

[24]Breedon (1995) and Deacon and Derry (1995) explain the technical details of the Bank's approach. King (1995) argues that the term structure of forward inflation rates provides a measure of the credibility of official inflation targets. Barr and Campbell (1995) present evidence that forward inflation rates do provide better inflation forecasts than nominal bond yields over the 1985–94 period in the UK.

were indexed to inflation, we would not have seen the impoverishment of many elderly, who chose a fixed nominal payment stream. If long-term mortgages were indexed to inflation, we would not have seen the tremendous redistribution of wealth towards homeowners that occurred in the United States during the inflation of the last twenty years. Nominal mortgages with prepayment options protect borrowers from declines in inflation (since they can refinance their mortgages if nominal interest rates fall); but they offer borrowers the potential for large gains if inflation rises. The cost of this option is substantial, perhaps as much as 125 basis points in the mortgage interest rate.[25] Indexed mortgages could be issued with prepayment options, but the comparative stability of real interest rates would make the prepayment options much less valuable and this would reduce the interest rates on indexed mortgages.

Another possible effect of more widespread understanding of indexation might be an increased public willingness to make all manner of longer-term contracts. There are today many contracts that might be made more usefully if there were a possibility of making them sensibly, in terms of real cash flows. It is impossible for us to predict the potential variety of long-term contracts that might prove to be economically efficient if there were a popular understanding of the possibility of couching their definition in inflation-indexed terms.

If the benefits of indexation were more widely appreciated, then the chances that our tax system could be indexed to inflation would probably be improved. The benefits of having a tax system indexed to inflation are very significant, see for example Feldstein (1983).

There is some reason to worry that government issuance of indexed debt may not have much of a demonstration effect. Certainly, there has not been much private issuance of indexed debt in the United Kingdom or in other moderate inflation countries where government indexed debt has been introduced. But one should not assume that this failure of the public to follow the government's example that we see in the United Kingdom is inevitable. Bootle (1991) argued that a large part of the reason for the failure of many private firms in the UK to issue indexed debt is the UK tax law, which has "seemed vague or penal or both."[26] Possibly a more important reason is just that opinion leaders have not yet impressed on the public the importance of indexed private debt, to overcome their habitual impulse to money illusion. History suggests that advances in public enlightenment

[25] At 1.30 pm on February 1, 1996, a newly issued 7% GNMA pass-through security traded at a price of 101–11. Under Bloomberg median prepayment assumptions, the implied yield was 6.8% and the duration was just over 6 years. At the same time a 6-year Treasury strip traded at a yield of 5.4%. The spread of 140 basis points is mostly attributable to the prepayment option, since government agency bonds trade at premiums to Treasury yields of only 20–25 basis points. Similar calculations for a newly issued 7.5% GNMA pass-through give a spread of 170 basis points.

[26] Bootle (1991), p. 122. See also Fischer (1983).

are not easily generated, and may come long after the initial stimulus or only when institutional circumstances are changed. If the United States were to issue indexed debt, the public response might well be different.

There might also be some negative consequences of increased indexation of private-sector contracts. One common objection to the widespread indexation of the economy is that indexation diminishes the incentives for the government to fight inflation. As this argument goes, the people who are potentially most hurt by inflation will protect themselves by indexation. The political forces to prevent inflation will then be weakened, and the large number of people who are hurt somewhat by inflation, and who do not avail themselves of protection via indexation, will find their interests harmed. A problem with this argument is that the direction of the political effect of indexation is ambiguous; the political impact of indexation may go the other way, along the lines argued by Margaret Thatcher.[27]

A related argument is that indexation of labor contracts may worsen problems caused by the reluctance of workers to take wage cuts. If labor contracts are specified in nominal terms, then inflation can reduce real wages without provoking worker resistance; this ceases to be possible when labor contracts are indexed to the price level (Card and Hyslop 1996).

Although we appreciate the possibility of negative side-effects from indexation, we believe that the importance of these should not be overstated. Although the theory of the second-best tells us that the elimination of some distortions in the economy may worsen other distortions and thereby indirectly reduce welfare, we find this to be unlikely in the case of indexed bonds, where the direct benefits are so substantial.

