Understanding Inflation-Indexed Bond Markets
John Y. Campbell, Robert J. Shiller and Luis M. Viceira

Discussion by Jonathan H. Wright[1]

It is now a bit over a decade since the United States began issuing index-linked bonds (TIPS). The paper by Campbell, Shiller and Viceira is a timely and excellent analysis of what we have learned from the pricing of these new securities and their counterparts in other countries. TIPS yields have been more volatile than might have been anticipated. Campbell, Shiller and Viceira discuss the reasons why, before turning to the most topical question—the behavior of TIPS over the recent financial crisis.

Are real risk premia positive or negative?
Abstracting for the moment from issues of liquidity, a real bond yield is the sum of the average expected real-short term interest rate over the life of the bond and a real risk premium. Campbell, Shiller and Viceira use both a consumption-based model of asset pricing and a CAPM to argue that real risk premia ought to be low, or even negative. That in turn makes them an ideal instrument for the Treasury, if it is seeking to minimize expected debt servicing costs.

There are some simple pieces of empirical evidence that can be brought to bear on the question of the typical sign of the risk premium on real bonds. The average level of the five-to-ten-year forward TIPS yield from January 2003 to August 2008 was 2¾ percent. If real risk premia are zero or negative, then this means that expectations of r*, the equilibrium real short-term interest rate, must be at least 2¾ percent (abstracting from liquidity premia, but this was a time when TIPS liquidity was generally good). This seems a rather high number for r*. The expectations of real short-term interest rates from five to ten years hence computed from the survey conducted by Blue Chip Economic Forecasters twice a year are volatile, but were around 2 percent over this period. This reasoning suggests that real risk premia are positive.

Another simple calculation is from the slope of the real yield curve. In normal circumstances, one might suppose that expectations of real short-term interest rates from five to ten years' hence are fairly flat. If the real forward yield curve at those horizons slopes up, that suggests that real term premia are positive, and vice-versa. Table 1 shows the average slopes of the real and nominal forward curves from five to six years hence in the U.S. and in the U.K. over the period from January 2003 to August 2008.[2] In the U.K., the nominal yield curve slopes up while the real yield curve slopes down. This is indeed evidence for the view expressed in the paper. In the U.S., it's not so clear. The real curve is flatter than the nominal one, but both slope up.

Overall, this simple evidence doesn't seem to me to support the view that real risk premia have typically being negative in the U.S., though I agree that they are much lower than their nominal counterparts.

[1] Department of Economics, Johns Hopkins University, Baltimore MD 21218; email: wrightj@jhu.edu; phone: (410)-516-5728.
[2] Piazzesi and Schneider (2006) did a similar comparison for an earlier sample period.

The TIPS Market and the Financial Crisis

Since the collapse of Lehman Brothers in September 2008, yields on index-linked and nominal bonds have decoupled and have been exceptionally volatile. The yields on some index-linked bonds rose above those of their nominal counterparts, making the breakeven inflation rates negative. This could represent a fear of deflation, or special demand for the comparative liquidity of nominal securities. Knowing which it is matters a lot. It's a hard question to answer, but there are some clues. It's surely the most important thing to understand from the TIPS market right now.

TIPS bonds have the feature that the principal repayment cannot be less than the face value of the bond, even if the price level falls over the life of the bond. This gives TIPS an "option-like" feature in which the strike price is the reference CPI (i.e. the price level at the time that the bond is issued). For a recently issued bond, any deflation will result in this option being in the money. For a bond issued (say) five years ago, the deflation has to be very severe—representing an unwinding of all the cumulative inflation over the past five years—before this deflation option has any value.

This means that we can obtain information on the probability of deflation by comparing the real yields on pairs of TIPS with comparable maturity dates but different reference CPIs. For example, Figure 1 plots the real yield on the April 2013 and July 2013 TIPS. These were issued in 2008 and 2003 and the reference CPIs are 211.37 and 183.66, respectively. Prior to September 2008, the real yields were comparable, as the deflation option was perceived to be too far out of the money to matter to investors. But subsequently, the spread soared to 2 percentage points. The only reasonable interpretation of this is that investors started to put substantial odds on deflation taking hold, increasing the relative attractiveness of the more recently-issued TIPS.

