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73

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UNDERSTANDING AND USING INFLATION BONDS

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Introduced in 1997, the U.S. Treasury Inflation-protected Securities market has grown to over $150 billion at the end of August 2002, which is about 6.0 percent of the market for publicly held U.S. Treasury Securities.

Increased interest in inflation bonds is due both to their recent high returns compared with stocks and regular bonds and, more fundamentally, recognition of their status as a new asset class. Unique features of inflation bonds include their ability to provide low or negative return correlation with other assets, long duration with respect to real interest rates, and low yield volatility. These features make inflation bonds well suited to saving for the future, portfolio diversification, and ensuring a retirement or endowment income stream. As new inflation-bond-based products are developed, the market for inflation bonds will continue to grow.

in this issue

>>> INTRODUCTION

Introduced by the U.S. Treasury in 1997 and in 21 other countries over the last two decades, inflation bonds encompass a variety of securities and monikers: TIPS, TIIS, *i*-STRIPS, I-Bonds, inflation-indexed bonds, inflation-protected bonds, inflation-linked bonds, real bonds, real return bonds, and even "linkers" and "OATei's" (see the accompanying glossary of inflation bond terms).

Since 1997, the U.S. Treasury inflation bond market has grown to over $150 billion as of August 2002, representing over 6 percent of the $2.3 trillion in total tradable US Treasury Notes and Bonds (Barclays Capital 2002a). In addition, about $12 billion of the $200 billion in outstanding US savings bonds are inflation-linked (U.S. Treasury 2002), and 18 other agency, municipal, and corporate entities have issued over $2.5 billion in dollar-denominated inflation bonds. The US market represents over 47 percent of the world's actively traded government inflation bonds (Barclays Capital 2002a).

Scholarly interest in inflation bonds is widespread and longstanding (Bodie 1980 and 1990; Benninga and Protopapadakis 1983; Hammond 1996; Campbell and Shiller 1996; Kandel et al 1996; McCulloch and Kochin 2000). Despite intermittent uncertainty about future US government support for inflation bonds, including the cancellation of the Treasury's 30-year inflation bond,[1] public interest in them has broadened as individuals, endowments, pension plans, and other institutions increased their purchases in the past several years.

The heightened public interest in inflation bonds may have two motivations, one transient and the other more fundamental. One possible reason for increased interest in inflation bonds is the ephemeral one of high returns. A US inflation bond index returned about 13 percent in 2000, about 8 percent in 2001, and over 15 percent through the end of September 2002 — about 12 percent per year for the time period between 2000 and September 2002 (Salomon Smith Barney 2002). This compares with annualized returns over the same time periods of about -17 percent for the S&P 500 stock index, 11 percent for the Lehman Aggregate index of corporate and government bonds, and about 5 percent for money market funds. Since the return divergence favoring inflation bonds is based on falling interest rates and a general flight out of stocks into safer government securities, it will not continue indefinitely.

A more sustainable and fundamental reason for interest in inflation bonds is they represent a new asset class. To go along with the availability of US TIPS, Series I savings bonds, foreign inflation bonds, and other individual inflation-linked securities, at least seven US mutual funds have been created whose assets are primarily or exclusively invested in inflation bonds. It is common to find that inflation bonds represent between 5 and 10 percent of major endowments' policy portfolios.[2] As such, inflation bonds and various investment options based on them are beginning to play a significant role in asset allocation, retirement savings, and other purposes. Because of their special characteristics and growing availability, inflation bonds are and should be of special interest to retirees, retirement savers, endowments, and other individuals and institutions.

This article examines what we know about US inflation bonds, including what makes them different from regular bonds and other assets, how they behave and can be used, and what benefits they provide. It concludes that these bonds' inflation-tracking ability, low price and yield volatility, low or negative return correlation with other assets, enable investors to (1) protect assets and future income against inflation, (2) better match liabilities and assets when both are affected by inflation, and (3) provide diversification in combination with other asset classes.

>>> WHAT ARE INFLATION BONDS?

Perhaps the easiest way to understand inflation bonds is to compare them with regular bonds in the case of buyers who hold them until they mature. For these investors, regular bonds provide a nominal return or interest rate, R_r^{RB}, that reflects the sum of at least three components: (1) a real return component, r; (2) additional interest or return that corresponds to expected inflation, $E(i)$; and (3) an inflation risk premium, p_i, an extra bit that compensates holders for the uncertainty associated with future inflation (i.e., the chance that actual future inflation will exceed

Glossary of Inflation Bond Terms

Coupon. A coupon is the stated interest rate for a bond. Most bonds have a fixed coupon that does not change during the life of the bond. Most bonds have two semi-annual coupon payments per year.

Duration. Generally, the effect of changes in interest rates on a bond's price.

Efficient Portfolio. An investment portfolio that provides the greatest expected return for a given level of risk, or equivalently, the lowest risk for a given expected return.

Efficient Frontier. The line or curve on a risk-return graph comprised of all efficient portfolios.

I-Bonds. The inflation-indexed version of US savings bonds.

***i*-STRIPS.** Barclays Capital principal-only and interest-only derivatives of TIPS.

Inflation Bonds. Bonds, notes, etc., issued by governments, agencies, municipalities, and corporations, whose principal and/or interest payments automatically adjust with changes in some measure of inflation.

Inflation-indexed Bonds. Another name for inflation bonds.

Inflation-linked Bonds. Another name for inflation bonds.

Linkers. Inflation bonds issued by the United Kingdom.

Maturity Date. The date on which the bond will be repaid.

Nominal Bonds. See regular bonds.

Nominal Return. Asset returns that have not been adjusted for the effects of inflation. Published returns on stocks, bonds, and other assets are usually reported in nominal terms.

OATei's. Euro-denominated inflation bonds issued by France.

Par Value. The value of the bond at maturity, also known as face value.

Principal. The amount borrowed. It is often referred to as par value, or face value.

Regular Bonds. Bonds, notes, etc., whose principal and interest payments are not adjusted for inflation. Also known as nominal bonds.

Real Return. The asset return that remains after the effects of inflation have been accounted for. Often calculated by subtracting a measure of historical inflation (e.g., CPI-U) or expected inflation from the nominal return.

Real Return Bonds. Inflation bonds issued by Canada.

Series I Savings Bonds. First issued in 1998, these are the inflation bond version of US government Series E savings bonds. Issued in denominations of $50 through $10,000, these bonds accrue earnings for up to 30 years based on a combination of a fixed interest rate and a semi-annual inflation adjustment. In the event of deflation, this combined interest rate cannot fall below zero.

