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The Case for TIPS: An Examination of the Costs and Benefits

Jennifer Roush
William Dudley
Michelle Steinberg Ezer

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Abstract

Several studies have shown that, *ex-post*, the issuance of Treasury Inflation-Protected Securities (TIPS) has cost U.S. taxpayers money. We propose that evaluations of the TIPS program be more comprehensive and focus on the *ex-ante* costs of TIPS issuance versus nominal Treasury issuance and, especially when these costs are negligible, the more difficult-to-measure benefits of the program. Our study finds that the *ex-ante* costs of TIPS issuance versus nominal Treasury issuance are currently about equal and that TIPS provide meaningful benefits to investors and policymakers.

Key words: Inflation-indexed debt, Treasury Inflation-Protected Securities (TIPS), liquidity premium, inflation risk premium

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Roush: Board of Governors of the Federal Reserve System (e-mail: jennifer.e.roush@frb.gov). Dudley: Federal Reserve Bank of New York (e-mail: william.dudley@ny.frb.org). Steinberg Ezer: Federal Reserve Bank of New York (e-mail: michelle.steinberg@ny.frb.org). The authors thank Joshua Frost, Joseph Gagnon, Kenneth Garbade, Warren Hrung, Lorie Logan, Simon Potter, Anthony Rodrigues, and Jonathan Wright for thoughtful comments.

I. Introduction

A bit more than a decade has passed since the inaugural issue of inflation indexed debt by the U.S. Treasury Department. Eleven years and thirty issues later, we are at a good vantage point in which to evaluate the successes and failures of the TIPS program.

From a purely financial perspective, a number of recent studies have suggested that the program has been a disappointment. After calculating the direct costs of TIPS issuance relative to an alternative nominal issuance scheme, these studies show that the first ten years of the TIPS program have cost the Treasury billions of dollars. (Sack and Elsasser(2004), Roush(2007)).

Importantly, these studies rely entirely on *ex-post* analysis. In other words, these studies ask: Given the actual inflation outcome, did the costs of TIPS issuance exceed the costs of nominal Treasury issuance of similar duration? This approach depends on the actual inflation outcome, which may differ from expectations at the time the TIPS investment was made because investors do not have perfect foresight of inflation. If investors happen to under-predict actual inflation when purchasing TIPS at auction, then these positive forecast errors would increase the payments that the Treasury has to make to TIPS holders to compensate them for realized inflation.[1] [2] Upside inflation surprises tend to increase the *ex-post* cost of issuing TIPS compared to nominal Treasuries.

While inflation forecast errors are relevant to calculating the actual costs incurred over the first ten years of the TIPS program, we think they are irrelevant in

[1] Conversely, negative inflation forecast errors decrease the inflation payments by Treasury relative to the amount it received for promising to protection investors against inflation at auction.

[2] As we will see below there are other factors which also help determine whether an issue brings in more revenue than it generates, including illiquidity and inflation risk premiums.

assessing the expected benefits or costs of the TIPS program over the long run. In other words, current *ex-post* analysis suffers from the problem of a small sample size, particularly since most of the issues have over-lapping lifetimes and, therefore, are not necessarily independent from each other. In the long run, investors learn from their mistakes and inflation shocks will tend to average out over time. When investors make a particular forecast error, they adapt their expectations for the future accordingly such that they do not persistently make the same error. This means that eventually, amid shifting economic conditions, their accumulated forecast errors will average to zero. Similarly, over time, the amount of upside and downside inflation surprises should average to zero. The implication of this process for the TIPS program is that, in the long run, factors other than inflation forecast errors will determine its relative cost compared to nominal Treasury issuance.

What are these other factors? Two primary factors remain: the compensation investors require to hold a security that is less liquid than its nominal counterpart, termed the illiquidity premium; and the insurance value they attach to obtaining protection against inflation risk, known as the inflation risk premium.[3] Regarding the first, when investors are worried about their ability to resell TIPS securities into a liquid secondary market, they require compensation for holding it versus more liquid alternatives. This illiquidity premium will tend to drive up TIPS yields and increases the Treasury's borrowing costs. The second factor works in the opposite direction. To the extent that

[3] In addition to these factors, TIPS yields also reflect the taxation difference between TIPS and nominals, the convexity difference between real and nominal yields, and the price of the embedded deflation floor. Regarding the tax differential, since an investor has to pay taxes currently on the accrual of the principal amount payable at maturity on an inflation-protected issues, non-tax exempt investors may require a higher yield on TIPS securities (lower TIPS breakeven) than their true inflation expectations. As a result, it may be more difficult for Treasury to capture investors' full inflation expectations and inflation risk premium. In contrast to this, the attractiveness of TIPS may be enhanced as a result of the fact that, at maturity, TIPS holders will receive the higher of the inflation-adjusted principal amount or the par amount.

investors are willing to pay for inflation protection, they will bid up the value of TIPS securities above that implied by their expected payment stream. As such, inflation risk premia mean lower expected borrowing costs for the government and savings for the TIPS program versus nominal Treasury issuance.

Table 1: Impact of Changes in Factors on TIPS Breakeven Inflation

Factor	Impact on TIPS Breakeven if Factor Increases
Inflation Expectations	Increase
Illiquidity Premium	Decrease
Inflation Risk Premium	Increase

To determine which factor has been historically dominant, we conduct an *ex-ante* cost analysis: We compare the amount that the Treasury received for inflation compensation at auction to an observable measure of contemporaneous inflation expectations.[4] The difference between these series yields a measure of the net savings or loss incurred by the Treasury that is independent of inflation forecast errors. It is also equal to the net value of the illiquidity and inflation risk premia associated with each TIPS issue. We find that prior to 2004 the breakeven inflation rate[5] is below a survey measure of inflation expectations. This indicates that the illiquidity premia exceeded the

[4] The measure of contemporaneous inflation expectations may differ from that embedded in TIPS breakevens at a TIPS auctions because the subset of investors is slightly different. Primary dealers, who are awarded an average 54 percent of the competitive bids accepted at TIPS auctions since mid-2003, are not the end-users of TIPS and likely put in an under-writing bid at auction. That said, since the Treasury is paid at the auction stop-out rate, we believe this measure is most appropriate for our analysis.

[5] The breakeven inflation rate is the spread between a TIPS yield and a nominal yield with a similar maturity. It is the inflation rate that will equate the return on a TIPS security to the return on a nominal security.

inflation risk premium over this period. Since 2004, however, we find that breakeven rates were approximately equal to expected inflation, indicating that the two factors were roughly in balance.

This change in fortune for TIPS issued after 2004 may have occurred for two reasons. Over time, as the TIPS market developed, the illiquidity risk premium shrank and/or inflation risk premia increased. Evaluating the two components independently, we conclude that a decline in the illiquidity premium is the more convincing explanation. In particular, our review of the evidence shows a downward secular trend in the TIPS liquidity premium. In contrast, the inflation risk premia appear to have remained relatively low and stable in recent years.

These findings have important implications in assessing the benefits and costs of future TIPS issuance. The TIPS illiquidity that persisted during the first several years of the program and that appears to explain much of the costs of past issuance no longer seems to be an important factor.[6] As a result, as long as the illiquidity premium and inflation premiums do not shift in systematic ways, future TIPS issuance should be much more cost effective to the Treasury Department.

