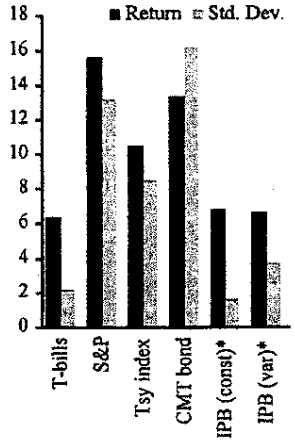
New York
September 12, 1996

J.P. Morgan Securities Inc.
Fixed Income Research
Nanette Abuhoff (1-212) 648-0639
abuhoff_n@jpmorgan.com
Hussein Malik (1-212) 648-0666
malik_hussein@jpmorgan.com

JPMorgan

Introducing inflation-protected bonds

Risk-return profile of different asset classes
since 1984; percent



* Hypothetical inflation-protected bonds, constant and variable real yields

- **The objective of inflation-protected bonds is to provide "real" returns for investors and savings for the Treasury**
- **An estimate for the real yield of 10-year inflation-protected bonds should lie between the real 3-month T-bill yield and the real 10-year note yield**
- **Inflation-protected bonds should be a good adjunct to other asset classes that are not directly inflation protected**

The objective of inflation-protected bonds is to provide "real" returns for investors and savings for the Treasury. Treasuries have long been recognized as the safest of all nominal instruments, yet they retain the risk of having their purchasing power erode. Inflation-protected bonds should eliminate this risk. The structure also suits the Treasury: the Treasury's funding costs should be reduced by the premiums currently required by investors to compensate for inflation risk. The Treasury acquires this benefit at the expense of assuming future inflation risk.

An estimate for the real yield of 10-year inflation-protected bonds should lie between the real 3-month T-bill yield and the real 10-year note yield. If we assume that real yields are approximately equal to nominal yields less inflation, then the Treasury yield curve gives us an estimate for the possible range of the real yield that inflation-protected bonds may have. In that case, real T-bill yields would form the lower end of this range and real 10-year yields would form the upper end.

Inflation-protected bonds should be a good adjunct to other asset classes that are not directly inflation protected. Considering that the inflation rate is historically low and the economy is running at or through full employment, it is reasonable to expect that inflation risk is currently biased to the upside. In such an environment, we expect demand for these bonds to increase, real yields to fall, and investors to reap returns in excess of the real yield at purchase. Our analysis shows that *hypothetical* inflation-protected bonds would have outperformed a "rolling" T-bill investment strategy – with lower risk.

The emergence of an inflation-protected bond market in the U.S. promises to be an important development in the financial markets. Not only will it represent a funding innovation for the Treasury and a potentially desirable asset class for investors, but also it facilitates a swap and swap derivatives market, providing ultimate flexibility for issuers considering inflation-linked debt. Questions about the bonds' structure, liquidity, pricing, and performance characteristics remain to be answered. Even after the static details are filled in, fit within an asset-allocation framework can be assessed only when empirical information is captured and a deep enough market exists to render that discussion practical. Despite scant details, we believe the proposed security will be highly valued by investors averse to inflation risk, and that this appeal will eventually create a wide and deep market with desirable performance characteristics.

Inflation-protected bonds, a major innovation in the U.S. markets, may be auctioned by year-end. The Treasury is finalizing details regarding structure, maturity and index. This article, a practical guide to evaluating this asset class, should help issuers and investors assess how to incorporate these securities into their investment and issuance strategies.

