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TIPS IN TOTAL RETURN PORTFOLIOS

Introduction

Since their first issuance in February 1997, TIPS have increased in importance compared with both nominal Treasuries and the overall U.S. bond market. Figure 1 depicts the ratios of the market value of the Lehman Brothers TIPS Index to the market values of the U.S. Treasury and Aggregate indices. Since January 31, 1997, these ratios have grown from 0.3% and 0.1% for the Treasury and Aggregate index, respectively, to 10.2% and 2.2% on May 31, 2003. Since April 2000, the ratio between the TIPS and Aggregate index market values has stayed within 1.9% and 2.2%.[1] The TIPS market value ratio to the Treasury Index has increased almost monotonically since 1997.[2, 3] Although the size of the TIPS market is almost negligible compared with the U.S. Aggregate Index, TIPS have become a permanent fixture of the U.S. Treasury market.[4]

After the first 20 months of their existence, during which they substantially underperformed nominal bonds, TIPS have outperformed the Aggregate Index in all subsequent years. TIPS also outperformed the Treasury Index during all years except 2000, when they underperformed by 35 bp. Their more recent performance, as seen in Figure 2, has been nothing short of outstanding. In 2002, the TIPS Index outperformed the Treasury Index by almost 5% and the Aggregate by more than 6.4%. This outperformance continued into the first five months of 2003. Over the full period of our investigation, total

[1] This was a consequence of the declining relative importance of net Treasury issuance versus net increases in the non-Treasury fixed-income securities.

[2] The only significant drop of this ratio occurred in July 2001, when the 5-year TIPS of 7/15/2002 left the TIPS Index when its maturity fell below the required minimum of one year.

[3] From the inception of the Lehman Brothers TIPS Index on January 31, 1997, until November of 1997, TIPS were part of both the Treasury and the Aggregate indices. For the purposes of this study, TIPS are assumed excluded from these indices throughout the historical period studied, to avoid any overlap between inflation-linked and nominal bonds.

[4] On May 31, 2003, the market values of the U.S. Aggregate, the U.S. Treasury Index, and the TIPS Index were $8.2 trillion, $1.8 trillion, and $181 billion, respectively.

Figure 1. **Market Value Comparison: TIPS versus the Treasury and Aggregate Indices**

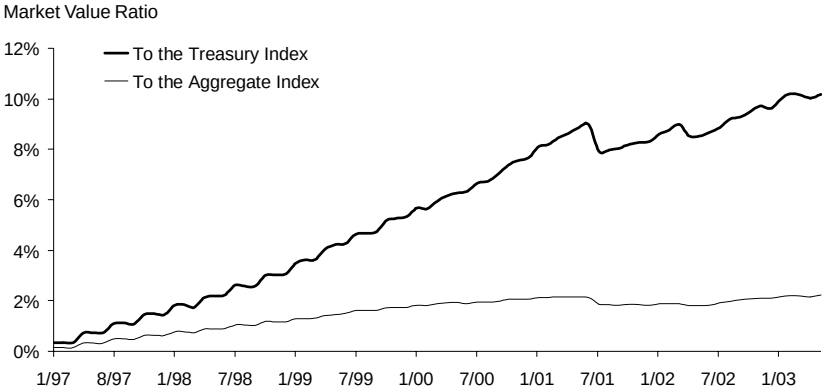

Figure 2. **Annual and Cumulative Total Returns: TIPS versus the Treasury and Aggregate Indices,** %

	Aggregate	Treasury	TIPS
1997	9.35	9.53	2.38
1998	8.69	10.03	3.95
1999	-0.82	-2.56	2.40
2000	11.63	13.52	13.17
2001	8.44	6.75	7.89
2002	10.26	11.79	16.57
2003 (through May)	4.14	4.39	7.44
Cumulative (1/97-5/03)	63.82	66.06	66.63

cumulative returns of the three indices turned out to be very close, with the Aggregate lagging the Treasury and the TIPS indices slightly. The reliable performance of TIPS, as well as their increased share of the publicly held Treasury debt, generated interest in this asset class from both institutional and individual investors.[5]

We published two shelf pieces on TIPS in the six months following their inception.[6] The first covered valuation and asset allocation issues; the second introduced the Lehman Brothers approach to computing nominal durations for TIPS. Given the increased relevance of TIPS in the marketplace today and armed with more than six years of history that we have accumulated since then, we decided to take another look at TIPS as an asset class, to investigate the role they can play in broad asset allocation and to substantiate empirically the hedging properties of Lehman Brothers nominal durations.

The next section of this study lays the foundation for the rest of the report by describing the salient features of TIPS and the most important aspects of their valuation. After that, we compare the historical performance of TIPS with that of nominal Treasuries. The section following that looks at TIPS as an asset class from two different perspectives. First, it considers the merits of TIPS as a long-term investment, in particular versus U.S. Treasuries. Second, it looks at TIPS from an asset-allocation perspective, both in a broad framework spanning fixed-income and equity markets and in the context of purely fixed-income portfolios. The last section looks at the empirical performance of our method for computing nominal duration for TIPS and compares it with a regression-based (beta) alternative.

[5] Large institutional investors and mutual fund companies have set up funds managed against the Lehman TIPS Index. For example, as of the end of the 2001-2002 fiscal year, The New York State Common Retirement Fund had 4.1% of its assets under management, or $4.6 billion, in TIPS. Half of that amount was added in 2002. This translated to 14.3% of the fund's fixed-income assets. The UC Retirement System made TIPS part of its policy asset allocation in May 2002, attaining the desired allocation of 5% by the end of June 2002. The actively managed TIPS fund of a large mutual fund firm went from inception to $3.6 billion in assets in less than three years.

[6] *Inflation Protection Securities: Opportunities and Risks*, by P. Vankudre, P. Lindner, and A. Arora, Lehman Brothers, January 1997; and *Risk Characteristics of TIPS Compared to Nominal Treasury Securities*, P. Vankudre, and P. Lindner, Lehman Brothers, May 1997.

Treasury Inflation-Protected Securities: Structure

In 1997, following the examples of several other countries,[7] the United States decided to issue debt with its value linked to inflation. TIPS are indexed to the non-seasonally adjusted U.S. Price Index for All Urban Consumers (CPI-U). This index compares the cost of purchasing a fixed market basket of goods and services at current prices in a given month with a base month.

TIPS Principal Is Adjusted for Inflation

To protect the value of TIPS against inflation, their principal amount, as well as their coupon payments, increases with inflation from the time of issuance. The inflation indexing is done by adjusting the nominal outstanding par amount of the bonds. The adjustment is computed as the ratio of the value of the CPI-U applicable at a given date to the CPI-U at issuance. The coupon *rate* on the securities is fixed. Semiannual coupon payments for a given par amount are determined by multiplying the inflation-adjusted principal by the fixed coupon rate. At maturity, investors receive the greater of the inflation-adjusted principal or the par amount; i.e., investors have a put option on the principal against the possibility of deflation over the life of the security. This put option, however, applies only to the principal amount. Coupon payments are calculated using the inflation-adjusted principal at all times, including at the maturity date, and theoretically can decrease as well as increase. TIPS are eligible for stripping, with the interest strips whose payments come due on identical dates being fungible between different issues.

Inflation Adjustment Is Reflected with a Two-Month Delay

The United States decided to follow the Canadian example and adjust the nominal value of the TIPS to changes in the CPI with a two-month lag.[8] Specifically, the reference index on the first calendar day of a month is the CPI for the third preceding calendar month. For example, the reference index applicable on April 1 is the CPI for January (released in February). Similarly, the reference index for May 1 is the CPI for February (released in March). The reference index value for any date within a month is then calculated from the values of the index at the beginning of the current and the subsequent month, using linear interpolation based on calendar dates.[9] This way, investors are assured to know all nominal accrued values for a given month ahead of time, usually by about two weeks. If the index is revised in a subsequent month, the unrevised value of the index will still be used as the reference value.[10]

Duration and Convexity

TIPS exhibit a direct sensitivity to real interest rates, measured by *real duration*. It is computed as the sensitivity of the TIPS real price to changes in its real yield. Similarly, *real convexity* can be computed for any TIPS bond.

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[7] For example, Canada, Israel, and the United Kingdom.