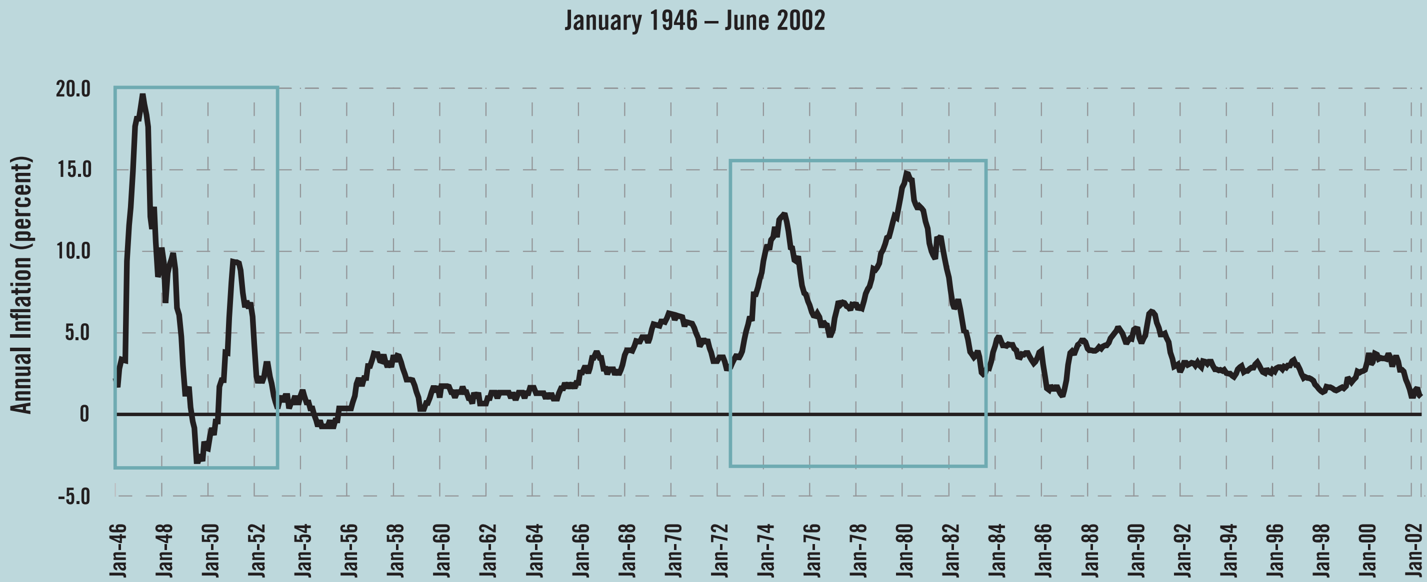
TIIS. US Treasury Inflation Indexed Securities — the formal name for TIPS.

TIPS. US Treasury Inflation Protected Securities.

US CPI-U. The US Bureau of Labor Statistics Consumer Price Index for Urban consumers. This is the federal government's widely known inflation measure used to adjust the principal and interest payments of US inflation bonds.

Yield to Maturity. The calculated return on investment that an investor will get if they hold the bond to maturity. It takes into account the present value of all future cash flows, as well as any premium or discount to par that the investor pays.

Exhibit 1 Rolling Annual Inflation (CPI-U)



Source: U.S. Bureau of Labor Statistics.

expected inflation — Hammond et al 1999):[3]

$$R_r^{RB} = r + E(i) + p_i$$

The challenge for regular bondholders is to accurately gauge future inflation, which, if higher than their expectations, could lead to a real (i.e., inflation-adjusted) return that is less than anticipated. Conversely, if future inflation is lower than expected, a regular bondholder will receive a real return that is higher than anticipated.

In contrast, investors who buy and hold inflation bonds can eliminate the uncertainty associated with future inflation. They can achieve a guaranteed return that exceeds inflation. This guaranteed return, R_r^{IB}, consists of two components: (1) the real return component, r; plus (2) actual inflation, i, over the life of the bond.

$$R_r^{IB} = r + i$$

In exchange for inflation certainty, inflation bond investors will give up the inflation risk premium, p_i. Returns that reflect actual inflation are possible because unlike regular bonds, the principal of US TIPS is adjusted each month in step with the general price inflation as measured by the US Bureau of Labor's Consumer Price Index for Urban areas (CPI-U). Each semi-annual coupon payment — the investor's income stream — changes as the original coupon rate is applied to an inflation-adjusted principal.

Example 1

Consider a regular bond of $1,000 that offers a coupon rate of 5 percent. Each year, the bondholder would receive an income of $50 on the bond. At maturity, the bondholder would get back the $1,000 principal.

Example 2

Consider an inflation bond of $1,000 that offers a coupon rate of 3 percent. In the first year, the bondholder would receive an income of $30. Assuming a 2 percent inflation rate, the value of the bond's principal would rise to $1,020 in the second year, and the bondholder would receive an income of $30.60 in that year. This $30.60 reflects the 2-percent inflation adjustment.[4] In the subsequent years, inflation would continue to add to the principal value and to future income. At maturity, the principal, now larger by the amount of inflation during the life of the bond, would be returned.[5] In exchange for this CPI-based guarantee, buyers give up the extra inflation risk premium (Hammond et al 1999).[6]

Therefore, inflation bonds enable investors to purchase insurance or hedge against a major source of systematic risk, to match assets and liabilities in an uncertain world, and to diversify portfolios that contain stocks and other types of assets (Bodie, Hammond and Mitchell 2002).

Some people have argued that there is little current need for inflation protection. For example, inflation in the United States has been relatively benign over the past several years. Between the introduction of TIPS in January 1997 and July 2002, the CPI-U rose a total 11.8 percent, or an average of 2.3 percent per year. During 2001, CPI-U increased only 1.6 percent (US Bureau of Labor Statistics 2002). But even when inflation is a modest 2 percent, over long periods the real value (i.e., purchasing power) of a dollar can fall considerably — about 18 percent over 10 years.

Viewed in a wider historical context, inflation is often far from benign. Since 1925, inflation has averaged just over 3 percent per annum, which translates into a loss in real savings or purchasing power of more than 25 percent over 10 years. Exhibit 1 shows that since World War II, there were two major inflationary spikes (annualized inflation rates of about 20 percent in March of 1947 and about 15 percent in May of 1980). These inflationary spikes took big bites out of families' current purchasing power as well as their savings (i.e., future purchasing power). Perhaps even more important, inflation was persistent for 5-10 year periods around those peaks. For example, from 1973 to 1982, inflation averaged about 8.7 percent per year. Over that 10-year period the value of a dollar declined by over 50 percent. Had inflation bonds been available during those periods, investors who bought them would have been protected against a loss of purchasing power.

>>> ASSESSING AN INFLATION HEDGE

Are there other candidates for an effective inflation hedge? These might include investments or income sources that are likely or guaranteed to grow as fast or faster than inflation. Candidates could include equities, regular bonds, real estate, commodities, wages and salaries, and Social Security. Social Security, for example, is legislatively guaranteed to keep up with inflation, while wages and salaries, as well as equities, have exceeded inflation over long periods of time.

Criteria for examining any candidate for inflation hedge should include the following considerations:

True insurance

What is the nature of the inflation promise? In the case of both Social Security and inflation bonds, the US federal government places its creditworthiness behind the legal promise that payments will match or exceed some measure of inflation. Social Security is backed by legislation, but some have predicted that legislation may be changed in the future to reduce the program's built-in CPI escalator.

Other sorts of potential inflation hedges such as regular bonds, real estate, commodities, and equities, often outpace inflation over the long run, but are not guaranteed to do so and have not during certain periods. For example, the S&P 500 stock index has returned well over 10 percent per year since 1925, while inflation has averaged a little over 3 percent in the same period. However, the overall correlation between inflation and the annual returns of S&P 500 is rather low (-.02). Moreover, about a third of the years the return of S&P 500 failed to beat inflation (25 out of 76 years).

