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Risk and Return in the TIPS Market

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Abstract

In this article, the risk and return characteristics of Treasury Inflation Protected Securities (TIPS) are empirically examined and compared to those of a series of investments in Treasury Bills. Using secondary market prices for the period January 1997 to May 2001 on TIPS issued in the United States, we show that TIPS offer a marginally higher average return but a much higher volatility of returns than a series of Treasury Bills, for various investment horizons. We argue that the observed risk/return qualities are introduced by the variability of real rates and the taxation of inflation adjustments made to TIPS.

1. Introduction

Recently, we have seen the advent of inflation-protected investments. Since 1997, the U.S. Treasury has issued five-year, ten-year, and thirty-year notes and bonds indexed to the Consumer Price Index (CPI-U). These are collectively known as Treasury Inflation Protection Securities or TIPS. Also, since September 1, 1998, other indexed securities have been issued by governmental agencies such as the Tennessee Valley Authority and the Federal Home Loan Bank System. In addition, at least four mutual funds have been created to invest solely in these securities. In this article we examine the realized return and volatility of returns of TIPS for the period January 1997 to May 2001. Our results provide financial planners a clear idea of TIPS characteristics and their suitability for inclusion in an investment portfolio.

In spite of this recent activity, market acceptance of TIPS has been limited. TIPS represent only about three percentage of the total Treasury marketable debt (Dupont and Sack, 1999). Also, secondary market trading has been very limited (Lucas and Queck, 1998). One possible

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reason for the lackluster performance is today's relatively low inflation rate and the reduced need for inflation protection. The market may be further limited because of the Treasury's decision to tax inflation adjustments as current income.

Because the inflation adjustments made to TIPS are taxed as current income and because the adjustments rise in periods of inflation, taxes paid can exceed the cash coupon in any period. Thus, investors can end up making net payments to the Treasury merely to preserve the inflation-adjusted principal. Depending upon the inflation rate, the after-tax cash flow on TIPS can be either positive, zero, or negative. At best, under moderate inflationary conditions, the after-tax cash flow declines as inflation rises. This is clearly not the intended outcome for those seeking inflation protection. TIPS deliver this protection only for investors not subject to income taxation.

Beyond their failure to deliver inflation protection to taxable investors, TIPS also have the following negative qualities for taxable investors:

- Because both real and nominal returns on TIPS vary with future rates of inflation, taxable investors are unable to lock in either a nominal or a real yield on TIPS.
- For taxable investors, net after-tax coupons/cash flows can become negative. This would not occur when taxable investors buy traditional securities nor when tax-exempt investors purchase TIPS. If positive cash flows are deferred until TIPS mature, they carry an embedded market risk.

Theoretical TIPS returns in the absence of taxes are similar to those of a series of investments in Treasury Bills plus an adjustment for possible changes in real rates. Given the tax consequences and the risks from an investment in TIPS, they would appeal to a taxable investor only if the holding period return is significantly higher than a series of investments in one-month Treasury Bills. We empirically show that returns on TIPS are marginally higher than corresponding investments in Treasury Bills for the similar investment horizons. However, TIPS returns are much more volatile than Treasury Bill returns. We argue that these observations are due to the volatility introduced by changes in the real rates and the taxation of principal adjustments as current income.

Background information and a review of recent literature dealing with taxation and its impact on TIPS is provided in Section 2. Section 3 of this article contains a general description of TIPS. The impact of income taxation on real coupon rates is examined in Section 4. During periods of relatively high inflation, TIPS are shown to change in character from positive to negative coupon bonds. In Section 5, market price data since 1997 are used to determine the average and standard deviation of returns for different holding periods (investment horizons). Finally, in the last section, we present a summary of main points and conclusions.