A second objective of this paper is to argue that relative cost calculations, on either an *ex-ante* or *ex-post* basis, are just one aspect of a comprehensive analysis of the costs and benefits of the TIPS program. We believe that TIPS issuance provides the taxpayer with other benefits that should be taken into account when evaluating the TIPS program, especially when cost analysis shows that TIPS are either only marginally more expensive or about even to issue compared to nominals. Some of these benefits, such as

[6] Roush(2007) finds that outstanding TIPS issuance under the counterfactual assumption that there was no illiquidity premium implies significant cost savings.

broadening Treasury's investor base and diversifying its funding sources were cited by Treasury Deputy Assistant Secretary for Federal Finance Bitsberger as a way for Treasury to "reduce our borrowing costs over time."[7] As such, some of the difficult-to-measure benefits of the TIPS program are consistent with the Treasury's current debt management objectives. In a November 2001 speech, Under Secretary of the Treasury for Domestic Finance Fisher highlighted that,"The debt management strategy of Treasury has been to strive to be regular and predictable in the issuance of debt while minimizing borrowing costs over many years and interest rate cycles."[8] This has meant issuing and paying down debt in a manner that promotes market liquidity and that obtains financing across the yield curve.

To more fully assess the net benefits and costs of the TIPS program, we discuss some of the other benefits of TIPS that we believe are important in a complete evaluation of the program. Although these are not easily measured, they may be considerable. They include, among others, important benefits to investors with real saving objectives and valuable information to policy makers whose directive is to contain inflation.

The rest of this paper is structured as follows. The next section examines the *ex-ante* costs of TIPS issuance. Section 3 then reviews measures of illiquidity and inflation risk premium embedded in TIPS. Section 4 discusses some of the other economic benefits of inflation-indexed debt not captured in relative cost measures and Section 5 concludes.

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[7] Speech by Timothy S. Bitsberger to the Fixed Income Summit on December 5, 2002, (http://treas.gov/press/releases/po3673.htm)

[8] See also Treasury Assistant Secretary for Financial Markets Gensler's address to the President's Commission to Study Capital Budgeting, April 24, 1998(http://www.ustreas.gov/press/releases/rr2493.htm) and Stigum and Crescenzi (2007) for an overview of Treasury debt management.

II. *Ex-ante* Cost Analysis

Studies that have evaluated the costs of TIPS issuance versus nominal Treasuries issuance have typically done so by comparing the *ex-post* costs of a program of TIPS issuance relative to the costs of a comparable program of nominal Treasury issuance. Studies of this sort have typically shown that TIPS issuance has resulted in a higher net cost to the Treasury. For example, a 2004 paper by Sack and Elsasser found a net cost to the Treasury from the start of the program through early 2004 of slightly less than $3 billion. Roush (2007) finds that total *ex-post* costs of TIPS through March 2007 were in the range of $5-8 billion[9].

A problem with current *ex-post* analysis is that it depends upon the performance of inflation over a relatively short period of time. If inflation turns out to have been meaningfully different than what was expected at the time of TIPS issuance, then this difference—the "inflation surprise"—affects the relative costs of TIPS versus nominal Treasury issuance. If inflation turns out to be higher than expected, then TIPS issuance becomes more expensive relative to nominal Treasury issuance. If inflation turns out to be lower, however, an *ex-post* analysis shows higher savings (lower costs) from the TIPS program.

The importance of the "inflation surprise" in determining *ex-post* costs can be seen in other countries that have similar programs of inflation-linked sovereign debt issuance. In fact, several other developed countries' inflation surprises have resulted in inflation-linked debt issuance having lower costs compared to nominal debt issuance.

[9] To put the $5 to 8 billion in perspective, the average yearly increase in publicly held outstanding Treasury marketable debt since 2002 is approximately $227 billion. Furthermore, $5 to 8 billion represents 0.1 to 0.2 percent of total outstanding Treasury marketable debt held by the public as of June 2008.

For example, in their 2000 to 2001 Annual Review, the U.K. Debt Management Office noted that the "significant reduction in the cost of funding [from the inflation-linked debt program]… has partly been due to the reduction of inflation risk but more importantly because of the fact market expectations of inflation have exceeded the inflation outturn ("outcome") for much of the last 20 years.[10] Similarly, a 2006 *ex-post* cost study by the Agency France Trésor found that their inflation-linked debt program saved the government €120 million between 1998 and 2004[11]. In this study, the authors point out that any such analysis is difficult since it does not include some of the hard-to-measure benefits of the program (i.e. the diversification of the government's debt portfolio) and it only applies in retrospect. In other words, if actual inflation turns out to be higher than expected in the future, the inflation-linked program could appear costly instead.

Over the long run, however, inflation surprises should not matter. This is because investors are likely to learn from their mistakes so that their forecast errors are not repeated indefinitely. If investors incorporate all known information into their predictions, inflation surprises should be unbiased, with as many downward surprises in inflation performance as upward surprises.

When considering the performance of TIPS over the expected life of the program, we believe this longer-term perspective is most relevant. If an experiment were to be run thousands of times drawing from the underlying distribution of possible inflation outcomes, would Treasury's costs have been lower, on average, with TIPS or with nominal Treasuries? Alternatively, we can ask whether the Treasury obtained the

[10] U.K. Debt Management Office. (2000 – 2001), pg. 39
[11] Coeuré, Benoît and Nicolas Sagnes. (2005, November)

financing it needed at a low cost on an *ex-ante* basis — on a basis that is independent of inflation forecast errors.

To answer this question, we use a concept that TIPS analysts call the breakeven inflation rate. Essentially, this is a value which makes the marginal investor indifferent between buying TIPS or nominal securities. It includes investor expectations about the amount of inflation they will be compensated for, as well as any premium they are willing to pay for protection against inflation. It also includes the component of the TIPS yield that investors require as compensation for any deficiency in TIPS market liquidity relative to nominal Treasury securities.

We conduct an *ex-ante* analysis by comparing the auction breakeven rate[12] to a measure of inflation expectations. Ideally we would like to use a measure of inflation expected by TIPS investors at the time of the auction. Unfortunately, we do not have such an ideal measure. Instead we use real time estimates of expected inflation from the Survey of Professional Forecasters (SPF)[13] conducted by the Federal Reserve Bank of Philadelphia as an approximation. Although the survey's median estimate of the CPI inflation rate over the next 10 years[14] is available only on a quarterly basis, it is unlikely

[12] We apply the same methodology to calculate the auction breakeven rate as that used in Roush (2007). In particular, we estimate the breakeven rate received at auction to be the implied inflation rate that equates the price of the TIPS security at auction to a hypothetical on-the-run nominal security with the same real payment stream as the TIPS issue. For further details regarding the calculation, see Roush (2007).