The US Treasury officials who apparently have the authority to issue indexed bonds may not see it as consistent with their primary mission to generate public goods by promoting indexation in the economy. They should be urged to conceive of their mission more broadly, and to get on with the creation of this important new kind of debt instrument.

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[27] Fischer and Summers (1989) present a simple model to illustrate this ambiguity.

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Table 1

Dates of Introduction of Indexed Bonds with Inflation Rates

Date of Introduction	Country	Type of Indexation	Inflation Rate in Year Prior to Introduction
1945	Finland	Wholesale Prices	6.4% (a)
1952	Sweden	Consumer prices	2% (b)
1955	Israel	Consumer prices	12.3%
1955	Iceland	Consumer prices	0% (c)
1964	Brazil	Wholesale prices	69.2%
1966	Chile	Consumer prices	22.2%
1967	Colombia	Wholesale prices	19.7%
1972	Argentina	Wholesale prices	34.8%
1975 (d)	UK	Consumer prices	16.1%
1981	UK	Consumer prices	14.0%
1985	Australia	Consumer prices	4.5%
1989	Mexico	Consumer prices	114.8%
1991	Canada	Consumer prices	4.8%
1994	Sweden	Consumer prices	4.4%
1995	New Zealand	Consumer prices	2.8%

Source of inflation rates: International Financial Statistics, International Monetary Fund (consumer price index) unless otherwise noted. Indexation dates through 1972 are from Page and Trollope (1974) and Jud (1978).

(a) Source: Bank of Finland, *The Finnish Economy 1860-1985: Growth and Structural Change*, Government Printing Center, Helsinki, 1989, Table 13 page 278. This same source indicates that in Finland the cost of living index rose 99.1% from 1939 to 1944.

(b) Consumer prices in Sweden had risen 104.5% between 1938 and 1950; source: Central Bureau of Statistics, *Historical Statistics of Sweden*, Stockholm, 1960., Table 95, page 114.

(c) Consumer prices in Iceland had risen 102.7% from 1949 to 1954; source: *Statistical Abstract of Iceland*, Table 12.5, page 150.

(d) In 1975 the UK issued non-marketable index-linked national savings retirement bonds ("granny bonds"). Marketable index-linked debt was first issued in 1981.

Table 2

Size and Liquidity of Selected Indexed Government Bond Markets

	Australia	Canada	Israel	New Zealand	Sweden	UK
Outstanding ($ billions)	2.3	3.8	25.1	0.006	3.6	56.8
Outstanding (% of marketable debt)	3.8%	1.2%	86%	<1%	3.2%	15.3%
Average daily turnover 1994 ($ millions)	21.9	16.6	13.2	small	small	256.2

Source: Bank of England (1995), Appendix B.

TABLE 3

Volatility of Returns and Yields on Hypothetical Indexed Bonds in the US 1953-94

VAR sample, lag length	Bond mat. k years	1-quarter moments (1)	(2)	(3)	k-year moments (4)	(5)	(6)
A: 1953 - 94							
1 lag	1	1.833	2.091	1.675	1.217	1.539	0.781
	2	1.833	2.091	3.881	1.129	1.518	0.942
	5	1.833	2.091	6.223	0.726	1.471	1.070
	10	1.833	2.091	6.579	0.428	1.302	0.998
4 lags	1	2.024	1.927	0.999	1.432	1.392	0.635
	2	2.024	1.927	2.982	1.501	1.393	0.783
	5	2.024	1.927	5.266	1.279	1.392	0.969
	10	2.024	1.927	7.354	0.919	1.228	0.942
B: 1953 - 73							
1 lag	1	0.439	1.492	0.386	0.299	0.851	0.179
	2	0.439	1.492	0.747	0.326	0.719	0.206
	5	0.439	1.492	1.890	0.218	0.501	0.217
	10	0.439	1.492	2.865	0.106	0.254	0.138
C: 1974 - 94							
1 lag	1	2.525	2.421	2.045	1.701	1.657	0.975
	2	2.525	2.421	4.856	1.580	1.564	1.095
	5	2.525	2.421	7.970	0.989	1.505	1.174
	10	2.525	2.421	8.300	0.598	0.667	0.648