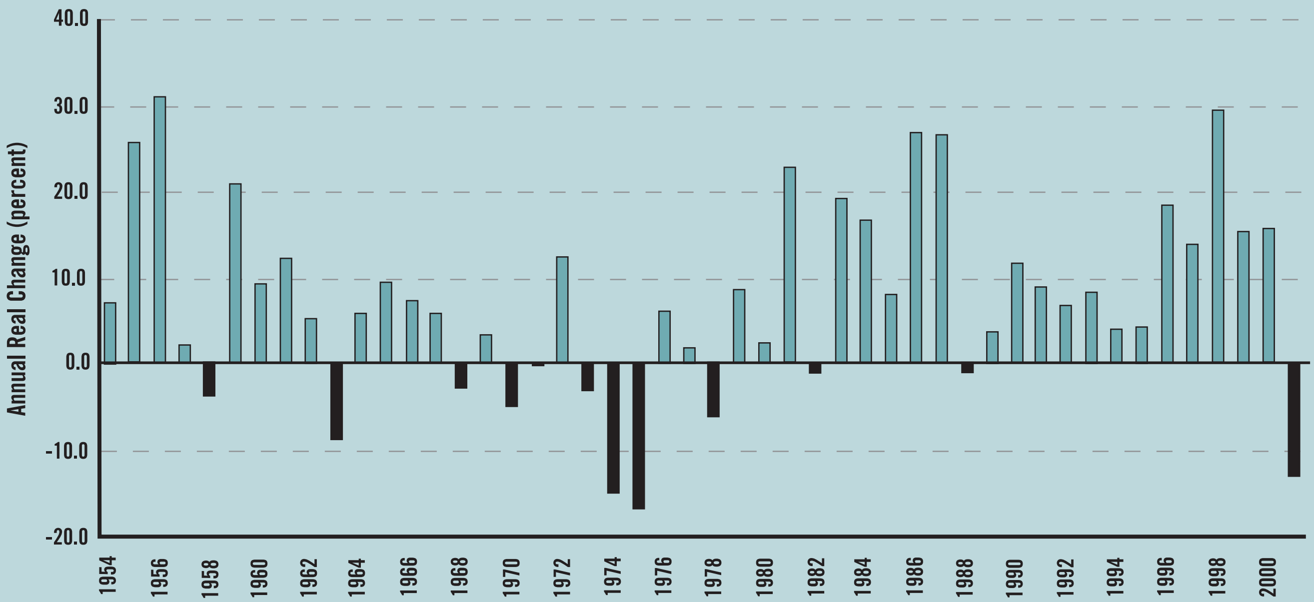
A similar story applies to other asset classes such as regular bonds, real estate, and commodities.[7] This conclusion also applies forcefully to retirement assets. Exhibit 2 shows that growth in retirement income from the CREF stock account (the longest existing variable annuity) has exceeded inflation by an average of 3 percent per year between 1954 and 2001. However, in 12 of the 48 years, retirement income from the account did not keep pace with inflation. The 10-year period beginning in 1973 was particularly difficult for retirees who relied for a portion of their income on stocks.[8]

Insurance for whom?

Inflation can refer to several sorts of price increases. We have already considered the CPI-U, which is the US government's estimate of what families in urban

Exhibit 2 Annual Real Change in Variable Annuity Income

(Change in CREF Stock Account Annuity Income Minus Change in US CPI-U)
1954-2001



Note: 1) Average Annual Growth in CREF Stock Annuity Income = 7.0%.
2) Average Annual Increase in US CPI-U = 4.0%.
3) Calculations are based on calendar year proration of annual changes in the AUV, which is adjusted on April 1 to reflect the CREF Stock Account's performance during the prior 12 months.

Source: TIAA-CREF.

areas pay for food, shelter, clothing, transportation, entertainment, and other purchases. This measure has evolved over the years, is regularly improved, and is still the most widely known measure of change in prices.[9]

The CPI-U is not the only measure of price changes, however. Other inflation measures include those designed to address costs faced by manufacturers, employers, colleges and universities, or those interested in the real value of the nation's gross domestic product. The point here is that an effective inflation hedge should be geared to the investor's primary inflation concerns.

Asset-liability matching

Another major potential benefit of an inflation hedge is its ability to match future liabilities. Inflation is a key determinant of many future liabilities — be it an individual's consumption needs in retirement, a firm's pension obligations that depend on salaries, college endowment liabilities that are associated with future education and research costs, or a bridge construction bond that can be paid using future tolls that can be raised with inflation. As mentioned earlier, the returns of most assets exceed inflation over the long run. Yet, none but inflation bonds can provide a return that will allow investors to match exactly the effects of inflation with future needs.

Diversification benefits

In a marked-to-market setting, inflation will have roughly similar effects on many investments. In contrast, the current value of a true inflation hedge would not suffer during inflationary times and, thus, might function as a good diversifier in portfolios with other types of assets.

Inflation tracking error

Some assets and employment income have generally risen faster than inflation over a long period of time, but may suffer from a delayed response to inflationary movements. Consequently, the timeliness of an inflation hedge's response can be important. For example, the correlation between the annual return of the CREF Stock Account and annual inflation is low and negative (-.36), while the returns of inflation bonds are highly correlated with inflation.

Opportunity for additional return

An inflation hedge should also be evaluated in terms of its ability to provide returns above the level of inflation. The inflation bond is the only asset that provides such a guarantee. The structure of inflation bonds guarantees that they will not only preserve purchasing power over time, but they will provide an extra return associated with inflation-adjusted coupon payments.

Counterparty strength

Any hedge or insurance arrangement involves transfer of risk from one entity to another. It is important to understand the capacity of the institution or "counterparty" accepting the risk to meet its obligations. In the case of inflation bonds, the federal government has a greater capacity to make inflation-adjusted coupon payments and return to investors their inflation-adjusted principal than any other actual or potential counterparty.

Cost of insurance

An entity offering an inflation hedge should be compensated for taking on additional risk. In the same vein, an investor who purchases a product that provides certain inflation insurance should be willing to pay something extra for that protection. How much is that charge compared with the cost of alternatives, if any? In theory, by issuing inflation bonds, the federal government should be able to save on the inflation risk premium contained in regular bonds. One study estimates that the long-term saving on inflation risk premium is about .50 percent per annum (Hammond et al 1999). In fact, estimates of the US inflation risk premium since the introduction of inflation bonds have generally been negative (Barclays Capital 2002b).

Taxation

An ideal inflation hedge would provide inflation protection on an after-tax basis. However, no current candidate, including inflation bonds, can provide this. Of course, any taxes on inflation bonds held in tax-deferred accounts are not due until savings are withdrawn. Outside of tax-deferred accounts, investors must pay income tax on coupon payments as well as any positive inflation adjustments that are made to a bond's principal. In other words, bondholders owe income tax each year on the rise in the bond's principal, even though that principal is not paid out until maturity. In the case of regular bonds, the principal does not change and is therefore not subject to tax. However, the coupon payments of regular bonds are generally larger than those of inflation bonds and therefore subject to more income tax.

One additional criterion for evaluating inflation bonds concerns the federal government's public debt management program. As mentioned earlier, one of the most important incentives for the federal government to issue inflation bonds rather than regular bonds is the opportunity to save on the inflation risk premium demanded by regular bond investors for the uncertainty associated with future inflation. In theory this premium should not appear in inflation bond returns, thus providing a saving to the issuer. Other incentives for the federal government could include providing an asset class that could appeal to a group of investors, and creating a market gauge of future inflation.

Since the introduction of inflation bonds, the inflation risk premium as measured by subtracting similar maturity inflation bond yields from regular bond yields, has most often been negative rather than positive. This indicates the federal government has not saved on the premium (Barclays Capital 2002b). In addition, two of the early inflation bond auctions (November 1998 and January 1999) were especially costly to the federal government compared with regular bond issuance and most other inflation bond auctions have involved modest extra costs. Recent studies indicate that some costs were temporary ones associated with general bond market turmoil in late

Exhibit 3 Composition of Inflation Bond Total Return

based on monthly returns from 3/97 to 8/02

	1997 - 2002		*August 2002*	
	Annualized Return	Contribution to Total Return	Annualized Return	Contribution to Total Return
Coupon	3.65%	47.33%	0.30%	7.98%
Inflation Adjustment	2.32%	30.00%	0.07%	1.86%
Price Change	1.55%	20.11%	3.39%	90.16%
Cash Reinvestment	0.02%	0.30%	0.00%	0.00%
Lehman TIPS Index	7.72%	100%	3.76%	100%

Source: Barclays Capital.
Note: Columns may not sum to total due to weighting and rounding.

