BRIDGEWATER ASSOCIATES

Inflation Linked Bonds

US Inflation-Indexed Bonds

The US Treasury recently announced the details of its January 1997 issuance of inflation-indexed bonds (also known in other countries as inflation-linked (I/L) bonds). This is one of the most important developments for US institutional investors since the Treasury's offering of traditional bonds in 1919. Inflation indexed bonds provide investors with a new, US dollar denominated asset class that has:

a) a US dollar real return that is known and fixed to maturity,

b) an expected return that is equal to (or marginally higher than) conventional nominal bonds,

c) a risk which is considerably lower than conventional bonds of the same duration, and

d) correlations with conventional bonds and stocks that are low or negative (depending on the time horizon).

Therefore when put into a portfolio optimizer, inflation-indexed bonds entirely displace conventional bonds and merit allocations that rival equities. In addition, for investors with inflation linked liabilities, they are clearly the lowest risk investment. From this asset base, other forms of inflation-linked securities will most likely be created. In these respects, US inflation-indexed bonds will provide investors with greater diversity, an important ingredient required to create balanced portfolios.

Inflation-indexed bonds will also change how we all think of the markets, and how economic policies and risks are managed. For example, we will no longer think of bonds in the same way. Henceforth, we will think of them as consisting of two parts – the inflation expectation and the real rate – and we will watch these two parts trade separately throughout the day. We will know precisely what the market is betting each will be, and we can bet against these expectations. The real rate will be traded explicitly and the inflation rate can be traded by spreading the nominal bond against the I/L bond. Because inflation can literally be traded, it can also be hedged. Just as the credit market futures contracts created the hedging vehicles that allowed financial institutions to offer instruments such as floating and fixed rate mortgages and other forms of debt, US I/L bonds will generate numerous forms of inflation-tied or hedging instruments. In addition, with the US Treasury issuing I/L bonds, it is now likely that other countries will follow, while I/L bonds already in existence will gain liquidity. Because of I/L bonds, currency traders will be able to deal in real as well as nominal exchange rates. Economists will be able to see, and thereby better understand, the effect changing conditions (e.g., growth, budget deficits, and monetary policy shifts) have on real interest rates as distinct from inflation. Misunderstandings, such as those arising from not knowing whether interest rates are rising because of inflation fears or because money is too tight, will not occur. This will allow for better management of fiscal and monetary policies and lead to more stable and improved economic conditions. The beneficial ripple effects of the Treasury's issuance of inflation-indexed securities will be felt in more sectors than we can imagine.

Needless to say, we are excited about this development. For the last several years, we have managed global I/L bond portfolios which, through currency hedging, provided investors with a facsimile of what the Treasury is about to issue. In the process, we developed a deep appreciation of this asset's characteristics and idiosyncrasies. We learned how to trade them against each other based on anomalies in their relative pricing. The development of a US inflation-indexed bond market will add depth and liquidity to other inflation linked (I/L) markets. We also expect that our unique experience will give us an advantage in pricing the US issue off of the other markets, giving us some good trading opportunities.

In this report, we tell you what we know about US inflation-indexed bonds and how they are likely to fit into US institutional investors' portfolios. As we learn more, we will pass it along via similar research pieces. In addition, relevant observations have been sent out in two prior pieces – *Global Inflation Linked Bonds* and *Inflation Linked Bonds vs. The GSCI* – and a more recent piece, *US Inflation-Indexed Bonds: Questions and Answers*. These research articles will serve as good background materials for investors seeking to become acquainted with this asset class.

What We Know About the Current US Plan:

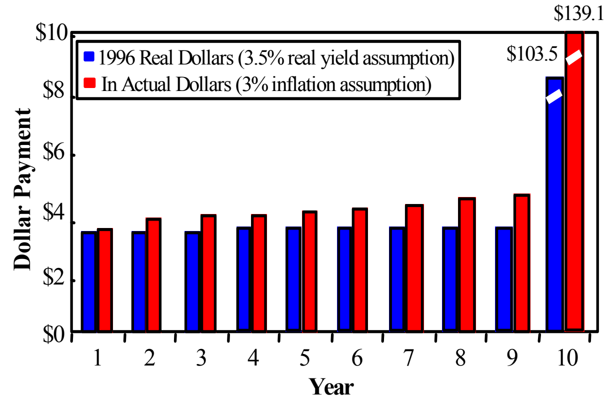
The US Treasury Department has released most of the relevant details about the characteristics of the US inflation linked bonds. We now know their indexing structure, the likely maturity and payout pattern of the first issue, and the choice of inflation index. Only the issuance size and the probable real yield have yet to be determined.

