Treasury Inflation-Protected Securities

8

Quentin C. Chu and Deborah N. Pittman

Abstract

In January 1997, the U.S. Treasury began to issue inflation-protected securities (TIPS). TIPS protect investors from inflation by linking the principal and coupon payments to the Consumer Price Index (CPI). Empirical studies of TIPS have focused on their term structure, their role in diversifying portfolios, and their usefulness in generating a measurement of expected inflation. This paper discusses TIPS unique characteristics, the role they play in aggregating inflation information and price discovery in Treasury security markets.

An econometric method is proposed to identify the speed and timing of TIPS price adjustments to inflation information. The econometric method is based on a pooled time-series cross-sectional regression analysis of TIPS daily holding period returns on inflation surprises. The inflation surprise is measured by the difference between actual inflation and the observed nominal and real interest rate spread. The speed and timing of TIPS price adjustments are revealed in the estimated cumulative regression coefficients. In addition, vector error correction model and common-factor model are applied to investigation price discovery in Treasury bond and TIPS markets.

Keywords

Inflation information aggregation • Inflation risk premium • Information risk • Price discovery • Real interest rate • Treasury inflation-protected securities

8.1 Introduction

The fundamental notion behind inflation protection is to preserve the purchasing power of money. By linking value to the Consumer Price Index (CPI), Treasury inflation-protected securities (TIPS) provide investors with a "real" rate of return. This security can be viewed as one of the safest financial assets due to its minimal exposure to default risk and uncertain inflation. Today, inflation protection may be accomplished by linking investment principal to some form of a price index, such as the Consumer Price Index (CPI) in the United States, Canada, the United Kingdom, and Iceland; the Wholesale Price Index (WPI) in Finland, Brazil, and Argentina; and equities and gold in France. In essence, investors purchasing inflation-protected securities are storing a basket of goods for future consumption. Fifteen countries, including the U.S, have issued inflation-protected securities, starting in the 1940s.[1] Some of the countries had extremely high inflation, such as Mexico and Brazil (114.8% and 69.2% in the year prior to the introduction of inflation-protected securities), and others had moderate inflation like Sweden and New Zealand (4.4% and 2.8%). As of the end of 2008, inflation-protected securities made up 24% of the United Kingdom's total outstanding debt portfolio, 15% of

Q.C. Chu (✉)
University of Memphis, Memphis, Tennessee 38152, USA
e-mail: qchu@memphis.edu

D.N. Pittman
Rhodes College, Memphis, Tennessee 38112, USA

[1] According to the date of introduction of inflation-protected securities, these countries are: Finland, France, Sweden, Israel, Iceland, Brazil, Chile, Colombia, Argentina, the U.K., Australia, Mexico, Canada, New Zealand, and the U.S.

C.-F. Lee and A.C. Lee (eds.), *Encyclopedia of Finance*, DOI 10.1007/978-1-4614-5360-4_8,

France's outstanding debt portfolio, and 10% of the United States' outstanding debt portfolio (U.S. GAO, 2009).

8.2 Size of Market

The first U.S. Treasury inflation-protected securities were issued in January 1997. Thirty-two issues of TIPS are traded in the U.S. market as of October, 2010, with maturities ranging from 2011 to 2040. According to the Treasury Department, TIPS are an important component of Treasury's debt management strategy, although they represent by June 2009 only about 7% of the U.S. Treasury debt that is outstanding. Over the past year, Treasury has increased overall TIPS issuance by a relatively small amount, and replaced the 20-year TIPS with 30-year TIPS. As of June 2009 the U.S. Treasury had $3.4 trillion outstanding in Treasury notes, $1.6 trillion outstanding in Treasury bills, $0.6 trillion in Treasury bonds, and $0.5 trillion in TIPS. Between December 2007 and June 2009, the Treasury issued $1.6 trillion in new debt. TIPS only increased by $0.06 trillion during that period of time, representing only 3.7% of the new debt (U.S. GAO, 2009).

8.3 Reference CPI

TIPS provide two guarantees: (1) that investors will receive an inflation-adjusted amount or the real par value at maturity, whichever is greater; and (2) that coupon payments will be adjusted for inflation occurring between issuance and payment dates. The consumer price index for all urban consumers (CPI-U) was chosen to measure price level changes. As the most widely used index, the CPI-U is generally accepted as a measure of inflation. The Bureau of Labor Statistics (BLS) surveys prices each month. Around the middle of the month, it announces changes in retail prices experienced by American consumers during the previous month. Although the CPI-U is not a cost of living index, it is the deflator commonly used to adjust wages and salaries for collective bargaining agreements, and to keep pensions, rents, and child support payments in line with inflation.