J.P. Morgan Securities Inc.
Fixed Income Research
Nanette Abuhoff (1-212) 648-0639
Hussein Malik (1-212) 648-0666

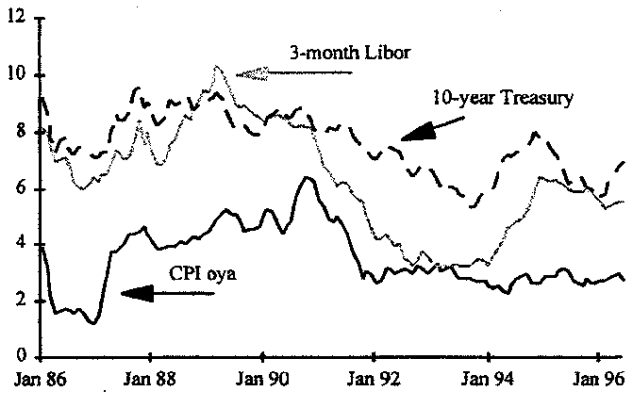
The potential audience for inflation-adjusted bonds: investors seeking an inflation hedge...

The potential audience

Investors will benefit from inflation-protected bonds in several different ways. Long-term investors will achieve inflation protection in long-dated inflation-protected bonds. This group includes investors whose liabilities are linked to inflation, such as individuals as well as insurance companies and pension plans offering annuities. Short-term investors may find benefits in inflation-protected bonds as well. One way investors gain short-term inflation protection is by "rolling" short assets, like Treasury bills. If the Treasury issues inflation-protected bonds in shorter maturities, investors may choose not to roll Treasury bills and instead to buy inflation-protected securities. This strategy would provide a superior return/risk profile (see page 8). These bonds are likely to be appealing during periods of rising inflation expectations, when all fixed income investors would want to protect the value of their investments. In this environment, inflation-protected bonds should outperform other fixed income securities. In fact, increased demand for inflation protection could cause the real yields of these bonds to fall.

CPI may appeal to issuers seeking more stable floating-rate funding

percent



...and issuers seeking a new funding benchmark

With inflation-protected bonds and Strips in a full range of maturities, a "real" Treasury yield curve would ultimately exist. This would facilitate the development of an over-the-counter inflation-linked swap and swap derivatives market. With a natural set of "receivers" of CPI, corporations might join the Treasury as "payers" of CPI by issuing public inflation-linked debt. "Paying" CPI would be particularly well-suited to corporations with net revenues positively correlated to CPI, such as general retailers. These bonds could also be issued opportunistically and then swapped to Libor or fixed rate funding.

Inflation-protected bonds may also provide a more stable source of funding than Libor-based structures. For example, since 1984, CPI has averaged 3.46%, with a standard deviation of 62 bps, whereas three-month Libor has averaged 6.81% per year, with a standard deviation of 111 bps.

Cash flows of the two structures

	Semiannual payment	Final payment
Fixed rate bond	$c_{nom}/2$	$100 + c_{nom}/2$
Canadian-structure IPB	$r/2*\pi_t/\pi_0$	$100*\pi_{mat}/\pi_0 + r/2*\pi_{mat}/\pi_0$
Floating-structure IPB	$r/2*\pi_t/\pi_{t-1} + 100*(\pi_t/\pi_{t-1} - 1)$	$100*\pi_{mat}/\pi_{mat-1} + r/2*\pi_{mat}/\pi_{mat-1}$

where:

c_{nom} = annual coupon rate on a fixed rate bond
r = annual real coupon rate on an inflation-protected bond
π_0 = value of the inflation index when the bond is issued
π_t = value of the inflation index on coupon payment at time t
π_{mat} = value of the inflation index at maturity
π_{mat-1} = value of the inflation index one coupon payment before maturity

Structure

The Treasury has identified two possible structures

One possible structure is the Canadian model, which pays a current real coupon on an inflation-adjusted principal amount and the inflation-adjusted principal at maturity. The other is an inflation-protected floater, which differs only in that the principal inflation accrual is paid currently with the real coupon. This structure has been called the "current-pay" variety by the Treasury.