Comparing the yields on these two TIPS, a lower bound on the implied probability of deflation over the period till 2013 can be worked out. This requires a number of strong assumptions, including risk neutrality. The assumptions and details of the calculation are given in the Appendix. But the calculation is based on comparing two TIPS yields, not a TIPS yield with a nominal yield, and so the technical factors that Campbell, Shiller and Viceira cite that pushed down the prices of TIPS in the fall of 2008 should not distort this calculation, unless they affected one TIPS issue more than another. Figure 2 shows how this implied probability of deflation evolved over time. It was around zero before September 2008, soared to over 60 percent, before falling back to about 10 percent early in 2009. The calculation embeds many strong assumptions, but it is any case only a lower bound on the probability of deflation and so it seems reasonable to think that fear of deflation was a significant part of the unusual behavior of TIPS last fall. That fear is now much reduced, but has not entirely gone away.

Fear of deflation was surely not the only influence on index-linked bonds over this period—issues that come under the broad heading of "liquidity" were important too. Campbell, Shiller and Viceira make a compelling case that TIPS prices were depressed last fall by leveraged investors being forced to unwind large TIPS positions quickly.[3] Gürkaynak, Sack and Wright

[3] As Campbell, Shiller and Viceira point out, the divergence between TIPS breakeven rates and rates quoted on inflation swaps is strongly suggestive of distressed TIPS sales. It is however worth pointing out that in the United States, the inflation swaps market is tiny, with trading volume of roughly 2 percent of that in TIPS.

(2009) estimated that worsening liquidity pushed up five-year TIPS yields by more than a percentage point in the fall of 2008. The issue of liquidity can be seen starkly by comparing the April 2013 TIPS with the nominal yield curve. Because this TIPS was issued in 2008 (when the CPI was around its current level) and because the inflation adjustment to the TIPS principal cannot be negative, this particular TIPS effectively becomes a nominal security in the event of deflation[4], while of course it pays off more than a nominal security in the event of inflation. Thus the payoff on this security stochastically dominates the payoff on a corresponding maturity nominal bond. Figure 3 plots the spread between the real yield on the April 2013 TIPS over a comparable maturity nominal bond. This spread went *negative* for an extended period in late 2008 and early 2009, and it was large and negative at some times. This is impossible to make sense of from a standard asset pricing perspective, as it means that investors were leaving an arbitrage opportunity on the table. And, even though the spread is now positive once again, it remains remarkably low given that there are surely sizeable odds on a pickup in inflation between now and 2013.

Summers (1985) quipped that financial economics entailed simply checking that two quart bottles of ketchup sold for twice as much as one quart bottles. Alas, it is not so any more—there have recently been many examples of investors seemingly leaving arbitrage opportunities unexploited. The comparison between the April 2013 TIPS and the nominal yield curve is one example. A second example is that the yield on old thirty-year Treasury bonds is systematically higher than the yield on off-the-run ten-year notes that have the same maturity. Another is that the yields of Resolution Funding Corporation (Refcorp) bonds that are explicitly guaranteed by the Treasury are nonetheless substantially higher than yields on comparable maturity ordinary Treasury securities.