1998 and others with the difficulties of starting a new federal bond program (Sacks and Elsasser 2002). The US Treasury has issued reassurances that the inflation bond program will continue for the foreseeable future.

>>> INFLATION BOND BEHAVIOR AND ISSUES

Like regular bonds, inflation bonds and bond funds based on them are bought and sold on the open market and, therefore, have changing prices that affect anyone who wishes to buy or sell a bond before its maturity date as well as all inflation bond mutual fund investors. In addition, investors who wish to hold their savings longer than a single bond's maturity date are also subject to reinvestment risk.

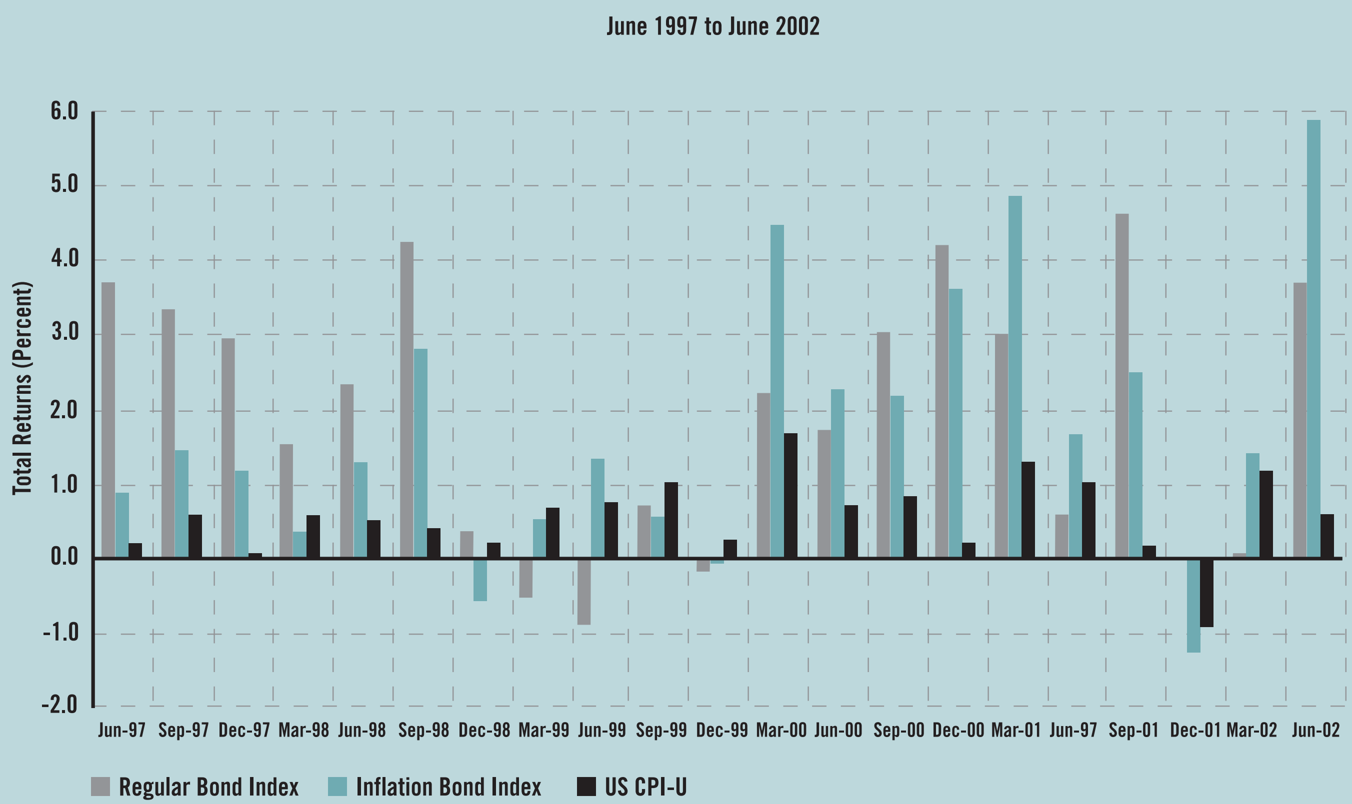
Exhibit 3 shows three basic return components for the Lehman Brothers US TIPS index since 1997 and for the month of August 2002. For the entire period a little less than half of the nearly 8 percent (annualized) total return came from TIPS coupons. About 30 percent of the total return was due to changes in the CPI-U over this period (a surprisingly high proportion considering how low inflation has been over the past 5 years). Only about 20 percent of total return has come from capital appreciation or depreciation due to changes in inflation bond market prices. Inflation bond prices can rise and fall significantly, but over time they should average out near their par value. Exhibit 3 also illustrates a

Exhibit 4 Effect on Existing Bond Prices of Changes in...

	Real Interest Rates		*Inflation Surprise*		*Cash Flows*	
	rise	fall	rise	fall	rise	fall
Inflation Bonds	-	+	+	-	+	-
Regular Bonds	-	+	-	+	+	-

Source: Author's estimates.

Exhibit 5 Quarterly Total Returns for Regular and Inflation Bonds versus Inflation



Source: Lehman Brothers, Salomon Smith Barney, and U.S. Bureau of Labor Statistics.

short-term price effect for August 2002, when rising prices accounted for 90 percent of the index's 3.76 percent total return. Therefore, while coupons and inflation have contributed the bulk of the bonds' total return over time, during short time periods prices can boost or detract significantly from returns.

Inflation bonds react differently than other assets to certain changes in broad market conditions. Exhibit 4 shows how the prices of existing inflation bonds and regular bonds should theoretically respond to changes in real interest rates, inflation surprises, and investor demand. The market price for existing regular bonds and inflation bonds should respond similarly to changes in real interest rates, since a fall/rise in interest rates would make existing bonds of both kinds more/less valuable. In the middle column of Exhibit 4, inflation surprises, or unexpected inflation, should have significant, but opposite effects on inflation bond and regular bond prices. A positive inflation surprise will make inflation bonds more valuable and regular bonds less valuable to investors. Finally, the last column shows that an increase in investor demand will push up the prices of both inflation bonds and regular bonds. The effect of demand changes is hardly surprising, but it is interesting to consider the combined effects on bond prices from these factors. For example, during early 2002 real interest rates fell, unexpected inflation rose modestly, and cash flowed into inflation bonds or inflation bond funds. These forces pushed up inflation bond prices and returns dramatically. Increased investor demand continued to raise returns through August 2002, even as inflation and real interest rates leveled off.

Exhibit 5 illustrates the relative attractiveness of regu-

Inflation Bond Duration

Bond duration is the sensitivity of a bond's price to changes in interest rates. This concept was developed to allow investors to compare the riskiness of bonds with different coupon rates and maturities. The commonly used modified duration measure is calculated by taking the weighted average amount of time that it takes to receive the interest payments and final return of principal, the weights being the present value of the payments, using the bond's yield-to-maturity as the discount rate. By definition, the higher a bond's duration, the more sensitive a bond's price to changes in interest rates, the riskier the bond.

A duration comparison of two bonds requires an examination of the present value of the bonds' cash flows. Two bonds might have identical maturity dates, but the back-loaded bond — the one with a greater proportion of total cash flow (in present value) occurring later in the life of the bond — would have the longer duration. For example, the price of a zero-coupon bond is very sensitive to changes in interest rates because all of its cash flows occur right at maturity (i.e., its duration is always equal to its maturity date).