The Treasury has decided to format the US inflation-indexed bond in an almost identical way as Canada structured its inflation-indexed bond. The "Canadian type" structure is one where the inflation compensation accrues to the principal of the bond and is paid out at maturity. The "real" component of the return is paid out via semi-annual coupons, whereby the coupon payment is simply the real coupon of the bond times the inflation-adjusted principal at each point in time. We point out that 99% of the current outstanding I/L bonds all around the world are structured in this way, such that every cash flow is fixed in real terms. The Treasury's decision to structure the bond this way creates consistency among country I/L bonds and will facilitate arbitrage between them, thus enhancing liquidity for all I/L markets.

While the first issue on January 15, 1997 will carry a 10 year maturity, the Treasury is planning on introducing a second maturity within a year. The Treasury may look to make the second maturity somewhat shorter, something that would have greater appeal to the retail market (less volatility). I/L bonds have very long durations relative to their maturities. That is because I/L bonds pay all the inflation compensation on the principal value at maturity, effectively pushing cash flows further into the future than is the case for conventional bonds. So a 10-year maturity I/L bond would have something like an 8 year duration and a 30-year I/L bond would have roughly an 18 year duration. Keep in mind that this duration represents the price sensitivity of the US inflation-indexed bond to change in real interest rates. Real interest rates tend to be about one-third to one-half as volatile as nominal interest rates, so that the volatility of the US inflation-indexed bond will be comparable to a conventional bond with a duration of about 3 to 4 years. In other words, the US inflation-indexed bond will be less volatile than the Lehman bond index.

To graphically illustrate how the US inflation-indexed bond will work, we show the following chart. The chart shows the annual cash flow of the US inflation-indexed bond assuming a 3.5% real yield and a 3% inflation rate. The chart shows the value of the cash flows in both real dollar terms and actual nominal dollar terms. Note that in actual dollar terms, the cash flows gradually rise with accumulating inflation, and then the bond would pay $139.10 at maturity, which is the principal plus the 10 years of accumulated inflation compensation on the principal.

Cash Flow Structure of the US Inflation-Indexed Bond



The Treasury will use the non-seasonally adjusted CPI-U to calculate the adjustment to inflation portion of the coupon and the principal with a lag of 2 to 3 months. There are a number of reasons for this. The CPI is obviously the most well known and accepted benchmark for inflation, particularly to individual investors who the Treasury is courting somewhat. It is a comparatively broad-based index (e.g., unlike the employment cost index which covers only wage inflation) and most cost of living contracts are tied to it. The criticism of CPI is that it may overstate inflation. The Treasury is probably (and correctly) not too concerned about that, because the market will price the real yield of this security against whatever inflation index the Treasury chooses. Even if we assume inflation is overstated, the market will price the real yield lower in response. We note that all other issuing countries have chosen their versions of the CPI to make inflation adjustments to their own inflation linked bonds. Choosing the same type of index makes international comparisons of real yields easier and therefore will facilitate spread/arbitrage trading and enhance liquidity.

One major aspect of the issuance of US inflation-indexed bonds that is not yet known is the issuance size. The Treasury will probably look to set size in accordance with demand, which they will be gauging over the next few months. Of course, since the second maturity will not be introduced until later in 1997 or early 1998, the quarterly auctions that follow the January 15, 1997 initial auction will simply be re-openings of the 10 year issue. Treasury officials have indicated that to have a viable ongoing commitment to this new kind of security, that it ought to represent at least 2% of total Treasury issuance. Anything smaller would be seen as not large enough to have any affect on total borrowing costs. Right now, the Treasury is issuing about $2.5 trillion worth of securities of all types each year. Therefore, we think that the targeted issuance size will be at least $50 bln per year or more, and we have heard suggestions of about $70 bln per year, which we think are reasonable. In the first year, however, it is clear that Treasury wants to start with smaller amounts. They have indicated that something on the order of about $8 bln for the first year, then moving up to the $50-$70 bln per year target in two or three years, though they have also suggested that the first year's offerings could be larger if the demand is strong. This would come out to four quarterly auctions of $2 bln in I/L securities in the first year, gradually moving up to more than $12 bln per quarterly auction after that.

The other major area of uncertainty regarding the first issue is where the real yield and real coupon will come in. Of course, just as is done with conventional bonds, the Treasury will set the real coupon equal to the real yield at which the auction clears. So, both real yield and real coupon will be a function of market demand. Ultimately, just as with conventional bonds, the only thing that really matters is where the real yield comes in; the coupon is only important as it slightly affects the duration. Although the initial rate could vary depending on issuance size and initial demand, our guess is that the real yield would come between 3.25% to 3.75% if issued today. This is based on a number of factors, most importantly where real yields are trading in all the other countries, what currency hedging costs into the US dollar imply they should be, credit quality considerations, and likely relative liquidity premiums.