Choice of index

Index is not yet designated; the CPI has broadest appeal

Regardless of the chosen coupon-principal structure, we believe the inflation index the Treasury will use will be the Consumer Price Index (CPI). The CPI has the greatest name recognition and probably the most general applicability of any existing measure of inflation. The Employment Cost Index (ECI) has also been suggested as an appropriate underlying inflation index, especially for those investors whose liabilities are closely linked to labor costs. Nonetheless, we believe the wider appeal of the CPI will support its use. Concern has been raised regarding the structural alteration to the CPI and its impact on inflation-protected bonds. While it is well known that the CPI overstates the rate of inflation in the United States, estimates as to how much vary widely. If the market's adjustment is larger than the actual difference, inflation-protected bonds may hold even greater appeal.

Canadian-style inflation-protected bond

Canadian model pays inflation-adjusted principal at maturity

The Canadian-style inflation-protected bond structure is issued with an initial principal of 100 and a real yield determined through the auction process. Over time, the principal adjusts according to changes in the CPI from the time the bond is issued; for a bond issued at t_0, the adjusted par amount at time t equals $100*\pi_t/\pi_0$, where π_t is the value of CPI at time t, and π_0 is the value of CPI at time t_0. If this bond is issued with a real coupon of $r\%$, the bond will pay a semiannual coupon of $r/2\%$ of the adjusted par amount. Furthermore, if CPI grows at 4% per year, in six months the new level of the inflation index, π_t, will equal $(1+4/200)*\pi_0$, or $1.02*\pi_0$. Ignoring lags, the redemption value of the bond would equal $100*\pi_t/\pi_0 = 102$. The first semiannual coupon would therefore be $102*r/200$. As time passes, the redemption value increases in such a way as to keep its inflation-adjusted value at 100, and the coupon paid is always the real coupon multiplied by the adjusted redemption value. With the inflation-adjusted value of both the coupon and the principal always preserved, the bond hedges the risk of rising inflation. However, the hedge is slightly imperfect, since the index will be lagged. Between CPI releases, the redemption value is adjusted daily by linearly interpolating the CPI values recorded for the past two months.

Inflation-protected floater

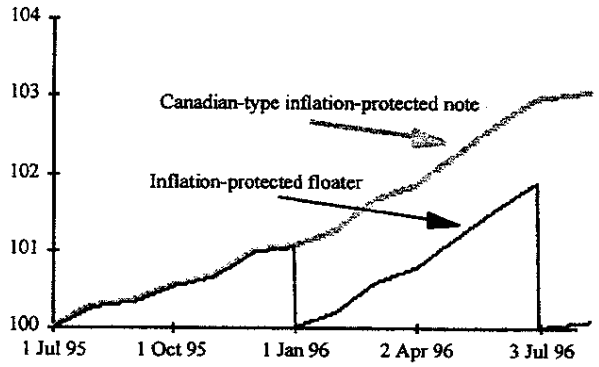
For floaters, inflation accrual is paid currently along with coupon

The only difference between the two structures is when the principal inflation accrual is paid. In the Canadian model, inflation-adjusted principal is repaid as an inflation-adjusted zero coupon bond, while in the inflation-protected floater, it is paid currently along with the coupon. This latter structure is similar to a traditional floating rate note, because its redemption value reverts to par after each coupon payment.

The graph shows the adjusted par amount of a hypothetical inflation-protected bond issued on July 1, 1995, under the two proposed structures. The adjusted par amount of the inflation-protected floater resets to 100 after each semiannual coupon payment, while that of the Canadian-style inflation-protected bond continues to grow through coupon payments. The graph also shows that when the inflation rate changes, using the interpolated three-month lagged CPI eliminates jumps in the adjusted par amount due to changes in inflation. Rather, changes in the inflation rate cause the rate of growth of the adjusted par amount to change.