2. Background and literature review

Inflation indexation of government debt in the United States dates as far back as 1780, when the state of Massachusetts created a commodity-based formula for debt payments (Campbell and Shiller, 1996). For the most part, foreign experience has been similar to that

of the United States, with inflation-indexed debt tending to be a small percentage of the total debt (Kopcke and Kimball, 1999). Even so, some noteworthy patterns exist. The most success in issuing such debt has been in countries experiencing high and/or volatile rates of inflation (Kopcke and Kimball, 1999; Campbell and Shiller, 1996; Hochman and Palmon, 1988). Huh (1995) also suggests that countries wishing to signal their intention to reduce inflation have also been important issuers. In the United Kingdom, where inflation adjustments are not taxed as current income, the amount of inflation-indexed debt was 22% as of September, 1999 (Dupont and Sack, 1999). More importantly, among foreign issuers, this represented the largest total amount of such debt outstanding.

Notwithstanding the experience of the United Kingdom, the decision to tax the inflation adjustments was made by the United States Treasury in order to avoid a relative subsidy for TIPS investors (Campbell and Shiller, 1996). This also suggests that no subsidy would exist because the market would price the securities commensurately with their tax-exempt status, had the Treasury chosen otherwise.

TIPS have been the subject of some attention in the academic literature. Several writers (e.g., Dupont and Sack, 1999; Shen, 1995) have noted that taxation may reduce the appeal of TIPS for taxable investors. Also, in periods of high inflation, Campbell and Shiller (1996) note the potential for negative after-tax cash flows on TIPS. In part because of taxes, Jayne (1998) notes that TIPS fail to deliver a fixed real return and, therefore, are not suited for use as compensation for real losses in legal settlements. Others, including Shen (1995), have observed that taxes reduce the inflation protection provided by TIPS. However, Shen also notes that the inflation protection provided by TIPS, even for taxable investors, is greater than that provided by traditional securities. Lucas and Queck (1998) examine the potential role of TIPS in a fixed-income portfolio. They also note a highly variable correlation between real and nominal returns on TIPS. Fraser, Jennings and King (2000) draw parallels between Social Security benefits and TIPS. Finally, Kopcke and Kimball (1999) conclude that TIPS appeal to risk-averse investors in high tax brackets, investors wary of rising inflation and investors who are not especially concerned about fluctuations in the real rate of interest. These conclusions presume that TIPS are priced to provide after-tax yields competitive with traditional Treasury securities.

In this paper we add to the literature by providing an empirical analysis of the risk and return characteristics of TIPS in comparison to a series of investments in Treasury Bills. We outline the impact of taxes and conclude that these tax effects make TIPS attractive primarily to tax-exempt investors.

3. Overview of TIPS

Like other marketable issues, the initial sales of TIPS are through the Federal Reserve System. After issuance, TIPS are sold by dealers alongside other marketable issues. In six-month intervals, the principal amount is indexed up or down to reflect the inflation rate. The index used is the CPI-U (the non-seasonally adjusted U.S. City Average All Items

Consumer Price Index for All Urban Consumers) published monthly by the Bureau of Labor Statistics of the US. Department of Labor (data on the consumer price index is obtained from the web site http://www.stls.frb.org/fred/data/cpi.html). When marking up the principal, the CPI-U is lagged by three months. This lag makes the inflation adjustment a retrospective one but does provide for certainty at the time of the markup. Because the CPI-U index is published monthly it is possible, using linear interpolation, to infer a daily value for the index, albeit lagged three months. Using this, on any day, a value for the adjusted principal can be inferred.

The real coupon payments on TIPS are a constant percentage of the adjusted principal. As the principal changes with inflation, the coupon payments change commensurately. Because of this, both the real value of principal and coupon are preserved over the life of the security

The characteristics needed to describe TIPS, including patterns in their after-tax payments, are listed below:

CPI_0 = CPI-U value applied at time of issue (beginning of the period)
π_t = Growth rate in the CPI-U during time period t.
CPI_t = CPI-U value applied at time t such that $CPI_t = CPI_0\Pi_1^t(1 + \pi_t)$.
F_0 = Principal value of the TIPS at time of purchase.
F_t = Adjusted principal value at time t such that $F_t = F_0\Pi_1^t(1 + \pi_t)$.
n = Remaining time periods to maturity
r = Real coupon rate attached to the security
ζ = Investor's marginal tax rate
C_t = After-tax real coupon rate in period t.