We would note, though, that in the UK, Canada, and Australia, initial issues of I/L bonds all tended to come expensive. The real yields at which I/L bonds were first issued tended to be too low. Within 6 months of trading, they all rose higher. Canada was a recent example, where the I/L bond was issued at a 4.25% real yield on November 14, 1991. Within ten days, the real yield rose to 4.5% and within five months it was 4.75% and stayed there for the rest of the year. New Zealand was an even more recent example of the same thing. This phenomenon is due in part to initial I/L bond offerings being priced to squeeze the last basis point out of the market at the first offering. Because there is always some initial pent-up demand that is not too price sensitive, and because the initial offering amounts were always small, the initial pricing was typically pushed too high. After initial demand is sated at an inflated price and the prospect of more supply arises, real yields typically fell as more price sensitive buyers are inevitably brought into the market. Although Treasury officials know of this problem and would prefer that it not occur, it is not yet clear what can be done, other than to offer a reasonable amount at the first auction.

Side Effects of US Issuance

Once the Treasury has established an ongoing market for I/L securities, we think that it is likely that other I/L issuers will follow, as has happened in other countries. On the top of the list may be state and local issuers, who rely on individual investors and who have inflation-linked revenue (i.e., tax revenue). Other likely issuers are utility companies and infrastructure issuers. These entities have revenue streams that are highly subject to prevailing inflation and also tend to want to issue very long term instruments. As we noted, I/L securities tend to be longer term (duration) than conventional bonds because their payments are so heavily loaded at maturity.

We also think that when the US is able to establish a liquid market in I/L securities, it will bring down real yields somewhat in other countries. It is very clear that real yields in foreign countries carry a liquidity premium and the issuance of liquid securities in the US would reduce that. For example, there are a total of about $65 bln in sovereign government I/L securities in the UK, Canada, and Australia right now. The US plan to issue more than $50 bln per year will obviously radically change the global market for I/L securities. Canada, whose securities tend to trade directly off their US counterparts, will be most impacted by the US entry into this asset class. We note that Canadian real yields have already dropped about in anticipation of this and, we think, could trade even lower.

How US I/L Bonds Will Fit Into US Institutional Investor's Portfolios:

Institutional investors acquire assets with two perspectives. Some are focused almost exclusively on the returns and risks of their assets, and consider the most important measure of risk to be the standard deviation of the assets. Others give considerable attention to how the value of their assets moves in relation to changes in their liability costs and consider measures of shifts in these asset-liability mismatches to be best in gauging risk. US inflation-indexed bonds will have a radical impact on both types of investors and their portfolios.

We already noted that inflation-indexed bonds have the following key characteristics:

a) a US dollar real return that is known and fixed to maturity,

b) an expected return that is equal to (or marginally higher than) conventional nominal bonds,

c) a risk which is considerably lower than conventional bonds of the same duration, and

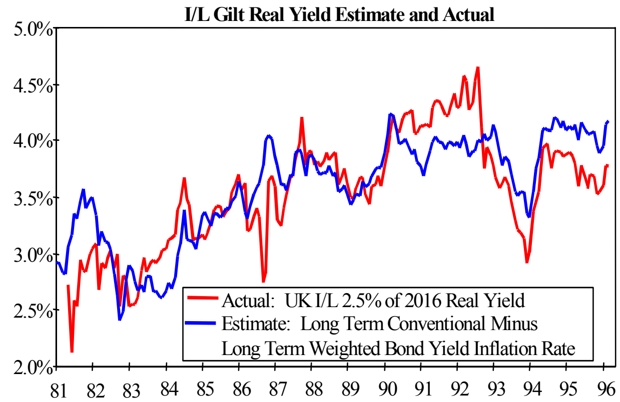
d) correlations with conventional bonds and stocks that are low or negative (depending on the time horizon).

As we show in this section, inflation-indexed bonds, when put into a portfolio optimizer, entirely displace nominal bonds and merit allocations that rival equities. Therefore, there should be a large demand for these investments from the types of institutional investors who focus on the returns and risk of assets only.