To calculate a bond's duration, we need to know the amount of all future cash flows, the dates on which they will occur, and the history of relevant interest rates. Assuming no possibility of default, we can know in advance the timing and amount of payments for regular bonds in nominal (i.e., regular) dollars. The challenge posed by inflation bonds is that we know in advance the amount of payments in real dollars, but not in nominal dollars. In theory, this should not be a problem, because inflation bonds are designed to pay investors in real dollars. However, investors live in the regular, inflation-affected world. Hence investors should also be interested in how the price of inflation bond fluctuates with changes in nominal interest rates as well as real interest rates and inflation.

The duration analysis of regular bonds does not separate these components, but the special characteristics of inflation bonds almost compel such a separation. It is impossible to mathematically determine the nominal duration of inflation bonds, but given the fact that both inflation nominal bonds and regular treasury bonds are traded in the open market, we can estimate it empirically. Following an approach suggested by Leibowitz et al (1989), we use estimates of real yields and expected inflation (for an alternative approach, see Rudolph-Shabinsky and Trainer 1999; Risa 2001; and Seppala 2001). Exhibit 6 contains empirical estimates of duration (for a three-month period through August 14, 2002) for three inflation bonds and regular bonds with similar maturities.[11] The results clearly indicate that inflation bonds and regular bonds respond differently to changes in the inflation component and the real yield. As we might expect, inflation bond prices are not at all sensitive to changes in inflation (i.e., duration is nearly zero) compared to regular bonds, but they are relatively sensitive to changes in real yields or interest rates (i.e., duration is higher than for regular bonds).

Using similar methods, Exhibit 6 also shows the somewhat surprising result that inflation bonds are less sensitive to changes in nominal interest rate than we might have expected. The same method, when applied to regular bonds, produces figures that match duration calculations done by more traditional approaches. If these estimates are stable over time, we might conclude that the inflation component of nominal interest rate is relatively influential in determining an inflation bond's duration with respect to nominal interest rates. In other words, the relatively low inflation bond duration with respect to changes in nominal interest rate may be due to the relatively large influence of the inflation factor as compared to the real interest rate factor.

Exhibit 6 Modified Duration Estimates for Three US TIPS & Three T-Bonds

			Price Sensitivity to Changes in		
			Inflation	**Real Interest Rates**	**Nominal Interest Rates**
5-Year					
TIP	TII 3 3/8	1/15/07	-0.001	4.10	1.10
T-Bond	T 6 3/8	2/15/07	3.932	3.91	3.90
10-Year					
TIP	TII 3 3/8	1/15/12	-0.001	8.02	3.40
T-Bond	T 4 7/8	2/15/12	7.440	7.44	7.40
30-Year					
TIP	TII 3 7/8	4/15/29	-0.018	17.10	5.40
T-Bond	T 6 1/8	8/15/10	13.306	13.45	13.30

Source: Author's calculations.

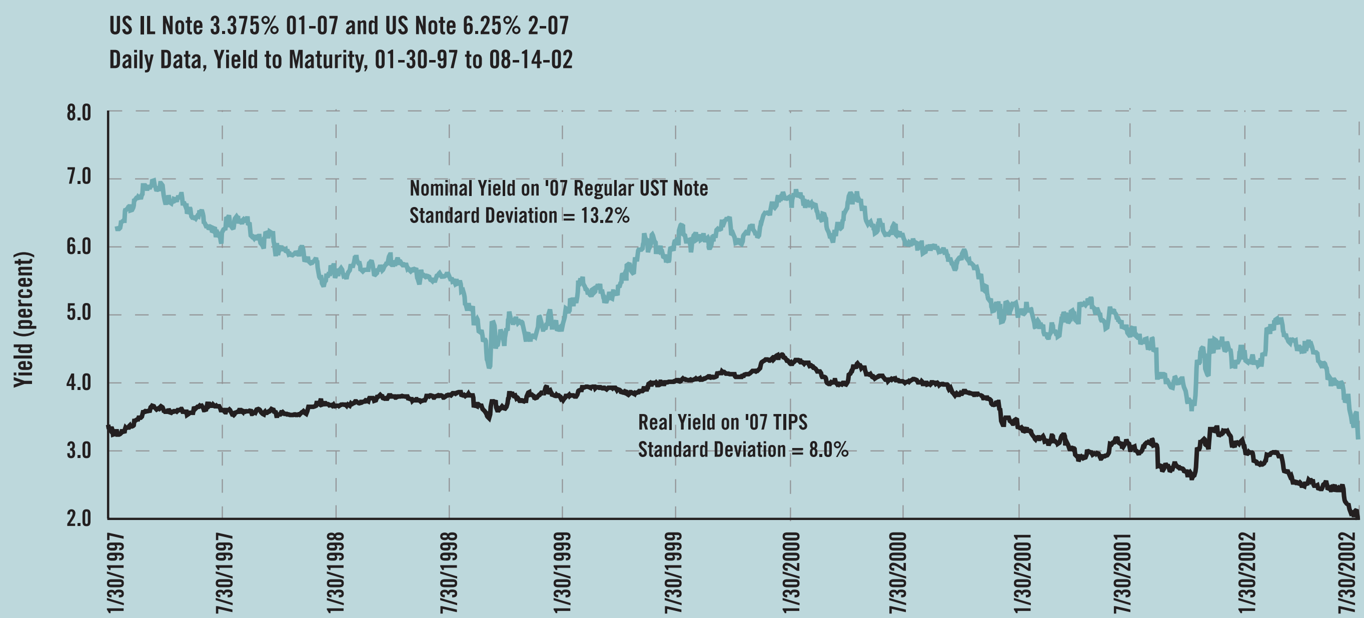
lar and inflation bonds by showing quarterly returns for the Lehman Brothers Aggregate Index of corporate and government bonds, the Salomon Smith Barney index of US TIPS, and inflation (US CPI-U) during the period since US inflation bonds were first issued.[10] As might be expected because of the extra return that is associated with an index containing corporate bonds, most of the time regular bonds beat inflation bonds (12 out of 21 quarters). But a closer look shows that inflation bonds outperformed regular bonds in 8 of the 10 quarters when inflation was above its overall average. In other words, although overall inflation was relatively benign during this entire period (averaging about 0.58 percent per quarter), even slightly-higher-than-average inflation boosted the returns for inflation bonds compared to regular bonds.

A more general question concerns the sensitivity of inflation bond prices to changes in inflation and interest rates (duration). A new analysis shows that, compared to regular bonds, inflation bond prices are relatively insensitive to changes in nominal interest rates (not surprisingly, inflation bonds are not at all sensitive to changes in inflation and are highly sensitive to changes in real interest rates). This suggests that inflation is more influential and real rates less influential on inflation bond prices than we might have expected. The accompanying box provides a more complete discussion of these findings.

Although inflation bond prices may be quite sensitive to changes in real interest rates, inflation bond yields have been relatively stable over time. As shown in Exhibit 7, a regular 10-year Treasury bond issued in 1997 had an annualized standard deviation of about 13 percent over the past 5 years, compared to a similar inflation bond's standard deviation of only about 8 percent.