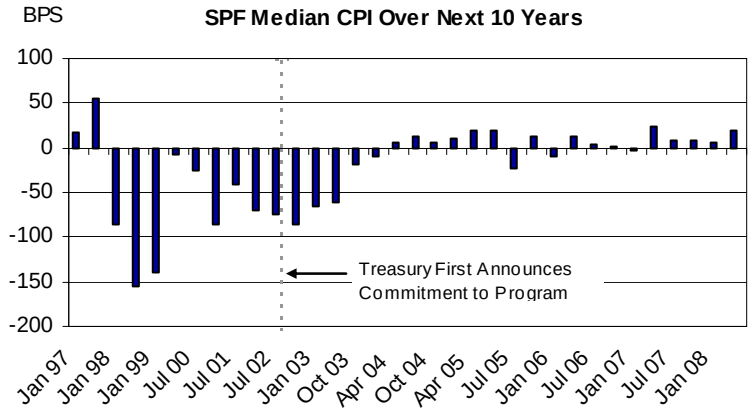
[13] The Federal Reserve Bank of Philadelphia conducts the Survey of Professional Forecasters on a quarterly basis. The survey respondents are professional economic forecasters in the business world or on Wall Street.

[14] In our analysis, we used the median 10-year ahead CPI inflation forecast, which represents the median expectation of respondents for the average annual headline CPI inflation rate over the next 10-years. As such, this forecast is for a similar inflation index and almost similar time period as a newly issued 10-year TIPS. Though the SPF forecast is based on seasonally-adjusted headline CPI, if it were based on non-seasonally adjusted CPI there should be no difference between the two forecasts since they would be forecasts of average annual rates and, therefore, assumptions about seasonality over the year are irrelevant. The time period of the survey is slightly off, given that TIPS are linked to non-seasonally adjust CPI lagged by approximately 2.5 months.

that inflation expectations are very volatile at a high frequency, leading us to expect that the SPF measure may be a reasonable measure of market expectations.[15]

Graph 1 compares the auction breakeven rate at the ten-year maturity point with the Philadelphia Survey of Professional Forecasters' long-run estimate of CPI inflation. As can be seen in the exhibit, during the early years of the TIPS program, the auction breakeven inflation rate was lower than median inflation expectations from professional forecasters. This means that the *ex-ante* cost of ten-year TIPS issuance was higher than the cost of nominal ten-year Treasury issuance.

Graph 1: 10-year TIPS Auction Breakeven Minus SPF Median CPI Over Next 10 Years



Source: FRB of Philadelphia, Board of Governors.

As of June 2008, however, the breakeven inflation rate at the ten-year maturity point is about 2.50%, which is equal to the Philadelphia Survey of Professional Forecasters' most recent long-run estimate for CPI inflation of 2.50%. If we assume that the SPF fairly represents the expectations of investors, then the current constellation of data indicates

[15] Although there are no direct measures of inflation expectations, we believe that the Survey of Professional Forecasters is a good proxy. An alternative survey measure is the University of Michigan's Survey of Consumers median long-term (5-year) inflation expectations measure. This measure is based on the forecasts of consumers as opposed to professional economists. A similar analysis, using this forecast measure instead, shows a comparable pattern, where the early years of the TIPS program appear more costly.

that on an *ex-ante* basis, it appears that the cost of issuing TIPS is currently roughly equal to the cost of issuing nominal Treasuries.[16] From this perspective, there appears to be little net benefit or cost from TIPS in terms of expected financing costs.

The breakeven inflation rate obtained from a comparison of TIPS yields versus nominal Treasury yields also includes two other key elements in addition to expectations about the future inflation rate: (1) the inflation risk premium that investors pay for inflation protection and (2) the illiquidity premium associated with TIPS versus nominal Treasuries. If the insurance value of inflation protection exceeds the illiquidity premium, then the breakeven rate is greater than expected inflation and the *ex-ante* cost of TIPS is lower than for nominal Treasuries. If, however, the illiquidity premium is greater than the inflation risk premium, then the breakeven rate will be below the expected rate of inflation and the *ex-ante* cost of TIPS issuance is greater. The fact that breakevens were below expected inflation during the first several years of the program indicates that the illiquidity premium must have been a dominant influence on *ex-ante* costs during this period.[17] More recently, however, breakeven rates and inflation expectations appear to be about equal, implying that the two factors about cancel each other out. This shift could have happened in two ways: the illiquidity premium in TIPS yields could have declined and/or the inflation risk premium increased. The next section examines this issue in more detail.

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[16] Though the sample size is limited, the median 10-year ahead CPI inflation rate forecasted by the SPF has typically over-predicted actual 10-year CPI inflation for the forecasts taken between 1979 and 1997. If, in a longer sample period, the SPF proves to always over-predict 10-year ahead CPI inflation, then the *ex-ante* cost estimates in our analysis may be overstated. That said, we believe that over a longer sample period, the forecast errors of the SPF should net out to zero.

[17] Roush[2007] finds that the illiquidity premium in TIPS account for most of the ex-post cost of TIPS during this period.

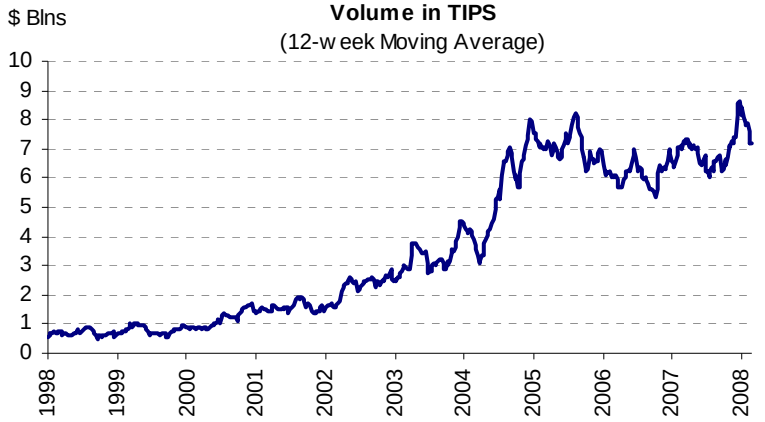
III. TIPS illiquidity versus Inflation Risk Premia

Direct evidence of the illiquidity premia in TIPS yields and on inflation risk premia do not exist, so we must rely on indirect evidence and model based estimates. In this section we consider several approaches to modeling both, as well as observable evidence on changes in liquidity in the TIPS market.