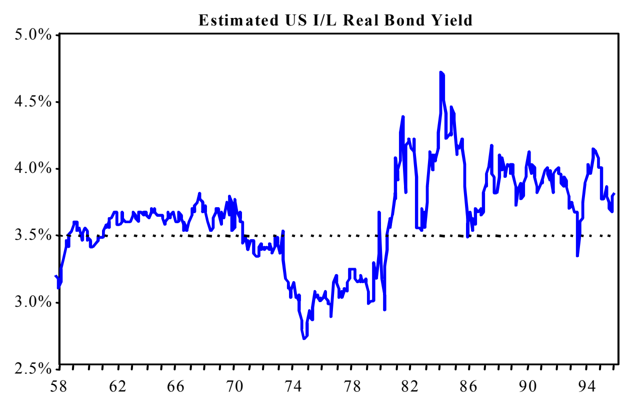
For those who focus on asset liability risk, the value of I/L bonds will depend on whether the liability is more fixed or inflation-linked. From this group, those with fixed dollar liabilities (e.g., to pay existing retired pensioners a fixed nominal payout) will continue to find the best value in conventional fixed income securities. However, for those with inflation-linked liabilities (e.g., foundations, endowments, active-lived pensioners, nuclear de-commissioning trusts, and many others), inflation-indexed bonds will be the least-risk alternative. At a minimum, they will serve to immunize inflation sensitive liabilities the way nominal bonds now are used to fund fixed dollar liabilities. The liability matching demand for them will be enormous largely because there are no really good alternatives. Equities, real estate and commodities are all extremely risky alternatives to I/L bonds in funding inflation-sensitive liabilities.

In order to study the implications of including US I/L bonds in portfolios, we have simulated how we think they would have behaved going back about 40 years. This simulation is based both on their behavior in other countries, such as in the UK after 1981, and the behavior which is implied by their structure. Over the life of an I/L bond, the real rate is known, just as the nominal payments are known for nominal bonds. Interim volatility arises from changes in real yields just as interim volatility in nominal bonds arises from changes in nominal yields. So, you can think of an I/L bond as trading like an nominal bond but in response to changes in real yields rather than nominal yields. As we explained earlier, the duration of I/L bonds is relatively long in relation to maturity, because the principal is indexed to inflation and paid upon maturity. While we could easily estimate what the long term (e.g., over 10 year horizons) nominal returns of US I/L bond would have been by simply adding an assumed real interest rate to the inflation rate, this would not have captured the interim volatility arising from changing real yields.

As previously mentioned, the nominal bond yield minus the I/L bond yield roughly equals the implied expected inflation rate. As a result, the real yields on I/L bonds, and in turn, I/L bond prices have tended to vary as a function of the nominal bond yield ex-inflation expectations. Not having explicitly stated 10 year inflation expectations to rely on, we used a proxy for them based on the long term, cyclically adjusted, core inflation rate. For example, the next chart shows where I/L bond real yields actually traded since they were issued in 1981 in the UK. Also shown is our estimate of the I/L real yield based on the conventional bond yield versus this inflation expectation proxy. As the chart suggests, our estimate is a fairly good, though certainly not perfect, proxy for how I/L bond real yields were actually priced by the market. The estimates have worked comparably well in other countries.



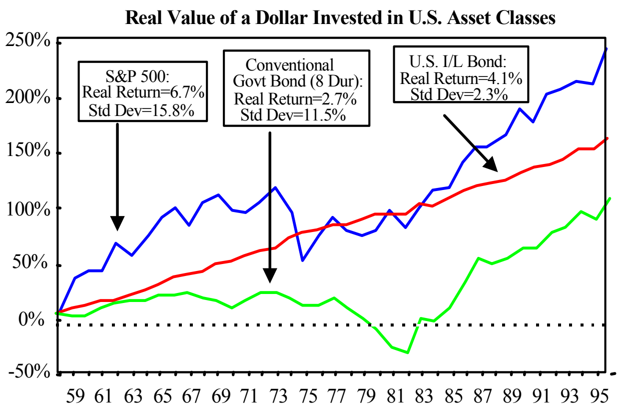
In order to estimate what I/L bond yields would have been in the past in the US and how US I/L bond yields would have behaved on a monthly basis, we went through the same process for the US. While imperfect, the estimates are more than adequate given our purposes and are certainly better than the alternative of assuming no volatility in real bond yields. The derived estimates of past US real bond yields are shown in the next chart. As indicated, we estimate that real bond yields would have averaged about 3.5% over the last 40 years and would be marginally above that level right now. Assuming that our process in the US works about as well as it did in the UK since 1981, the average error in any one of the estimated points below is about 25 bp.



With an estimate of where the I/L real yield would have traded, it is a straightforward calculation to derive the total return of a US I/L bond. We derived a total return based on a 10-year maturity, roughly 8-year duration US I/L bond.

The Real Returns and Risks of US I/L Bonds Relative to Fixed Income Bonds and Stocks

In the next chart, we show what the total real return of a US I/L bond would have looked like given the real yields indicated in the previous chart. We were then able to make a comparison to the real returns of 8 year duration conventional government bonds and the S&P 500 over the same time frame. The chart shows the cumulative *real* value of a dollar invested in each asset*.



