Features and Risks of Treasury Inflation Protection Securities

By Pu Shen

In 1997, the U.S. Treasury began the quarterly issuance of inflation indexed bonds, called Treasury Inflation Protection Securities (TIPS). So far, the Treasury has issued both 5-year and 10-year indexed bonds and will begin to issue 30-year indexed bonds and inflation indexed savings bonds in 1998. TIPS differ from conventional Treasury bonds in both their payment flows and risks. With virtually no inflation risk, they are the safest assets currently available in the U.S. market. Combined with conventional Treasury bonds, they allow investors to separate inflation risk from real interest rate risk and thus manage risk more efficiently.

To help investors understand and take full advantage of these new securities, this article discusses the features and risks of the Treasury inflation indexed bonds. The first section of the article discusses the features of inflation indexed bonds. The second section explains why these bonds can benefit many investors. The third section shows how the tax code prevents these bonds from being entirely inflation-risk free. Finally, the article shows that historically the market risk of an indexed bond has been small compared to that of a conventional bond with similar maturity.

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I. FEATURES OF TREASURY INFLATION PROTECTION SECURITIES

The U. S. government has accumulated approximately $5 trillion in debt due to years of deficit financing.[1] Most of this debt is borrowed in the form of Treasury securities, which can be traded (changing ownership) among investors before they mature. TIPS are a special form of Treasury securities because their principal and coupon payments are indexed to inflation, while most other Treasury securities are not. In this article, they will often be called indexed bonds, whereas the non-inflation-indexed Treasury securities are referred as conventional bonds or nominal bonds.[2]

What are indexed bonds?

While both indexed and conventional bonds pay interest semiannually and principal at the time of maturity, the pattern of the payments of indexed bonds is unique. The nominal (dollar) payments of a conventional bond, including both coupon interest and the principal, are fixed at the time of issuance. In contrast, both the coupon interest and the principal of an indexed bond are fixed in *real* terms, that is, in terms of purchasing power. The dollar payments of an indexed bond are adjusted according to the actual inflation during the life of the bond.

Table 1

PAYMENTS OF AN INDEXED BOND AND A NOMINAL BOND

Year	Dollar payments of a nominal bond	Real payments of an indexed bond	Dollar payments of the indexed bond under three different inflation scenarios		
			π = 0%	π = 2%	π = 4%
1	**55**	**35**	**35**	**35.70**	**36.40**
(Adjusted principal)			1,000	1,020.00	1,040.00
2	**55**	**35**	**35**	**36.41**	**37.86**
(Adjusted principal)			1,000	1,040.40	1,081.60
3	**55**	**35**	**35**	**37.14**	**39.37**
(Adjusted principal)			1,000	1,061.21	1,124.86
4	**55**	**35**	**35**	**37.89**	**40.95**
(Adjusted principal)			1,000	1,082.43	1,169.86
5	**55**	**35**	**35**	**38.64**	**42.58**
(Principal)	**1,000**	**1,000**	**1,000**	**1,104.08**	**1,216.65**

Table 1 shows the payments of hypothetical 5-year indexed and nominal bonds, each with $1,000 par value. The table assumes that interest on the bonds is paid annually, at the end of each year. The real coupon rate on the indexed bond is 3.5 percent, and the nominal coupon rate on the conventional bond is 5.5 percent. The table shows how the dollar payments of the indexed bond are adjusted in three different (yet constant) inflation scenarios. In the first scenario, the actual annual inflation, π, is zero; in the second scenario, actual inflation equals 2 percent, which is the market expected rate of inflation; and in the third scenario, actual inflation is 4 percent.

The numbers in the table are calculated as follows. For the nominal bond, the calculations are straightforward since both the par value and the coupon payments are fixed in nominal terms. The par value is fixed at $1,000 and the coupon payment is fixed at $55 ($1,000 times 5.5 percent) per year. For the indexed bond, it is straightforward to calculate the *real* values of the par and coupon interest since they are fixed in real terms. The real value of the par is fixed at $1,000 and the real value of the coupon payment is fixed at $35 ($1,000 times 3.5 percent). The calculation of the inflation-adjusted coupon payments, however, requires first calculating the inflation-adjusted principal at the end of each year, which equals the dollar value of the principal at the beginning of the year times 1 + π, with π being the actual inflation rate during the year. The dollar coupon payment of the indexed bond at the end of a given year is then calculated by multiplying the inflation-adjusted principal by the coupon rate. For example, the far right cell in the first row shows that if inflation is 4 percent, the inflation-adjusted principal is equal to $1,040 ($1,000 times 1.04) at the end of the first year, and the coupon interest is equal to $1,040 time 3.5 percent, which is $36.40. At the end of the fifth year, both bonds mature, thus their principals are paid back to investors. The conventional bond pays $1,000 in nominal terms, and the indexed bond pays $1,000 in real terms. The dollar amount of the principal actually paid is the real principal times the accumulated inflation over the life of the bond. In the scenario of 4 percent inflation, for example, the nominal principal is $1,000 times $(1.04)^5$, or $1,216.65.