The above relationships indicate that, any point in time, the principal value ΔF_t is equal to the ratio CPI_t/CPI_0 times the initial principal value of the security F_0. This is true because the ratio of CPI_t/CPI_0 is the mathematical equivalent to a compound growth rate of $\pi_t$per period. This relationship provides the rationale for indexing. The markup occurring each period of time is stated by:

$$\Delta F_t = F_t - F_{t-1} = F_{t-1}(\pi_t). \tag{1}$$

This indicates that each period's adjustment to principal is equal to the prior period's adjusted principal times the most recent period's growth in the CPI-U.

4. The impact of taxes and real rates

The Treasury treats each period's markup to principal ΔF_t as ordinary income for tax purposes. The cash flow to an investor, net of taxes, is therefore equal to the sum of the real after-tax coupon received each period less the tax on the principal adjustment:

$$rF_t(1 - \zeta) - \Delta F_t\zeta. \tag{2}$$

The real after-tax coupon rate can be defined by dividing the above expression by F_t:

$$r(1 - \zeta) - \frac{\pi_t\zeta}{(1 + \pi_t)}. \tag{3}$$

The above relationship defines the net after-tax real coupon rate. Rather than being the pretax coupon rate multiplied by 1 minus the marginal tax rate, the after-tax real coupon rate actually varies inversely with both the investors' tax rate and the growth rate in the CPI-U.

4.1. Examples

The real after-tax coupon rate depends on both the investor's tax rate and the growth rate in the CPI-U. Given a 3.5% pretax real return, a 28% tax rate and a 2% growth rate in the CPI-U, the after-tax coupon rate would be:

$$r(1 - \zeta) - \frac{\pi_t \zeta}{(1 + \pi_t)} = .035*(1 - .28) - \frac{0.02*0.28}{1 + 0.02} = 1.97\%$$

If the CPI-U growth rate is 4%, then the above computations yield 1.45%. The examples above indicate that the after-tax real coupon rate varies inversely with the inflation index.

As inflation rises, the after-tax real coupon declines. If the securities were truly protected against inflation, then the real return would be constant regardless of the inflation assumption. Since the after-tax real coupon rate varies with this growth rate, no consistent inflation protection is provided. Also, given the inverse relationship, the more rapidly inflation grows, the lower the coupon payments. In periods of rapid inflation, when protection is most desired, real coupon returns can become negative. The inflation rate at which the coupon rate becomes negative is calculated by setting the equation for the after-tax coupon rate equal to zero:

$$r\,(1 - \zeta) - \frac{\pi_t \zeta}{(1 + \pi_t)} = 0 \text{ or when} \pi_t = \frac{r(l - \zeta)}{\zeta + r(l - \zeta)} \tag{4}$$

For a given tax rate, the coupons received can be either positive, zero, or negative. If π_t is less than $r(1-\zeta)/\zeta + r\,(1-\zeta)$, a positive coupon will be received. If π_t is equal to this, the security is a zero coupon bond, paying only the inflation-adjusted principal at maturity. Finally, if π_t is greater than this amount, a negative coupon exists and net payments must be made to the Treasury (in the form of taxes in excess of the current coupon interest) to preserve the inflation adjusted principal. With rising π_t TIPS thus change in character from positive to zero to negative coupon bonds. Also, with rising π_t positive cash flows necessarily become more and more concentrated at the maturity of TIPS. As this occurs, discounts in the secondary market become necessary to sustain a real return to maturity. In addition to future inflation rates, prices of TIPS will vary inversely with changes in real rates. An examination of TIPS issued over the past four years shows that real rates have fluctuated by over 1 percentage point with a range of 3.375% to 4.25% (Table 1).

4.2. TIPS versus Treasury Bills

As discussed above, returns on TIPS comprise two parts: 1) a real return and 2) an inflation adjustment of the principal (based on the increase in the consumer price index). As

Table 1
Data description

Issue date	Real coupon	Issue amount (M)	Maturity date	Years to maturity
1/15/97	3.375	16728	1/15/07	10
7/15/97	3.625	17661	7/15/02	5
1/15/98	3.625	17469	1/15/08	10
4/15/98	3.625	17479	4/15/28	30
1/15/99	3.875	16278	1/15/09	10
4/15/99	3.875	15061	4/15/29	30
1/18/00	4.25	6001	1/15/10	10

This table has a description of TIPS issued since 1997. Data is obtained from the *Bloomberg Information Services*. The first three issues are used in the empirical study.

an alternative to investment in TIPS, an investor could invest in a series of one-month Treasury Bills.