All these Treasury market anomalies are conventionally treated as the effects of "liquidity premia." For example the cheapness of TIPS could be thought of as compensation that investors demand for the poor liquidity of these instruments relative to nominal bonds. But TIPS are mainly bought by "buy-and-hold" investors and bid-ask spreads on these securities are tiny. The cheapness of TIPS cannot really be rationalized as simply amortizing the transactions costs of a long-term investor. Moreover, Figure 4 shows the trading volume in TIPS, from the New York Fed's survey of primary dealers. While this has stepped down, it is still around its level in 2003. All this indicates to me that the "liquidity premium" in TIPS has to have some explanation beyond just transactions costs. As Campbell, Shiller and Viceira indicate, this explanation might be along the lines of a segmented market with aribtrageurs who rationally pass up hold-to-maturity arbitrage opportunities at times of market stress (Greenwood and Vayanos (2008) and Shleifer and Vishny (1997)).[5]

[4] Neglecting the inflation adjustment to the coupons, which can be negative. The coupons on the April 2013 TIPS are tiny (5/8ths of a percentage point) and so even a sizeable deflation should have only a small effect on the pricing of the security through coupon indexation.

[5] One possibility from improving TIPS market functioning might be to encourage the formation of a TIPS futures market. A futures market would make hedging cheaper and easier, and should improve liquidity in the cash market too.

Central Bank Purchases of TIPS

In standard equilibrium asset-pricing models, a decision by the Fed to purchase bonds should do nothing to their price, unless expectations of future short-term interest rates are affected (Eggertson and Woodford (2003)). Large enough purchases would result in a corner solution in which the Fed owns all of the particular security being purchased, but the price would still be unaffected. However, if markets are segmented and highly illiquid, then this story may break down.

The announcement following the March 2009 FOMC meeting is a telling "event study" of the effects of central bank purchases. At that meeting, the FOMC surprised market participants by announcing that it would buy $300 billion in nominal and index-linked Treasury securities. The yield curves right before and after this announcement are shown in Figure 5. Both yield curves moved down sharply; the TIPS yield curve moved down even more, especially at shorter maturities. The magnitude of the decline is far more than investors could possibly have learned about the expected path of future short-term interest rates. Other announcements of this sort by the Fed and foreign central banks have had comparable effects. This indicates that central banks can indeed drive down longer-term interest rates by direct purchases of securities, at least at times of market stress. Of course, aggregate demand is more sensitive to the long-term interest rates paid by household and businesses than to Treasury yields. But lowering Treasury rates could affect spill over into private sector borrowing costs. More importantly, if changing asset supply affects prices in the Treasury market, then the same should be true in the markets for corporate bonds and mortgage-backed securities, meaning that the Fed can improve financial conditions by buying assets in these markets too.

Conclusions

TIPS contain valuable information for economists and policymakers. In normal times, they can be used to infer expectations of inflation and real short-term interest rates. They still can, but in the financial crisis, the most important information in these securities is that they are a barometer of how dysfunctional asset markets were, and to a large extent, still are. I emphasize two conclusions. First, in the financial crisis, markets are segmented and illiquid, and changes in effective asset supply brought about by Fed purchases can and evidently do have large effects on price. Second, policymakers and the press are often obsessed with finding the "market price" of extraordinarily opaque securities. TIPS are extremely simple securities. If, for whatever reason, the market cannot price TIPS coherently, then any faith in the ability of the market to come up with the textbook valuation of esoteric financial instruments seems quite misplaced.

Additional References

Eggertson, Gauti B. and Michael Woodford (2003): The zero bound on interest rates and optimal monetary policy. *Brookings Papers on Economic Activity* 1, pp. 139–234.

Summers, Lawrence H. (1985): On Economics and Finance. *Journal of Finance*, 40, pp. 633-635.

Shleifer, Andrei, and Robert W. Vishny (1997). The Limits of Arbitrage. *Journal of Finance*, 52, pp. 35-55.

Appendix: Computation of Deflation Probability

Pretend that the April 2013 and July 2013 TIPS are both zero coupon bonds with maturity date June 1, 2013 and are identical apart from their reference CPIs. Let m denote the remaining time to maturity in years. Let x denote the CPI at the maturity date, let $f(x)$ and and $F(x)$ denote the probability density and cumulative distribution functions of x, respectively. Assume that agents are risk-neutral. The reference CPIs are $x_u = 211.37$ and $x_l = 183.66$ for these two bonds, so that their principal repayment for bonds with \$1 face value are $\max(1, x/x_u)$ and $\max(1, x/x_l)$, respectively.