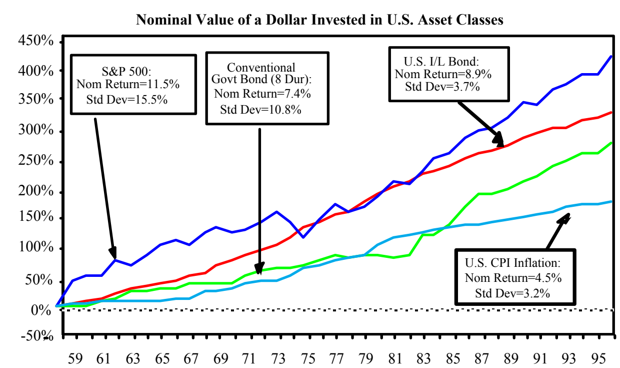
We make several observations about the chart shown above. The first is that one should not necessarily extrapolate the past returns. For example, many would adjust upward the historical bond return and perhaps downward the historical stock return. But the historical riskiness of assets is probably more representative, particularly in a relative sense. The chart indicates that in real terms, the riskiness of traditional stocks and bonds in comparison to that of I/L bonds is massive. For example, in the numbers over the past 40 years, conventional bonds carried about 5 times the risk of I/L bonds in real terms, and stocks carried about 7 times the risk in real terms. This is because I/L bonds are directly linked to inflation and the other assets aren't, and the volatility of real yields is considerably less than the volatility of nominal yields.

Why do I/L bonds have some real return risk? When one buys I/L bonds, one locks in a known real return over the life of the bond. However, just as year by year returns of a conventional bond are driven by movements in the market-determined nominal bond yield, so the year by year returns of an I/L bond are determined by movements of the market determined I/L real yield. Therefore, interim volatility of I/L bonds is a function of the volatility of real yields.

Real yields, by definition, are not affected by changes in inflation expectations, and instead are affected by less volatile factors such as fluctuations in real economic growth rates and the tightness of monetary policies. We estimate that about 70% of the historical movements of nominal yields on conventional bonds are driven by changing inflation expectations. The fact that real yields are far more stable than nominal yields can be seen very directly in the countries that have issued both I/L bonds and conventional bonds. All this factored into our estimate of where the US I/L real bond yield would have traded, which as previously indicated, would have had a range of about 3% to 4.5%, far less than the 3% to 15% range of nominal bond yields over the same period. So in the end, even though I/L bonds do carry some uncertainty of real return, the stability of their yields has meant that this volatility has been very small relative to other asset classes.

The Nominal Returns and Risks of US I/L Bonds Relative to Fixed Income Bonds and Stocks

In the next chart, we show the cumulative nominal value of a dollar invested in the same assets as above and their returns and risks in nominal terms. Also indicated is the "return" and "risk" of inflation itself. Of course, I/L bonds have had a higher risk when measured in nominal terms because inflation itself has "risk" in nominal terms. Note that the annual standard deviation of inflation was 3.2% while the standard deviation of I/L bonds on an annual basis is slightly higher at 3.7%. Even in nominal terms, conventional bonds were about 3 times as risky as I/L bonds and stocks were about 4 times as risky as I/L bonds. Note also the gradually increasing margin between the I/L bond nominal return and inflation, which again reflects the stability of real return.



US I/L Bond Correlation to Other US Assets and Inflation

Expected returns, risks and correlations are the building blocks of modern portfolios. So far, we have dealt with the return and risk characteristics of US I/L bonds and how they compare against traditional stocks and bonds in the US. We will now examine their correlations between different asset classes.

Before looking at the numbers, you can imagine why US I/L bonds should have a low or negative correlation with stocks and bonds. Since I/L bonds are structurally tied to inflation, we know that over longer time horizons I/L bond returns will have a strong positive correlation with inflation. Conventional bonds, of course, are likely to have a negative correlation with inflation since their returns are generally inversely related to changes in nominal interest rates and inflation. Stocks tend to be positively correlated with nominal bonds. So, we would expect I/L bonds to be positively correlated with inflation and negatively correlated with bonds and stocks.

* *The average real return is slightly higher than the average real yield due to a positively sloped yield curve.*

This is borne out by the correlation table that follows. The table shows the correlations between US I/L bonds and inflation over everything from one month returns up to ten year returns. Also shown in the table is the correlation between traditional bonds and stocks and inflation over all of these time horizons. The numbers generally confirm what is intuitively obvious. The correlation between I/L bond returns and inflation is moderately positive over short time frames and very highly positive over long time frames. The reason why the correlation between I/L bonds and inflation varies is because of movements in real yields. If, for example, real yields were to move higher in a month when inflation rises, that could make the I/L bond return fall even though inflation rose. But as we already noted, real yields tend to be fairly stable. Over long time frames, the impact of movements of real yields is minuscule in relation to the changes in the inflation rate, which is why we get long term correlations that are in excess of 90% I/L bond returns will never be 100% positively correlated with inflation because there is always some change in the real yield. Also note that the correlation between both conventional bonds and stocks and inflation is negative over all time frames. Again, this is not a surprise. In the past, it has always been the case that any upward movement in inflation, whether long term or short term, has had a very negative effect on both stocks and bonds. For example, both assets performed poorly during the 1970's as inflation rose and eroded real yields. On the other hand, the disinflationary period of the 1980's brought strong returns for both stocks and bonds.