[8] We will use CPI as an acronym in lieu of CPI-U, unless specially noted.

[9] The delay with which the CPI affects the cash flows of TIPS has implications for their effective real yield, price volatility, and response to changes in nominal rates. These effects are discussed in detail in *Inflation Protection Securities: Opportunities and Risks*, by P. Vankudre, P. Lindner, and A. Arora, Lehman Brothers, January 1997.

[10] So far, this situation has not occurred for the non-seasonally adjusted CPI.

TIPS prices also display sensitivity to nominal yield changes. The effect of the two-month delay in the adjustment of the TIPS principal to CPI changes, mentioned above,[11] can make TIPS behave somewhat like nominal bonds. Besides this effect, another reason for a direct and an indirect sensitivity of TIPS prices to nominal yield changes is the relationship between the latter and the real yields.

Formally, nominal rates can be expressed as

1) $$y_n = y_r + \pi^e + \mu + \lambda$$

The nominal rate y_n consists of the real rate y_r, the expected inflation rate π^e, the risk premium μ, and the liquidity premium λ. Due to the common factor y_r affecting both of them, real and nominal yields will be correlated. In addition, π^e and y_r might be directly correlated via business-cycle effects. To help investors evaluate the nominal rate sensitivity of TIPS, Lehman Brothers has published nominal durations for TIPS almost since the inception of the TIPS market. This measure of nominal rate sensitivity of TIPS represents, in essence, a multivariate empirical duration. The details of its construction and a historical evaluation of its performance are presented in the section on TIPS nominal durations.

[11] This is due to unanticipated changes in the CPI. For example, if inflation comes in above the rate expected for that month, the TIPS nominal prices will have to jump to incorporate the upward adjustment in the principal that the investor is going to receive in two months. Two months later, when that unexpected increase in inflation is incorporated in the TIPS principal, their yields will increase to keep the TIPS prices at their equilibrium level.

TIPS versus Nominal Treasuries: A Historical Perspective

Figure 3 shows how cumulative returns for the Aggregate, the Treasury, and the Lehman Brothers TIPS indices have evolved over the study period. For comparison, the compounded value of the CPI is included in the graph. The difference in cumulative returns between the Treasury and the TIPS indices had been the largest after almost two years since the TIPS inception, at 14.1% in December 1998. At present, at the end of May 2003, the cumulative returns of the Treasury, TIPS, and Aggregate were 66.23%, 66.62%, and 64.32%, respectively. Despite the substantial upheaval in all sectors of the fixed income market over these six years and four months, the pre-tax total returns of these three indices ended up being quite similar, with the performance of the nominal and real Treasuries virtually identical.

We believe that there is much to learn from the performance of these indices during these six-plus years, despite the fact that their cumulative returns ended up quite similar, if not identical. With the benefit of hindsight, Figure 3 suggests dividing the total period into four sub-periods based on the performance of the TIPS Index versus nominal bonds: from January 1997 through September 1998; from September 1998 through December 1999; from December 1999 through October 2001; and finally, from that point through May 2003. Since the main divergences in the cumulative return series occurred between the Treasury and the TIPS indices, we decided to concentrate the rest of this section on these indices. Summary statistics for all three indices are shown in Figure 4.[12]

The highest average monthly return for the full period was shown by the TIPS Index. Nominal Treasuries and TIPS exhibited similar volatilities over the total period. The Aggregate, with its high degree of diversification, beat both TIPS and nominal Treasuries in terms of the Sharpe ratio. During the first sub-period, TIPS suffered the largest underperformance compared with both of the nominal indices. This period ended with the LTCM crisis, with nominal Treasuries outperforming all spread assets. In the three subsequent sub-periods, TIPS outperformed the other two indices on a total return basis, but underperformed the Aggregate on a Sharpe ratio basis in the last sub-period.

[12] In this study, we use month-end data from the Lehman Brothers Index database.

Figure 3. **Cumulative Inflation and Total Returns for TIPS and the Treasury and Aggregate Indices,** %

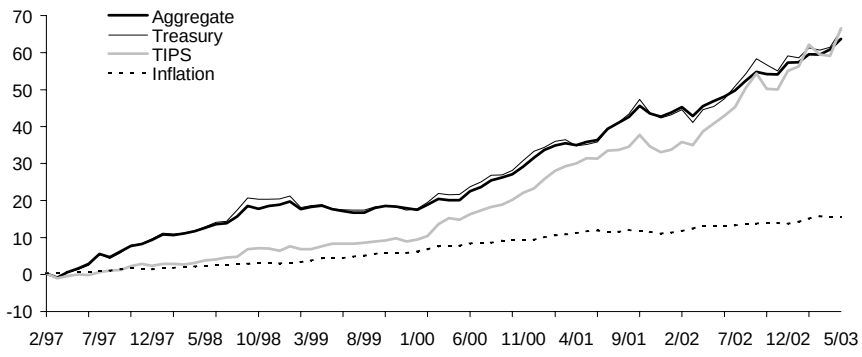


Figure 4. **Total Returns and Sharpe Ratios for the Aggregate, Treasury, and TIPS Indices,*** bp/Month

	1/97-5/03	1/97-9/98	9/98-12/99	12/99-10/01	10/01-5/03
Aggregate					
Mean	65.61	85.42	-3.01	96.81	62.81
StDev	96.17	93.69	72.76	79.82	110.28
Sharpe Ratio	0.28	0.29	-0.65	0.62	0.43
Treasury					
Mean	67.75	95.06	-17.93	104.13	64.51
StDev	126.78	111.65	78.87	96.93	171.58
Sharpe Ratio	0.23	0.42	-0.79	0.58	0.29
TIPS					
Mean	68.19	33.81	12.68	107.21	103.03
StDev	126.00	66.23	54.64	77.49	212.52
Sharpe Ratio	0.23	-0.21	-0.57	0.77	0.41

* 1-month LIBOR was used as the risk-free rate.

The Sharpe ratio represents a particular way of risk adjustment of returns. Clearly, return comparison is a credible exercise only when risk differences across assets are considered. *A priori*, though, it is not clear what the appropriate procedure for risk adjustment is.[13] Single-period investors might be content using the Sharpe ratio, or information ratio, if their investments are measured against a specific benchmark. In fixed-income land, for example, duration is often used as the common denominator for risk adjustment. As long as the parallel shift in rates is responsible for most of return variability, this is a valid procedure. But Equation 1 shows that such procedure is highly questionable when comparing nominal bond returns with TIPS returns. As we demonstrated in our January 1997 study, in the United Kingdom, the volatility of expected inflation and the risk premium had historically dwarfed the volatility of real rates. As we show in section 5, empirical nominal durations of TIPS in the U.S. have been on the low side. If the parallel shift in nominal rates was the main factor driving returns, then the return volatility of TIPS and nominal bonds would be roughly proportional to their duration. Return volatilities of the Aggregate and Treasury indices are comparable, with the somewhat lower volatility of the Aggregate Index reflecting its lower duration. The TIPS Index had an average nominal duration of only 1.86 during the third sub-period, versus 4.72 and 5.79 for the Aggregate and the Treasury indices. Yet the volatility of the TIPS returns almost equaled the volatility of the Aggregate Index.

To ensure a certain degree of risk-equivalence between TIPS and nominals, we decided to follow a different path, in this section and in the section on TIPS for long-term investors. We will limit ourselves only to the consideration of securities with about ten years to maturity. In essence, we look at TIPS versus other bonds from the perspective of an investor with a ten-year horizon. We will also only look at TIPS versus nominal

[13] In the CAPM framework, the portfolio on the efficient frontier with the maximum Sharpe ratio is the portfolio on the tangent line emanating from the risk-free rate point on the vertical axis. Frontier portfolios have certain desirable properties compared with non-frontier portfolios. But the tangency portfolios based only on narrow subsets of the asset markets (e.g., excluding equities, real estate, etc.) have limited economic meaning.