Table 1 highlights two major features of indexed bonds. First, the real values of the interest payments are constant under all inflation scenarios during the life of the bond, while the nominal values rise with the actual inflation rate. As a result, the real yield of holding an indexed bond to its maturity is invariant to actual inflation. This is why indexed bonds are called inflation protection securities: they protect investors from inflation.[3] In comparison, the interest payments of a conventional bond are constant in nominal terms but *decline* in real terms since inflation erodes the purchasing power of fixed payments over time. Further, while the nominal yield of holding a conventional bond to its maturity is fixed, the real yield depends on the actual inflation rate during its life. The real yield on a nominal bond, y^{real}, is roughly equal to its nominal yield, $y^{nominal}$, minus actual inflation, π.[4] That is, $y^{real} = y^{nominal} - \pi$. Hence, the real yield of a conventional bond varies inversely with actual inflation: the higher actual inflation is, the lower the real yield will be.

The second major feature of indexed bonds is that at the time of maturity, an investor in an indexed bond receives the full real amount of the principal. In comparison, an investor in a conventional bond only gets part of the principal back, in real terms, because the purchasing power of the dollar declines over time as long as inflation is positive.[5] For example, if inflation averages 2 percent per year as expected, the real yield on the nominal bond will roughly be 3.5 percent ($y^{real} = y^{nominal} - \pi = 5.5 - 2$), which is the same as the real yield on the indexed bond. Nevertheless, because of inflation, an investor will need $1,104.08 at the end of the fifth year to have the same purchasing power as $1,000 five years before. In other words, at the end of the fifth year, the $1,000 principal of a conventional bond is only worth $905.73 ($1000/(1.02)^5 = 905.73$) in terms of real purchasing power. In essence, some of the principal, in real terms, has been paid out in the form of coupon interest payments. As in the table, when inflation is 2 percent, both bonds have the same real yields, but the coupon payments on the nominal bond are greater than the coupon payments on the indexed bond.

How are the principal and coupon interest adjusted for inflation?

As shown in the calculation of Table 1, the main step in making the adjustment for inflation in an indexed bond is to adjust the dollar value of the principal for inflation. Once this is done, multiplying the dollar amount of the principal by the coupon rate determines the coupon interest adjusted for inflation. In practice, to adjust the principal for inflation, one needs to know what inflation index is used and how to adjust for inflation according to the index.

The inflation index used for Treasury indexed bonds is the nonseasonally adjusted Consumer Price Index for All Urban Consumers (CPI-U), published by the Bureau of Labor Statistics.[6] This index will hereafter be referred to as the CPI. The level of the CPI at the issuing time of a bond is called its reference CPI, or base CPI. At any point in time, the CPI ratio—the current CPI divided by the reference CPI—shows how much the nominal par value of the bond should be adjusted. For example, suppose the reference CPI for a particular indexed bond is 100 and the actual inflation rate is 1 percent for the first six

HOW TO BUY OR SELL TREASURY INDEXED BONDS

Treasury indexed bonds are bought and sold primarily through two channels: Federal Reserve banks and commercial dealers. An investor can also purchase mutual funds that specialize in the indexed bonds.[7]

Using the Federal Reserve banks. The Federal Reserve System is the fiscal agent for the U.S. Treasury. All Treasury security auctions are conducted through the Federal Reserve banks. An investor can buy an indexed bond directly at its auction by submitting a tender form to one of the three-dozen Federal Reserve bank offices around the country. Tender forms can either be obtained from the Federal Reserve banks or downloaded from the Treasury's Internet Web site.[8]

An investor must have a Treasury Direct account to buy Treasury securities in auctions, which can be set up in the tender form. Treasury Direct is the book-entry system for Treasury securities, operated by the Bureau of the Public Debt, and is separated from the private sector's commercial book-entry system. In order to keep up with technological innovations in financial markets, the Bureau of Public Debt stopped issuing paper certificates for Treasury securities a few years ago. Now, all purchases of Treasury securities are recorded in the Treasury Direct system. In setting up a Treasury Direct account, an investor provides bank account information, which allows direct automatic payment of both the semiannual coupons and the principal. Starting in September 1997, payments for purchases of the Treasury bonds can also be directly debited from an investor's bank account.

In the past, if an investor decided to sell an indexed bond before it matured, the investor first had to transfer the bond to the commercial book-entry system. Starting in September 1997, investors can sell Treasury securities directly through the Federal Reserve by submitting a "security transfer and sale request" form to the Federal Reserve Bank of Chicago. The Federal Reserve Bank of Chicago obtains price quotes from three government securities dealers and sells the bond to the dealer with the highest offered price.[9]

Using professional dealers of government securities. Investors who buy or sell indexed bonds through professional dealers of government securities usually incur an additional commission cost. The advantage of using a dealer to purchase indexed bonds is that investors can buy the bonds anytime, usually on the secondary market. In contrast, purchases through the Federal Reserve banks require investors to buy them at auctions, which is currently once per quarter. The other advantage of using dealers is that sells are quicker since the bonds are already held in the commercial book-entry system. In comparison, unless an investor lives in Chicago, selling through the Federal Reserve

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System is usually slower since the request form has to be physically submitted to the Federal Reserve Bank of Chicago.