Under these assumptions, the difference between the July and April 2013 continuously compounded TIPS yields is

$$r = \frac{1}{m}\{\ln(\frac{x_u}{x_l})F(x_l) + \int_{x_l}^{x_u} \ln(\frac{x_u}{x}) f(x)dx\}$$

which means that

$$r \le \frac{1}{m}\{\ln(\frac{x_u}{x_l})F(x_l) + \int_{x_l}^{x_u} \ln(\frac{x_u}{x_l}) f(x)dx\} = \frac{1}{m}\ln(\frac{x_u}{x_l})F(x_u)$$

So the risk-neutral probability of deflation (defined as the price index in 2013 being below $x_u = 211.37$, which is also approximately its current level) is bounded below as

$$F(x_u) \ge \frac{rm}{\ln(x_u / x_l)}$$

This is the probability shown in Figure 2.

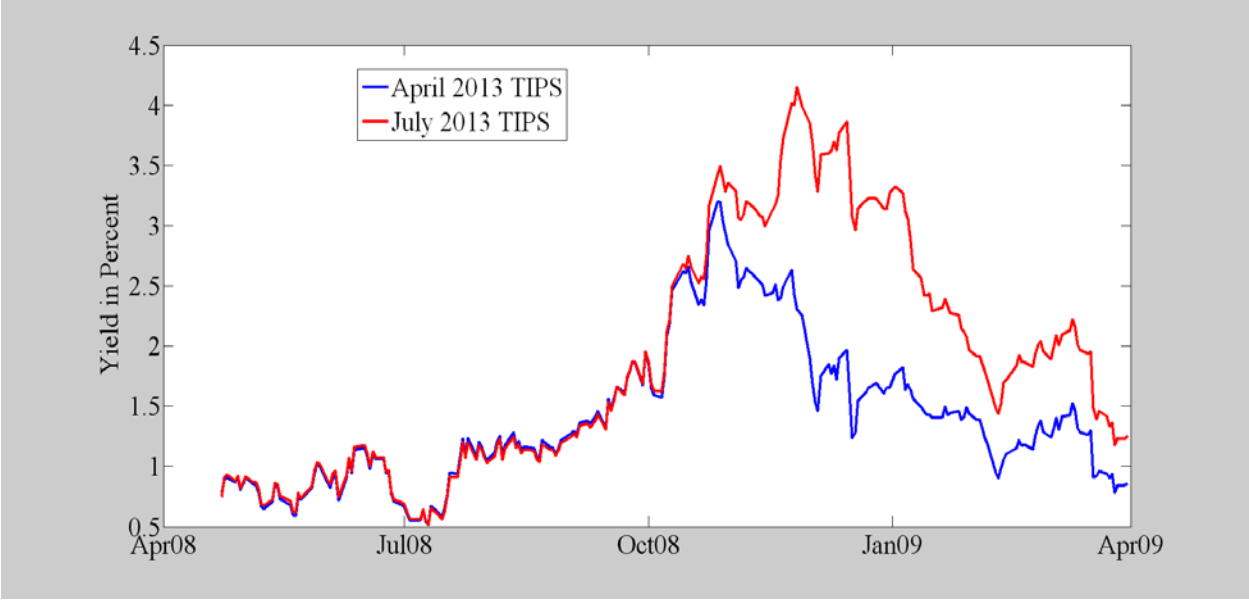
The assumptions made are strong; and it is possible that part of the spread between the April and July 2013 TIPS represents instead a premium for the greater liquidity of the on-the-run issue, which is the April 2013 TIPS. However, there has never been much evidence of an on-the-run premium in the TIPS market and qualitatively similar spreads between other pairs of TIPS issues with close maturity dates but different reference CPIs can also be observed since early fall 2008.