TABLE 4

Volatility of Returns and Yields on Hypothetical Indexed Bonds in the UK 1953-94

VAR sample, lag length	Bond mat. k years	1-quarter moments (1)	(2)	(3)	k-year moments (4)	(5)	(6)
A: 1953 - 94							
1 lag	1	2.773	4.791	2.222	1.891	3.011	1.137
	2	2.773	4.791	5.488	1.826	2.849	1.421
	5	2.773	4.791	9.579	1.262	2.918	1.786
	10	2.773	4.791	11.136	0.814	2.920	1.968
4 lags	1	3.562	4.296	1.685	2.216	2.868	1.071
	2	3.562	4.296	5.612	2.217	2.554	1.320
	5	3.562	4.296	10.696	1.453	2.599	1.670
	10	3.562	4.296	11.743	0.731	2.490	1.765
B: 1953 - 73							
1 lag	1	1.855	3.624	0.961	0.673	1.857	0.532
	2	1.855	3.624	1.732	0.552	1.555	0.454
	5	1.855	3.624	3.544	0.361	0.927	0.399
	10	1.855	3.624	7.065	0.299	0.581	0.331
C: 1974 - 94							
1 lag	1	3.921	5.351	3.051	2.719	3.560	1.599
	2	3.921	5.351	7.241	2.753	2.821	1.735
	5	3.921	5.351	13.879	2.095	2.099	1.447
	10	3.921	5.351	17.942	1.295	1.483	1.181

TABLE 5

Comparison of Hypothetical and Actual Returns and Yields on UK Indexed Bonds 1985:1–1994:10

		Yields			Returns		
VAR sample, lag length	Bond mat. k years	Mean ratio	S.D. ratio	Corr.	Mean ratio	S.D. ratio	Corr.
A: 1953 - 94							
1 lag	1	1.548	0.590	0.625	1.550	0.690	0.371
	2	1.235	0.679	0.456	0.870	0.845	0.186
	5	0.757	0.678	0.059	0.352	1.191	-0.054
	10	0.543	0.631	-0.276	0.255	1.211	-0.241
4 lags	1	1.826	0.897	0.367	1.857	0.735	-0.104
	2	1.527	1.314	0.382	1.128	0.908	-0.239
	5	0.969	1.891	0.486	0.581	1.498	-0.064
	10	0.664	1.580	0.522	0.576	1.621	0.041
B: 1974 - 94							
1 lag	1	1.810	0.603	0.497	1.865	0.809	0.095
	2	1.581	0.689	0.181	1.207	0.988	-0.076
	5	1.181	1.087	-0.265	0.603	1.581	-0.322
	10	0.984	1.110	-0.367	0.483	1.882	-0.371

TABLE 6

Volatility of After-Tax Returns and Yields on Hypothetical Indexed Bonds in the US 1953-94

$\tau = 0.300$

VAR sample, lag length	Bond mat. k years	1-quarter moments (1)	(2)	(3)	k-year moments (4)	(5)	(6)
A: 1953 - 94							
1 lag	1	1.619	2.100	1.483	1.072	1.566	0.694
	2	1.619	2.100	3.421	1.007	1.587	0.890
	5	1.619	2.100	5.742	0.666	1.496	1.052
	10	1.619	2.100	6.532	0.395	1.390	1.046
4 lags	1	1.852	1.920	0.897	1.292	1.401	0.603
	2	1.852	1.920	3.213	1.294	1.451	0.818
	5	1.852	1.920	5.178	0.942	1.431	0.995
	10	1.852	1.920	5.107	0.624	1.306	0.964
B: 1953 - 73							
1 lag	1	0.745	1.485	0.397	0.529	0.905	0.229
	2	0.745	1.485	1.331	0.617	0.764	0.278
	5	0.745	1.485	3.896	0.406	0.523	0.321
	10	0.745	1.485	5.434	0.189	0.294	0.274
C: 1974 - 94							
1 lag	1	2.181	2.451	1.837	1.455	1.677	0.839
	2	2.181	2.451	4.279	1.357	1.624	0.961
	5	2.181	2.451	6.901	0.843	1.517	1.070
	10	2.181	2.451	7.058	0.477	0.682	0.556