Using mutual funds. Currently, few mutual funds hold only Treasury indexed bonds since there are still relatively few Treasury indexed bonds available. There are, however, a few mutual funds that invest mainly in indexed bonds, both in Treasury indexed bonds and inflation indexed bonds issued by other government agencies and private companies. These funds provide another channel for investors who want to invest in indexed bonds. While there is limited value in investing in mutual funds dedicated to Treasury indexed bonds, mutual funds will be a convenient vehicle for investing in inflation indexed bonds issued by organizations that do not have as good a credit rating as the U.S. Treasury, once such issues proliferate.

months of the bond. The CPI will be 101 after the first six months and the index ratio will be 101/100, or 1.01. As a result, the dollar value of a $1,000 par bond after six months will be $1,010 ($1,000 times the index ratio of 1.01).[10]

The actual CPI ratio used in calculating the dollar par value of an indexed bond has a three-month lag built in, because the actual inflation for a given month is not known until almost two months later. Here is a real world example: The first 10-year Treasury indexed bond has an issuing date of January 15 1997. Thus, the CPI level on October 15,1996, which was 158.435, became the reference CPI for the bond. The coupon rate of the bond was set at the auction at 3.375 percent. On July 15, 1997, the CPI ratio was 160.155 (the CPI on April 15) divided by 158.435 (reference CPI), which equals 1.01086. Thus, the indexed bond with a real par value of $1,000 had a nominal par value of $1, 010.86 on July 15. Its semiannual coupon payment was $1,010.86 times one-half of 3.375 percent, or $17.06.[11]

II. HOW CAN INVESTORS BENEFIT FROM INDEXED BONDS?

Treasury inflation indexed bonds are a unique asset class that offers new opportunities to investors. These assets have virtually only one risk: the risk that the real interest rate prevailing in the market will change. In contrast, all other financial assets currently available embody more than one risk. In particular, conventional Treasury bonds have both real interest rate risk and inflation risk. Thus, Treasury indexed bonds provide investors with a safer asset than has historically been available. Further, because indexed bonds have only real interest rate risk, combining them with conventional bonds allows investors to disentangle inflation risk from real interest rate risk and thus to manage financial risk more efficiently.

Indexed bonds are safer than conventional bonds

The first section showed that while both indexed bonds and conventional bonds are debt securities issued by the U.S. Treasury, fundamentally they are quite different. Both bonds are free from default risk, but indexed bonds are much safer for two reasons. First, during an indexed bond's life, its market price is only affected by the real interest rate prevailing in the market. That is, the only market risk associated with indexed bonds is real interest rate risk. In comparison, the market price of a conventional bond is affected by both the real interest rate and inflation expectations prevailing in the market. Second, if held to maturity, the real yield on an indexed bond is certain *ex ante*, while the real yield on a conventional bond is not.

The market price of an indexed bond will only be affected by the real interest rate. In general, the market price of an existing bond, which reflects the value of the bond perceived by financial market participants, will change due to changes in the corresponding interest rate prevailing in the market. Specifically, the market price of an indexed bond varies inversely with the *real* interest rate, while the market price of a conventional bond varies inversely with the *nominal* interest rate. Thus, the only market risk in indexed bonds is the risk that the real interest rate prevailing in the market will vary over time. Because indexed bonds are also free of default risk, they are the only financial asset currently available that embodies only one risk.[12]

In comparison, the market price of a conventional bond varies inversely with the *nominal* interest rate prevailing in the market. The nominal interest rate is the sum of two components. One is the real interest rate prevailing in the market, r^{real}, and the other is the market expected future average inflation, π^e. As a result, there are two risk factors in conventional bonds: real interest rate risk and inflation expectation risk. Changes in either component could cause changes in the nominal interest rate and consequently in the market price of a conventional bond.

The reason that the market price of a bond varies inversely with the corresponding market interest rate is as follows: If the market interest rate goes up (down), an existing bond with an already fixed coupon rate will become less (more) desirable; thus, its market price will fall (rise) until its yield is the same as the market interest rate. For example, suppose an indexed bond with $1,000 par value pays 3 percent coupon interest but the market real interest rate increases to 3.3 percent. Clearly, no investor will be willing to pay $1,000 for the 3 percent coupon bond. Therefore, the market price of the bond will fall so that the yield on the bond is equal to 3.3 percent as well, which would be roughly a bit more than $900 for every $1,000 par value.[13]

The real yield of holding an indexed bond to maturity is certain. If an indexed bond is held to maturity, it guarantees the real yield prevailing in the market at the time of its purchase. For example, an investor buying an indexed bond at a price equal to its par value knows that the real yield of the bond will equal the coupon rate if held to maturity. There is no uncertainty or risk. The *ex post* real yield of holding the bond to maturity will be equal to its *ex ante* real yield.

In contrast, the real yield of holding a conventional bond to maturity is unknown *ex ante*. The real yield of a conventional bond, which is what really matters to investors, equals the nominal yield minus the actual average inflation rate during the life of the bond. Since the nominal yield of holding a conventional bond to its maturity is fixed, investors need to forecast future inflation, π^e, in order to forecast the real yield of a conventional bond. If the forecast has large errors, which is likely for long-horizon forecasts, the actual, or *ex post*, real yield can turn out to be quite different from the *ex ante* forecast. This can be called the forecast error risk, which is quite different from the inflation expectation risk.