The major difference between the two structures is how principal accrues

adjusted par amount



The table below shows the cash flows of two-year bonds under three different structures: a regular fixed rate structure, inflation-protected bonds with the Canadian structure, and inflation-protected bonds with a floater structure. We assume that both inflation-protected

Hypothetical cash flows of two-year bonds

cash flows of fixed rate bonds, inflation-protected Canadian bonds, and inflation-protected floater bonds

	9/5/96	3/5/97	9/5/97	3/5/98	9/5/98	Sum of cash flows	IRR
Inflation index	300.00	306.00	312.12	318.36	324.73		
Fixed rate bond							
Coupon		4.00	4.00	4.00	4.00		
Principal					100.00		
Cash flows		4.00	4.00	4.00	104.00	116.00	8.00
Inflation-adjusted cash flows		3.92	3.84	3.77	96.08	107.62	3.92
Canadian structure IPB							
Adjusted par amount		102.00	104.04	106.12	108.24		
Coupon		1.53	1.56	1.59	1.62		
Principal					108.24		
Cash flows		1.53	1.56	1.59	109.87	114.55	7.06
Inflation-adjusted cash flows		1.50	1.50	1.50	101.50	106.00	3.00
Inflation-protected floater							
Adjusted par amount		102.00	102.00	102.00	102.00		
Coupon		1.53	1.53	1.53	1.53		
Principal		2.00	2.00	2.00	102.00		
Cash flows		3.53	3.53	3.53	103.53	114.12	7.06
Inflation-adjusted cash flows		3.46	3.39	3.33	95.65	105.83	3.00

Assumptions:
Annual coupon on fixed rate bonds = 8%
Real coupon on inflation-protected bonds = 3%
Inflation rate = 4%

bonds are issued at a *real* yield of 3%, while the fixed rate bond is issued at a *nominal* yield of 8%. Furthermore, inflation is assumed to grow at a rate of 4% per year. The table shows that, while the payments of a fixed rate bond are constant in nominal terms, their real value falls. On the other hand, the coupon payments of inflation-protected bonds retain their real value over time. Because we do not assume any reinvestment of cash flows, the real value of the coupons on the inflation-protected floater fall slightly over time. Lastly, we note that the Canadian-structure bond pays the inflation-adjusted principal at maturity and retains its initial real value of 100. Conversely, the inflation-protected floater pays the principal inflation accrual currently along with the semiannual coupon payments.

Strippability

An inflation-adjusted floater is ideal for repackaging

A desirable feature of inflation-protected bonds is the ability to strip the bond into its component cash flows. An inflation-protected floater lends itself well to repackaging because it is divisible into three components: real coupons, inflation accrual payments, and a final principal payment. An active Strip market in these securities would satisfy the customized needs of a variety of investors. For instance, an investor who needed to meet an inflation-adjusted payment in 10 years could purchase a 10-year principal Strip off a 10-year Canadian-style inflation-protected bond. Canadian-style bonds can be stripped only into the real coupons and an inflation-adjusted principal payment at maturity. If the Treasury issues inflation-protected bonds in various maturities, the result would be that real-coupon, inflation-accrual, and principal-payment Strips would be available in a full range of maturities. Depending on the size of the first offering, the amount of coupon Strips created could be very small. For example, $10 billion dollars of a 3% real-coupon Canadian-structure bond will create only a $150 million par amount (in real terms) of coupon Strips in each maturity, if the entire issue is stripped. An inflation-protected floater would provide more Strips, because including the inflation accrual on the principal amount would make the semiannual payments larger.

The key performance features of inflation-protected bonds: yield, duration, liquidity, reinvestment risk, deflation risk, and taxes

Yield

An estimate for the real yield lies between 235 and 395 bps

The Treasury yield curve gives us an estimate for the possible range of the real yield of inflation-protected bonds. Three-month bills currently yield 5.30% and 10-year notes yield 6.90%, while inflation is currently running at a rate of 2.95% over-year-ago. This implies a current CPI/T-bill spread of 235 bps and a CPI/10-year spread of 395 bps. We think it is reasonable to assume that the real yield on a 10-year inflation-protected bond would lie between these two levels. On one hand, investors would require more than 235 bps because of the increased duration risk in inflation-protected bonds compared to T-bills. On the other hand, the CPI/10-year spread includes substantial inflation risk premium.