TABLE 7

Quarterly Summary Statistics for US Nominal Zero-coupon Bonds

	1 yr.	2 yr.	5 yr.
A: 1953 - 94			
Excess return over	0.463	0.721	0.676
3-month bill	(4.340)	(7.746)	(14.668)
Change in yield	0.030	0.032	0.031
	(1.048)	(0.924)	(0.708)
Yield spread over	0.440	0.634	0.981
3-month bill	(0.480)	(0.704)	(1.076)
B: 1953 - 73			
Excess return over	0.171	0.116	-0.138
3-month bill	(2.647)	(4.744)	(9.518)
Change in yield	0.061	0.054	0.051
	(0.672)	(0.594)	(0.476)
Yield spread over	0.366	0.431	0.686
3-month bill	(0.317)	(0.420)	(0.585)
C: 1974 - 94			
Excess return over	0.755	1.326	1.490
3-month bill	(5.543)	(9.873)	(18.465)
Change in yield	-0.012	-0.002	0.003
	(1.325)	(1.168)	(0.885)
Yield spread over	0.513	0.837	1.277
3-month bill	(0.594)	(0.859)	(1.345)

TABLE 8

Quarterly Betas and Correlations of Excess Returns with State Variables

	Nominal bonds			Indexed bonds			Stocks
	1 yr.	2 yr.	5 yr.	1 yr.	2 yr.	5 yr.	
A: 1953 - 94							
Value-weighted stock index return	0.021 (0.209)	0.047 (0.225)	0.101 (0.239)	-0.022 (-0.208)	-0.025 (-0.150)	-0.020 (-0.088)	1.000 (1.000)
50% bond-50% stock index return	0.087 (0.503)	0.189 (0.534)	0.407 (0.564)	-0.044 (-0.249)	-0.042 (-0.149)	-0.020 (-0.052)	1.593 (0.937)
Consumption growth (lag)	-0.324 (-0.190)	-0.665 (-0.192)	-1.079 (-0.153)	-0.272 (-0.156)	-0.544 (-0.199)	-0.863 (-0.228)	2.775 (0.167)
Consumption growth (lead)	0.172 (0.101)	0.388 (0.112)	0.618 (0.087)	-0.347 (-0.199)	-0.448 (-0.164)	-0.476 (-0.126)	4.040 (0.242)
B: 1953 - 73							
Value-weighted stock index return	0.010 (0.142)	0.016 (0.112)	0.034 (0.111)	-0.027 (-0.281)	-0.036 (-0.239)	-0.040 (-0.194)	1.000 (1.000)
50% bond-50% stock index return	0.049 (0.375)	0.095 (0.365)	0.215 (0.383)	-0.055 (-0.313)	-0.070 (-0.250)	-0.072 (-0.188)	1.785 (0.961)
Consumption growth (lag)	-0.227 (-0.223)	-0.505 (-0.245)	-0.855 (-0.194)	-0.360 (-0.261)	-0.637 (-0.291)	-0.927 (-0.309)	2.901 (0.198)
Consumption growth (lead)	-0.069 (-0.070)	-0.163 (-0.082)	-0.544 (-0.127)	-0.296 (-0.222)	-0.476 (-0.224)	-0.658 (-0.227)	3.328 (0.235)
C: 1974 - 94							
Value-weighted stock index return	0.030 (0.251)	0.070 (0.287)	0.152 (0.307)	-0.018 (-0.166)	-0.017 (-0.096)	-0.006 (-0.026)	1.000 (1.000)
50% bond-50% stock index return	0.108 (0.562)	0.239 (0.609)	0.512 (0.644)	-0.038 (-0.215)	-0.026 (-0.095)	0.008 (0.020)	1.488 (0.926)
Consumption growth (lag)	-0.416 (-0.177)	-0.791 (-0.166)	-1.274 (-0.132)	-0.195 (-0.090)	-0.501 (-0.147)	-0.906 (-0.192)	2.669 (0.137)
Consumption growth (lead)	0.594 (0.245)	1.349 (0.273)	2.541 (0.254)	-0.456 (-0.203)	-0.467 (-0.133)	-0.288 (-0.059)	5.192 (0.257)