- The primary difference between the two investments is that Treasury Bills are priced based on expected inflation rather than realized inflation. However, for short maturity periods (e.g., one month) this discrepancy is not large. Note that TIPS are priced based on *realized* inflation (albeit with a lag).
- A second difference is that real returns are fixed in the case of TIPS but will vary with each new investment in Treasury Bills. As a result, Treasury Bill investments do not encounter the risk of adverse movements in real rates. This aspect will again increase the volatility of holding period returns of TIPS relative to Treasury Bills because a change in real rates is compounded over the lifetime of a TIPS. A higher average return on TIPS would be expected as a compensation for real return risk.
- Since TIPS are less liquid than corresponding investments in Treasury Bills, there should also be a liquidity premium for investment in TIPS.

5. Empirical analysis of risk and return characteristics

The hypothesis that we wish to evaluate is whether the risk and return tradeoff makes TIPS a more favorable investment than a series of Treasury Bills. The risk and return qualities of TIPS are important for practical reasons. If relative returns of TIPS reflect the tax status of one group of investors, others can exploit these differences in their portfolio decisions (Green and Odegaard, 1997). They are also important to financial planners and portfolio managers for making informed investment decisions.

5.1. Data and methodology

Data for this study are obtained from the *Bloomberg Information Services*. Table 1 provides a description of TIPS in the data set (only the first three issues are studied). The data

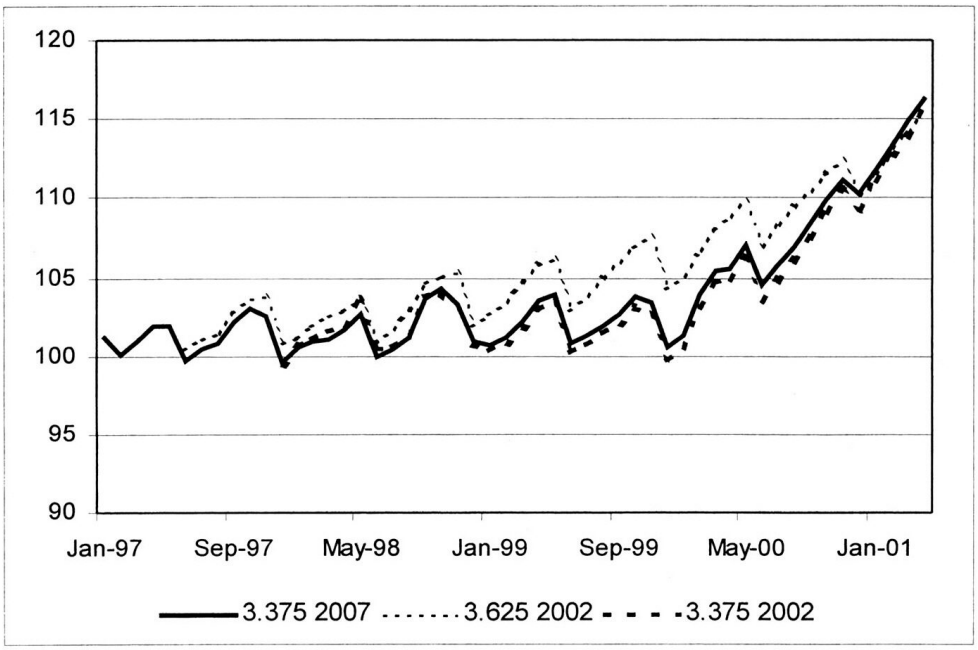

Fig. 1. Historical prices of TIPS. This graph illustrates the time-series of secondary market prices (plus accrued interest) of the first three TIPS sold by the United States Treasury in January 1997, June 1997, and January 1998. Data are obtained from the Bloomberg Information Services.

set includes monthly closing prices on three issues of TIPS from the time they were first introduced in 1997. Fig. 1 is a graphical depiction of the prices of each of the three TIPS. Data on Treasury Bills is obtained from the H15 release of the Federal Reserve Board. The Consumer Price Index (CPI-U) is also obtained from the Federal Reserve Board Web site.