Duration

Duration of floater is lower than that of the Canadian-type structure

Price sensitivity to real yield is central to the performance of the proposed inflation-protected bonds. The duration of the floater structure tends to be lower than that of a Canadian-style inflation-protected note with the same real yield. This is because in the case of the floater, the inflation accrual is paid currently with coupon payments, and so its semiannual payments are higher. The table on the next page highlights the duration difference between the structures. In 10-year bonds, the duration difference is approximately 1.3 years, whereas in 30-year bonds, the difference can be as much as 7.6 years. Investors with long-dated liabilities might actually desire a long-duration asset – as in the Strips market – but the increased price risk of holding a position in an undeveloped sector may reduce liquidity in the inflation-protected bond market. Given that the duration

J.P. Morgan Securities Inc.
Fixed Income Research
Nanette Abuhoff (1-212) 648-0639
Hussein Malik (1-212) 648-0666

of a Canadian-style inflation-protected note can be almost 50% more than that of a same-maturity fixed rate bond with the same yield, mark-to-market investors, as well as dealers, may find it difficult to hold positions in these securities, especially in a volatile market.

Canadian-type inflation-protected bonds have longer durations than inflation-protected floaters

duration (years)

	Duration of par 10-year note at issue		Duration of par 30-year bond at issue	
Real yield (%)	Canadian-type	Floater	Canadian-type	Floater
2.0	9.0	7.7	22.5	14.8
2.5	8.8	7.6	21.0	14.0
3.0	8.6	7.4	19.7	13.3
3.5	8.4	7.2	18.5	12.6

Real rates may be less volatile than nominal rates

While the duration of Canadian-style inflation-protected bonds exceeds that of other coupon bonds, a credible argument can be made that the variability of real interest rates is typically less than that of nominal interest rates. Specifically, if the nominal interest rate (i) is approximately equal to the sum of the real interest rate (r) and inflation (π), and the correlation between r and π is not significantly negative, the volatility of r should be lower than that of i. Hence, as long as the ratio of the durations, *dur (r)/dur(i)*, is less than *vol(i)/vol(r)*, inflation-protected bonds would have lower volatility-adjusted durations than would fixed rate bonds.

Ultimately, investors sensitive to price risk need to be concerned about changes in the real yield of inflation-protected bonds as a result of liquidity and market technicals. Thus, even if real interest rates are less volatile than nominal interest rates, the short-term volatility of real yields on inflation-protected bonds may be higher than that of nominal rates.

Liquidity

U.S. bonds should be more liquid than U.K. or Canadian bonds

Liquidity is a primary determinant of the performance of inflation-protected bonds. Questions about this issue are understandable since markets for inflation-protected bonds in both the U.K. and Canada have been overshadowed by illiquidity. We believe that the Treasury is sensitive to liquidity concerns and that it will attempt to provide an environment in which illiquidity does not dominate the bonds' performance. The announcement that 2-, 5-, 10-, and 30-year maturities would be eventually issued is a signal that the Treasury wants to achieve a reasonable level of liquidity in these bonds, though it is unlikely this market will have the same liquidity as the rest of the Treasury market.

Reinvestment risk

Canadian-style bonds would provide better inflation protection

Canadian-style inflation-protected bonds would provide better inflation protection than would the floater structure for long-term investors. Since the inflation accrual on the principal compounds continuously over the life of the bond, investors do not face reinvestment risk on the inflation-accrual component. This is analogous to the difference between regular coupon bonds and Strips: investors in coupon bonds must reinvest their coupon income at the purchased yield of the bond in order to realize the bond yield. Inflation-protected floaters offer complete protection against inflation only if investors reinvest the inflation-accrual income in the same-yielding inflation-protected bonds. This reinvestment risk can benefit investors – if the coupons are reinvested at higher real yields.