Table 2

RISK COMPARISON OF INDEXED AND CONVENTIONAL BONDS

	Market risk	Real yield risk (held to maturity)
Indexed bonds	Real interest rate risk	None
Conventional bonds	Real interest rate risk; Inflation expectation risk	Forecast error risk

While an investor who can hold a bond to its maturity may not be too concerned about inflation expectation risk, there is reason to worry about forecast error risk. Historical experiences have shown that the forecast error risk in conventional bonds can be quite high. For example, in 1955, many investors bought a 40-year Treasury bond with a nominal coupon rate of 3 percent. Presumably, investors who agreed to lend the money so cheaply to the government were expecting a fairly low inflation for the next 40 years. If one looked at the average annual inflation rate for the 30 years before 1955, it was a little over 1 percent. Therefore, investors' inflation forecast at the time seemed quite reasonable. Unfortunately for these investors, average inflation for the 40 years of the life of this bond was actually 4.4 percent. Therefore, the real return for investors in this bond turned out to be a *negative* 1.4 percent. In fact, if an investor bought $1,000 par value of this bond at issuance and held it to maturity, the sum of all the coupon payments during the 40 years and the final principal payment was equivalent to only $582.73 of the purchasing power of 1955. In other words, the investor lost more than 40 percent of the original investment due to forecast errors!

In summary, indexed bonds are much safer than conventional bonds (Table 2). In fact, they are the safest medium-term to long-term assets currently available in the market. Indexed bonds are much safer for two reasons. In terms of market price risk, indexed bonds have only one risk—real interest rate risk—while the conventional bonds have both real interest rate risk and inflation expectation risk. In terms of the real yield risk, if held to maturity, the *ex post* real yield on an indexed bond is equal to its *ex ante* real yield with certainty, regardless of actual inflation.[14] In contrast, the *ex post* real yield of holding a conventional bond to maturity is unknown, with a potentially large forecast error risk.

Indexed bonds are convenient for investors who want stable real investment income

It is clear why indexed bonds are attractive to investors whose goal is to put some of their long-term investment in a safe asset that guarantees a fixed real yield. Indexed bonds are particularly convenient for investors who, in addition to wanting safety, also want to live off the steady interest income of their investment while keeping the principal intact. Because both the principal and coupon payments of an indexed bond are adjusted for inflation, an investor can count on the steady purchasing power provided by the coupon interest payments during the life of the bond. Further, when an indexed bond matures, its principal has the same purchasing power as when it was invested.

In comparison, conventional Treasury securities are much more cumbersome, complicated, and costly to use for an investor who wishes to live off a steady interest income while preserving the principal. For example, for the 5-year conventional bond in Table 1, when actual inflation equals the expected inflation of 2 percent, the $1,000 principal is only worth about $900 in terms of real purchasing power at maturity. Therefore, to preserve the purchasing power of the principal, investors in the conventional bond must constantly save some interest income (roughly $20 the first year, $20 times 1.02 the second year, $20 times $(1.02)^2$ the third year, etc.) and reinvest it in order for the dollar value of the principal to increase at the same rate as inflation. While this strategy preserves the real purchasing power of the principal and leaves investors with a constant *real* amount of interest to consume, it is complicated and costly to execute, even in this simple scenario where actual inflation equals expected inflation every year. If actual inflation fluctuates over time, or differs from expected inflation, it is even more difficult to use conventional bonds to achieve the goal of keeping both the principal and the investment income constant in real terms.

Indexed bonds allow investors to manage risk more efficiently

Many investors, especially fund managers, use Treasury securities as a risk management tool. That is, they use Treasury securities as vehicles to take or hedge risks. Historically, conventional bonds bundle together both real interest rate risk and inflation expectation risk; therefore it has been difficult for an investor to take (or hedge) only one risk. Now with the help of the Treasury indexed bonds, this can be accomplished quite easily. Specifically, if an investor wants to take (or hedge) only real interest rate risk, this can be done through buying or selling indexed bonds. On the other hand, if an investor wants to take (or hedge) inflation risk, indexed bonds can be combined with conventional bonds to create a portfolio—a synthetic asset—which only has inflation risk. Thus, the creation of Treasury indexed bonds allows investors to manage real interest rate risk and inflation risk much more efficiently: Investors can now precisely keep the risk they are comfortable with and remove the risk they do not want to bear.

Let us look at a numerical example. Because it is straightforward to see that buying or selling indexed bonds involves only real interest rate risk, the example aims to show how indexed bonds can be combined with conventional bonds to create a portfolio with only inflation risk. As mentioned earlier, the nominal yield of a conventional bond consists of two components: $y^{nominal} = r^{real} + \pi^e$, where r^{real} is the real interest rate prevailing in the market, and π^e is the market expected future average inflation during the life of the bond, both at the time of the purchase. Assume that r^{real} is currently equal to 3.5 percent and π^e is equal to 2 percent, so that the nominal yield on the conventional bond is roughly 5.5 percent. Now consider a portfolio that sells short the conventional bond and buys the indexed bond.[15] Ignoring transaction costs, the nominal yield of selling short a conventional bond is the negative of the nominal yield on the bond, or -5.5. The nominal yield of the indexed bond will equal the real yield plus the actual inflation, that is, $3.5 + \pi$. Consequently, the nominal yield of this portfolio will be equal to the net of the two bond yields, or $\pi - 2$.[16] In other words, the only risk in this portfolio is inflation risk since its yield varies positively with actual inflation and only actual inflation. There is no real interest rate risk in this synthetic portfolio asset. As a result, an investor can manage inflation risk easily by buying or selling this portfolio.