Treasuries, excluding for now the complicating features of credit and prepayment risk. Studying TIPS with close to 10 years to maturity also allows us to use the TIPS data from the start of the market and not to have to deal with the curve impact from the addition of new maturities to the TIPS market or changes in the nominal Treasury market that had only a temporary impact.[14] In 1997, the 8-10 years to maturity sample consisted of only one bond, while during the second half of 2002, it included three bonds. In all other periods, there were two such bonds. We select nominal Treasuries with 8-9 ½ years to maturity.[15] This sample starts out with nine bonds, but since the middle of 1999 usually comprises 2-4 securities. Figure 5 shows the same statistics as Figure 4 for the 10-year TIPS and nominal Treasuries as defined above.

The statistics for the 10-year TIPS index are relatively close to the statistics for the full TIPS Index, with the mean, volatility, and Sharpe Ratio for the overall period being somewhat lower for the 10-year TIPS index than for the full TIPS Index. This is partially because, initially, the 10-year TIPS constituted a significant share of the index. The 10-year nominal index differs more significantly from the summary values for the Treasury Index. The 10-year mean return exceeds the mean return of the Treasury Index by 8 bp/month, with its volatility exceeding the index volatility by 60 bp/month. Mean returns during the sub-periods differ even more from the corresponding index returns, underperforming the index during market declines, outperforming during rallies. Its volatility is always significantly higher than the volatility of the Treasury Index.

Overall, 10-year TIPS do not compare as well with 10-year nominal Treasuries on a total return basis as they do on an index-over-index basis. The 10-year nominal index outperformed TIPS both on a total return and a Sharpe ratio basis. Looking at the sub-periods, though, it becomes apparent that this outperformance was driven primarily by the sub-period ending with the LTCM crisis. Subsequently, 10-year TIPS outperformed 10-year Treasuries on the Sharpe ratio basis, and in two out of three sub-periods on the total return basis as well.

[14] Consider, for example, the suspension of the long bond in the aftermath of September 11, 2001.

[15] This allows us to avoid the initial periods of often extreme richness of the on-the-run 10-year.

Figure 5. **Total Returns and Sharpe Ratios for the 10-Year Nominal Treasuries and TIPS,*** bp/Month

Nominal Treasuries	**1/97-5/03**	**1/97-9/98**	**9/98-12/99**	**12/99-10/01**	**10/01-5/03**
Mean	75.96	117.69	-48.68	117.91	81.85
StDev	182.24	168.60	116.24	136.49	243.02
Sharpe Ratio	0.20	0.42	-0.80	0.51	0.20
TIPS	**1/97-5/03**	**1/97-9/98**	**9/98-12/99**	**12/99-10/01**	**10/01-4/03**
Mean	66.30	34.15	16.24	100.14	100.49
StDev	114.48	72.26	49.76	72.49	187.53
Sharpe Ratio	0.19	-0.19	-0.55	0.74	0.46

* 1-month LIBOR was used as the risk-free rate.

It is interesting to look at the historical yield levels of the two indices. Figure 6 depicts the time series of the nominal and real 10-year yields, together with their difference, which is often called the *breakeven rate of inflation*. If the sum of the risk and the liquidity premiums equals zero, then the breakeven rate of inflation represents the relative value boundary that separates "good" from "bad" TIPS investments. Over a ten-year period, if the future realized rate of inflation exceeds the breakeven rate, TIPS will outperform nominal bonds; if the future realized rate of inflation is below the breakeven rate, nominal bonds will outperform TIPS.[16] It is clear that nominal yields were far more volatile than real yields. It is also apparent that temporary lows of the breakeven rate of inflation occurred at the culmination of periods of stress in the financial markets: in September 1998 at the end of the LTCM-crisis, in October 2001 after the 9/11 attacks, and at the 5-year lows of the equity markets at the beginning of October 2002. Sometimes, the breakeven rate of inflation is also equated to the market implied expected inflation rate.

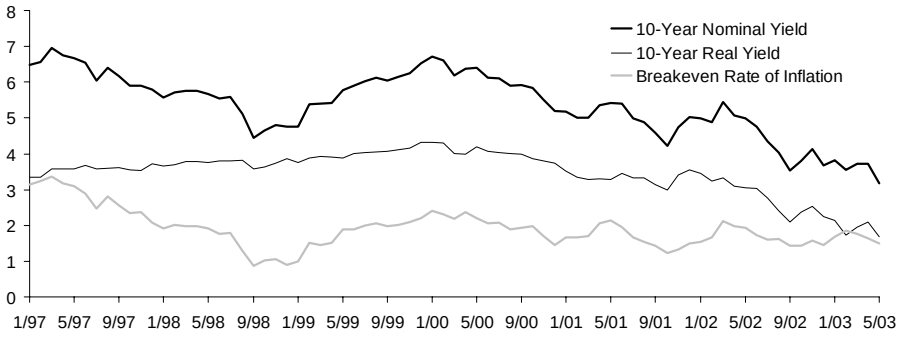
It is questionable whether, over short time periods, the expected inflation varied as much as the breakeven rate did. The numbers in Figure 7 imply a collapse in the breakeven rate of inflation of 228 basis points from January 1997 to September 1998. The 10-year expected inflation as published as part of the Survey of Professional Forecasters[17] decreased only by 50 basis points, from 3.0% to 2.5%, in the period from March 1997 to September 1998. If we define "liquidity" in a wide sense as encompassing the price impact of the flight-to-quality phenomenon, one has to assume that the liquidity premium is highly variable and can become quite substantial at times.[18] As Figure 6 shows, at the time of the LTCM crisis, nominal yields fell much more than real yields. Looking at the decrease in the breakeven rate of inflation from July to September 1998, we can estimate the impact of the LTCM crisis on the liquidity premium of TIPS to be about 100 basis points. Therefore, the breakeven rate of inflation is probably a deficient indicator of inflation expectations.

[16] This is only an approximation, but serves to make the point.

[17] The Survey of Professional Forecasters is a quarterly survey of individuals who provide forecasts of a number of real economic and financial variables, e.g., 1- and 10-year rates of growth of inflation and real growth, short-term and long-term bond yields, etc. It is currently compiled and published by the Federal Reserve Bank of Philadelphia.

[18] In the literature, we found estimates of the "normal" liquidity premium of TIPS to be at least 25 basis points. See, for example, *Can TIPS Help Identify Long-Term Inflation Expectation?*, by Pu Shen and Jonathan Corning, Federal Reserve Bank of Kansas City, Fourth Quarter 2001, pp. 61-87.

Figure 6. **10-Year Nominal and Real Yields and Breakeven Rate of Inflation,** %



We will discuss the impact of inflation expectations, the risk, and the liquidity premium in greater detail in the next section. But before we do so, we conduct a simple *return attribution* exercise on TIPS and nominal bonds. From Figure 6, we see that yields fell substantially in the last six-plus years, and the nominal yields more so than the real yields. For investors comparing TIPS with nominal Treasuries, it might be interesting to know the factors driving the historical performance of TIPS and nominal bonds and how they compared in relative importance. A forward-looking investor may have opinions on each factor, for some future period. The historical relevance of these factors may provide an insight on the future relative performance of TIPS versus nominal bonds.

The main components of a bond total return are its yield and the effect of yield changes on its price. Yield changes, in turn, consist of the *rolldown effect*, with a bond's yield changing with its age, assuming an unchanged curve. In addition, a bond's yield changes due to movements of the yield curve. For an inflation-linked bond, the inflation adjustment received has to be taken into account as well. In this study, we are interested in the most important factors that drive total returns. For this purpose, we formulate a simple return attribution model that allocates the impact of these main factors. To simplify things, we treat our 10-year Treasury and TIPS indices as constant maturity portfolios. This allows us to disregard the rolldown effect.

Figure 7 contains the data necessary for our exercise in return attribution. For the full period and for each sub-period, cumulative total return will be approximated as

$$2) \qquad r = y + I \cdot \pi + dur \cdot \Delta y + \tfrac{1}{2} \cdot conv \cdot (\Delta y)^2,$$

with r denoting total return, y the yield at the beginning of the period, π the inflation at the start of the period, Δy the yield change over the period, *dur* the duration and *conv* the convexity of the index. π is the realized inflation applicable to TIPS for the period, with I being an indicator function, equal to one for TIPS and zero for nominal Treasuries. Besides the yield changes over the period, the average duration, convexity,[19] and inflation are shown. The CPI increases used in the return attribution for TIPS are the CPI increases lagged by two months. As one can see from Figure 7, 10-year nominal yields fell by 330 basis points, with TIPS yields falling by only about half that amount. Over the most recent 1 ½ years, TIPS yields fell somewhat more than the nominal yields.