Correlations Between US Asset Classes and US Inflation

	I/L Bond (8 Yr. Dur)	Conventional Bond (8 Yr. Dur)	S&P 500
1 Mo.	48.2%	-10.8%	-16.6%
3 Mo.	56.2%	-16.3%	-20.5%
12 Mo.	77.5%	-25.3%	-24.9%
3 Yr.	93.4%	-27.5%	-25.5%
5 Yr.	94.1%	-20.1%	-24.5%
10 Yr.	96.8%	-8.6%	-19.4%

We also looked at correlations between I/L bonds and traditional stocks and bonds. These are shown in the next table. Note that the correlation between I/L bonds and conventional bonds is high on a very short term basis. That is because short term movements in nominal yields and real yields tend to move together, while the impact of changes in monthly CPI inflation tends to be small, because the changes in real yields dominate I/L bond performance. But as the time frame is extended, the correlation between I/L bonds and conventional bonds drops precipitously and turns negative. Again, this is because over longer time horizons the inflation impact grows while the volatility of real yields becomes less significant. Negative correlations between I/L bonds and conventional bonds exist when looking at 3 year returns or longer. The correlation between I/L bonds and stocks are close to zero over short time frames and also becomes negative as the return time frame was extended and changes in inflation become dominant in I/L returns.

Correlations to US I/L Bonds (8 Yr. Duration)

	Conventional Bond (8 Yr. Dur)	S&P 500
1 Mo.	77.7%	12.0%
3 Mo.	65.4%	1.8%
12 Mo.	27.8%	-16.5%
3 Yr.	-8.5%	-28.3%
5 Yr.	-2.6%	-27.2%
10 Yr.	-1.3%	-24.4%

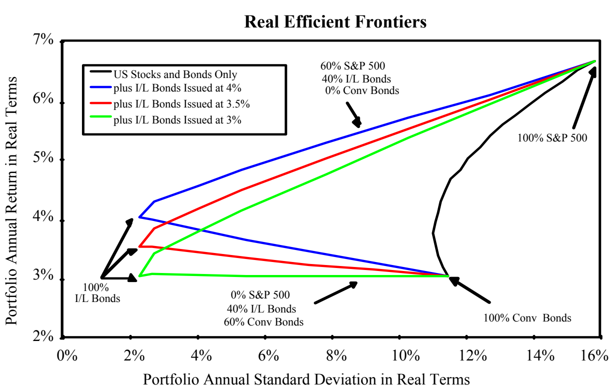
The fact that correlations between I/L bonds and inflation are high, and I/L bonds and other financial assets are low or negative (depending on the time frame one chooses) confirms what is intuitively obvious: that these securities are a highly effective inflation hedge and an excellent portfolio diversifier.

US I/L Bonds in The Portfolio: An Efficient Frontier Analysis

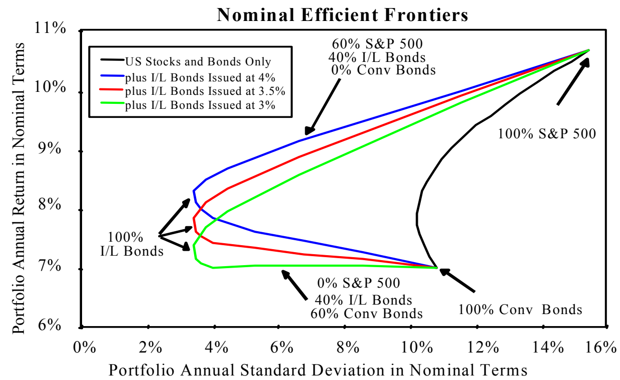
Given the characteristics of I/L bonds, how much should be added to an existing portfolio and at the expense of what? The best way to answer this question is through an analysis of the impact of US I/L bonds on a US efficient frontier. We did this both in real terms and in nominal terms to reflect both of the previously mentioned perspectives.