Table 1: Average slope of forward yield curves (in basis points)

	United Kingdom	United States
Nominal	-0.2	28.2
Index-Linked	-6.7	13.7

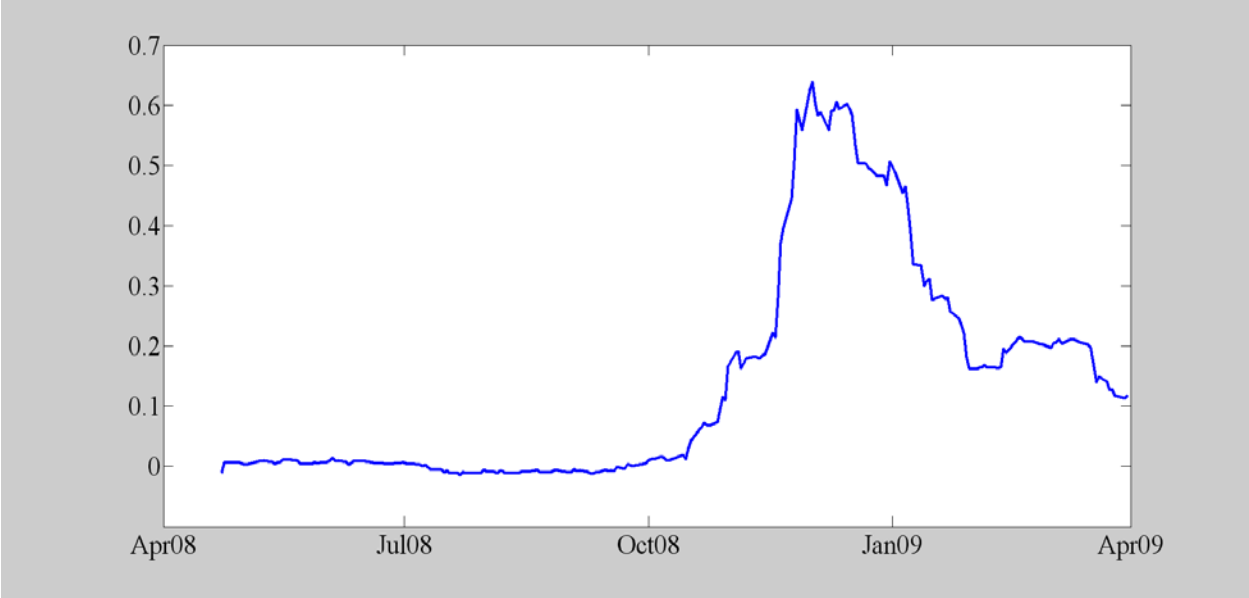
Notes: Spread of six- year-ahead over five-year-ahead continuously compounded instantaneous forward rates obtained from the Bank of England and Federal Reserve Board estimates of U.K. and U.S. yield curves. Averaged over all days from the start of January 2003 to the end of August 2008.