8.4 Conversion from Real to Nominal Prices

Prices quotes in the market are real clean prices. When there is a transaction, the invoice price is computed from the real clean price, the reference CPI-U index, and the accrued nominal coupon. The coupon payments and the lump sum payment at maturity are adjusted according to inflation rates. With a fixed real coupon rate, the adjustment to a nominal coupon payment is accomplished by multiplying the principal value by one plus the inflation rate between the issuance date and the coupon payment date. Inflation-protected securities set a floor (par value), an implicit put option, guaranteeing the bond's value on maturity date will not fall below its face value if the U.S. experiences cumulative deflation during the entire life of the TIPS, a highly unlikely event.

8.5 Three-Month Lag Effect

One feature of the TIPS that impedes its use as a perfect measure of the *ex ante* real rate is the CPI indexing procedure. There is a 3-month lag in the CPI indexing system for TIPS. Figure 8.1 indicates how the reference CPI is calculated on May 15, 2007. The reference CPI for May 1, 2007, is the CPI-U for the third-previous calendar month, i.e., the announced CPI for February 2007. The Bureau of Labor Statistics surveys price information for the February CPI during the month of February, and then announces the February CPI on March 16, 2007. The reference CPI for any other day of May is calculated by linear interpolation between the CPIs of February and March (the CPI for March became available on April 17, 2007). Once the March CPI is announced, the reference CPI for any day in May 2007 is known. The reference CPI for May 15, 2007 can be calculated according to the following formula:

$$\begin{aligned} RCPI_{May15} &= CPI_{Feb} + (14/31)(CPI_{March} - CPI_{Feb}) \\ &= 203.499 + (14/31)(205.352 - 203.499) = 204.33584 \end{aligned}$$

where *RCPI* represents the reference CPI for a particular day.[2]

The principal value of TIPS on any particular trading day is determined by multiplying the face value at the issuance by an applicable index ratio. The index ratio is defined as the reference CPI applicable to the trading date divided by the reference CPI applicable to the original issuing date.

8.6 Public Issuance

The design of the U.S. TIPS underwent considerable discussion in determining the linking price index, the cash flow structure, the optimal length of maturity, the auction mechanism, and the amount of issuance. TIPS are auctioned through the Dutch uniform price auction method used by other Treasury securities. Participants submit bids in terms of real yields. The highest accepted yield is used to price the newly issued TIPS for all participants (Roll, 1996). TIPS are eligible for stripping into their principal and interest components

[2] The U.S. Treasury website (http://www.publicdebtreas.gov) posts the reference CPI for the following month after the CPI announcement date which is around the 15th of each month.

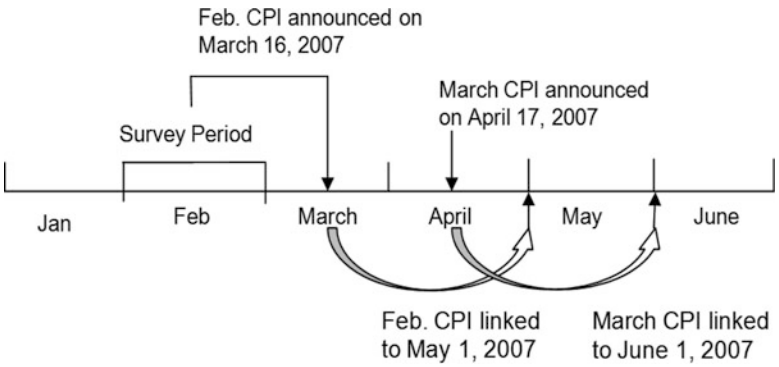

Fig. 8.1 Calculation of Reference CPI This figure illustrates the lag effect in indexing the CPI. Due to CPI-U reporting procedures, the reference CPI for May 1, 2007, is linked to the February CPI-U, and the reference CPI for June 1, 2007, is linked to the March CPI-U

in the Treasury's Separate Trading of Registered Interest and Principal of Securities Program. Since March 1999, the U.S. Treasury Department has allowed all TIPS interest components with the same maturity date to be interchangeable (fungible). Fungibility is designed to improve the liquidity of stripped interest components of TIPS, and hence increase demand for the underlying inflation-protected securities. Other Treasury securities are strippable as well. Each issue has a unique CUSIP number for identification purposes, which is also used in a case of reopening (Grieves and Sunner, 1999).