TABLE 9

Inflation Forecasts from Nominal and Hypothetical Indexed Bond Yields

	Levels			Differences		
Forecasting variable	1 yr.	2 yr.	5 yr.	1 yr.	2 yr.	5 yr.
A: 1953 - 94						
Nominal Bond Yield	0.597	0.448	0.301	0.119	0.137	0.220
	(0.361)	(0.227)	(0.137)	(0.018)	(0.018)	(0.049)
Expected Inflation	0.877	0.721	0.464	0.471	0.518	0.463
Rate	(0.592)	(0.415)	(0.228)	0.084)	(0.100)	(0.144)
B: 1953 - 73						
Nominal Bond Yield	0.866	0.755	0.897	0.728	0.781	0.923
	(0.671)	(0.580)	(0.469)	(0.381)	(0.363)	(0.487)
Expected Inflation	0.920	0.802	0.946	1.054	1.072	0.995
Rate	(0.670)	(0.544)	(0.355)	(0.348)	(0.325)	(0.380)
C: 1974 - 94						
Nominal Bond Yield	0.305	-0.026	-0.649	0.057	0.106	0.241
	(0.078)	(0.001)	(0.385)	(0.006)	(0.016)	(0.077)
Expected Inflation	0.813	0.544	-0.555	0.320	0.416	0.445
Rate	(0.411)	(0.152)	(0.148)	(0.050)	(0.091)	(0.177)

Notes to Tables 3, 4, and 6: Yields and returns are measured in annualized percentage points. Bond maturity is measured in years. Data frequency is quarterly. The variables in the VAR include the lagged real bill return, the nominal bill yield, and the lagged inflation rate over the previous year. Column (1) reports the standard deviation of the yield on a hypothetical indexed 3-month bill. Column (2) reports the standard deviation of the difference between the real quarterly return on a nominal 3-month bill and the yield on a hypothetical indexed 3-month bill. Column (3) reports the standard deviation of the difference between the real quarterly return on a hypothetical k-year indexed bond and the yield on a hypothetical indexed 3-month bill. Column (4) reports the standard deviation of the yield on a hypothetical indexed k-year bond. Column (5) reports the standard deviation of the difference between the real k-year return on rolling over nominal 3-month bills and the yield on a hypothetical indexed k-year bond. Column (6) reports the standard deviation of the difference between the real k-year return on rolling over hypothetical indexed 3-month bills and the yield on a hypothetical indexed k-year bond. Table 3 uses US data ignoring taxes, Table 4 uses UK data ignoring taxes, and Table 6 uses US data where the real interest rate is taken to be 0.7 times the nominal interest rate minus the inflation rate, corresponding to a tax rate of 0.3 on nominal interest.

Notes to Table 5: This table compares the yields and returns on hypothetical indexed UK government bonds, as calculated in Table 4, with the yields and returns calculated from actual index-linked gilts by Barr and Campbell (1995). The columns headed "Mean ratio" report the ratio of the mean hypothetical indexed yield or return to the mean actual indexed yield or return. The columns headed "S.D. ratio" report the ratio of the standard deviation of the hypothetical indexed yield or return to the standard deviation of the actual indexed yield or return. The columns headed "Corr." report the correlation between the hypothetical indexed yield or return and the actual yield or return.

Notes to Table 7: All units are annualized percentage points. Quarterly data on US nominal bond yields and returns are constructed from the Fama files on the CRSP tapes. In each pair of numbers the top number is the sample mean, the bottom number in parentheses is the sample standard deviation.

Notes to Table 8: Quarterly nominal or hypothetical indexed bond returns and the value-weighted stock index return from the CRSP tapes are regressed onto the value-weighted stock index return, or the return on a portfolio with 50% weight on the value-weighted stock index and 50% weight on the 5-year zero-coupon nominal government bond, or the backward difference of log nondurables and services consumption (the "lag" row), or the forward difference of log nondurables and services consumption (the "lead" row). In each pair of numbers the top number is the regression or "beta" coefficient and the bottom number in parentheses is the correlation coefficient.