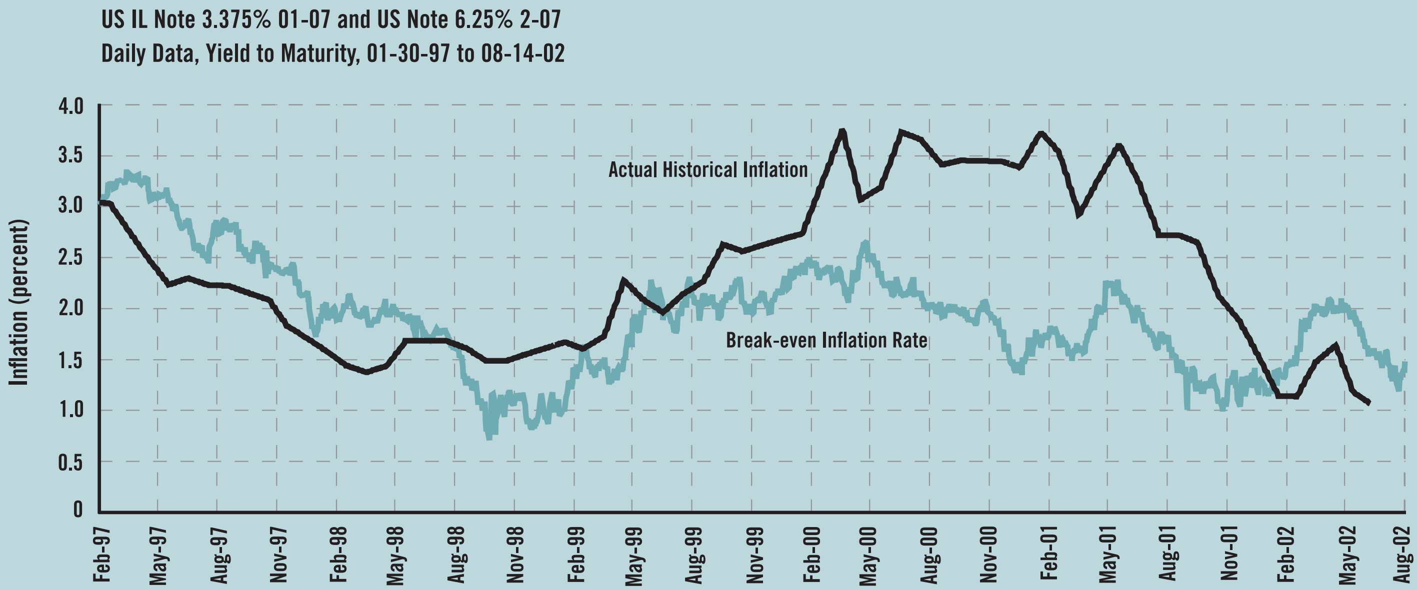
Another element of inflation bond yield is its relationship to expected inflation. Economics has long looked for a measure for what the market expects inflation to be. The difference between regular and inflation bond yields could provide a rough estimate. In addition, such a comparison might tell us whether inflation bonds are expensive or "cheap" relative to regular bonds. Exhibit 8 shows rolling annual inflation over the past few years along with the breakeven inflation rate. The latter is simply the yield on a regular bond less the yield on a similar maturity inflation bond.[12] This could be considered the market's estimate for future inflation. Between June 1998 and January 2002, the breakeven inflation

Exhibit 7 Regular versus Inflation Bond Yields



Source: U.S. Department of Treasury.

Exhibit 8 US Breakeven Inflation Rate and Historical Inflation



Source: U.S. Department of Treasury and Bureau of Labor Statistics.

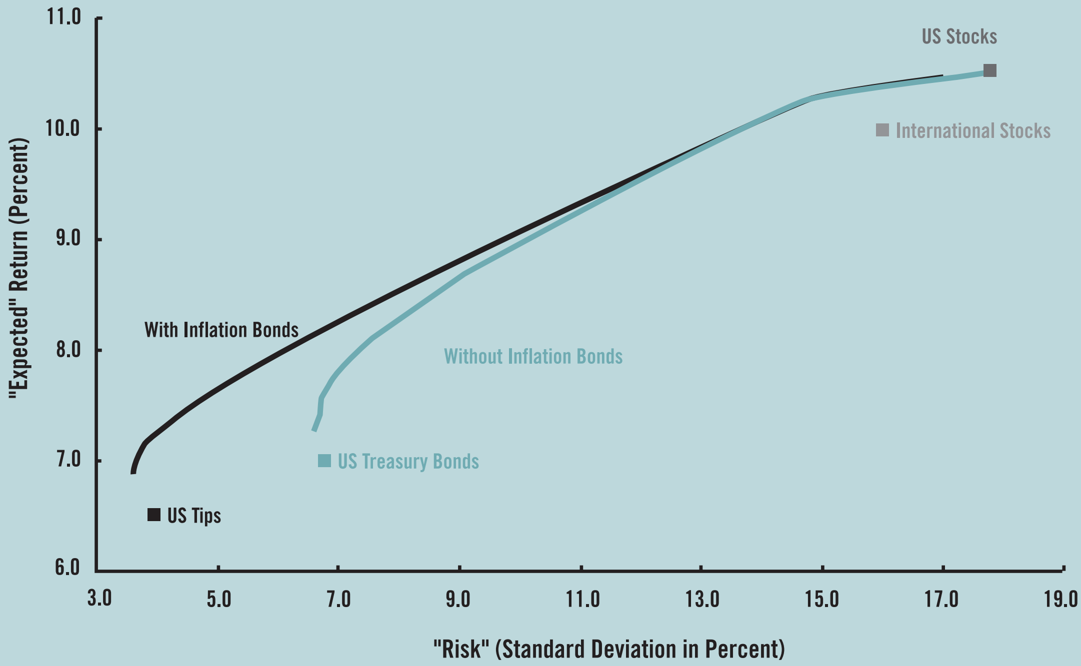
Exhibit 9 Inflation Bonds and Other Asset Classes — Historical Statistics Through June 2002

	Starting Date	Geometric Return (percent)	Standard Deviation (percent)	*Correlations* Inflation Bonds	Domestic Stocks	International Stocks	Regular Bonds	Real Estate	T-Bills
US Inflation Bonds	1997	7.27	3.56	1.00	-0.72	-0.63	0.61	-0.14	0.09
Domestic Stocks	1979	13.87	16.60		1.00	0.66	0.23	-0.03	-0.02
International Stocks	1970	10.77	18.66			1.00	0.23	0.03	-0.12
Regular Bonds	1976	9.27	7.34				1.00	-0.14	0.08
Real Estate	1978	9.39	3.46					1.00	0.50
T-Bills	1926	3.81	1.54						1.00

Source: Author's calculations based on annualized quarterly return data from Ibbotson Associates.

Note: US Inflation Bonds = Salomon Smith Barney US Inflation Linked Securities Index
Domestic Stocks = Russell 3000 Index
International Stocks = Morgan Stanley EAFE Index
Regular Bonds = Lehman Bros. Aggregate Bond Index
Real Estate = NCREIF Property Index

Exhibit 10 Adding Inflation Bonds to the Portfolio



rate was below the historical inflation rate, suggesting that inflation bonds could provide a greater yield than similar regular bonds. More recently, the breakeven rate has risen above the actual inflation rate, suggesting that inflation bonds may not provide as good a total yield relative to regular bonds.

However, if we were to use an estimate of inflation expectations rather than historical inflation, the answer may be different. According to one recent estimate based on survey data, expected inflation over the next few years is about 2.5 percent, well above the 1.5 percent breakeven inflation rate (Barclays Capital 2002b). This implies a negative inflation risk premium of about 1.0 percent. In fact, a comparison of breakeven inflation rates across the world's major inflation bond issuers shows very small or negative risk premiums, suggesting that inflation bonds could provide attractive yields over the next few years.