The above discussion shows why indexed bonds can benefit all investors, not just investors who do not want to be exposed to inflation risk. The combination of indexed bonds and nominal bonds allows investors, especially fund managers, to disentangle real interest rate risk and inflation risk so that they can remove (or take) precisely the risk according to their individual choices. In this sense, the Treasury's issuance of the indexed bonds expands the investment universe for all investors and allows more efficient risk sharing and risk management for all participants in the market.[17]

III. IMPACT OF TAXES ON TIPS

In the earlier discussions, all the returns discussed were before taxes. For most investors, however, investment income is subject to taxes, which complicates the matter. One of the most substantial complications is that because the current U. S. tax code does not distinguish nominal income from real income, income taxes re-expose indexed bonds to inflation risk. As a result, for investors who are subject to taxes, even indexed bonds are not completely inflation risk free. In fact, with the combination of high inflation and taxes, it is possible that an indexed bond can have negative after-tax real returns. When this happens, it shows up as a cash flow problem for investors.

The tax code re-exposes indexed bonds to inflation risk

All interest income and appreciation of the principal of an indexed bond are taxed as normal interest income, even though the appreciation of the principal only keeps the principal constant in terms of purchasing power. Further, the appreciation of the principal is taxed in the year it is accrued, rather than in the year it is realized. For example, in Table 1, in the third scenario of 4 percent actual inflation, the principal will become $1,040 at the end of the first year. Thus, an investor in the bond will be subject to income tax on $76.40 of interest income that year ($36.40 in coupon interest plus $40 in the appreciation of the principal).[18]

Unfortunately, because the tax code does not distinguish nominal income from real income, the tax burden of an investor in indexed bonds increases when inflation increases. Consequently, in terms of after-tax yield, even indexed bonds are not entirely inflation risk free. Table 1 illustrates this point. Assume the marginal tax rate for an investor is 30 percent. At the end of the first year, in the first scenario of zero actual inflation the total investment income subject to tax will be $35; thus, the investor's tax liability will be $10.50 ($35 times 0.3). In the third scenario of 4 percent actual inflation, the total investment income subject to tax will be $76.40 ($36.40 + $40); thus, the investor's tax liability will be $22.92 ($76.40 times 0.3). Because the before-tax *real* yield does not change under the higher inflation scenario but the tax liabilities are more than doubled, the investor's after-tax real yield declines.[19]

Even though the tax code brings inflation risk back to indexed bonds, the risk is small compared with nominal bonds. For every percentage point increase in inflation, the after-tax real yield on a nominal bond is reduced by a whole percentage point, while the after-tax real yield on an indexed bond is reduced only by the fraction of the marginal tax rate facing the investor of the bond. To understand this difference, note that the after-tax real yield of a bond is the before-tax real yield minus the percentage tax burden. For a conventional bond, the before-tax real yield varies inversely one-for-one with

Table 3

IMPACT OF TAXES

Nominal bond with 5 percent coupon rate

Inflation rate (1)	Before-tax nominal yield (2)	Before-tax real yield (3) = (2) – (1)	Tax burden (4) = (2) x 30%	After-tax real yield (5) = (3) – (4)	Change in after-tax real yield (6) = change in (5)
2	5	3	1.5	1.5	—
5	5	0	1.5	-1.5	-3.0

Indexed bond with 3 percent coupon rate

Inflation rate (1)	Before-tax real yield (2)	Before-tax nominal yield (3) = (1) + (2)	Tax burden (4) = (3) x 30%	After-tax real yield (5) = (2) – (4)	Change in after-tax real yield (6) = change in (5)
2	3	5	1.5	1.5	—
5	3	8	2.4	.6	-.9

actual inflation since it is just the fixed nominal yield minus inflation. The tax burden does not vary with inflation because it is a percentage of the fixed nominal yield. Thus, every percentage point increase of inflation will cause the real yield (both before-tax and after-tax) to decline by one percentage point. For an indexed bond, in contrast, the before-tax real yield is fixed because the nominal yield rises one-for-one with inflation. But the rise in the nominal yield increases the tax burden. Specifically, the tax burden rises by the increase in the nominal yield, which is the inflation rate, π, times the tax rate, t, or πt. Thus, for an indexed bond, inflation reduces the after-tax real yield by increasing the tax burden. The decline in the real yield, however, is a percentage of the inflation rate rather than the entire amount of inflation.

Table 3 presents a numerical example using two inflation scenarios. In the first scenario, actual inflation is 2 percent as expected, and in the second scenario inflation unexpectedly surges to 5 percent. The marginal tax rate is 30 percent. The top panel of the table shows what happens to the after-tax real yield of a conventional bond. The before-tax nominal yield is fixed at 5 percent in both inflation scenarios, which implies that the tax burden is 1.5 percent (30 percent of the 5 percent nominal yield) in both scenarios as well. Consequently, the 3-percentage-point increase of inflation has reduced both before-tax and after-tax real yields of the nominal bond by three percentage points.

The lower panel of the table shows what happens to the real yield of an indexed bond. Notice that columns two and three are switched, since the real yield of the bond is fixed now at 3 percent and the nominal yield is derived. In the first scenario, the before-tax nominal yield is 5 percent; thus, the tax burden is 1.5 percent. Consequently, the after-tax real yield is 1.5 percent. In the second scenario, as inflation unexpectedly surges, the before-tax nominal yield of the indexed bond rises accordingly to 8 percent. While the before-tax real yield of the indexed bond is still 3 percent, the after-tax real yield declines to 0.6 percent because the tax burden increases to 2.4 percent. The 0.9-percentage-point decline in the after-tax real yield, however, is much smaller than the 3-percentage-point decline in the real yield of the conventional bond.