[19] Nominal duration and convexity for nominal bonds, and real duration and convexity for TIPS.

Figure 7. **Sources of Total Return for 10-Year Nominal Treasuries and TIPS,** %

	Nominal Treasuries			TIPS			Inflation (Annualized)	
	Yield Chg.	Ave. Dur.	Ave. Conv.	Yield Chg.	Ave. Dur.	Ave. Conv.	Actual	2 Month Lag
1/97-5/03	-3.30	6.51	0.55	-1.66	7.46	0.68	2.30	2.39
1/97-9/98	-2.04	6.26	0.52	0.24	7.69	0.72	1.69	1.73
9/98-12/99	2.08	6.52	0.56	0.74	7.27	0.65	2.29	2.44
12/99-10/01	-2.30	6.50	0.55	-1.32	7.23	0.64	3.01	2.98
10/01-5/03	-1.04	6.79	0.58	-1.32	7.62	0.70	2.15	2.37

The results of the return attribution according to Equation 2 are summarized in Figure 8. The total approximated return that includes all components is displayed in the second-to-last column, with the actual cumulative realized total return shown in the last column. For the full period, our approximation underestimates the total return of nominal bonds by about 17%. This considerable bias is due to the cross-sectional aggregation of individual bond data, i.e., yields, durations, and convexities. Another source of this bias is the use of average duration and convexity for the whole period. The biases in the four sub-periods are far smaller on an absolute as well as on a relative basis, particularly for the TIPS.[20]

The return due to yield in Figure 8a (nominals) should be compared with the return due to yield plus inflation for TIPS in Figure 8b. Except for the first sub-period, the yield plus inflation return of TIPS exceeded the yield return of nominals. A greater part of total returns of nominal Treasuries compared with TIPS came from yield change and convexity, i.e., from the decline in yields. If history is any guide, when the yields stabilize or increase slightly, TIPS will probably outperform nominals. This will be the case as long as the actual realized inflation rate exceeds the breakeven inflation rate implied in bond prices. Therefore, the decision whether and how much of TIPS to add to a portfolio of nominal bonds will depend on the investor's view about future inflation and real rates, as well as the Federal Reserve policy. The attractiveness of TIPS compared with the nominal bonds will be directly addressed in the following section.

The results in Figure 8 also highlight an interesting aspect of the use of the breakeven rate of inflation as a relative value tool. Strictly speaking, if realized inflation exceeds the breakeven rate, TIPS will be a better investment than same-maturity nominal bonds only if held to maturity. When the breakeven rate is used as a relative value

[20] Summing up the underestimates for the four sub-periods for the nominals approximation leads to a total of 4.70%, and to only 1.67% for the TIPS approximation.

Figure 8. **Return Attribution for 10-Year Nominal Treasuries and TIPS**

a. Nominal Treasuries

	Due to Yield Chg.	Due to Convex.	Due to Yield	Total Curve	Due to Inflation	Inflation + Yield	Total	Actual Total Return
1/97-5/03	21.49	3.01	34.22	58.73	-	-	58.73	75.56
1/97-9/98	12.75	1.09	10.08	23.92	-	-	23.92	26.03
9/98-12/99	-13.56	1.20	6.31	-6.05	-	-	-6.05	-7.15
12/99-10/01	14.95	1.46	10.96	27.37	-	-	27.37	29.17
10/01-5/03	7.07	0.32	6.88	14.26	-	-	14.26	16.14

b. TIPS

	Due to Yield Chg.	Due to Convex.	Due to Yield	Total Curve	Due to Inflation*	Inflation + Yield	Total	Actual Total Return
1/97-5/03	12.37	0.93	22.13	35.44	16.14	41.85	57.30	64.45
1/97-9/98	-1.85	0.02	6.07	4.23	2.90	9.14	7.26	7.00
9/98-12/99	-5.40	0.18	4.54	-0.68	3.06	7.75	2.37	2.45
12/99-10/01	9.58	0.56	7.24	17.37	5.53	13.16	23.86	24.44
10/01-5/03	10.05	0.60	4.29	14.95	3.77	8.23	19.29	20.55

* With 2-month lag

trading tool, shorter holding periods are often assumed, at the end of which the original mispricing is expected to have been largely reversed. There are two additional assumptions necessary for the success of such a trade: first, inflationary expectations cannot decline too much because that would make nominal prices increase compared with the prices of inflation linkers; second, real yields cannot increase too much because price declines of the TIPS compared with nominal bonds might outweigh the elements of the trade going in the right direction. For example, in Figure 8, over the period from September 1998 to December 1999 (the sub-period with the largest absolute outperformance of TIPS), the outperformance of TIPS on a yield basis was only 1.44%. Thus, if the breakeven rate had stayed constant over that period, the outperformance of TIPS would have been approximately the difference of realized inflation minus the breakeven rate, on a period-equivalent basis. Investors should consider the economic environment at the outset of the trade and be conscious which of the three elements of the breakeven rate (expected inflation, risk premium, liquidity premium) are potentially mispriced and can be expected to change over the anticipated horizon of the trade.

TIPS as an Asset Class

TIPS for Long–Term Investors

Making an asset-allocation decision in favor of one asset class versus another involves a host of variables. The risk of a portfolio is usually described by the covariance matrix of its components, based on historical data. The estimation of second moments from historical data is considered far more reliable than the estimations of mean returns. Investors usually construct estimates of mean returns conditional on a set of fundamentals at a point in time. The section on TIPS in a Mean-Variance framework will look at TIPS versus nominal bonds and equities, based on alternative sets of covariance matrices and mean return vectors.

In this section, we want to answer the far narrower question: Do TIPS represent value for long-term investors? The relative value of holding same-maturity nominal versus inflation-linked securities until maturity is determined mostly by the magnitude of realized inflation versus the breakeven rate of inflation embedded in the two bonds. The factors determining differential performance between a nominal Treasury and an inflation-linked bond are summarized in Equation 1, which we repeat here for the sake of convenience:

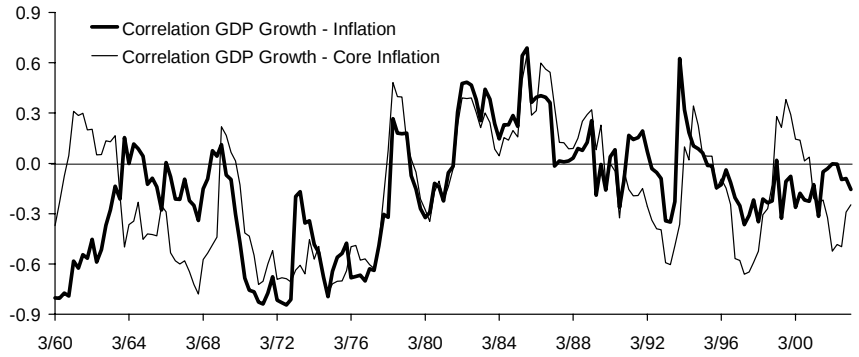
$$1) \qquad y_n = y_r + \pi^e + \mu + \lambda$$

π^e, μ, and λ are expected future inflation, risk premium, and liquidity premium, respectively. The sum of these three factors constitutes the breakeven rate of inflation. If future realized inflation is, in fact, higher than the sum of these three variables, TIPS will most likely outperform nominal bonds. Equation 1 makes it clear that if $\mu + \lambda$ exceeds zero, investors expect a return on their TIPS that is below the return of same-maturity nominal bonds. μ is often more specifically called the inflation risk premium and is assumed to be positive. Investors are presumed to accept a lower expected return on an inflation-linked bond than on a nominal bond, since it offers insurance against unexpected inflation. In our January 1997 report, we also assumed this risk premium to be positive, based on our research of the U.K. index-linked Gilt market and in line with the results of other research.