8.7 Tax Disadvantage: Phantom Income

One disadvantage of TIPS is the potential tax liability on phantom income. Although the securities are exempt from state and local taxes, they are subject to federal taxation. Positive accrued inflation compensation, if any, is reportable income, even though the inflation-adjusted principal will not be received until maturity. Some taxable investors may thus hesitate to invest in TIPS, while others with non-taxable accounts such as retirement accounts might find this market attractive. Consequently, investor tax brackets may affect decisions about including TIPS in a portfolio. The emergence of mutual funds and exchange traded funds (ETFs) specializing in TIPS have attracted more individual investment in the form of IRA and 401(K) savings, although these investors are more likely to buy and hold.

8.8 TIPS as an Asset Class

The real yield of 10-year TIPS averaged 2.06% in 2003, 1.83% in 2004, 1.81% in 2005, 2.31% in 2006, 2.29% in 2007, 1.77% in 2008, and 1.66% in 2009. Comparable yields of conventional 10-year Treasury bonds were 4.10% (2003), 4.27% (2004), 4.29% (2005), 4.80% (2006), 4.63% (2007), 3.66% (2008), and 3.26% (2009).

The performance of TIPS as an asset class has been extremely well since its inception in 1997. The Sharpe ratio for a 10-year TIPS has averaged 0.61 from 1997 to 2009, while the Sharpe ratio for a 10-year Treasury bond has averaged 0.58 for the same period. This compares to 0.01 for the S&P 500 (Katz and Palazzolo, 2010).

Inflation-protected securities offer an alternative financial vehicle for portfolio management. Since the returns on nominal bonds are fixed in nominal terms, they provide no hedge against uncertain inflation. Kaul (1987) and Chu et al. (1995) have documented a negative correlation between equity returns and inflation in the U.K. That is, investors in equity markets suffer during periods of unexpected high inflation. Inflation-protected securities, by linking returns to the movement of a price index, provide a hedge for investors who have a low risk tolerance for unexpected inflation. Those most averse to inflation will purchase inflation-protected securities, and those less sensitive to inflation will purchase the riskier nominal bond. These unique U.S. Treasury instruments that protect against future inflation are now viewed as belonging in most well-diversified investment portfolios (Roll, 2004). The Investment Company Institute survey data finds that mutual funds invested only in TIPS increased from $11.8 billion in December 2002 to $54.4 billion in May 2009 (U.S. GAO, 2009).

8.9 Size of the Inflation Risk Premium

According to the Employment Act of 1946, one of the four primary goals of the U.S. federal government economic policy is to stabilize prices through a low inflation rate. Inflation-protected securities provide a way for the public to evaluate the government's performance in controlling inflation. For a constant level of expected inflation, the wider the yield spread between nominal and real bonds, the higher the inflation risk premium, and presumably the lower the public's confidence in the monetary authorities. When there is no risk of inflation, the inflation risk premium is reduced, if not eliminated completely. Benninga and Protopapadakis (1983) revise the Fisher equation to incorporate an inflation risk premium. Prior to the issuance of the U.S. TIPS, Chu et al. (1995) measured the inflation risk premium in the United Kingdom between 1985

and 1991 using the real yield on the indexed linked gilt (similar to the U.S. TIPS), and found it was 2.41% and statistically significant. Recent research has found that the inflation risk premium in the United States over the past decade has been insignificant and less than 25 basis points (Dudley et al., 2009).

8.10 Cost of TIPS to the Treasury Since Inception

One motivation for the issuance of inflation-protected securities is that governments can reduce public financing costs through reducing the interest paid on public debt by the amount of an inflation risk premium. Rates on Treasury securities are thought to consist of the expected real rate, plus expected inflation and an inflation risk premium, while TIPS provide investors with a real rate of interest plus actual inflation. The TIPS real return is guaranteed, whatever the course of inflation. The lower the *ex post* inflation in the U.S., the lower the amount of interest paid on the outstanding TIPS debt, while the interest on conventional bonds remains constant at the contracted amount when issued.

Market experts have measured costs of TIPS versus cost of conventional bonds by comparing the cost of TIPS and nominal securities based on what inflation actually was during a given time period. This approach concludes that the TIPS program has been less cost-effective for Treasury than nominal securities. A 2008 study by a Federal Reserve economist estimated that the total cost of the TIPS program through October 2007 was between $4.5 billion and $7.5 billion (U.S. GAO, 2009). Through July 2009, Treasury's Office of Debt Management (ODM) estimated the total cost differential of TIPS at $10 billion to date. This more recent study includes the anomalous period characterized by the financial market crisis and the related flight to quality which made nominal securities relatively inexpensive for Treasury.