Potential cash flow problem indicates negative real after-tax yield

Since the appreciation of the principal due to inflation is taxed in the year it occurs, an investor could face a cash flow problem in the sense that the tax liability due to high inflation could exceed the coupon interest income. For example, assume that the coupon rate on an indexed bond, c, is 3.5 percent, actual inflation, π, is 10 percent, and the marginal tax rate, t, is 30 percent. Then the coupon interest payments for $1,000 par are equal to the dollar value of principal of $1,100 ($1,000 times $1 + \pi$) times the coupon rate 0.035 (c), which is $38.50. The tax liability is 30 percent of the sum of the coupon payment ($38.50) and the increase in the dollar value of the principal ($100), which is equal to $41.55 ($138.50 times 0.3). The interest income will not be enough to pay the tax bill.

The fundamental issue here, however, is not the cash flow problem *per se*. Conceptually, it is easy to solve the cash flow problem: if an investor does not have other sources of cash, a small portion of the principal of the bond can always be sold to raise cash for the tax bill. The fundamental issue is that when the coupon interest is not enough to pay the tax bill; that is, when the net cash flow of the interest income and tax liability is negative, it indicates unambiguously that the combination of inflation and taxes has eroded the real purchasing power of the principal. Why? By the design of indexed bonds, the principal of a bond remains constant in terms of real purchasing power and the coupon payments represent the total investment income from the bond. If the coupon payments are not enough to cover the tax bill for an investor, it indicates that inflation and taxes have more than eliminated the entire real investment income of the indexed bond at that point. In other words, since a net cash flow of zero indicates the after-tax real yield on the bond to be zero, a negative net cash flow indicates the after-tax real yield to be negative as well. The negative cash flow is just the symptom, not the disease. In comparison, even though there will never be a cash flow problem associated with conventional bonds, inflation has a larger negative effect on their real yields.[20]

IV. THE MARKET RISK OF INDEXED BONDS

While indexed bonds are the safest assets currently available in the financial market, they are not risk free. As the earlier discussion showed, they do have the risk that the market prices of the bonds may change due to changes in the real interest rate prevailing in the market. The risk that the market price of an asset will change over time is sometimes called market risk, emphasizing that an investor who wants to sell the asset before its maturity is at the mercy of the market.

Why do investors need to be concerned about market risk?

Investors need to consider the market risk of indexed bonds when making their investment decisions. Market risk is clearly relevant for investors who use indexed bonds to manage risks. For those investors, it is necessary to frequently change the type or amount of the bonds in their possession according to the overall changes in the investment environment, and investors must do so at the prices determined by the market. Similarly, for investors who frequently rely on the financial market for funding purposes, market risk is relevant since indexed bonds may be used as collateral and their value depends on market prices. Though less obvious, market risk is also relevant for investors who use indexed bonds to lock in fixed real yields for the long run and plan to hold them to maturity, because they may decide to sell earlier due to unexpected events.

More fundamentally, investors should be concerned about the market risk of a bond because the market price represents its true value. If the market price of a bond is below (above) its purchasing price, the difference represents the opportunity cost (gain) of the funds tied up in holding the bond to its maturity. For example, assume there is a 1-year bond that pays 5 percent coupon interest at the end of the year. That is, for $1,000 par value, the bond owner will be paid $1,050 at the end of the year. If the market interest rate is 5 percent, the price of the bond will be at its par value of $1,000. If, however, the market interest rate suddenly changes to 6 percent, the price of the bond will fall to $990.57 (990.57 divided by 1,050 equals 6 percent). An investor selling this bond after the change in the market interest rate will suffer a loss of $9.43 ($1,000-$990.57). What is less obvious, but not less true, is that even if the investor does not sell, $9.43 still represents the opportunity cost of tying up $1,000 in a bond with only a 5 percent coupon. If the investor had not committed the funds to the bond, the $1,000 would have yielded $1,060 at the end of the year because the market rate has changed to 6 percent. In this case, $9.43 is just the lost income of $10 discounted by the market interest rate ($10/1.06).

How does the market risk of indexed bonds compare with nominal bonds?

It is difficult to theoretically assess the quantitative difference of the market risks of indexed bonds and nominal bonds. This might seem surprising given that the earlier discussion showed that indexed bonds are safer than conventional bonds because, ignoring the tax effect, prices of indexed bonds are affected only by the real interest rate, while prices of conventional bonds are affected by both the real interest rate and inflation expectations.[21] The quantitative difference between the market risks of indexed and conventional bonds is difficult to assess because, while changes in inflation expectations do not affect the price of an indexed bond, changes in the real interest rate have a larger effect on the price of an indexed bond than on the price of a conventional bond with a comparable maturity.

The same change in the real interest rate will cause a larger change in the price of an indexed bond primarily because payments of an indexed bond are more "back-loaded." In other words, compared with a nominal bond of similar maturity, the payments of an indexed bond tend to be smaller in the early years of the bond, but larger in the later years. For example, in Table 1, with actual inflation of 2 percent, the indexed bond and nominal bond have basically the same yield. The payments of the indexed bond, however, are smaller than the payments of the nominal bond for the first four years but are much larger for the fifth year. Because the change in the prices represents the opportunity costs (gains) of the funds tied up in the bonds, the more funds that are tied up, the higher the opportunity cost (gain), and the larger the change of the price. An indexed bond has more payments back-loaded;