Illiquidity Premia

Over the past decade, TIPS issuance has grown nearly five times as quickly as nominal issuance so that it now comprises almost 10 percent of the Treasury's marketable debt portfolio.[18] During this period, the investor base for TIPS securities appears to have widened and, according to the FR-2004 data, trading volume among primary dealers in the secondary market has increased ten-fold.[19]

Graph 2: Average Daily Secondary Market Trading Volume in TIPS



**Interdealer and customer. Interdealer volumes represent one side of a trade.*
Source: FR 2004

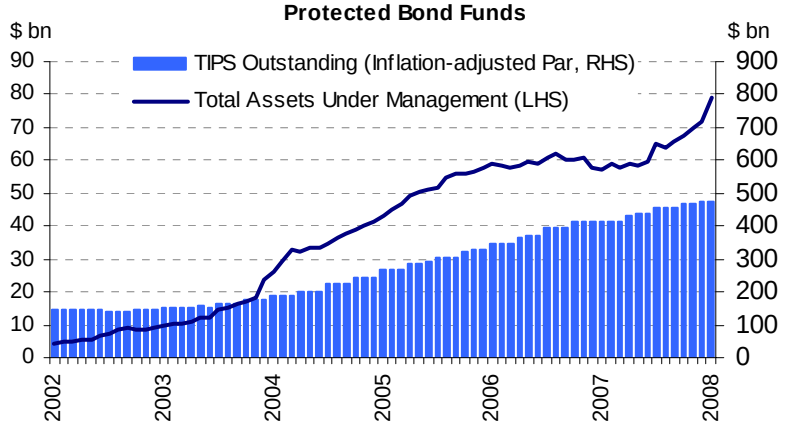
While data on the distribution of TIPS holders is not available, there are some signs that TIPS market participation has increased and the market has become less

[18] This estimate does not take into account the current principal inflation accretion on TIPS issues. If it is taken into account, the percentage increases to 11.9%. United States Treasury, Bureau of the Public Debt. (January 2008) Monthly Statement of the Public Debt of the United States.

[19] The increase in average daily trading volumes exceeds the increase in TIPS outstanding over the same period. Over the past 10 years, the inflation-adjusted par amount of TIPS outstanding has increased almost 6-fold.

concentrated. For example, in our conversations with TIPS investors, they noted the ability to execute trades with a larger number of primary dealers compared to 5 to 10 years earlier. Similarly, when looking at the FR 2004 data, primary dealer trading in TIPS has become somewhat less concentrated across institutions.[20] For example, the top quintile (by volume) of primary dealers was responsible for an average of 68% of total TIPS volume in 2007, 10 percentage points lower than the 2001 average[21] [22]. In addition, there has been a notable increase in the size of mutual funds that hold inflation-indexed securities. According to the Investment Company Institute, assets under management in inflation protected mutual funds have grown 712 percent over the past five years, as shown in Graph 3 below.

Graph 3: Assets Under Management in Inflation Protected Bond Funds



Source: ICI, U.S. Treasury Department.

TIPS traders and investors have reported to us an increased confidence in the longevity of the program and in the ability to carry out transactions in the secondary

[20] In our conversations with TIPS traders and one electronic brokerage firm, they suggested that a large majority of trading in TIPS goes through the primary dealer community.
[21] In comparison, the nominal total transaction volume among the top quintile of primary dealers averaged 44% and 49% in 2007 and 2001, respectively.
[22] According to the Federal Reserve's primary dealer data, the breakdown of total TIPS transaction volume between the interdealer market and dealer to customer market has also changed since 2001. Trading between primary dealers and customers accounted for 78.4% of total primary dealer transaction volume in 2001. In 2007, this percentage declined to 73.4% while interdealer trading increased.

market over the past 10 years.[23] Of note, volume in TIPS was sufficient to support the expansion of electronic trading platforms, such as BrokerTec, Bloomberg, and TradeWeb, to enable TIPS electronic trading in 2003, 2001, and 2003, respectively. Furthermore, when looking at bid-ask spreads, TIPS liquidity appears to have improved somewhat in longer-term markets since 2003, and is roughly the same in the 5- and 10-year sectors. For example, according to Fleming and Krishnan (2008)[24], when there were bid and ask quotes in the interdealer broker market, bid-ask spreads averaged approximately 2/32, 3/32, and 7/32 in the 5-, 10-, and 20-year benchmark issues, respectively, between March 2005 and March 2008[25]. Though not directly comparable given the different data sources, Sack and Elsasser estimated bid-ask spreads of 2/32 for TIPS maturing between 5 and 10 years and between 4/32 to 16/32 for TIPS maturities beyond 10-years in 2003. Our discussions with TIPS market participants also suggest that secondary market liquidity has improved over the past 5 years.

Even if TIPS liquidity has improved, it undoubtedly remains below that of on-the-run nominal securities. Daily trading volumes in on-the-run nominal securities far exceed those shown for TIPS above (Fleming and Mizrach (2008)). The important question for future issuance is not whether TIPS liquidity has improved, but rather whether TIPS liquidity has improved *enough to shrink the illiquidity premium sufficiently*

[23] Most notably, TIPS market participants cited Treasury's 2002 public affirmation of its commitment to the program (http://treas.gov/press/releases/po3149.htm), which it has reaffirmed in public statements as recently as the August 2008 refunding (http://www.treas.gov/press/releases/hp1095.htm).

[24] Fleming and Krishnan (2008) note that a drawback of using the bid-ask spread to analyze TIPS market liquidity is that there is not always a two-sided market. For example, they estimate that between March 2005 and March 2008 there was a two-sided market in the on-the-run 10-year TIPS approximately 60% of the time in the interdealer broker market. As such, information on the extent to which there is a two-sided market complements the bid-ask spread when analyzing liquidity. Unfortunately, a longer time series of this data is not available.

[25] Bid-ask spreads are measured in 1/32s of a point, where a point roughly equals 1 percent of the security's par value.

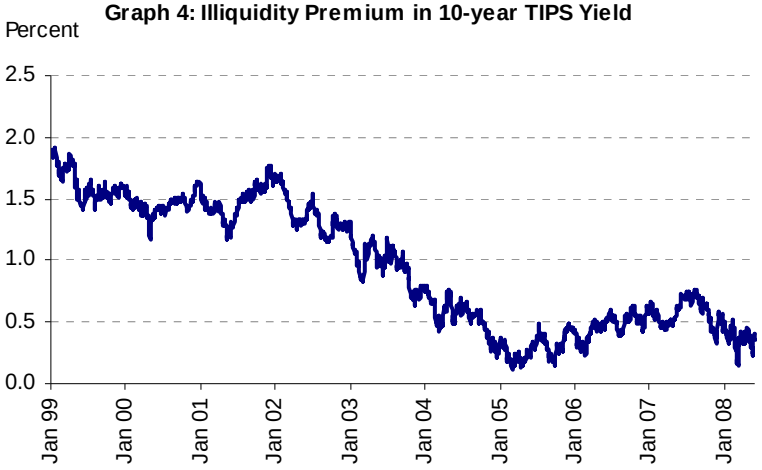
to make TIPS issuance cost-effective from the perspective of the Treasury. More precisely, are investors currently demanding substantial compensation in order to hold TIPS relative to a more liquid security? The larger such premiums are going forward, the greater will be the costs to the Treasury of future issuance, all else equal.

D'Amico, Kim and Wei(2007, "DKW") provide an estimate of the illiquidity premium in TIPS yields versus off-the-run nominal securities from a no-arbitrage latent factor model of the real and nominal term structure. The authors derive this measure by comparing observed TIPS yields to predictions based on an affine model of nominal term structure and an estimated process for inflation.[26]

As shown in Graph 4, these authors estimate that the liquidity premium in the ten-year TIPS yield was as large as 200 basis points in the early years of the program. Since then, however, this has trended down, and within the last six months has fluctuated below 50 basis points. The fact that the premium is positive for most of the sample indicates that TIPS have remained illiquid relative to off-the-run nominal securities, and thus even more so versus their on-the-run counterparts. Nonetheless, the fact that the premium investors demand in compensation for this illiquidity has shrunk to lower levels in recent years suggests that TIPS market liquidity has improved enough to have a dramatic effect on the cost effectiveness of TIPS issuance. Indeed, as we will discuss below, it now compares favorably with estimates of the size of the inflation risk premium.