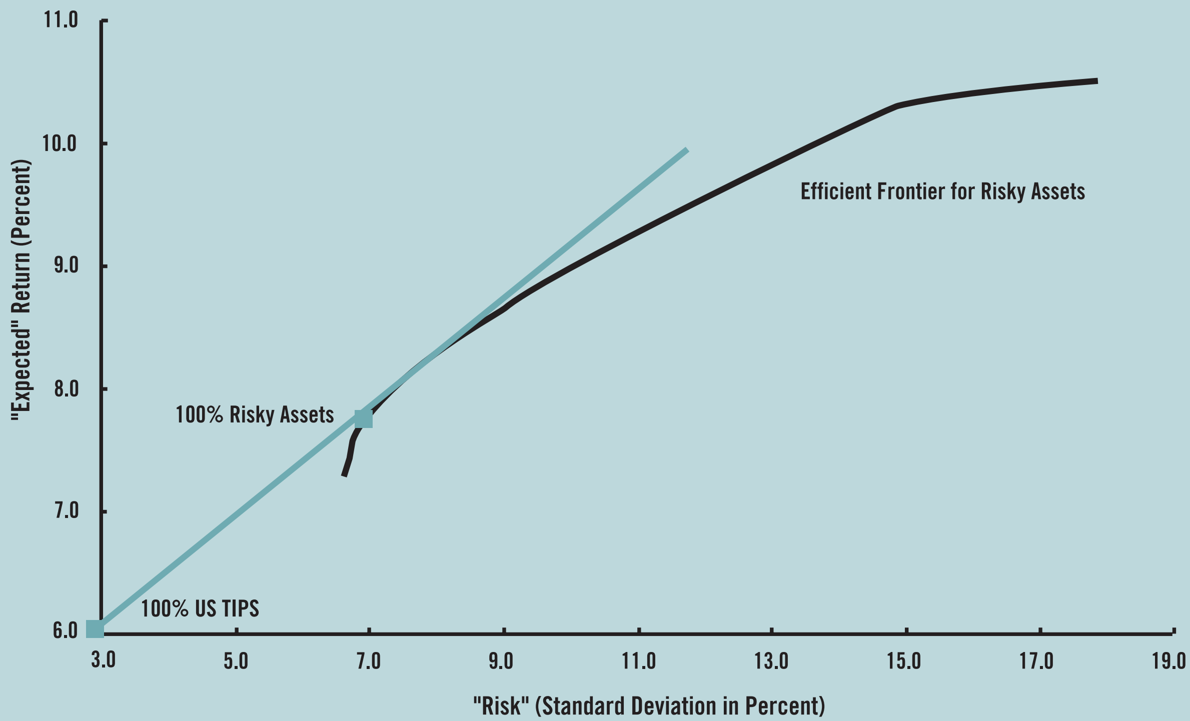
> > > USING INFLATION BONDS IN PORTFOLIOS

As mentioned earlier, inflation bonds represent a different asset class that can provide portfolio diversification as well as inflation insurance (Lamm 1998). To illustrate how the bonds can do both, Exhibit 9 shows the historical average returns, standard deviations, and correlations of several major types of assets including US TIPS. Starting dates are based on the availability of data or inception date of the asset class.

Because the market for US TIPS was, by definition, immature during its first couple of years, it is quite possible that as the market gains experience with these assets, inflation bonds will have lower correlation with domestic and international equities as well as regular bonds. In addition, their correlation with real estate could rise as we gain more experience over a full real estate cycle.

Adjusting for the possible effects of a maturing market and ignoring taxes, we see in Exhibit 10 that a

Exhibit 11 Inflation Bonds as the "Risk Free" Asset



mean-variance analysis of major asset classes shows that at low levels of risk (left-hand side of the chart), inflation bonds can reduce a portfolio's risk while maintaining return or it can improve return while maintaining a level of risk.

Two lessons emerge from this analysis. First, inflation bonds dominate regular bonds — even an index that combines regular corporate and government bonds — at the more conservative end of the efficient frontier. This indicates that an investor might be able to increase the allocation to equity and maintain the risk level by substituting inflation bonds for regular bonds. Second, individuals nearing or in retirement, or endowments with near-term liabilities that may be affected by inflation, may wish to consider using inflation bonds to provide diversification and inflation protection.

In fact, it might be more appropriate to think of inflation bonds, not as one of the portfolio's risky assets, but rather as the closest we can get to the theoretical riskless asset. If we accept this assertion, then Exhibit 11 shows the mean-variance results for a portfolio of assets and a tangent line representing inflation bonds. In this case, efficient portfolios can be found along the tangent line. At the y-axis intercept point the portfolio would consist of 100 percent inflation bonds and at the tangent point the portfolio would contain 100 percent risky assets. In this case, inflation bonds are used, not to change the mix of risky assets relative to each other, but rather the total proportion of risky assets to the riskless asset (i.e., inflation bonds). Whether we look at inflation bonds as just another risky asset or as the closest thing to the riskless asset, it is clear that they can provide excellent diversification in an investment portfolio.

>>> FUNDING RETIREMENT

Retirement poses special challenges for the analysis of investments, including inflation bonds. The overall goal of retirement savings is to save and invest in order to meet retirement consumption needs plus desired bequests to individuals and organizations. Because the time horizon of retirement savings is generally long — up to 30 years for a person age 65 — inflation can wreck havoc with any retirement plan (Hammond 1999). The most important source of pre-retirement inflation protection, namely a salary or wage, is absent or greatly reduced in retirement.

Currently, the Social Security program provides participants with a guaranteed inflation-protected income for life. The federal government effectively provides retirees with an inflation-indexed lifetime annuity. As a point of comparison, either TIAA-CREF or the Federal Thrift Savings Plan for government employees can provide a single-life participating annuity of $20,000 per year at age 65, including payments that increase automatically each year, for a purchase price of roughly $280,000 (Poterba and Warshawsky 2002).[13] Such annuities do not, however, provide an inflation guarantee. Increasing payments each year have historically done a good job of inflation protection over many years, but are not guaranteed to keep up with future inflation (King 1995). One estimate is that it would take roughly an additional $50,000 to $70,000 to purchase an annuity with guaranteed inflation protection (i.e., annual income would be about 20 percent less than with a regular annuity, cf Brown et al 2002).[14] In fact, one company, Irish Life of North America, offers an inflation-guaranteed annuity whose benefit is 30-35 percent less than its comparable regular annuity (Brown et al 2002). Through 2001, the company had sold no inflation-guaranteed annuities; in the practical world where the inflation rate is currently below its historical average, the additional cost/lower payout for this annuity (in exchange for guaranteed inflation protection) might be more than potential purchasers are willing to bear.

From the perspective of assuring retirement income security, low-cost annuities that guarantee inflation-protected income over a lifetime or a certain number of years would be the gold standard (McGill et al 1999). For example, TIAA-CREF's Inflation-Linked Bond Account invests in inflation bonds and thus can provide the possibility of keeping up with inflation. However, annuities based on this account do not provide an inflation-protection guarantee.[15] The first-year annuity income from this account is based on an assumed interest rate (AIR) or total return of 4 percent. Income is adjusted in subsequent years based on actual nominal returns. For example, if the actual first-year return is 6 percent, then the second-year income will rise by 2 percent (6 percent minus the 4 percent AIR).

Inflation-guaranteed annuities have been available in the United Kingdom for several years. We may anticipate that as the US inflation bond market develops, we can and should see additional inflation-guaranteed annuity offerings in this country. In the interim, a graded-benefit annuity whose payout increases each year or variable annuities may be able to provide the possibility if not the certainty of keeping up with inflation in retirement. The TIAA graded-benefit annuity is based on the TIAA Traditional Account. The first-year income is based on an AIR of 4 percent, which is usually lower than the standard annuity rate. Assets in excess of the amount needed to produce first-year income are retained and invested, allowing income to be adjusted upward each year during the life of the annuity.