Figure 1: Yields on April and July 2013 TIPS



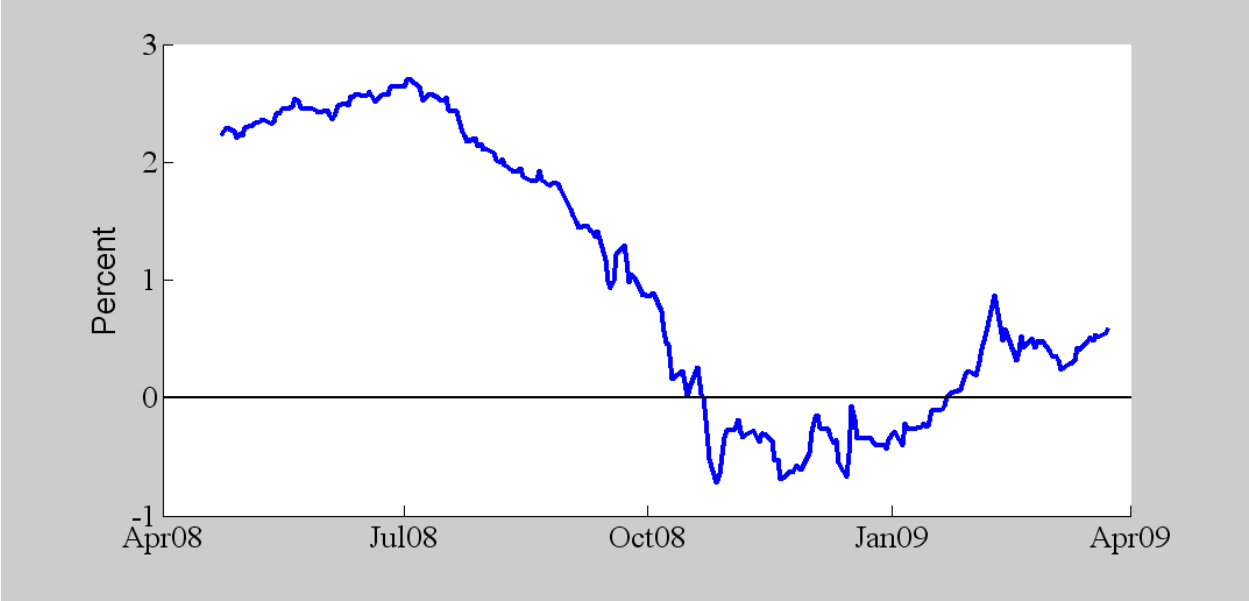
Source: Bloomberg.

Figure 2: Probability of Deflation



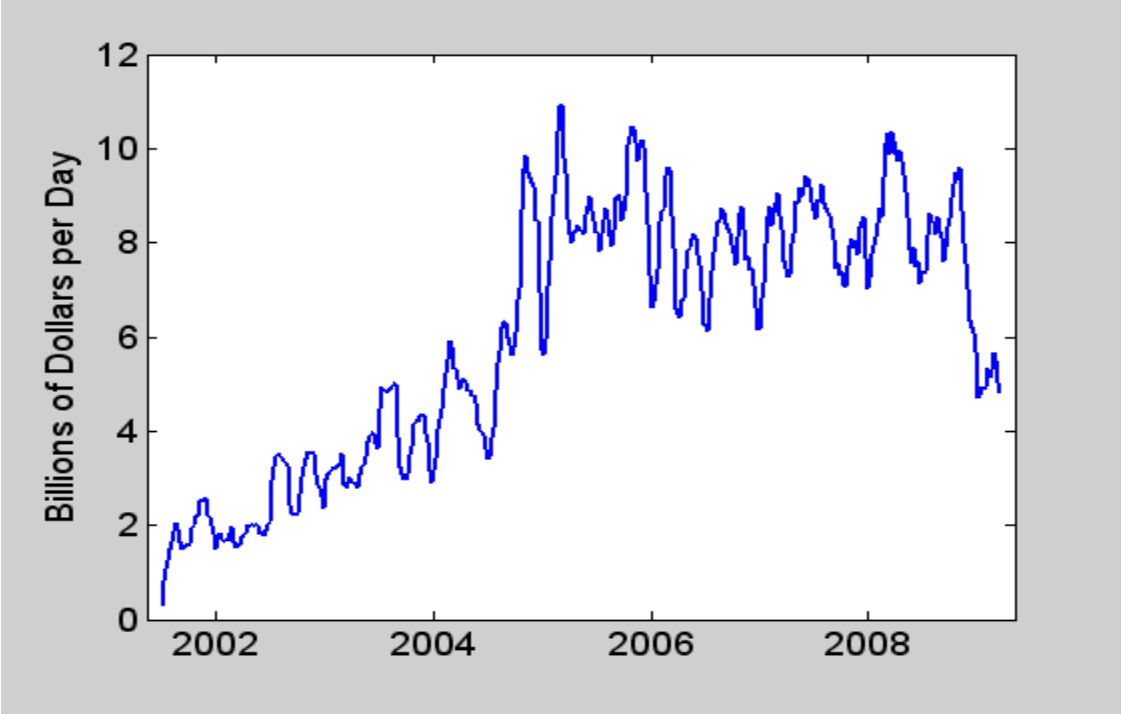
Source: Author calculations as described in the Appendix.