[26] More details of the D'Amico, Kim and Wei model are included in an appendix.

Graph 4: Illiquidity Premium in 10-year TIPS Yield

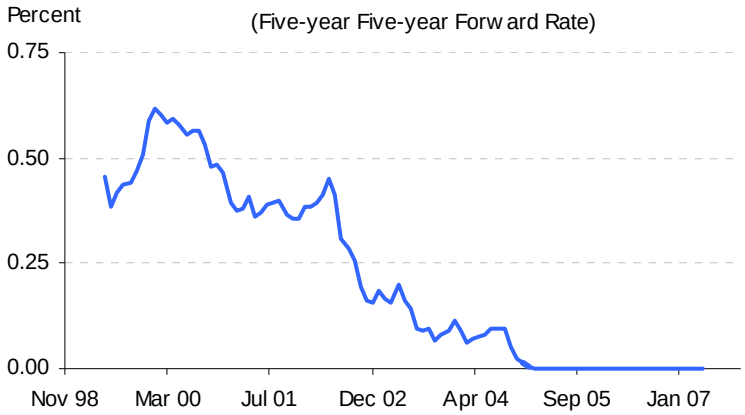


Source: DKW.

Sack (2005) provides an alternative measure of the illiquidity premium in five-year forward TIPS yields beginning in five years. This measure is derived from a regression of TIPS yields on a variety of macroeconomic variables as well as the secondary market turnover in TIPS.[27] Consistent with the findings in DKW, he finds that the TIPS yields in the early years of the program were above the level predicted by the macroeconomic fundamentals alone, and interprets the part of the TIPS yield that is predicted by TIPS turnover as a proxy for the illiquidity premium. This measure, shown in Graph 5 below, also points to a notable improvement in TIPS liquidity during the period from 2000 to 2004. Of note, the level of Sack's illiquidity measure is different from the DKW estimate since Sack measures the illiquidity premium indirectly through a multi-factor regression.

[27] In his regression, Sack includes a measure of the difference between the unemployment rate and NAIRU, expected real GDP over the subsequent year, the spread between WTI futures and spot prices, lagged WTI oil price inflation, the three month moving average of correlation between daily changes in the stock market and breakeven rates, and the squared difference between TIPS volume at each point in the sample with the end period volume.

Graph 5: Sack Measure of the TIPS Liquidity Premium Also Declined Since 1998
(Five-year Five-year Forward Rate)



Source: Macroeconomic Advisors.

Inflation Risk Premia

The notable declines in estimates of the illiquidity premiums in TIPS yields in recent years suggests that it now costs the Treasury relatively less to issue TIPS versus nominal securities than it did in the past. But the key question is the size of this illiquidity premium versus the size of the inflation risk premia.

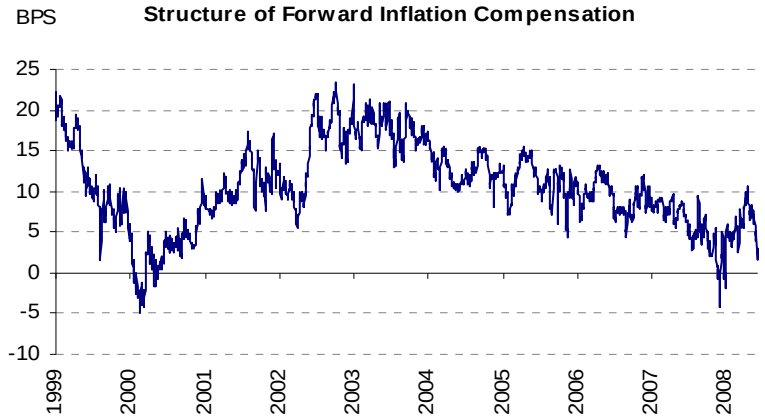
To better estimate the size of the inflation risk premia, we consider several model estimates. A simple measure of the inflation risk premium can be calculated based on the term structure of forward inflation compensation rates at distant horizons, as described in Sack (2007). The rationale is that most factors affecting movements in inflation tend to die out after a few years, so that investors are unlikely to expect inflation to be different at adjacent forward rates, for example, at nine and ten years ahead.[28] Thus

[28] This simplifying assumption ignores factors that affect the level of long run inflation expectations. However these are likely to occur infrequently.

the spread between one-year forward inflation ending in nine and ten years is likely to be driven mostly by inflation risk premiums.[29]

Graph 6 presents a time series of the inflation risk premium from nine to ten years ahead measured according to this approach.[30] These estimates are based on smoothed zero-coupon yield curves for real and nominal bonds [Gürkaynak, Sack, and Wright (2006, 2007)]. The inflation risk premium has varied between zero and twenty-five basis points since 1999, with an average value of 11 basis points.

Graph 6: Inflation Risk Premium at Ten Years from Term Structure of Forward Inflation Compensation

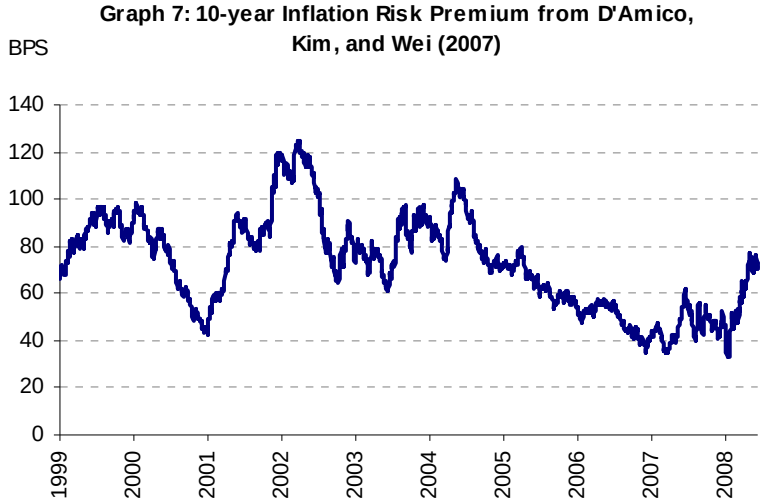


Another model used to estimate the inflation term premiums embedded in nominal Treasury yields is the no-arbitrage model used by DKW. Graph 7 below presents a time series of the inflation risk premium for ten-year zero-coupon inflation compensation from their model. This measure of the inflation risk premium varies between 40 and 120 basis points over of the history of the TIPS program. The levels of the two measures of inflation risk premiums are not directly comparable since one is a

[29] Although this approach does not explicitly account for liquidity effects, the fact that the illiquidity premium at nine years is unlikely to be very different from ten years means that, in effect, liquidity effects are approximately excluded by taking the spread at these adjacent horizons.