Note that the quoted price in the secondary market does not account for accrued interest and the indexation effect on the price. Therefore, in order to calculate the return and volatility of returns on TIPS, we need to account for accrued coupons and any indexation lags. Assume the following notation:

- FV = Face Value.
- *Reference CPI* = The reference Consumer Price Index at the settlement date or purchase date (i.e., the CPI is lagged by three months).
- *Index Ratio* (IR_t) = The increase or decrease in the reference inflation rate between issuance date and settlement date. This is equal to the ratio of the Reference CPI on settlement date and the Reference CPI on the issue date.
- *Quoted Price* (QP_t) = The secondary market price collected from the Bloomberg.
- r = The real coupon rate payable every six months.
- x = Days from last coupon date.
- T = Total days from last coupon date to next coupon date.

The gross cash outflow from the purchase of a tips is computed as

$$Price_t = FV \times \left(QP_t + r \times \frac{x}{T} \right) \times IR_t \tag{5}$$

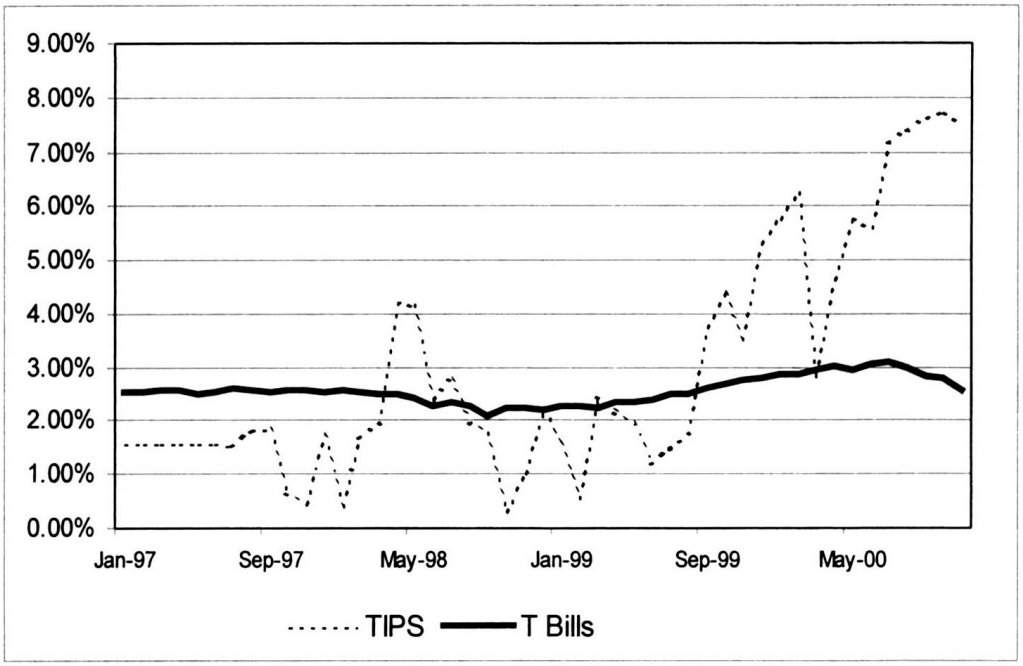

Fig. 2. Historical returns (for a 6-month holding period). This graph illustrates the time-series of 6-month holding period returns computed using secondary market prices of TIPS sold by the United States Treasury. The returns are computed by computing the difference between gross proceeds at purchase and sale and divided by the purchase amount. Interim coupon payments are included in the computations.

Using this relationship we compute the gross proceeds from a TIPS on each of the sample date. The return for a given period is computed as:

$$Return_t = \frac{Price_t - Price_{t-1} + Coupon_t}{Price_{t-1}} \tag{6}$$

5.2. Results

Fig. 2 is a graphical depiction of TIPS returns (for the issue 3.375 2007) computed on each day of the sample for a six-month holding period. A six-month holding period assumes that an investor buys TIPS at a certain time and sells it in the secondary market after a period of six months while collecting coupons in the interim. Note that the holding period returns are lower than corresponding investments in Treasury Bills for the initial sample period (a period of rising real rates and low inflation) but are higher toward the end of the sample period (declining real rates and higher inflation).