Although, intuitively, the assumption of a positive risk premium makes sense, what really matters for the determination of the risk premium is the correlation of real growth and inflation. If inflation and real growth are negatively correlated, then nominal bond will not provide a hedge against unanticipated declines in real growth, and the risk premium will be positive. If, on the other hand, real growth is above its mean during times of higher inflation, than the risk premium that nominal bonds demand will be negative. In that case, nominal bonds would provide a hedge against unexpected declines in growth. The currently tight breakeven rates of inflation have been cited by some observers as evidence of a negative risk premium.

Besides the real rate of interest, the remaining three components of the nominal rate in Equation 1 cannot be observed. Their values would have to be estimated. We use the 3-year rolling correlation between quarterly GDP growth and quarterly inflation to gain insight into the direction and magnitude of the risk premium. We look at both the seasonally adjusted CPI inflation and the core rate of inflation, which is the rate of growth in the CPI ex-food and energy. The results are presented in Figure 9.

Figure 9. **3-Year Rolling Correlations: Real GDP Growth with Inflation**
Quarterly Data; Seasonally Adjusted Series



The correlations based on the CPI and the core rate track each other well most of the time, with the correlations based on the core rate displaying higher amplitudes in the late sixties and the nineties. The only time there was a substantial deviation between the two correlation series was in the early sixties, when at one point, the correlations based on the core rate exceeded the correlations based on the raw CPI by about 1.1.

The correlations in Figure 9 are mostly negative during the sixties and the seventies. This should indicate positive risk premia during this period. The correlations were largely positive during the eighties, suggesting negative risk premium for that period. Since about 1994, the correlations were mostly on the negative side, although not as much as in the seventies. This would lead us to expect a slightly positive risk premium in the current environment.

The other important factor in the pricing of TIPS versus nominal bonds is the liquidity premium λ. It can be assumed to be negative, given that TIPS make up a relatively low share of the total trading volume of the Treasury market. Liquidity premium pushes the yields of nominal Treasuries down compared with TIPS, which have higher bid-ask spreads and are generally harder to trade. As we pointed out above, the liquidity premium has been estimated to be about 25 basis points. Adding up these estimates for μ and λ, we will probably arrive at a negative number. This implies that long-term investors in TIPS will be paid a slight premium for owning TIPS for a given expected inflation rate.

This argument establishes that TIPS should have the potential to be a good long-term investment compared with nominal Treasuries of the same maturity. We will consider this point in more detail now.

As stated, TIPS will turn out to have been the superior investment if the actual inflation rate comes in above the breakeven rate of inflation. As of June 25, 2003, the yield of our 10-year nominal Treasury portfolio was 3.2%, while the real yield of our 10-year TIPS portfolio was 1.6%, implying a breakeven inflation rate of 1.6%. To determine the value of TIPS based on the breakeven rate, the breakeven rate has to be compared with a 10-year inflation forecast. For this study, we use the inflation forecasts from the

Survey of Professional Forecasters (SPF).[21] In particular, one- and ten-year forecasts of CPI inflation are provided. In the most recent quarterly forecast, made public in June 2003, the mean expected 10-year inflation rate was 2.5% and the mean expected 1-year inflation rate was 2.4%. The 10-year expected inflation rate clearly exceeds the breakeven rate of 1.6%. From this perspective, TIPS are clearly a buy.

The preceding statement is based only on the 10-year point forecast of inflation. Clearly, the inflation forecasts of the SPF were not perfectly on target in the past and can't be expected to be so in the future. One way of estimating the precision is to compare past forecasts with future realizations. Unfortunately, the 10-year CPI forecasts are available only from 1981 on. This leaves us with only two independent observations. We will try to draw inferences from the 1-year-ahead forecast errors.

Before we do so, it should be noted that the forecasts themselves adjust slowly to changes in the economic environment. For example, during the disinflation of the eighties, the expectations from the SPF were usually higher that the subsequent realization. Looking at the differences of inflation expectations and their realizations from 1986 onward, a period in which inflation took on a more stable pattern, we find a mean of 16 basis points of inflation overestimation a year, with a standard deviation of 76 basis points. For reference, the yearly actual and expected increases in the CPI are displayed in Figure 10. For the first five months of 2003, we show the seasonally adjusted rate of inflation and compare it with the annual expected rate. The 2003 numbers happen to be very close. For the six years before that, expected inflation overestimated actual inflation by 34 basis points per year.

Now, inflation is probably harder to estimate over a 10-year horizon than over a year. Even if, with a sufficiently large sample, the mean of 10-year inflation exceeded actual mean inflation by only 16 basis points, the standard deviation of this estimate could be expected to be much higher than 76 basis points. To gauge the quality of the 10-year inflation estimates better, Figure 11 shows a few 10-year inflation rates and their associated ex-ante estimates.

Figure 11 shows actual and expected inflation, as well as their difference, for two sets of two 10-year periods. First for the decades of the eighties and the nineties, and then for the

[21] See footnote 17 for details.

Figure 10. **Annual Expected and Actual Inflation Rates,** %

	Actual	Expected
1997	1.70	3.03
1998	1.61	2.60
1999	2.68	2.33
2000	3.39	2.53
2001	1.55	2.68
2002	2.38	2.18
2003 (through May; Annualized)	2.26	2.20
Mean 1997-2002	2.22	2.56
1/97-5/03 (Annualized)	2.36	

Figure 11. **10-Year Expected and Actual Inflation Rates,** %

	Actual	Expected	Difference
1980-1989	5.09	6.90	-1.81
1990-1999	2.94	4.20	-1.26
1983-1993	3.86	5.30	-1.44
1993-2003	2.53	3.50	-0.97
January 1997-May 2003	2.36	3.00	-0.64

two decades ending with the first quarter of 1993 and 2003, respectively. The figure also shows the annualized inflation rate from January 1997 through May 2003 (the period of existence of TIPS) and the 10-year inflation rate expected for the period starting with January 1997. The over-estimation of future inflation shown is generally quite considerable. We see, though, that it declined over time, as forecasters were adjusting toward the reality of lower inflation.

We conclude that the 2.5% expected inflation quite possibly overstates the inflation we are to experience in the next ten years. The basic fact remains that the estimate of future inflation is the core element in the valuation of TIPS. Even if 2.5% is considered to be on the high side of future inflation, the avowed intention of the Fed is to fight inflation by any means possible. Two percent inflation may therefore be a reasonable rate to expect over the next ten years. Although we do not believe that the risk premium of nominal bonds over TIPS is necessarily negative, it probably is close to zero in the current environment. Together with a negative liquidity premium of TIPS over nominal bonds, a conservative estimate of the ex-post yield advantage that investors should be able to realize is, in our opinion, 20-40 basis points per year.

TIPS in a Mean-Variance Framework

As we have shown above, since their inception in the early 1997, the historical total return performance of TIPS has been in line with or better than that of nominal Treasuries or the Lehman Aggregate Index. Because inflation expectations and changes in risk and liquidity premia are the main factors driving the differences between TIPS returns and returns on other assets, one can expect to see prolonged periods in which the correlation of TIPS with other asset classes, both fixed-income and equity, would be relatively low. These two factors, respectable historical performance and low correlation with other asset classes, suggest that TIPS could be valuable diversifying components in asset allocation, potentially enhancing the risk-return profile of an asset mix.

We have conducted several experiments with efficient frontiers to see the effect of adding TIPS first to a purely fixed-income mix and then to a broader asset class set including both fixed-income and equities. The expected returns in these experiments were set to equal long-term historical averages over the period from January 1990 through May 2003 (since February 1997 for TIPS). First, we considered an asset allocation using TIPS and the main asset classes in the U.S. Aggregate Index: Treasury, credit, MBS, and ABS. We left out agencies because of their high correlation with Treasuries. We conducted this analysis over the full time period for which TIPS returns are available, i.e., from early 1997 through present, and then looked at the sub-period immediately following the crisis of 1998 (October 1998 through December 1999),

when the correlation between TIPS and nominal Treasuries was particularly low. Finally, we studied the effect of adding TIPS to a broad asset class mix that included both fixed-income markets, represented by the U.S. Aggregate Index, and the equity markets, represented by the S&P 500 and Russell 2000 indices. For both equity indices, we used the same annualized expected return of 11% based on their long-term average returns.