[30] We use a smoothed spline to abstract from small deviations in yields based on liquidity. Furthermore, we believe that any differences between our estimates, which are derived from a smoothed spline, and those derived from a bid, ask, or mid spline would be small.

short-term far forward rate and one is long-term spot rate, however it is useful to note that the correlation between the two measures is positive and statistically significant, albeit at only 0.28. More importantly, although the DKW measure exhibits somewhat different variation, particularly in the first half of the sample, both series generally declined between 2004 and 2008, before picking up recently. This provides further evidence that the recent improvement in the cost of TIPS issuance was associated with a decline in the TIPS illiquidity premia rather than an increase in inflation risk premia.



The Inflation Risk Premium Earned by Treasury at Auction

We conclude by explicitly decomposing our *ex-ante* cost analysis into the components related to illiquidity in TIPS and inflation risk premia. As above, we compare the breakeven rate of inflation to a measure of expected inflation from the Survey of Professional Forecasters. However, we now exclude the illiquidity premium in TIPS yields estimated in DKW before computing the breakeven rate.[31] A comparison of

[31] DKW calculate the liquidity component for five- and ten-year TIPS yields, which we use to adjust the auction prices of five and ten year TIPS issues. For twenty and thirty year TIPS issues, we assume that the

this breakeven rate with inflation expectations yields an estimate of the premium investors were willing to pay for inflation protection at previous TIPS auctions.

Graph 8 below presents estimates of the inflation risk premium on TIPS auction days using this method.[32] The average risk premia over the sample is within the range of the other estimates at 47 basis points. Furthermore, this measure of auction inflation risk premiums appears to have decreased over time. This may indicate that the initial purchasers of inflation indexed bonds were also those investors who put the highest value on inflation protection.[33] An alternative explanation is that as inflation has stayed low, inflation expectations have become better anchored. As this has occurred, the inflation risk premium that investors have been willing to pay for inflation protection has diminished somewhat over time.[34]

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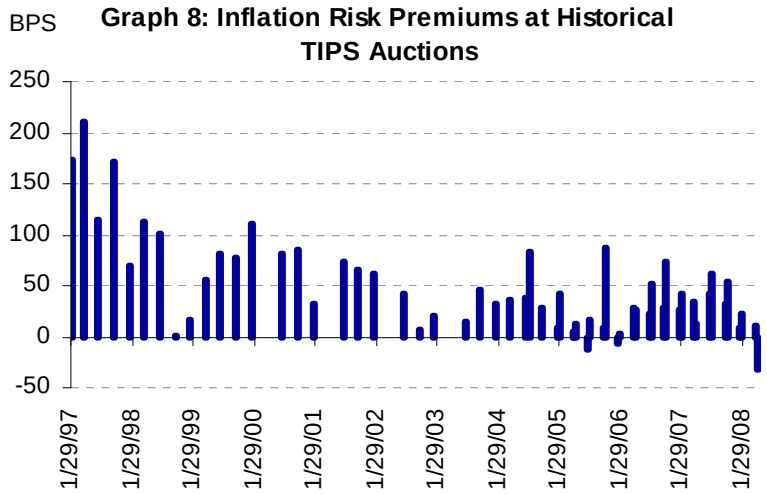
liquidity component is equal to that for a ten year security, which in the event that these securities are less liquid than the ten-year note, understates this effect, and thus underestimates the risk premium at this horizon. DKW also do not calculate liquidity yield components before 1999, because there were too few TIPS issues to construct a zero coupon yield curve until then. For auctions occurring between 1997 and 1999, we assume that the liquidity yield component at these auctions is equal to its value at the start of 1999.

[32] Note that the maturity of TIPS changes at each auction in Figure 8, making comparison with the above time series of the inflation risk premia problematic. Put another way, the inflation risk premia presented in Graph 8 are not for a constant time horizon, but vary between 5, 10, 20, and 30 years, depending on the maturity of the TIPS being auctioned on a given date.

[33] The fact that the inflation risk premia by this measure are sometimes negative suggests that there may be measurement error in estimation of inflation expectations. Furthermore, with the exception of the two recent negative estimates of inflation risk premia, the other negative estimates are not significantly different from zero.

[34] The -32.3 basis point estimate of inflation risk premium at the April 2008 5-year TIPS auction may be a reflection of market conditions at the time of the auction as opposed to investors' actual value for inflation protection. In particular, the historically low level of 5-year TIPS yields (and the low expected coupon rate) reportedly may have deterred some investors from participating at the auction. Of note, the pre-auction day yield of the 5-year TIPS, at 0.53%, was the lowest pre-auction day level compared to prior 5-year TIPS auctions and was notably below the 1.79% average 5-year TIPS yield since the Treasury brought back the 5-year maturity point in 2004. In addition, part of the negative inflation risk premium may also reflect the flight-to-quality bid in the nominal market at the time. When we conduct a calculation of the inflation risk premium that assumes TIPS are as liquid as an on-the-run security (instead of an off-the-run security), the inflation risk premium increases to -10.3 basis points.



The table below presents the average inflation risk premium by maturity of the securities auctioned. Although the size of the inflation risk premium does not appear to increase consistently with maturity, this result may be misleading as it is due, at least in part, to changing issuance patterns. For example, with the exception of the July 2002 TIPS, 5-year TIPS have only been issued during the past 3 years – a time period where oil prices increased over 175 percent. This could contribute to the high estimate of inflation risk premium for 5-year TIPS. In contrast to the relatively limited issuance of 5-, 20-, and 30-year TIPS, 10-year TIPS were issued throughout the sample and thus may provide the best overall estimate that also is maturity constant. According to this estimate, a typical risk premium over this period has been about 40 basis points.

Table 2: Estimate of Inflation Risk Premium by Maturity of Issue

5-Year	52 basis points
10-Year	41 basis points
20-Year	37.5 basis points

30-Year	83 basis points

The fact that investors appear willing to pay about 40 basis points for inflation protection indicates that the TIPS program does satisfy a real demand held by investors that is not met via nominal Treasury issuance. It also suggests that there is potential for significant gains to Treasury from enhancing secondary market trading liquidity. For example, if the TIPS market were as liquid as off-the-run Treasuries, the Treasury would have incurred a total cost savings from the TIPS program of $22 to $32 billion.[35] [36]

IV. Other Benefits of Inflation-Indexed Debt

The Treasury's ability to issue TIPS at lower inflation-adjusted yields because of a significant inflation risk premia is only one of several benefits inflation-linked debt issuance provides investors and monetary policymakers. The other benefits of the TIPS program, though difficult to quantify, are potentially considerable. As such, when taking into account these benefits, TIPS issuance may be more favorable to the Treasury and U.S. taxpayer than additional nominal issuance.

Inflation Hedge for Households

James Tobin made one of the most convincing arguments in favor of inflation indexed debt on behalf of households with real savings objectives:

> "…markets do not provide, at any price, a riskless way of accumulating purchasing power for the future, whether for old age, or for college

[35] We estimate the *ex-ante* cost of the TIPS program as the present discounted value of the difference in the payment stream paid by Treasury to TIPS holders from the expected payment embedded in TIPS prices assuming that actual inflation equals the SPF measure of expected inflation and that there is no illiquidity premium.