To calculate an efficient frontier, one obviously needs assumptions of return, risk, and correlation for each asset. To derive ours, we adjusted returns to what we think are reasonable forward-looking expectations. We started with real returns. For the US stock return, we used the historical real return of 6.7% since 1958. While we think this is at the high end of reasonable prospective returns, we know that many analysts use the historical return of stocks as a proxy for their return, so we made no adjustments. For conventional bonds, we used a real return of 3%. This is above the historical implied real yield of 2.5% for conventional US bonds and above the historical real return of bonds that was downward biased by a generally rising rate environment since 1958. For I/L bonds, the best looking forward real return expectation would be based on where their real yields come in. Since we do not know yet where that will be, we ran the efficient frontier analysis based on 3%, 3.5%, and 4% US I/L real yields. We think that covers the range in which the actual real yield will come in when issued. For risk, we simply used the historical standard deviations of one year returns since 1958. That period encompasses both the non-volatile 50's and 60's and the volatile 70's and 80's, and therefore seems reasonable to us as a proxy period for risk. We also used the historical correlations since 1958, as we had no reason to think that past correlations would change much going forward.

The next chart shows the results of our efficient frontier analysis in "real space." This would represent the perspective of an investor with an inflation-linked liability perspective. In the chart, the black line indicates what the efficient frontier would look like with only the S&P 500 and 8-year duration conventional bonds. Moving up from the bottom line, which represents an all-bonds portfolio, one can see that initially risk is reduced and return is raised because of both the diversification and higher return benefits of stocks. Then the risk begins to rise as the portfolio is weighted more toward all stocks because the volatility of stocks overshadows the diversification benefits. All the other lines are efficient frontiers that are the result of adding US I/L bonds to a portfolio of traditional stocks and bonds. As noted, we do not know yet where the real yield of US I/L bonds will be, so we ran the analysis three ways, using 3%, 3.5%, and 4% real US I/L bond yields. In all three cases, the "real risk" of the portfolio was reduced dramatically. This is a function of both the low real risk of US I/L bonds themselves (2.3% annually) and the low/negative correlation between I/L bonds and the other assets. Whatever real rate the US I/L bonds are priced at, it is clear that the introduction of this asset into a portfolio will dramatically alter the return to risk trade-off when measured in inflation adjusted terms. Note that there is no reason to hold nominal bonds as they are both riskier and more correlated with the highest returning asset class (stocks). The trade off becomes solely between I/L bonds and stocks, based exclusively on one's preference for return relative to risk. Additionally, it is noteworthy that while we used standard deviation around an expected return as our measure of risk, there is also uncertainty concerning the expected return. Will the real returns of stocks and bonds be 6.7% and 3% respectively? We will never know for sure. In the case of I/L bonds, there is no such uncertainty.



We also ran the efficient frontier in "nominal space." We did this by adding a 3.5% inflation expectation to all of our real return assumptions noted above. Again, historical risks and correlations were used as is. The picture is not much different. The risk reduction of shifting out of nominal bonds to I/L bonds is large, though a bit less than in real terms, and the trade-off once again becomes between risk and return. Again, this is a function of both the stability of US I/L bonds, both in real and nominal terms, and their low/negative correlation with equities.



The efficient frontier analysis makes a few things clear. First, as mentioned, the risk trade off between US I/L bonds and other assets is likely to be stark. Most stark of all is the comparison to conventional bonds. Depending on where the US I/L bond is priced, they have roughly similar expected returns with US conventional bonds with about a third as much risk and a lower correlation to US stocks. How can any allocation to conventional bonds be justified? Unless one has liabilities that are fixed in nominal terms, or perhaps a tactical view that inflation will go down, any allocation to conventional bonds rather than I/L bonds would only provide lower returns without any real risk reduction.

A New Asset Class

Rather than being classified as a "fixed income" security, inflation linked bonds are a new asset class. Their income stream is not fixed. Their characteristics are such that, over the long run, they will be uncorrelated or negatively correlated, with bonds, depending on the magnitudes of changes in inflation. For example, the 1970's would have been a fantastic time to own I/L bonds, whereas it was virtually the worst environment to own conventional bonds. Conversely, in the disinflationary 1980's and early '90's, I/L bonds would have performed poorly while fixed income securities would have done exceptionally well.

The more appropriate way to view I/L bonds is as an asset class with particular return, risk, and correlation characteristics. We did just that with the efficient frontier analysis above. People will make different assumptions about the return, risk, and correlation inputs and will therefore come up with different optimal allocations. We are convinced that no matter how one reasonably structures the inputs, this asset class will occupy a significant position in one's portfolio.

As mentioned, this piece will be followed by regular updates. If you have any questions, please call.

Appendix: US Inflation-Indexed Bond Terms and Formulas

PAYMENT DATES:

Inflation-adjusted principal on the security will be paid on the maturity date as specified in the offering announcement. Interest on the security is payable on a semiannual basis on the interest payment dates specified in the offering announcement through the date the principal becomes payable. In the event any principal or interest payment date is a Saturday, Sunday or other day on which the Federal Reserve Banks are not open for business, the amount is payable (without additional interest) on the next business day.