Figure 12 shows correlation matrices of total returns for all asset class mixes and the time periods for which we produced efficient frontiers. In the all-fixed-income mix, we can see that over the full study period, the correlation of TIPS with credit, MBS, and ABS was considerably lower than the correlation of these asset classes with nominal Treasuries. The correlation between TIPS and nominal Treasuries was 0.71. Over the low-correlation period after the 1998 crisis, all correlation numbers in the fixed-income set are lower across the board. For example, the correlation between TIPS and MBS and ABS stands at a very low level of 0.30. The correlation between TIPS and the nominal Treasuries during this period was only 0.48. In the broad asset mix, both the U.S. Aggregate and TIPS have negative correlations with equity indices. Yet the levels are significantly lower for TIPS than for the U.S. Aggregate. The correlation between TIPS and the Aggregate is also

Figure 12. **Correlation Matrices and Asset Expected Returns**

	February 1997-May 2003				
	Treasury	**Credit**	**MBS**	**ABS**	**TIPS**
Treasury	1				
Credit	0.803	1			
MBS	0.785	0.745	1		
ABS	0.898	0.813	0.888	1	
TIPS	0.714	0.643	0.486	0.645	1

	October 1998-December 1999				
	Treasury	**Credit**	**MBS**	**ABS**	**TIPS**
Treasury	1				
Credit	0.805	1			
MBS	0.665	0.758	1		
ABS	0.844	0.930	0.832	1	
TIPS	0.479	0.297	0.305	0.447	1

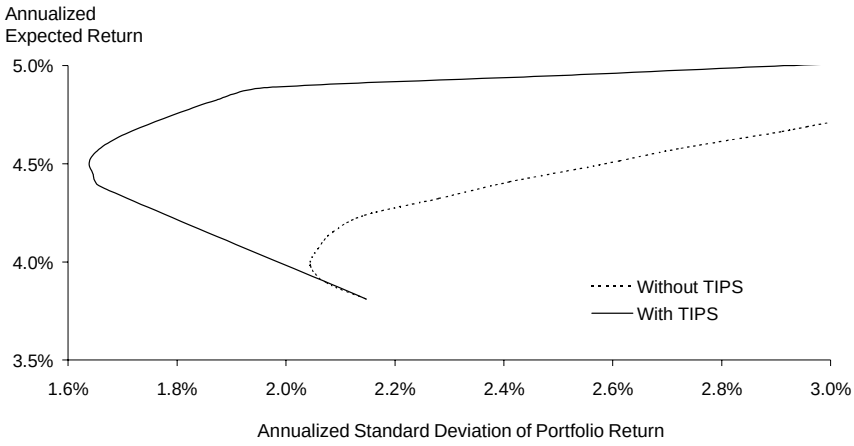
	February 1997-May 2003			
	US AGG	**S&P 500**	**Russell 2000**	**TIPS**
US AGG	1			
S&P 500	-0.121	1		
Russell 2000	-0.085	0.714	1	
TIPS	0.675	-0.222	-0.154	1

	Expected Monthly Return over LIBOR (%)	
	Mean*	**Stand. Deviation****
TIPS	0.292	1.266
Treasury	0.257	1.277
Credit	0.313	1.267
MBS	0.233	0.713
ABS	0.208	0.759
US AGG	0.259	0.971
S&P 500	0.807	5.295
Russell 2000	0.807	6.637

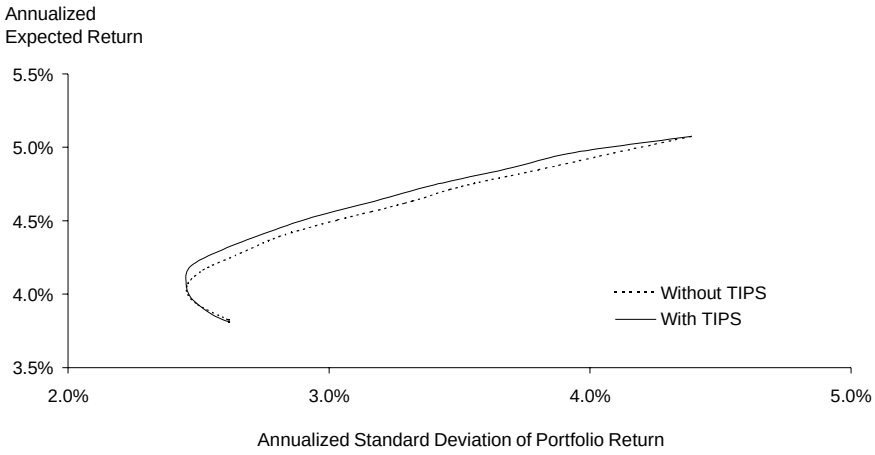
* 1990-May 2003; TIPS: February 1997-May 2003.
** February 1997-May 2003.

Figure 13. **Efficient Frontiers**

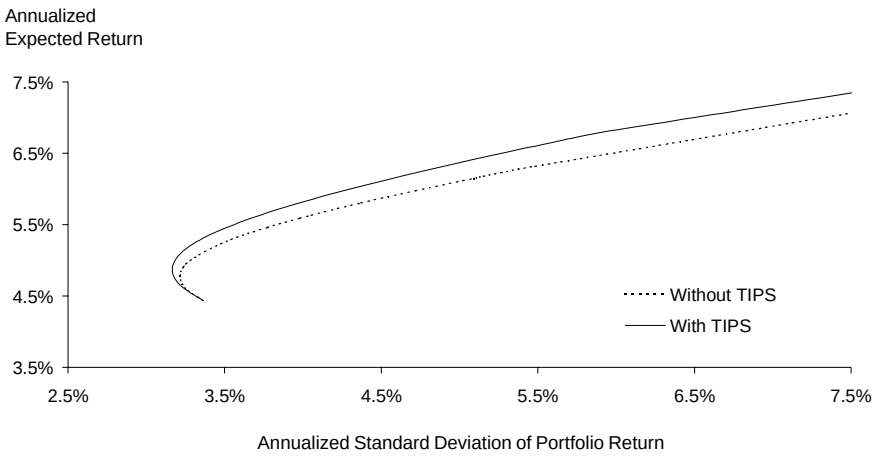
Treasury, Credit, MBS, ABS, TIPS, October 1998-December 1999



Treasury, Credit, MBS, ABS, TIPS, February 1997-May 2003



U.S. Aggregate Index, S&P 500, Russell 2000, TIPS, February 1997-May 2003



low, at about 0.68. Also shown in Figure 12 are the expected monthly returns over LIBOR for each asset class and their volatilities. It must be mentioned that in forming expected return estimates, we used the longest history available to us—since January 1990 for all asset classes except TIPS. Covariance matrices, on the other hand, are built for each period separately.

Figures 13 plots the efficient frontiers for the asset sets described above, with and without TIPS. In all cases, we see that the addition of TIPS pushes the frontier out. Over the full study period, both in the all-fixed-income mix and in the broad set including equities, the improvement is undeniable but relatively modest. Yet for the low-correlation period, the effect on the frontier is dramatic. The addition of TIPS to the set reduces the minimum achievable annualized portfolio standard deviation by roughly 40 bp while significantly increasing portfolio returns.