[36] Similarly, if the TIPS market were as liquid as on-the-run Treasuries, the Treasury would have incurred a total cost savings from the TIPS program of $28 to $37 billion.

> education or for heirs….Meanwhile we force savers to take risk, even if they would gladly pay for the privilege of avoiding it…..No private institution can fill this gap. No insurance company or pension fund could assume the risk of offering purchasing power escalation to its creditors without similarly (inflation) escalated securities in which to invest at least some of their funds."[37] [38]

The important point in this argument is that even if nominal bond yields are high enough on average to compensate investors for the expected rate of inflation, an individual investor at any point in time may be over-compensated or under-compensated vis-à-vis the realized rate of inflation. By providing individuals a way to insure against inflation risk, TIPS embed less risk than any other asset class. With virtually no credit risk or inflation risk, TIPS are one of the safest of investments.[39] Equities or other assets with uncertain nominal returns provide only an imperfect hedge depending on their correlation vis-à-vis inflation. [Fischer(1975), Chu Lee, and Pittman(1995)].

This benefit has implications for individual investors as well as the broader economy[40]. By providing individuals a way to insure against inflation risk, the government enables individual investors to choose how much inflation risk they want to hold, allowing for a more optimal allocation of inflation risk among investors with different risk preferences [Campbell and Shiller (1996)]. In addition, as argued by Tobin (1963), the existence of a risk-free inflation hedge may, in turn, encourage saving behavior on the part of households.

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37 Tobin (1963, pg 204,206

38 While investors could purchase short-term debt and renegotiate the interest rate every three months, this would expose them to roll-over risk.

[39] There is some inflation basis risk in that TIPS are based on the not seasonally adjusted consumer price index and a household's expenditure basket might differ from the basket in the CPI. Also, pension and endowment liabilities may be more closely related to other inflation or wage measures than the CPI.

[40] It should be noted that there are potential income distribution effects if TIPS are more expensive to issue than nominal securities and TIPS holders are not evenly distributed across income groups. We do not address these here, however.

Better Monetary Policy

The existence of TIPS also helps to improve the conduct of monetary policy in a number of ways. Foremost of these, they provide up-to-date information about the evolution of inflation expectations and real *ex-ante* interest rates,[41] which are important inputs to monetary policy decisions. Because increases in inflation expectations are often difficult to predict and are difficult to reverse, up-to-date information about inflation expectations from TIPS may be important in helping policy makers conduct monetary policy in a way that keeps inflation expectations in check. This is important because inflation expectations are an important element influencing the inflation process.[42] In this role TIPS are particularly useful because survey measures of inflation expectations, such as those from the University of Michigan and the Survey of Professional Forecasters, are available only at a lag and are updated much less frequently. Although inflation swaps provide an alternative market source of daily information on inflation expectations, these securities are much less liquid than TIPS [Beechey and Femia (2007)].[43] Moreover, it is unclear that the U.S. inflation swaps market would exist without the TIPS market because TIPS provide a benchmark security that can be used to hedge the inflation payments on swaps.

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[41] Raw inflation compensation rates are not pure measures of inflation expectations because they contain inflation risk premium and potentially, distortions due to illiquidity. However, estimates of expected inflation can be derived using measures of these later components as demonstrated by D'Amico, Kim, and Wei (2007). Furthermore, significant changes in TIPS liquidity tend to be slow compared to inflation expectations and, as a result, over short periods of time changes in inflation compensation rates can reflect a change in inflation expectations and/or inflation risk premium.

[42] If long-run inflation expectations become less anchored, shocks to inflation may result in a larger effect on inflation expectations and trend inflation. Consistent with this, Mishkin (2007) noted that "because long-run inflation expectations are a key driver of trend inflation, monetary authorities monitor long-run inflation expectations closely. If they find that they are losing credibility with the markets, so that inflation expectations begin to drift and rise above (or fall below) a desired level, they will take actions to restore their credibility."

[43] Trading in CPI futures, which provided another financial market read on inflation expectations, was introduced on the Chicago Board of Exchange in (March 2004), however market liquidity had declined to near zero by the summer of 2005.

TIPS are also valuable in helping economists and policy makers understand the forces that influence inflation expectations. For example, the existence of minute-by-minute data on inflation compensation from financial markets provides a gauge of the effects of monetary policy actions and macroeconomic data releases on inflation expectations. In this way, TIPS help inform models of the macroeconomy that are important in the policymaking process.

Better Fiscal Policy

TIPS may also provide incentives for better fiscal policy. They provide an explicit incentive for the fiscal (as well as monetary) authorities to conduct policy with an eye toward the consequences for inflation. When the public, in turn, understands that the government is accountable for higher inflation in the form of higher inflation payments to TIPS holders, this may help hold down inflation expectations and cause inflation expectations to be more firmly anchored, i.e., less responsive to inflation shocks.

Moreover, TIPS help improve the management of the national debt. First, the fact that payments on TIPS are tied to realized inflation means that the receipts and expenditures of the Treasury Department are (all else equal) likely to be better matched—since tax receipts are also nominal and are likely to rise and fall with shifts in the underlying inflation rate. Thus, TIPS issuance may help reduce the overall volatility of the Treasury's financing needs.[44] A reduction in volatility helps promote the regularity and predictability of the issuance calendar. This increases the liquidity of outstanding Treasury securities and helps to foster demand at Treasury auctions.

[44] Since payments on nominal Treasury debt are tied to expected inflations at the time of the security's auction, differences in Treasury assets and liabilities can arise from divergences between realized and expected inflation.

Second, as noted by Deputy Assistant Secretary for Federal Finance Bitsberger, TIPS may give the Treasury access to a broader investor base. This may reduce Treasury's overall funding costs. In the same June 2003 speech[45], he further noted that "by diversifying our [Treasury's] borrowing, we reduce exposure to a single adverse shock and both lower and smooth our borrowing costs." The comparison between the prevailing interest rates on TIPS versus nominal Treasuries provides insight into the relative costs associated with issuing the last dollar of debt. But just as important is answering the question: Does TIPS issuance, by displacing nominal Treasury issuance, reduce the level of interest rates that the Treasury pays on its nominal Treasury issuance? In principle, a substantial shift in the composition of Treasury issuance into TIPS from nominal Treasuries could lead to lower interest rates paid on the remaining nominal Treasury issuance. This would occur if: (1) TIPS were not perfect substitutes for nominal Treasury securities; and (2) if the demand for nominal Treasuries were downward sloping — i.e., not completely elastic.