Table 2 provides the results in a tabular form. The overall holding period return for TIPS is higher than that for Treasury Bills for each holding period. For example, for a one-month holding period, the return on TIPS is between 0.58% and 0.61% while that for Treasury Bills is 0.448%. Similarly for longer holding periods, the return is marginally higher than that for

Table 2
Holding period returns

Holding period	Average (SD) of returns			
	3.375 2007	3.625 2002	3.625 2008	T bills
1 mo				
Raw return	0.61%	0.58%	0.66%	0.448%
	(1.60%)	(1.62%)	(1.70%)	(0.048%)
Raw return-T Bills	0.17%	0.14%	0.21%	
	(1.59%)	(1.63%)	(1.70%)	
3 mo				
Raw return	1.82%	1.74%	1.86%	1.28%
	(2.68%)	(2.55%)	(2.85%)	(0.15%)
Raw return-T Bills	0.54%	0.46%	0.58%	
	(2.66%)	(2.56%)	(2.81%)	
6 mo				
Raw return	3.52%	3.37%	3.45%	2.58%
	(2.30%)	(1.17%)	(2.46%)	(0.29%)
Raw return-T Bills	0.95%	0.79%	0.87%	
	(2.09%)	(1.02%)	(2.23%)	
1 yr				
Raw return	6.42%	6.48%	6.37%	5.14%
	(3.58%)	(1.78%)	(3.97%)	(0.59%)
Raw return-T Bills	1.28%	1.34%	1.23%	
	(3.16%)	(1.30%)	(3.45%)	

This table contains the average (%) and standard deviation (SD) of returns (in brackets) for investments in each of the three TIPS issues and for one-month Treasury Bills (raw returns). We also tabulate the difference between TIPS and Treasury Bill returns (raw return-T Bills). The sample period is January 1997 to June 2001. Data are obtained from the *Bloomberg Information Services*.

Treasury Bills. Given the real rate risk, liquidity constraints and cash flow drawbacks, one *would* expect a higher return on TIPS.

However, the returns on TIPS are three to eight times as volatile as the return on Treasury Bills. For example the standard deviation of six-month holding period returns are in the neighborhood of 1.17% to 2.46% compared to 0.29% for Treasury Bills. This pattern is evident in one-month, three-month, six-month, and one-year holding periods. In other words, an investor with these horizons must tolerate three to seven times additional volatility for the additional returns that accrue to TIPS. For an average premium of slightly over 0.9% for a holding period of six-months, an investor will increase the volatility of returns between four and eight fold. Clearly, such a tradeoff is unsuitable for risk-averse investors. One popular measure of the tradeoff between risk and return is the ratio of the expected returns on an asset divided by the standard deviation of returns of the asset (also referred to as the Sharpe ratio (Sharpe,1963). For example, the Sharpe ratio (for a 1 year horizon equals approximately $(\frac{5.14}{0.59} = 8.71)$ for Treasury Bills. The ratio is lower for each of the TIPS examined. For shorter holding periods, the evidence is largely in favor of Treasury Bill investments.

In our analysis, we choose Treasury Bills as the benchmark for comparison. The rationale for this comparison was that both TIPS and a strategy of rolling Treasury Bills each period

should provide similar returns if real rates do not change. A second avenue of investigation is to choose comparable maturity Treasury Bonds. However, Treasury Bonds incorporate both inflation risk and real return risk (TIPS incorporate real return risk only, which is of a smaller order than inflation risk). Thus the comparison is not really meaningful. A second alternative is to compute the yields-to-maturity rather than a series of holding-period returns. However, yields to maturity for TIPS must incorporate inflation assumptions that are not observable. The yield to maturity can only be estimated *jointly* with inflation assumptions. If the hypothesized scenario is not realized, the computation is of little value. The return on TIPS is a function of the realized inflation.