Figure 14 shows the portfolio composition for selected points on all three efficient frontiers. The first line in each case is the minimum variance portfolio. In the first case, the all-fixed-income mix for the full study period, the efficient part of the frontier begins with heavy allocation to mortgages because of the low historical variance of their returns. As the allowed variance is increased, the portfolio reallocates from mortgages to credit, while maintaining a sizeable position in TIPS. During the low-correlation period in the

Figure 14. **Efficient Portfolio Composition for Selected Points on the Frontiers,** %

Treasury, Credit, MBS, ABS, TIPS, February 1997-May 2003

Portfolio		Asset Weights				
Expected Ret	St Dev	Treasury	Credit	MBS	ABS	TIPS
4.08	2.45	0.00	0.00	79.26	18.20	2.54
4.30	2.59	0.00	4.48	74.15	0.00	21.36
4.52	2.94	0.00	23.83	51.97	0.00	24.20
4.74	3.40	0.00	44.52	28.25	0.00	27.23
4.96	3.94	0.00	65.39	4.32	0.00	30.29

Treasury, Credit, MBS, ABS, TIPS, October 1998-December 1999

Portfolio		Asset Weights				
Expected Ret	St Dev	Treasury	Credit	MBS	ABS	TIPS
4.51	1.64	0.00	0.00	44.18	0.00	55.82
4.64	1.69	0.00	1.34	26.76	0.00	71.91
4.70	1.75	0.00	5.27	19.23	0.00	75.50
4.82	1.87	0.00	13.13	4.19	0.00	82.68
5.01	3.05	0.00	74.73	0.00	0.00	25.27

U.S. Aggregate Index, S&P 500, Russell 2000, TIPS, February 1997-May 2003

Portfolio		Asset Weights			
Expected Ret	St Dev	U.S. AGG	S&P 500	Russell 2000	TIPS
4.87	3.17	76.74	5.31	0.33	17.62
5.31	3.36	55.33	10.37	1.04	33.27
5.75	3.90	34.37	15.44	1.75	48.44
6.19	4.65	13.14	20.51	2.46	63.89
6.85	6.05	0.00	29.00	3.79	67.20

all-fixed-income case, TIPS are used from the beginning. Their share actually exceeds that of mortgages in the minimum variance portfolio. As the portfolio moves to higher returns, credit again gains share. But in the middle of the shown range, TIPS actually dominate, reaching a greater than 80% share at some point. In the broad mix case, the minimum variance portfolio is allocated heavily to the U.S. Aggregate. After that, the share of the Aggregate starts to decline quickly, while TIPS gain share and begin to dominate the portfolio in the central region. Of course, the extreme part of the frontier with the highest returns and highest variance, not shown in the graph, will be represented by all-equity portfolios. The main conclusion we draw from these results is that as an addition to both fixed-income portfolios and balanced equity-fixed-income portfolios, TIPS can make a beneficial contribution.

Nominal Durations of TIPS Securities

At the time of the first U.S. TIPS issuance in the early 1997, we suggested a technique for estimating nominal durations of TIPS securities (see footnote 6). For each TIPS, this method creates a minimum-variance hedge portfolio of nominal Treasuries and cash. The duration of this portfolio becomes the estimate of the nominal duration of the TIPS security. To construct the hedge, a simple covariance matrix of price returns is built. The matrix is based on the trailing 60-days worth of daily yield changes multiplied by the appropriate duration of each instrument on day 60. The weights of each nominal bond in the hedge portfolio are constrained to be non-negative. Based on these weights, the nominal duration of each TIPS is computed as a weighted average of the interest rate duration of the nominal bonds.

The nominal duration estimated in this fashion remains an imperfect measure, subject to sudden changes as the composition of the minimum-variance portfolio changes. In turn, the hedge portfolio composition depends strongly on the correlation between yield changes (price returns) of the nominal Treasuries and the TIPS. Such correlation reflects changes in the underlying economic factors and may be quite unstable. Because the covariance matrix in the estimation procedure uses a relatively short trailing sample of 60 daily observations, a strong one-day event may materially influence the correlations.

Figure 15 shows the historical levels of the nominal duration for two TIPS securities, 10-year (9128276R, 3½ of 1/15/11) and 30-year (912810FD, $3\frac{5}{8}$ of 4/15/28). A sudden jump in duration in the beginning of November 2001 is a good example of the correlation-driven instability of the nominal duration measure. On October 31, 2001, the U.S. Treasury announced that it would suspend the future auction of the 30-year bonds. This announcement led to a strong rally in the long bond, and its yield dropped by 33 bp. The real yields of the 30-year TIPS dropped as well, giving a strong one-day boost to the correlations between the TIPS and the nominal 30-year. As a result, the allocation to the 30-year nominal Treasury in the hedging portfolio jumped up, leading to a corresponding increase in the portfolio duration (and so the nominal duration of the 30-year TIPS).

This observed volatility of the nominal duration measure does not necessarily mean that the nominal duration measure we compute is flawed. Rather, it places limitations on the time horizon over which this nominal duration should be used. By the nature of its computation method, it relies on short-term correlation between TIPS and nominal Treasuries. Over short time horizons, these correlations are likely to stay at the recent historical levels (barring such unpredictable events as the suspension of the 30-year auctions). Over longer time horizons, this duration measure might be less useful.

As a check on our current method of computing nominal durations, we also implemented an alternative method based on yield beta. We ran daily regressions over the trailing 60 days of daily changes of TIPS real yields against daily changes of the nominal Treasury yield. The coefficient of these regressions (beta) multiplied by the nominal Treasury yield is an estimate of the sensitivity of TIPS yield to nominal yield movements. Replacing the change in real yield by beta times the change in nominal yield, we see that the TIPS sensitivity to nominal yield changes is given by real duration times beta. We performed these regressions for the same 10- and 30-year TIPS securities as above. Durations computed in this fashion are compared with the minimum-variance durations in Figure 15. The two turn out to be quite close to each other. Most important, both methods exhibit large jumps in duration

caused by sudden changes in correlations. It is not really possible to decide which duration measure is better just from looking at their plots in Figure 15. To compare their relative merits, we will consider their hedging performance.

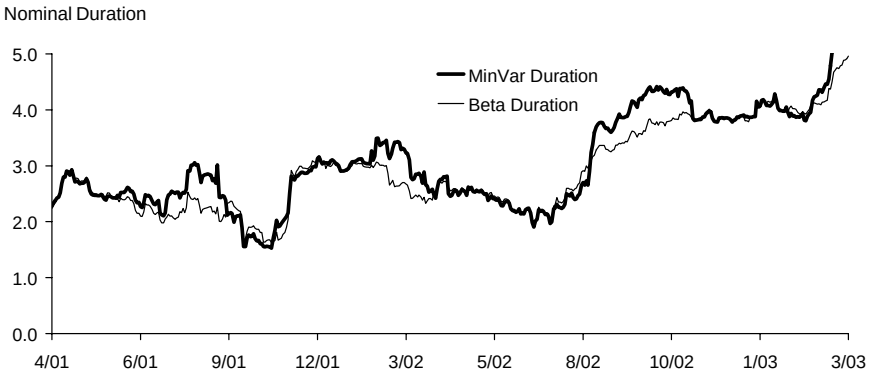
One obvious way to judge the performance of a hedge is to compare the variance of an unhedged TIPS with that of the hedged position. To the extent that the variance of the hedged position is below the variance of the unhedged position, we can claim that the hedging method (and the duration measure used by it) works. For the same two TIPS securities (3½ of 1/15/11 and $3\frac{5}{8}$ of 4/15/28) we have constructed, from January 2001 to March 2003, hedged positions using three different methods:

a) the multiple-bond minimum-variance hedging portfolio;
b) The single-bond hedge using the minimum-variance duration;
c) The single-bond hedge using the beta duration[22] ;

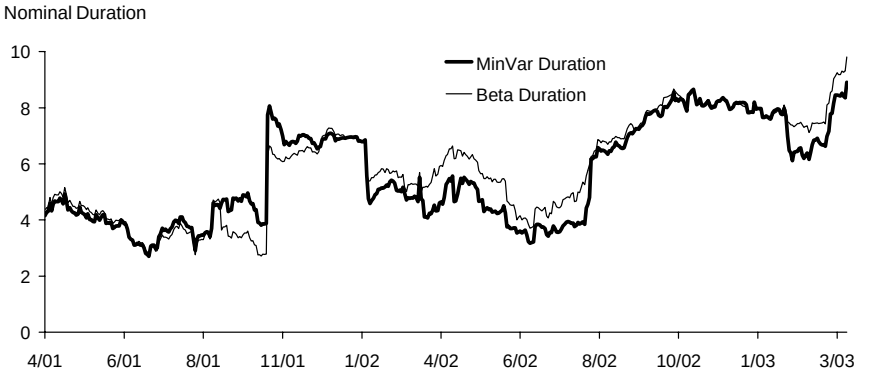
[22] For the single-bond hedge, beta is computed by a regression of the 10- and 30-year TIPS yields on 10- and 30-year par yields based on the Lehman Brothers Treasury spline. Similarly, the P&L of the hedged TIPS position is based on returns of the nominal par bonds used.