The first condition almost certainly holds given the different attributes of TIPS versus nominal Treasuries. If they were perfect substitutes, then there would not be a liquidity premium for nominal Treasuries versus TIPS. The second condition seems likely to hold as evidenced in a number of studies that have found that an increase in the net amount of Treasury borrowing leads to higher expected borrowing costs for the Treasury. [46]

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[45] Chart Presentation of Deputy Assistant Secretary for Federal Finance Timothy S. Bitsberger to the Bond Market Association's Inflation-Linked Securities Conference, June 26, 2003. (http://treas.gov/press/releases/js505.htm)

[46] Tests of market segmentation of different types of Treasury debt have resulted in mixed results. (Fleming, 2002; Krishnamurthy, 2002, Laubach, 2003) However this work is generally limited to consideration of different maturities of nominal debt and does not consider segmentation of real versus nominal debt. That there might be more evidence for the latter is suggested by conventional wisdom that

While it is very difficult to estimate the impact additional supply would have on Treasury yields, a few research papers have touched upon this subject. Fleming (2002) suggests that a $1 billion increase in issuance size for the most recently issued 3- or 6-month bill raises its yield, relative to neighboring bill yields, by approximately 0.35 basis points. At the longer end, Krishnamurthy (2002) finds that a $1 billion increase in bond supply would increase the bond yield, relative to the yield on the previously issued bond, by 0.2 basis points. These results suggest that by issuing securities in a segmented TIPS market the Treasury may keep realized yields on bill and nominal coupon securities lower than they otherwise would have been.

V. Conclusion

Summing up, we reach five major conclusions:

1. Determining whether it is in the interest of the U.S. taxpayer to continue TIPS issuance is a decision that should be based on a comparison of the *ex-ante* costs of TIPS versus nominal Treasury issuance and, especially when these costs are negligible, a consideration of the more difficult-to-measure benefits TIPS issuance provides taxpayers and policymakers. This decision should not be based on *ex-post* analysis since such analysis depends on the realized inflation rate over a relatively short history, which is irrelevant in assessing the expected costs of TIPS issuance versus nominal Treasury issuance on a prospective basis.

TIPS market participants tend to be buy and hold investors, including institutions such as pension funds. Consistently, the Treasury auction allotment data shows that pension funds and investment funds take-down an average 30 percent of the amount issued at TIPS auctions since 2000. In contrast, these investors took down only 10 percent of the amount offered at nominal coupon auctions over the same time period.

2. On an *ex-ante* basis, the cost of TIPS issuance is about equal to or less than the cost of nominal Treasury issuance since the value of inflation protection — the implicit premium that investors are willing to pay in terms of lower TIPS yields — is now greater than or equal to yield premium investors demand for holding relatively illiquidity TIPS versus their nominal counterparts.
3. Although the costs of TIPS issuance over the life of the program appear to have exceeded the costs of comparable nominal Treasury issuance, these costs were concentrated during the early years of the program when the illiquidity premium associated with TIPS was large. That illiquidity premium has shrunk significantly as the TIPS program has matured. Therefore, these early costs are "sunk" and should not be used to determine whether TIPS issuance is costly on an ongoing basis.
4. TIPS issuance has other significant benefits that are not included in an analysis of net issuance costs. These include the value to investors of having a risk-free asset that offers protection against inflation, the value to the monetary authority of having a real-time guide to shifts in inflation expectations, and the fact that a TIPS program likely displaces nominal debt issuance to some degree, allowing for a reduction in the average cost of nominal issuance as that supply is reduced.
5. Our analysis of the *ex-ante* costs of the TIPS program and the more difficult-to-measure benefits suggests that there is at least a modest net benefit to Treasury's issuance of TIPS. Since TIPS issuance appears to be attractive from the Treasury's standpoint, a natural next step is answering the question: "What is the

optimal allocation of the Treasury's liability portfolio between TIPS and nominal Treasuries?"

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Appendix

This appendix describes briefly how D'Amico, Kim and Wei (200x) (henceforth DKW) estimate the illiquidity premium in TIPS yields. Their first step is to estimate yields on hypothetical real bonds that have the same liquidity as nominal Treasury securities, using a joint model of nominal yields and inflation. Intuitively, they are constructing these yields by considering the time series properties of nominal Treasury yields and inflation, but do so in a coherent asset pricing framework that rules out the possibility that investors are leaving arbitrage opportunities unexploited.

Modern asset pricing theory starts from the premise that the absence of arbitrage implies that there exists a pricing kernel, m_{t+1}, such that the price of any asset satisfies the relationship $P_t = E_t(P_{t+1}m_{t+1})$. Because bond prices are not complicated by uncertain cash flows, the price of an n-period nominal zero-coupon bond is just given by $E_t(m_{t+1}m_{t+2}....m_{t+n})$. This imposes tight restrictions on the relationship between the time-series and cross-sectional properties of these bond prices. Following many researchers in the finance literature, DKW assume that the pricing kernel, m_{t+1} depends on the short-term interest rate, $y_s(t)$, and prices of risk, $\lambda(t)$. If investors were risk-neutral, then $\lambda(t)$ would be zero, but DKM make no such assumption. The short-term interest rate and prices of risk are assumed to be "affine" (linear plus a constant) functions of three unobserved factors, represented by $X(t)$

$$y_s(t) = \delta_0 + \delta_1 X(t)$$

$$\lambda(t) = \nu_0 + \nu_1 X(t)$$

In turn, these factors are assumed to follow a vector autoregression of the form

$$X(t+1) = \mu + \Phi X(t) + \varepsilon(t+1)$$

All this implies that the yield on an n-period zero coupon bond is given by an "affine" function of the factors::

$$y_n(t) = a_n + b_n' X(t)$$

where $a(n)$ and $b(n)$ are functions of the parameters of the model including μ, Φ, δ_0, δ_1, ν_0 and ν_1. Finally, a novel feature of DKM is that it is assumed that expected inflation is also an affine function of the same factors, $X(t)$:

$$\pi^e(t) = \phi_0 + \phi_1 X(t)$$

Because it jointly models the nominal term structure and inflation, the model can be used to price a hypothetical real bond, the yield on which turns out also to be an affine function of the factors:

$$y_n^{real}(t) = a_n^{real} + b_n^{real} X(t)$$

The model is estimated using data on nominal Treasury yields, CPI inflation, and survey forecasts of nominal short-term interest rates and inflation.[47] These survey forecasts are treated as noisy measures of true expectations of future rates and inflation. And substituting the parameter estimates into the last equation, gives the estimated real yields.

Estimating the Illiquidity premium in TIPS Yields

Because DKW derive estimated real yields from the nominal off-the-run term structure rather than directly from TIPS themselves, the resulting estimated real yields implicitly embody the same liquidity characteristics as nominal off-the-run securities. Thus by differencing these estimated real yields and observed TIPS yields, the authors obtain an estimate of the portion of observed real yields that owes to differences in nominal and real bond liquidity. A positive difference results when TIPS are less liquid than the nominal off-the-run securities, since in this case, TIPS investors require a yield premium for holding the less liquid securities.

Graph 4 in the body of this paper shows that this difference series is indeed positive throughout its history. It also exhibits a secular decline, which is consistent with improved liquidity as one would expect from a developing financial market. It also exhibits a small amount of variation around its downward trend. This may reflect high-frequency changes in the liquidity premium, but is probably also importantly influenced by model fitting error, as the model-implied nominal yields are close—but not identical —to the actual observed yields.

[47] TIPS are not included directly into the version of the model from D'Amico, Kim and Wei (2007) discussed here because the sample of available TIPS is too short. Instead the authors model inflation and use it to price synthetic real bonds. The authors also estimate a version of the model that incorporates TIPS, however the shortness of the available sample for TIPS means that these estimates are likely associated with greater estimation error.