Notes to Table 9: Annualized inflation over the next k years is regressed onto the k-year nominal bond yield, or the difference between the k-year nominal bond yield and the k-year hypothetical indexed bond yield. In each pair of numbers the top number is the regression coefficient and the bottom number in parentheses is the R^2 statistic. The columns headed "differences" subtract the 1-year lagged inflation rate from both the regressor and the dependent variable of the regression.

Figure 1: Ex–ante and ex–post real US 3–month T–bill rate
(Quarterly data: 53.1–94.4)

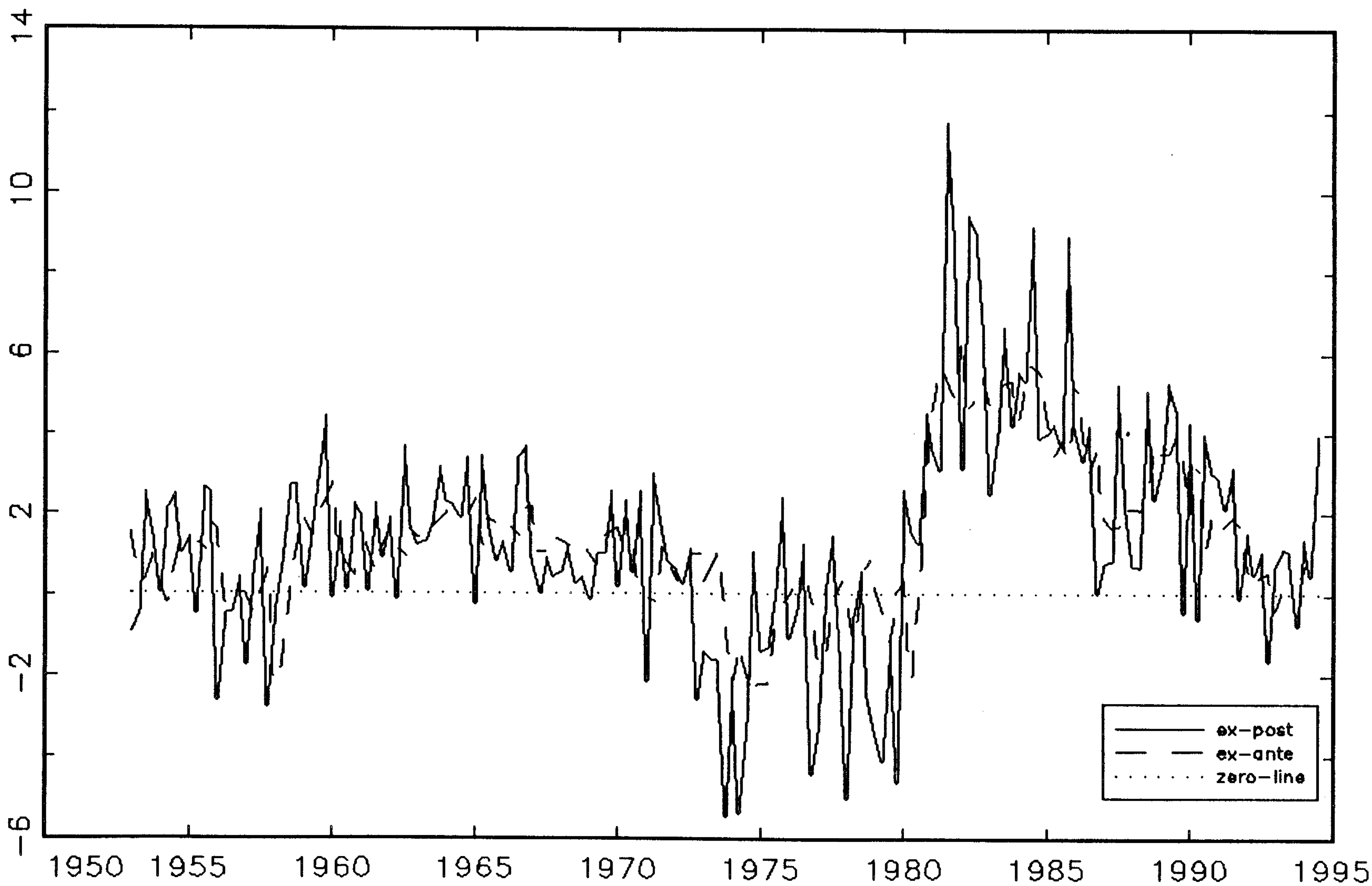

Figure 2: Ex-ante yield on k-year US indexed bonds
(Quarterly data: 53.1-94.4)