Figure 15. **Minimum-Variance and Beta Nominal Durations of the 10-Year and 30-Year TIPS**

$3\frac{1}{2}$ of 1/15/11 (9128276R)

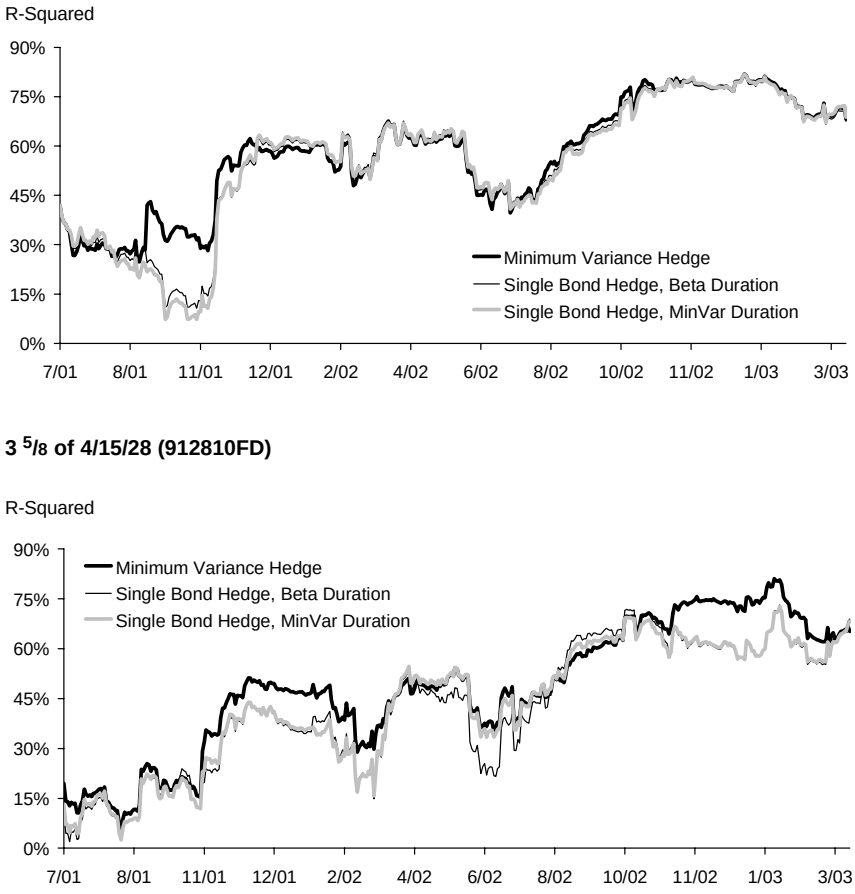


$3\frac{5}{8}$ of 4/15/28 (912810FD)



For each method we compute the 60-day trailing price returns for these positions and the unhedged TIPS bond. Then we calculated rolling R-squared, computed over the previous 60 days, to evaluate the variance-reducing properties of each hedge. Figure 16 presents the plots of the R-squared for the two TIPS securities we have been using. For both of them, the variance-reducing property of all hedges is evident. Predictably, in the recent years, the quality of the hedges improved. As inflation fears subsided, the yield movements became driven by real yield changes to a larger extent than in the prior, higher inflation, periods. In recent months, the minimum-variance hedge, for example, is shown to explain up to 80% of the unhedged TIPS variance. The hedge based on our variance minimization technique seems to perform at least as well as and often better than the two single-bond hedges. Comparison of the single-bond hedges performance does not reveal a clear advantage for either one. For the 10-year TIPS, the hedge using the beta duration performed somewhat better in late 2001 and very much in line with the other one after that. For the 30-year TIPS, the hedge using the minimum-variance duration was better through much of 2002. But overall, the performance of the two single-bond hedges has been similar. From the graphs in Figure 16, it seems that having multiple securities

Figure 16. **60-Day Trailing R-Squared of Various Hedging Techniques for the 10-Year and 30-Year TIPS**



in the hedge portfolio (as in the minimum-variance hedge) is a more important factor than which duration to use in a single-bond hedge.

We believe that these results confirm the merits of the variance minimization approach we have been using since the introduction of TIPS in the U.S. On the other hand, our findings also show that the simple, beta-based regression method of computing TIPS nominal durations is perfectly valid. Many investors use some kind of beta method to compute nominal durations for TIPS. In some cases, beta is set to be a constant (reset from time to time), or determined on the basis of subjective forecasts of future economic relationships. As our results show, a beta based on simple linear regressions can produce reasonable duration estimates. The regression method is somewhat simpler to implement than variance minimization and can be considered as providing a sensible trade-off between the latter and the overly simple qualitative ways of setting a constant beta.

Conclusions

The TIPS market has matured into a well-recognized part of the U.S. Treasury debt universe. The range of investors that hold TIPS or contemplate adding them to their portfolios spans insurance companies, pension funds, total return portfolios, and individual investors. As a result, the interest in this asset class and the need to understand it has grown considerably over the last few years. As with any asset class, TIPS investors need to be able to form relative value judgments and make timing decisions. Compared with other asset classes, TIPS valuation is rather challenging. As shown in this study, in the long term, the main factor that determines relative value calls is the difference between the breakeven rate of inflation, implied by the differential between the nominal and real yields, and inflation forecasts. As we demonstrated above, the current long-term inflation projections exceed the breakeven rate implied by TIPS yields, which seems to indicate that TIPS are a good investment opportunity.

On the other hand, we would like to mention some caveats. There are at least two reasons investors should be careful using this approach. Firstly, and obviously, inflation forecasts can be wrong. As we pointed out, survey estimates of future inflation, such as those published by the *Survey of Professional Forecasters*, tended to overestimate future inflation, although in the recent years this trend seems to be disappearing. Secondly, investors should realize that even if the long-term forecasts are assumed to be true, the timing or evolution pattern of inflation is also important. The path that inflation takes over the long horizon makes a difference, even if the resulting average rate is known with certainty. A scenario with higher inflation in the beginning and lower inflation at the end of a period is preferable for the TIPS owner to the opposite one with the same period average, because the upward adjustment of cash flows will happen sooner in the first scenario. Thus, investors should form their own opinions both on the validity of the available inflation forecasts and on the path inflation is likely to follow in the near future. The use of the breakeven rate as a relative value trading tool is conditioned upon the breakeven rate widening while real rates do not increase too much. Otherwise, investors may have to keep the trade on for a long period of time to reap the rewards of actual inflation exceeding the breakeven rate.

TIPS are particularly appealing for investors who face long-term, cost-of-living adjustment (COLA) dependent liabilities, such as pension funds and insurance companies. For this class of investors, our arguments, which indicated the long-term attractiveness of TIPS versus nominal bonds, have even more validity. First, such investors fully capture the liquidity premium, since they usually do not trade their TIPS position. Second, their subjective inflation risk premium can be considered to be positive, whereas the inflation risk premium charged by the market is likely close to zero. In essence, these investors are buying "free" inflation insurance.

We revisited the procedure for estimating nominal duration of TIPS that we had developed in 1997 at the outset TIPS of the market. This procedure is based on constructing a minimum-variance hedging portfolio from several nominal Treasuries and assigning the duration of this portfolio to be the nominal duration of the hedged TIPS security. Now that we have more than five years of historical nominal durations, we could look back to see if this estimate has been satisfactory. The criterion we use to judge its success was the variance-reducing properties of the minimum-variance hedge. As we have shown above, the variance of the hedged TIPS position has been less than that of the

unhedged one. The hedging efficiency was particularly good in the last couple of years, when the reduction of variance reached up to 80%. Finally, we performed historical back-testing of a somewhat simpler empirical procedure for computing TIPS nominal durations, based on the regression of TIPS yield changes versus nominal yield changes. These regressions produced betas that were used as multipliers for the nominal durations. The resulting empirical TIPS durations were found to be reasonably close to the minimum-variance durations. The best hedging efficiency was achieved with the minimum-variance multi-bond hedge.

We also looked at TIPS from the mean-variance perspective to see the effect they have both on all-fixed-income portfolios and on broad asset class sets including equities. Building efficient frontiers for various asset classes with and without TIPS, we found that in most cases, the addition of TIPS pushes the frontier out. Thus, regardless of the current relative value merits of TIPS, this asset class seems to play a beneficial diversifying role in most contexts.

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