As noted earlier, tax effects and liquidity influence the actions of different market participants. Dealers and institutions may dominate the process because dealers face lower transaction costs and tax arbitrage is not profitable for smaller investors. Our results may simply reflect tax-clientele effects as a result of the taxation and cash flow consequences of owning TIPS (Schaefer, 1982, Litzenberger and Rolfo, 1984, and Green and Odegaard, 1997).

Another question that arises in this context is: Should TIPS be held in tax-deferred accounts? Our analysis shows that TIPS provide a higher return than a corresponding investment in Treasury Bills. However TIPS returns are more volatile compared to Treasury Bills for horizons of one year and less. If an investor holds TIPS for longer horizons, in a tax-deferred account, it is possible that the tradeoff between returns and the volatility of returns is favorably skewed toward TIPS as investors realize the real risk premium implicit in TIPS prices. Furthermore TIPS investments will not incur transactions costs that are incurred during each roll over as Treasury Bills mature.

6. Summary and conclusions

TIPS are not suited for inflation-protection investments for investors subject to income taxation. While the real value of principal is preserved, the real after-tax coupon varies inversely with the inflation rate and the investor's marginal tax rate. As inflation rises, the real after-tax coupon rate declines. Also, as inflation rises, TIPS change in character from positive to negative coupon bonds.

In this article, the risk and return characteristics of Treasury Inflation Protected Securities (TIPS) are empirically examined and compared to those of a series of investments in Treasury Bills. Tax effects implicit in the relative pricing of TIPS influence the role of market participants. Using secondary market data on all TIPS issues in the United States, we showed that average one-year holding period returns on TIPS range between 6.37% and 6.48% in contrast to a Treasury Bill yield of 5.14%. However the volatility of returns on TIPS is three to eight times that of a series of investments in Treasury Bills. We argue that the observed risk/return qualities are introduced by the variability of real rates and the taxation of inflation adjustments made to TIPS. TIPS do not provide favorable risk-return tradeoffs for a taxable investor for holding periods up to one-year. Returns over longer holding periods depend critically on inflation rates and real-rate changes in the economy.

References

Campbell, J. Y., & Shiller, R. J. (1996). A scorecard for indexed government debt. *NBER Working Paper Series,* No, 5587.

Dupont, D., & Sack, B. (1999). The Treasury securities market: Overview and recent developments. *The Federal Reserve Bulletin, 85 (December, 1999),* 785–806.

Fraser, S. P., Jennings, W. W., & King, D. R. (2000). Strategic asset allocation for individual investors. The impact of the present value of Social Security benefits. *Financial Services Review, 9,* 295–326.

Green, R. C., & Odegaard, B. (1997). Are there tax effects in the relative pricing of U.S. government bonds? *The Journal of Finance, 52 (June 1997),* 609–633.

Huh, C. (1995). (September 29, 1995). Inflation-indexed bonds. *Federal Reserve Bank of San Francisco Weekly Letter,* Number *9,* 5–32.

Hochman S. & Oded P. (1988). A tax induced clientele for index-linked corporate bonds. *The Journal of Finance, 43,* 1257–1263.

Jayne, K. A. (1998). Why inflation-indexed securities are not well suited for discounting a future earning stream. *Journal of Forensic Economics, 11,* 1–2.

Kopcke Richard. W. & Ralph C. (1999). Kimball. Inflation-indexed bonds: The dog that didn't bark. *New England Economic Review,* January/February, 3–24.

Litzenberger, R. H., & Rolfo, J. (1984). An international study of tax effects on government bond prices. *Journal of Financial and Quantitative Analysis 29,* 403–418.

Lucas, G., & Queck, T. (1998). A portfolio approach to TIPS. *Journal of Fixed Income, 8,* 75–84.

Schaefer, S. M. (1982). Tax induced clientele effects in the market for British government bonds. *Journal of Financial Economics, 10,* 121–159.

Shen P. Benefits and limitations of inflation indexed treasury bonds. (1995). *Federal Reserve Bank of Kansas City Economic Review,* Third Quarter, 41–56.

Sharpe, W. F. (1963). A simplified model of portfolio analysis. *Management Science, 9,* 277–293.