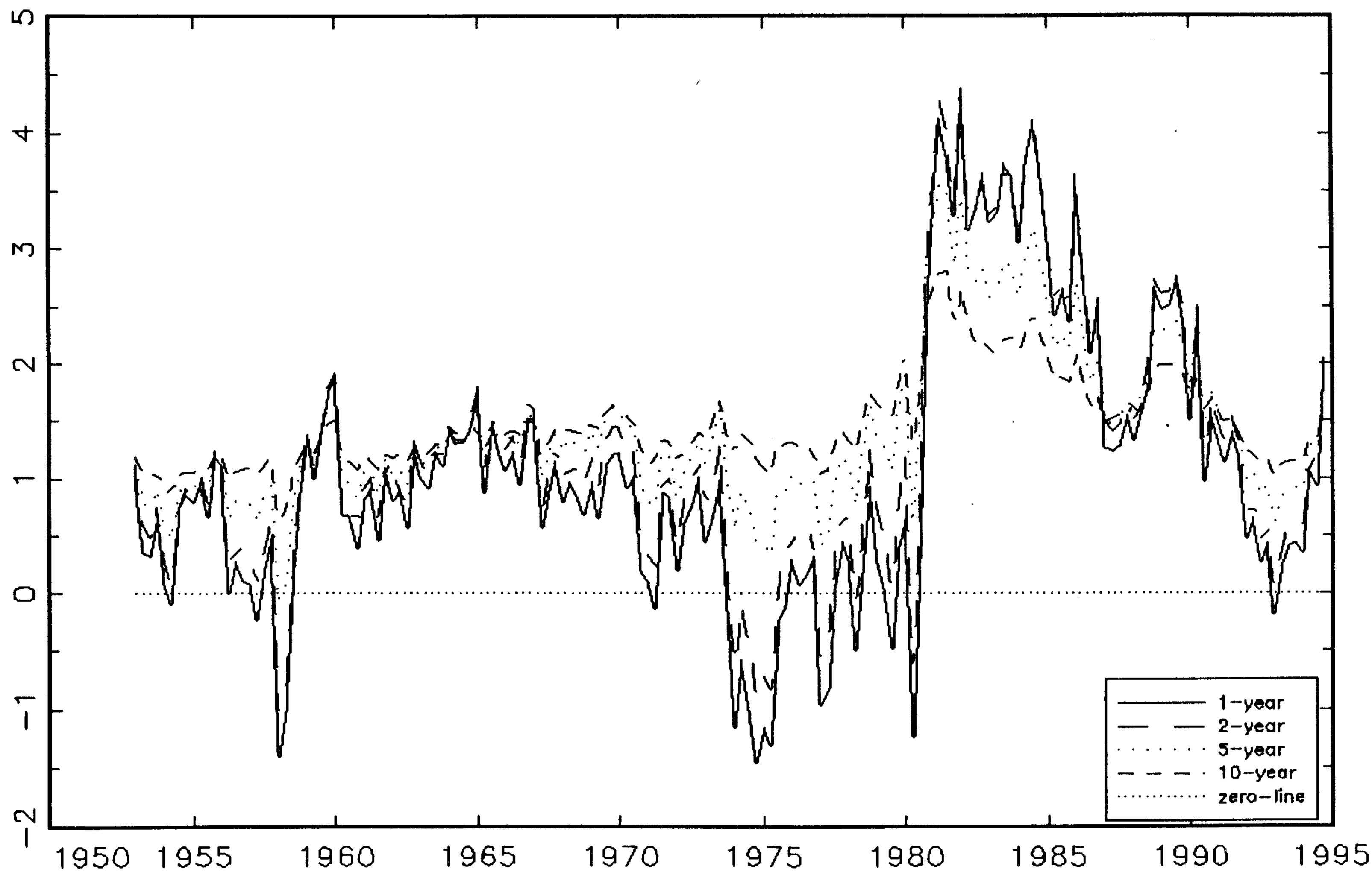

Figure 3: Yield on hypothetical and actual UK indexed bonds
(1–year bonds)
(Quarterly data: 53.1–94.4)