MATURITY: Ten years.

INDEXING METHODOLOGY:

To calculate the value of the principal for a particular valuation date, the value of the principal at issuance is multiplied by the *index ratio* applicable to that valuation date. Semiannual coupon interest is determined by multiplying the value of the principal at issuance by the index ratio for the coupon payment date by one half the stated rate of interest.

INDEX RATIO:

The index ratio for any date is the ratio of the reference CPI number (*reference CPI*) applicable to such date to the *reference CPI* applicable to the original issue date.

REFERENCE CPI:

The reference CPI for the first day of any calendar month is the CPI for the third preceding calendar month. (For example, the reference CPI for December 1 is the CPI reported for September of the same year, which is released in October). The reference CPI for any other day of the month is calculated by a linear interpolation between the reference CPI applicable to the first day of the month and the reference CPI applicable to the first day of the following month.

Any revisions that the agency responsible for the index makes to any CPI that has been previously released shall not be used in calculations of the value of Treasury inflation-protection securities.

In the case that the CPI for a particular month is not reported by the last day of the following month, the Treasury will announce an index number based on the last year-over-year inflation rate as measured by the CPI. Any calculations of the Treasury's payment obligations on the inflation-protection security that need that month's CPI number will be based on the index number that the Treasury has announced.

If the applicable CPI series is discontinued during the period the inflation-protection security is outstanding, the Treasury has stated that they will, in consultation with the agency responsible for the series, determine an appropriate substitute index and methodology for linking the discontinued series with the new price index series. Determinations of the Secretary in this regard will be final.

TAXATION:

Appreciation of the principal will be taxed as interest income in the period the appreciation occurs. Interest payments will be includible as interest income when received or as they accrue, depending on the taxpayer's method of accounting.

MINIMUM GUARANTEE:

If the sum of all the interest payments and the inflation-adjusted principal is less than the par value of the security at time of issuance, the Treasury will pay an additional sum at maturity equal to the difference.

MINIMUM AND MULTIPLES TO BID, HOLD, AND TRANSFER:

The minimum to bid, hold, and transfer is $1000 original principal value. Larger amounts must be in multiples of $1000.

FORMULAS

I. Reference CPI:

$$\text{Ref CPI}_{Date} = \text{Ref CPI}_m + \frac{t-1}{D}\left[\text{Ref CPI}_{m+1} - \text{Ref CPI}_m\right]$$

II. Index Ratio:

$$\text{Index Ratio}_{Date} = \frac{\text{Ref CPI}_{Date}}{\text{Ref CPI}_{Base}}$$

III. Real Price:

A. No initial partial semiannual coupon period:

$$RP = (C/2)a_n + 100v^n$$

B. With initial partial semiannual coupon period:

$$RP = \frac{C/2 + (C/2)a_n + 100v^n}{1 + (r/s)(i/2)} - [(s-r)/s]\ (C/2)$$

IV. Settlement amount, including accrued interest, for $100 Original Principal:

$$SA = A + [\text{Index Ratio}_{Date} \times RP]$$

V. Accrued Interest:

$$A = [(s-r)/s] \times (C/2) \times \text{Index Ratio}_{Date}]$$

VI. CPI not reported timely for month M:

$$\text{Ref CPI}_m = \text{CPI}_{m-1} \times \left[\frac{\text{CPI}_{m-1}}{\text{CPI}_{m-13}}\right]^{1/12}$$

Generalizing for last reported CPI issued N months prior to month M:

$$\text{Ref CPI}_m = \text{CPI}_{m-n} \times \left[\frac{\text{CPI}_{m-n}}{\text{CPI}_{m-n-12}}\right]^{1/12}$$

Definitions:

RP = real price

SA = settlement amount, including accrued interest, in current dollars per $100 original principal

A = nominal accrued interest per $100 original principal

r = days from settlement date to next coupon date

s = days in current semiannual coupon period

i = real interest rate, compounded semiannually

c = real annual coupon, payable semiannually, in terms of real dollars paid on $100 initial, or real, principal of the security

n = number of full semiannual periods from settlement date to maturity date

v^n = $1/(1 + i/2)^n$

a_n = $(1 - v^n) / (i / 2) = v + v^2 + v^3 + ...v^n$

Date = valuation date

D = the number of days in the month in which Date falls.

t = the calendar day corresponding to Date

CPI = not-seasonally-adjusted CPI-U

Ref CPI_n = reference INUM for the first day of the calendar month in which Date falls

Ref CPI_{m+1} = reference INUM for the first day of the calendar month immediately following date.