Table 4

AVERAGE PERCENTAGE PRICE CHANGES OF INDEXED BONDS AND CONVENTIONAL BONDS WITH THE SAME MATURITY

	U.S. 10-year bonds		UK 10-year bonds		UK 5-year bonds	
	Daily	Weekly	Daily	Weekly	Daily	Weekly
Indexed	.13	.28	.13	.32	.10	.26
Conventional	.26	.56	.30	.62	.16	.33

thus, more funds are tied up in the bond at any point in time. Consequently, an indexed bond's price response will be larger than a conventional bond's for the same real interest rate change.[22]

The higher price sensitivity of indexed bonds to real interest rate changes makes it difficult to compare the market risk of indexed and conventional bonds. On the one hand, if the prospect of future inflation changes, the price response of an indexed bond will be much smaller than that of a conventional bond. On the other hand, if the real interest rate changes, the price response of an indexed bond will be larger than that of a comparable conventional bond. It is not clear which impact is greater because both inflation expectations and real interest rates change over time, and there is no *a priori* reason to believe that one varies more than the other.

One way to find out the relative importance of the two risk factors is to look at the actual historical data. Actual price data on U.S. and United Kingdom indexed bonds suggest that the overall market risk is much smaller for indexed bonds, suggesting that inflation expectations are more variable than real interest rates (Table 4). The data are average percentage daily and weekly price changes of the indexed bonds and the comparable conventional bonds.[23] For the U.S. market, the data are from the end of January to the middle of September. The averages are calculated from the end-of-day prices of the 10-year TIPS (issued in January 1997) and the average of the 10-year conventional Treasury bonds issued in November 1996 and February 1997, respectively.[24] Because the market for indexed bonds is still quite new in the United States, similar data on UK government bonds, which are called gilt-edged bonds, or simply gilts, are also presented. The sample period for the UK market is from April 1993 to April 1996 for the 5-year gilt and from April 1993 to April 1997 for the 10-year gilt. The pattern in the UK market is similar to the pattern in the U. S. market: the total price fluctuation of the indexed bond has been much lower than the total price fluctuation of the conventional bond with a similar maturity.

V. CONCLUSION

Indexed bonds are a safe, new class of assets that bear little risk except real interest rate risk. These bonds benefit not only investors who are interested in investing in safe assets by providing them safer bonds than the conventional Treasury bonds, but also investors who wish to separate inflation risk from real interest rate risk and thus manage risk more efficiently. Indexed bonds, however, are not entirely inflation risk free for most investors due to the effect of the tax code. In regard to the market risk, historical data suggest that the overall market risk for indexed bonds is smaller than that for comparable conventional bonds.

ENDNOTES

[1] In comparison, the annual gross domestic product (GDP) for the nation is around $8 trillion.

[2] Technically, Treasury debt instruments with maturities of one year or less are called Treasury bills, maturities of between one to ten years are called Treasury notes, and maturities of more than ten years are called Treasury bonds. A Treasury bill is issued at a discount to its par value and pays its investor the full par amount at the time of its maturity. The difference between the par and the discounted issuing price is the interest payment. In contrast, a Treasury note or bond pays its investors interest in the form of semiannual coupons and the full par amount at the time of maturity. This article does not distinguish between maturities and calls all debt instruments with coupon payments, that is, notes and bonds, "bonds." Currently, indexed bonds form a very small portion of the total market of Treasury securities. The total outstanding value of 10-year indexed bonds is about $23 billion, and the total outstanding value of 5-year indexed bonds is about $16 billion. The total outstanding value for Treasury securities, on the other hand, is in the range of $4 trillion.

[3] This is only true in terms of before-tax considerations. In fact, the current tax code brings some inflation risk back to the Treasury inflation protection securities. This issue will be discussed in detail later in the article.

[4] This is called the Fisher identity for continuously compounded interest payments. If interest payments are discretely compounded, as in Table 1, the Fisher identity is slightly different. The difference is small when the inflation rate is less than 10 percent. Thus, the version for continuously compounded interest is used for expositional simplicity. Further, the article ignores the possibility of an inflation risk premium in the yield of nominal bonds. In most cases, including a risk premium will not qualitatively change the discussion.

[5] This is true even if actual inflation equals expected inflation, and thus the nominal coupon rate on the conventional bond has built in the proper compensation for the actual inflation.

[6] There has been much discussion about various biases in CPI-measured inflation, and the BLS is continuously working on improving the measure. Despite its various defects, the CPI is still considered one of the best measures of inflation currently available.

[7] Purchasing, redeeming, and reselling Treasury bonds are accomplished in the same way for both indexed and nominal bonds. Thus, most of the discussion also applies to nominal Treasury securities.

[8] On the tender form, an investor needs to indicate at what interest rate, in real terms, that she is willing to lend to the Treasury. An investor can either write this rate explicitly, which is called a competitive bid, or indicate that the bid is noncompetitive. For the indexed bonds, a single-price auction method is used. Thus, if an investor bids competitively and the resulted auction yield is at or above the investor's bid, the investor buys the bond at the price set by the auction. But if the auction yield is below the investor's bid, the investor does not get to buy this particular issue. In contrast, investors who bid noncompetitively buy the bond at the price set at the auction.

[9] For this service, the Federal Reserve Bank of Chicago charges a $34 service fee for each security sold. In general, there is no service charge for purchasing Treasury securities through the Federal Reserve banks. The Bureau of Public Debt, however, charges an annual fee of $25 for a Treasury Direct account with balances above $100,000.

[10] In the unlikely case that the CPI index is lower than unity at maturity, that is, the general price level actually declines during the life of an indexed bond, the Treasury has guaranteed that an investor will get the full par value back at maturity. In other words, if deflation occurs, investors in indexed bonds will get a windfall gain.