Deflation risk

Deflation is more problematic for the floater

Principal repayments that are linked to the rate of inflation could conceivably be negative if we were to experience significant deflation during some period. The effect on cash flows would be different, depending on whether inflation-protected bonds are the Canadian or floater type. The issue is more vexing for the floater structure, because one-period deflation

would translate into a negative principal inflation accrual for that period, and could even result in the Treasury being *owed* a payment (if deflation exceeds the "real" coupon payment in that period). Deflation will not affect the real yield earned on either structure. However, if the deflation *rate* over the life of the bond exceeds the real return, the nominal return could be negative. One solution proposed by the Treasury ensures a "minimum guarantee" in which a nominal return of 0% is ensured.

Few instances of deflation exist historically

While this issue is of concern to investors, there have been relatively few instances of deflation in recent history. Since 1980, there have been only five monthly periods in which the month-over-month change in CPI was negative: November 1982 (-0.10%), December 1982 (-0.31%), February 1986 (-0.18%), March 1986 (-0.55%), and April 1986 (-0.51%). More relevant to the proposed structures is the frequency of six-month periods when deflation did exist. In similar, future periods, if deflation exceeded the bond's real coupon, a net payment would theoretically accrue to the Treasury. Only three such instances have been recorded since 1980, and these were relatively small in magnitude: June 1986 (-0.09%), July 1986 (-0.36%), and August 1986 (-0.09%).

Taxes

Tax treatment should not adversely affect liquidity

While the exact tax treatment of inflation-protected bonds has yet to be definitively determined, a reasonable supposition is that they will be taxable in a manner similar to that of other Treasury securities. In that case, both the coupon payment and the inflation accrual on the principal would be currently taxed in both structures. In the case of an inflation-protected floater, both coupon and principal appreciation would be currently paid, and hence investors would experience no shortfall. In the case of the Canadian model, investors would have to pay taxes on the inflation accrual, which would not be paid until maturity.

It remains to be seen whether the tax treatment of the Canadian model would affect the liquidity of these bonds. U.S. Treasury Strips are subject to similar tax treatment, and they form a liquid market. Furthermore, we anticipate that inflation-protected bonds will replace long-dated Treasury Strips in individual investors' pension savings plans, which are generally tax-exempt anyway.

How might inflation-protected bonds have performed in the past, as compared to other asset classes?

Real yield on inflation-protected bonds should fall when inflation rises

Inflation-protected bonds' structures preclude them from being compared directly to either fixed income securities or equity. The features they share with fixed income securities are semiannual coupon payments and a final principal payment at a defined maturity. However, whereas fixed income securities would suffer losses in a rising inflation environment, inflation-protected bonds would probably appreciate in value, since real yields would likely fall in response to the growing demand for inflation protection. The structural features that inflation-protected bonds share with nominal bonds are the reasons they also do not naturally fit into an equity classification.

CPI data allows us to estimate historical performance

Because historical CPI data is available, we can perform a *hypothetical* historical analysis of inflation-protected bonds as though they had been issued years ago. To do so, an assumption needs to be made regarding how real yields change over time. We assume that real yields and inflation are negatively correlated and have devised the following simple rules:

- Real yields rise by 10% of the decline in the annual inflation rate over a two-month period.
- Real yields fall by 10% of the rise in the annual inflation rate over a two-month period.

For example, over the 12-month period ending November 1983, CPI rose at a 3.16% rate,

while over the 12-month period ending January 1984, CPI rose at a 4.29% rate. Using our assumption, the yield on inflation-protected bonds would fall by 0.10*(4.29-3.16) = 0.113%, or 11.3 bps. The results can then be compared to the historical performance of alternative asset classes, i.e. cash, bonds and equity.

We assume constant and variable yield over CPI

The table below shows the historical returns from cash (T-bills), Treasuries (both the long Treasury index and a constant-maturity long bond), equities (S&P 500), and hypothetical inflation-protected bonds (assuming a 10-year Canadian structure) from January 1984 through July 1996. We consider inflation-protected bonds under two assumptions: constant yield over CPI and variable yield over CPI.