Without annuities, retirees face the possibility of using up their savings before they die (there is evidence that an appropriate asset allocation can improve a retiree's chances of not outliving an income — Ameriks et al 2001). It may be possible to extend an individual's savings payout period during retirement using the lower volatility of inflation bonds versus regular bonds. We can illustrate this using a Monte Carlo simulation, assuming that, for all assets and inflation, past annual returns and inflation rates are equally likely to occur again each year into the future.[16] The model also assumes that a new retiree age 65 allocates 60 percent of savings to a broad equity fund and 40 percent to a bond fund (each year this portfolio is rebalanced back to the original 60/40 equity/fixed income split). Then, each year the retiree withdraws $4 for every $100 (e.g., $4,000 per $100,000) of the initial assets. Lastly, the model uses the Society of Actuaries 2000 mortality tables to simulate the probability of dying in any one year.

How long would retirement income last? The Monte Carlo simulation shows there is an 84 percent chance that the portfolio with a regular bond fund would continue providing income until the individual dies. If inflation bonds were substituted for regular bonds, the retiree would have a 93 percent chance of not running out of retirement income. In addition, if the retiree lives to be 100, he or she would have a 60 percent chance of continuing to receive an income in the last year with regular bonds and a 76 percent chance with inflation bonds. Although we cannot predict future returns, income needs, and actual behavior, this example suggests that inflation bonds can provide valuable assistance in financial planning.

>>> NEW USES AND PRODUCTS

Since the introduction of US inflation bonds over five years ago, a number of new uses and products based on them have begun to emerge. Investment managers have been able to bet on changes and differences between regular and inflation bond yields and between inflation bond yields of different countries (Bhansali 1998).

In November of 2001 Strips based on inflation bonds were introduced. These are principal only or interest only inflation bond versions of regular bond Strips (Barclays Capital 2001). These instruments are an important additional tool that allows investors to obtain either an inflation-protected income stream (interest only) or a zero coupon-like asset that rises with inflation (principal only). For example, a retiree or an institution interested in cash flow might wish to focus on interest-only inflation Strips, while an investor saving for retirement might wish to hold principal-only Strips. Accumulating and payout annuities based on inflation bond strips could also be constructed. More generally, inflation bond versions of a range of annuity types are possible, including annuities that would guarantee principal in inflation-adjusted dollars while allowing partial participation in any equity market gains.

Other products based on inflation bonds could appeal to institutions as well as individual investors. These could include tuition savings vehicles, public works bonds, inflation-adjusted mortgages, and any other investment where future income or liabilities might be affected by inflation experience.

>>> CONCLUSION

We now have more than five years of experience with US inflation bonds. This experience has taught us that inflation bonds are a new asset class with several unique features such as inflation protection, low or negative return correlation with other assets, long duration with respect to real rates and low yield volatility. These features make them attractive for saving to match future needs, diversifying portfolio, and assuring a retirement or endowment income stream.

Because of these features and uses, it may be surprising to some that inflation bonds have not become more popular in the US until recently. Perhaps low inflation in the past few years, analytical challenges, and uncertainty about the long-term behavior of these bonds and government support for them, have all contributed to some caution with respect to this developing asset class.

With experience as well as a renewed federal government commitment to the inflation bond program, investors and issuers are gaining greater confidence and understanding of this new instrument. As new inflation-bond-based products are created, the market should witness continued growth of an important new asset class.

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ENDNOTES

[1] The U.S. Treasury also cancelled its 30-year regular bond program at the same time. Recently, the Treasury announced its continuing support for its TIPS program and called for suggestions for new uses of these bonds.

[2] TIAA-CREF, Brown Brothers Harriman & Co., American Century, Pacific Investment Mangement Co. (PIMCO), Bridgewater Associates, Vanguard, and Fidelity have all introduced inflation-protected mutual funds since 1997. Major endowments using inflation bonds in their policy portfolios include Harvard University, Yale University, Washington University, Stanford University, the Ford Foundation, and many others.

[3] This is in the form of the venerable Fisher equation.

[4] US TIPS are adjusted for changes in the CPI-U with a 3-month lag so investors always know two to three months in advance the size of the next coupon payment. An alternative inflation bond structure leaves the principal amount level for the life of the bond but adjusts the coupon to reflect recent inflation.

[5] This description assumes that inflation rises. When the CPI-U falls, the inflation bond's principal amount is reduced accordingly, as long as that amount is higher than the original principal used to purchase the bond at auction. Should deflation persist beyond that point, the original principal amount would still be returned at maturity even though semiannual coupon payments would continue to fall, i.e., there is a built-in floor on the principal. This is equivalent to buying a kind of call option.

[6] In the case where inflation over the life of comparable regular and inflation bonds turns out to match prior expectations, the regular bond will, in theory, provide a return slightly in excess of the inflation bond. The difference should be equal to what investors are willing to pay to eliminate the inflation uncertainty.

[7] Fairbanks (1995) shows that other major asset classes as well as selected combinations of them (e.g., commodities plus T-Bills) do not track inflation closely over extended periods. Some, such as equities and real estate, have provided returns that exceed inflation over long periods, but can fail to do so over interim periods as in the examples provided in the text.

[8] The CREF Stock Account was created in 1952, largely to provide TIAA-CREF participants an option that would beat inflation over long time periods (Greenough 1979). Changes in the account's Annuity Unit Value (a measure related to retiree income) reflect the performance of the account's equity returns less a 4 percent Assumed Interest Rate (AIR) and mortality expenses.

[9] Although the U.S. Bureau of Labor Statistics does not announce publicly "improvements" to the CPI, it is believed that methodological changes made during the late 1990s have reduced the CPI's annual increase by about half a percent per year.

[10] Inflation bond calculations in this article are based on the Barclays Capital, Lehman Brothers, or Salomon Smith Barney US Inflation Linked Bond indexes. These indexes produce equivalent results over multi-day periods.

[11] The empirical duration estimates in Exhibit 6 relies on daily data for three US TIPS (5-year TII 3 3/8 1/15/07, 10-year TII 3 3/8 1/15/12, and 30-year TII 3 7/8 4/15/29) as well as comparable regular treasury bonds (5-year T 6 3/8 2/15/07, 10-year T 4 7/8 2/15/12, and 30-year T 6 1/8 8/15/10). We pair each TIP and its regular T-Bond to obtain an estimate of the inflation component and real yield implied in the TIPS and regular bond prices. The percentage changes in prices of the TIPS and the regular bond are then regressed on the changes in the estimated inflation component and real yields to obtain the duration estimates. Due to the time sensitivity of duration to maturity, we only used the daily data from June 15, 2002 through August 14 for our estimation.

[12] It would be more precise to match bond duration rather than bond maturity dates. This analysis will follow the current convention, which is to use maturity dates.

[13] No commercial insurer sells exact equivalent annuities. However, the cost of a similar annuity purchased from a commercial insurer would likely be higher.

[14] There would be two basic differences between a regular annuity that guarantees a 3 percent nominal return and an annuity that guarantees inflation protection. One is that it might be necessary to lower the assumed interest rate (AIR) from the usual 4 percent to 3 percent or 2.5 percent, since real rates are generally in this range. Any AIR higher than the real rate plus management expenses would, in essence, ensure that payments would be guaranteed not to keep up with inflation. The second difference is that an inflation-guaranteed account might need additional reserves to account for any difference between nominal and real guarantees in terms of reinvestment and default risk.

[15] The CREF Inflation-Linked Bond Account is a variable annuity whose value changes each day in response to price changes among the underlying inflation bond assets. Therefore, although income from an annuity based on the account will generally keep up with inflation, it could experience changes that are greater or less than inflation.

[16] Thanks to TIAA-CREF actuary Ben Goodman for developing this useful tool.

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