Figure 3: Spread between most recently issued five-year TIPS and the nominal curve



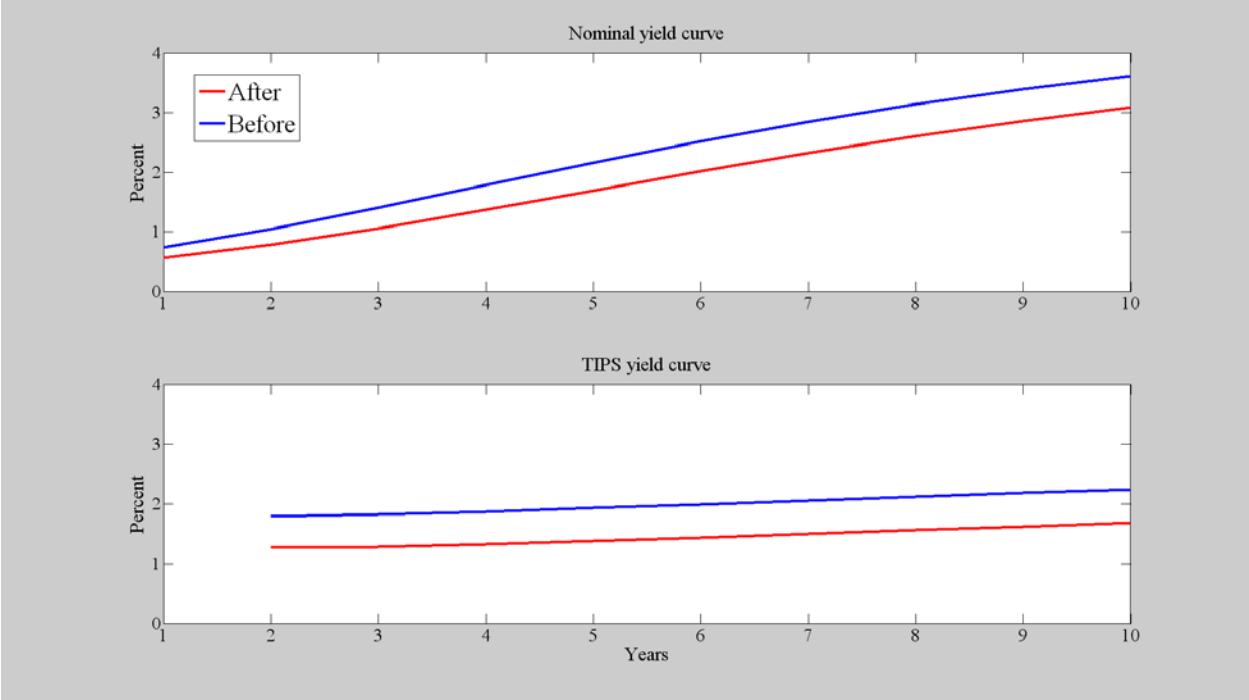
Source: Spread of April 2013 TIPS yield over the corresponding maturity nominal yield from the Federal Reserve Board's smoothed yield curve.

Figure 4: TIPS Trading Volume



Source: Eight-week moving average of interdealer volume in TIPS, as reported by the Federal Reserve Bank of New York using the FR-2004 survey.

Figure 5: Effect of March 2009 FOMC announcement on nominal and TIPS yield curves



Source: Federal Reserve Board estimates of nominal and TIPS yield curves for late afternoon March 17 and March 18, 2009, respectively.