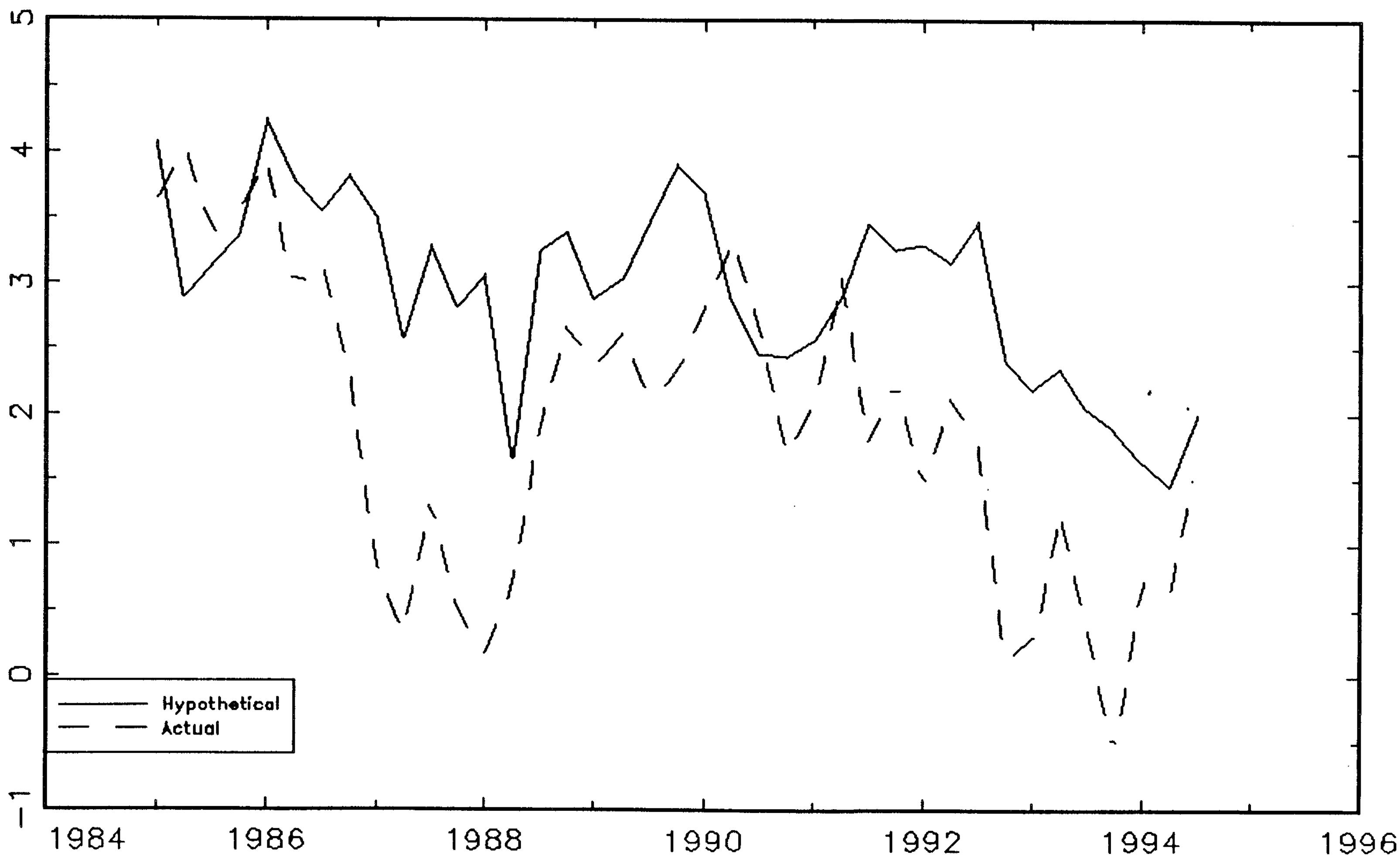

Figure 4: Yield on hypothetical and actual UK indexed bonds
(2-year bonds)
(Quarterly data: 53.1-94.4)