However, economists generally agree that at least part of the relatively higher cost of the TIPS program is due to its start-up costs that included a liquidity premium since TIPS were traded off the run. Market experts and the major institutional investors had indicated that other factors that may have contributed to the relatively higher cost to Treasury of the TIPS program to date are investors' perceptions of the Treasury's lack of commitment to the program and the relatively low inflation experienced throughout the life of the program. Since the TIPS program was introduced, the annual Consumer Price Index for All Urban Consumers (CPI-U) percent change never exceeded 3.80%, which is low by historical standards. The CPI-U averaged 7.08% and 5.55% during the 1970s and 1980s, respectively (U.S. GAO, 2009).

8.11 Liquidity Premiums

The surprisingly high yields of TIPS, relative to conventional Treasuries, have been both a puzzle and a concern to the U.S. Treasury Department due to the excess interest cost. Sack (2000), Shen and Corning (2001) and Sack and Elsasser (2004) focus on the possible reasons for a "too high" TIPS real yield and consider a liquidity premium, a lower supply, and a lack of knowledge about the new TIPS as possible reasons. Sack and Elsasser (2004) conclude, liquidity has improved over the past 7 years, the supply has increased, and there is wider acceptance of the securities, yet the relatively high TIPS real yield remains. D'Amico et al. (2008) estimate that the liquidity premium of the TIPS was as large as 200 basis points during its early years of trading, but had trended down to 50 basis points for 5-year maturities after 2004. While the prices of both nominal securities and TIPS could be influenced by inflation risk premiums and liquidity premiums, D'Amico et al. (2008) found these premiums to be relatively small and stable after 2004.

8.12 Observable Expected Real Rate

TIPS provide a direct measure of expected real interest rates that may help policy makers make economic decisions. According to economic theory, most savings, consumption and investment decisions depend critically on the expected real rate of interest, the interest rate one earns after adjusting the nominal interest rate for the expected rate of inflation. Real interest rates measure the real growth rate of the economy and the supply and demand for capital in the market. Before the trading of inflation-protected securities, there was no security in the U.S. offering coupon and principal payments linked to inflation and therefore enabling measurement of the expected real rate. Empirical studies testing the relationship between expected real rates and other macroeconomic variables have relied instead on indirect measures of the expected real rate such as *ex post* real rates estimated by subtracting actual inflation from realized nominal holding-period returns (Pennachi, 1991). Inflation-protected securities permit the direct study of the real interest rate. Wilcox (1998) includes this as one benefit motivating the Treasury to issue these new securities. For example, Chu et al. (2003) used measurements of the ex ante real rate with a constant 10-year maturity derived from TIPS prices, and found that a cointegrated system exists between the real and nominal rates. This casts doubt on the accuracy of previous Fisher Effect testing that assumed a constant or stationary real rate.

8.13 Information Content of Maturing TIPS

On July 15, 2002, the first maturity of a TIPS issue occurred. The distinctive properties of maturing TIPS during the last 6-month coupon reveal the market's anticipated inflation regime (Chu et al., 2004). During their last coupon period, TIPS have characteristics of both nominal bonds and real bonds. After the next-to-last coupon payment date on January 15, 2002, the July 2002 issue of TIPS had a single cash flow remaining. The distinctive properties of a maturing issue result in a special environment that permit researchers to observe relatively clean and useful information about an anticipated inflation regime. With a single cash flow remaining, there is no need to set the reinvestment rate for periodic cash flows in the pricing of maturing TIPS. Moreover, there is no difference in tax treatment to anyone purchasing Treasury bills or TIPS during the last 6 months prior to expiration, and there is no call feature. The relative pricing between the maturing TIPS and the synthetic Treasury bill reveals the market anticipation of an inflationary or a disinflationary regime.

As it has only one role to play, the pricing of a maturing TIPS represents a pure successive forecast of the target CPI linked to the maturity date of the TIPS. Under the assumption of risk-neutrality, the sequence of forecasts implied in maturing TIPS prices can be modeled as a martingale (Chu et al., 2007).

As the forecasted CPI must converge to the actual CPI to avoid any possibility of an arbitrage profit, a consistent upward or downward movement of the CPI forecasts implied in maturing TIPS prices indicates inflation hedge behavior. A consistent upward movement in the forecast series would indicate the market anticipates a disinflationary regime, while a consistent downward movement would indicate an anticipated inflationary regime.