[11] There are many easy ways to find out current CPI ratios for Treasury indexed bonds. All the Federal Reserve bank branches can provide this information. Further, the Department of Treasury has an Internet website

(www.publicdebt.treas.gov) which publishes reference CPIs and daily index ratios for all the Treasury indexed bonds.

12 The market risk of indexed bonds is discussed in further detail in the last section of the article.

13 The precise price is impossible to calculate without specifics on the time to maturity. Without consideration of the capital gains in the principal, the $900 price will give a coupon yield of 3.3 percent since every $1,000 par value will pay $30 in coupon interest per year. Since capital gains raise the total yield of the bond above the coupon yield, market competition will drive up the price of the bond to a bit over $900.

14 To be precise, it is the before-tax real return that will not change with inflation. The after-tax real return, discussed in the next section, declines with inflation.

15 In reality, even though professional fund managers short sell Treasury bonds frequently, it is costly for individual investors to do so. A more cost-effective approach is to use futures or options contracts to achieve this synthetic portfolio asset.

16 Since the nominal yield on selling short the conventional Treasury bond is the negative of $r^{real} + \pi^e$, and the nominal yield on buying the indexed bond is $r^{real} + \pi$, the net yield of the portfolio is the difference between the actual and expected inflation, $\pi - \pi^e$.

17 For readers who are familiar with the investment literature, indexed bonds expand the dimensions of the asset universe, which, theoretically, will change every investor's portfolio choice, even those who are not particularly concerned about inflation risk. In particular, investors might want to replace conventional Treasury bonds with indexed Treasury bonds as the safe asset in their portfolios and reevaluate the optimal portfolio mix accordingly. If the returns on indexed bonds are less correlated with the returns on stocks than conventional bonds, which is likely, this strategy could lead to more efficient portfolio diversification with higher return, lower risk, or both.

18 The rationale of taxing the appreciation of the principal even if it is unrealized is to keep the tax equitable with other Treasury securities. For example, the tax on the appreciation of the principal of Treasury stripped bonds is also due in the year it occurs. Further, for conventional bonds, the nominal coupon interest includes compensation for expected inflation, π^e. Nevertheless, all the coupon payments are taxed as interest income. Therefore, if the appreciation of the principal of an indexed bond were not taxed in the year it occurred, it would effectively allow investors of indexed bonds to postpone their tax liabilities. This would have created a tax advantage for indexed bonds and thus resulted in distortions in the demand for indexed bonds relative to the demand for conventional bonds.

19 The after-tax investment incomes for the investor, in nominal terms, are $24.50 ($35 - $10.50) and $53.48 ($76.40 - $22.92), respectively. In terms of purchasing power, however, the after-tax real investment incomes will still be $24.50 with zero inflation, but only $12.96 (($36.40-22.92) / 1.04) with 4 percent inflation.

20 There will never be a cash flow problem with a conventional bond because the design of a nominal bond keeps its principal constant in nominal terms; thus, all that is subject to taxes is the coupon interest. Since the tax rate is less than 100 percent, the coupon interest will always be enough to pay the tax. This is, in a sense, equivalent to an investor in an indexed bond selling a portion of the principal every year so that all of the dollar appreciation in the principal due to inflation is realized. Thus, another advantage of indexed bonds is that investors know when the combination of taxes and inflation has turned their real after-tax return negative, whereas it is less transparent with conventional bonds.

21 The tax code brings inflation risk back to indexed bonds, since the after-tax real yield is equal to $(y^{real} + \pi)(1\text{-}t) - \pi = y^{real}(1\text{-}t) - \pi t$. But the inflation risk is still much smaller than the inflation risk in conventional bonds, the after-tax real yield of which is equal to $y^{nominal}(1\text{-}t) - \pi$. Therefore, if the marginal tax rate facing an investor is 30 percent, the effect of inflation on the after-tax real yield of an indexed bond is only 30 percent of the effect on a conventional bond. Consequently, if the nominal interest rate prevailing in the market changes due to changes in expected inflation, the price of a nominal bond will change much more than the price of an indexed bond.

22 The intuition is similar to why the price of a bond with a remaining life of, say, seven years, will in general change more for the same change in the interest rate than the price of a bond with a shorter remaining life, such as three years. A reader familiar with the concept of "duration" might like to describe the indexed bond as having longer "duration" than its conventional counterpart. The article avoids the terminology because the duration of an indexed bond is not directly comparable with the duration of a conventional bond: One is calculated with the real interest rate as the discount rate, while the other is calculated with the nominal interest rate as the discount rate. For example, for a conventional bond, its duration represents the price risk

caused by changes in the nominal interest rate. But for an indexed bond, its price will change little if changes in the nominal interest rate are due to changes in inflation expectations.

[23] Another commonly used measure of the volatility is the variance (or standard deviation) of the daily return. While the results are qualitatively the same, the average percentage change of price, as used in Table 4, is more closely related to the price risk discussed in the article.

[24] For the conventional bonds, the average percentage price changes of bonds issued in both November 1996 and February 1997 are used. There are typically more trading and, consequently, more price movements in a newly issued (on-the-run) bond. Therefore, while the February bond is better matched in maturity with the indexed bond, its price risk may be overstated. This is why the November bond is included in the average. The results are qualitatively the same regardless of which conventional bond is used, whether a single bond is used, or the average is used.