The constant yield assumed for the analysis is 325 bps over CPI for a 10-year bond. Since 1984, the average CPI/T-bill spread was approximately 280 bps while the average CPI/10-year spread was approximately 475 bps. As inflation was both higher and more volatile over this period than currently, we think there was a substantial inflation premium built into 10-year yields. Therefore, our historical estimate lies closer to the lower end of this real yield range.

Inflation-protected bonds could provide a superior return/risk profile

hypothetical performance of inflation-protected bonds versus actual performance of three-month T-bills, S&P 500, Treasury index, and constant maturity bonds, percent

	T-bills	S&P	Tsy index	CMT bond	10-year IPB constant yield	10-year IPB variable yield
1984	10.16	6.08	14.30	14.97	7.44	8.27
1985	7.87	31.44	28.48	36.12	7.18	6.43
1986	6.44	18.08	15.77	30.12	4.50	0.84
1987	5.86	5.15	2.18	-7.66	7.83	13.53
1988	6.43	16.48	6.78	8.71	7.82	7.37
1989	8.54	31.31	13.97	20.63	8.05	8.24
1990	8.42	-3.17	8.64	5.47	9.71	12.25
1991	6.36	30.47	14.80	19.24	6.34	0.76
1992	3.96	7.69	7.24	8.05	6.33	6.45
1993	3.39	10.03	10.06	21.49	6.10	5.65
1994	4.49	1.35	-2.90	-11.14	6.02	6.14
1995	6.22	37.59	17.34	35.43	5.95	5.97
1996 (July)	3.07	9.84	-1.19	-9.16	3.95	4.32
Average total return	6.25	15.57	10.42	13.25	6.71	6.63
Standard deviation	2.14	13.20	8.45	16.08	1.54	3.65
Return/risk	2.93	1.18	1.23	0.82	4.37	1.82

Source: BARRA, J.P. Morgan Bond Index

At a constant real yield of 325 bps over CPI, inflation-protected bonds would have had lower returns than all the assets analyzed except for three-month T-bills. More importantly, the standard deviation of their yearly returns would have been the lowest among the asset classes. Naturally, this changes when we remove the assumption of constant yield and introduce price risk into the analysis. Since inflation has fallen over the period under consideration, the annualized returns would be lower than those under the constant-yield assumption. The more significant difference is that the volatility of the yearly returns increases considerably.

Where do inflation-protected bonds fit?

Real yield volatility and inflation expectations are key to asset allocation

If inflation-protected bonds do not provide the most stable returns in a varying inflation environment, under what circumstances does it make sense to own inflation-protected bonds? If expected real yield volatility is low, inflation-protected bonds would be attractive to a broad range of market participants, since the return/risk ratio would likely exceed that of other asset classes. On the other hand, if real yield volatility is high, the return/risk ratio would be

comparable to that of equity and fixed income markets. An inflation-protected bond market marked by high real yield volatility is likely to best suit buy-and-hold investors who are not exposed to adverse price movements prior to maturity.

Thus, the portion of a portfolio that should be invested in inflation-protected instruments depends on three factors: the expected change in inflation, the volatility in the real yields of inflation-protected bonds, and the level of risk aversion of the investor. The most obvious case for allocating to inflation-protected bonds occurs when inflation expectations are rising. If inflation does not rise, owning inflation-protected bonds will probably be costly from a total-return point of view. Considering that the inflation rate is historically low and the economy is at or through full employment, it is reasonable to expect that inflation risk is currently biased to the upside. In such an environment, we would expect demand for this sector to increase, real yields to fall, and investors to reap returns in excess of the real yield at purchase.

We would like to thank Richard Roll, professor of Finance at The Anderson School of UCLA, for his assistance in the preparation of this publication.