Most inflation outlooks are based on survey data or expert opinions. Few studies provide empirical evidence derived from security prices to reveal general overriding concerns about disinflation in the U.S. market. There is evidence that TIPS prices during a maturing issue's last coupon period are able to discern whether the market is anticipating a disinflationary regime or an inflationary regime. Monetary authorities can use this timely identification of the market's concern about a particular regime in adjusting monetary policy.

8.14 Inflation Information Aggregation

A nominal Treasury security alone does not allow measurement of the aggregation of information about inflation as it occurs. It rather incorporates estimates of future inflation information in its expected yield. The price of the TIPS, however, responds in a different manner. Its nominal price will increase over its life as the CPI level changes, because all future coupons and the principal adjust automatically to the CPI level. TIPS prices respond to changes in inflation as they occur; the higher the price index, the higher the nominal income from the bond.

Offering a certain real return, TIPS hedge against a rising price level. They are uniquely structured to aggregate inflation information prior to the monthly public announcement, due to the direct link between the future cash flows and *ex post* CPI. Since the cash flows associated with TIPS depend on actual inflation and a contractual real return, TIPS prices react far differently over time than conventional bond prices. While conventional bond prices respond to changes in the expected rate of inflation until maturity and also to changes in the expected real rate, the TIPS prices respond only to changes in actual inflation and changes in the expected real rate, assuming contemporaneous adjustment of the contractual cash flow to the current CPI.

Chu et al. (2011), using pooled time-series cross-section data from three matured TIPS issues, find that TIPS prices respond to the monthly update of the CPI, efficiently aggregating near-term inflation information. The evidence supports a market that is highly informed about upcoming inflation starting 44 business days prior to a CPI announcement date. In fact, 29% of the cumulative adjustment to information about the upcoming month's inflation is already incorporated into the TIPS price before the survey period begins. Moreover, the cumulative effects of unexpected inflation on TIPS returns peaks on the last day of the month as the survey period ends, with 98% of the inflation adjustment already in the TIPS price. After the month has ended, there is a statistically insignificant reversing trend that persists during the compilation period until the day before the public announcement. A significant adjustment on the announcement day returns the cumulative adjustment to a level slightly higher than at the end of the month. Thus, the market is very efficient in monitoring and responding to changes in consumer prices as they occur.

When the monthly CPI survey published by the *Blue Chip Financial Forecasts* was used to measure expected inflation instead of the breakeven inflation rate, there was no significant difference in the timing of TIPS price adjustments. This provides evidence that the market-determined measure of expected inflation, even using securities with a 5-year maturity, is robust in capturing near-term inflation surprises.

8.15 Price Discovery and Information Risk

Both nominal Treasury and TIPS markets share a common component – the expected real return – but they contain other return components that behave very differently in the presence of inflation, and therefore attract different clienteles who must

hold non-replicating portfolios. Investors holding TIPS are attracted to its inflation hedging properties. However, they cannot diversify into other securities without giving up the inflation hedging properties. If there is information risk by holding the TIPS, because the real rate information is likely to be revealed first in the nominal Treasury market, they will need additional compensation for taking this risk. Moreover, changes in real rates of interest create a more volatile price for TIPS than for nominal Treasuries due to longer real durations for TIPS (Roll, 2004), so perception of an informational disadvantage is a consequential risk.

TIPS investors are at a disadvantage in price discovery with a 1-day lag (Chu et al., 2005). While it is possible that informed traders could transact their trades in either market, the evidence is that information flows unilaterally from the Treasury bond market to the TIPS market. The reason for such a lag in price innovation is also analogous to Easley and O'Hara's (2004) description of stocks with more public information having a "greater institutional following." Bond market participants who have private information about the real rate of interest could act on this information either in the nominal Treasury market or in the TIPS market. Chu et al. (2005) find that they choose to act in the former. This is likely because the nominal Treasury market, with its highly developed infrastructure and large number of traders in both the spot and derivative markets, is the most profitable vehicle for trading on new information about expected real interest rates. The trading aggregates new information into the price, making information public.

Conclusion

Since the trading of TIPS in January 1997, the pooled time-series cross-sectional TIPS price data are used to investigate how quickly TIPS prices respond to the monthly update of the CPI. Our empirical results based on the proposed econometric method show that TIPS adjust to inflation information without delay during the U.S. Consumer Price Index (CPI) survey period and even before the beginning of the survey period. The cumulative effect of inflation surprise on the TIPS holding period returns peaks at the end of the survey period. The TIPS data are also used to investigate the presence of information risk in two closely linked interest rate securities traded in separate markets: the Treasury nominal bond market and the TIPS market. We find that information flows unilaterally from the Treasury bond market to the TIPS market with a 1-day lag. The information risk arising from asymmetric information flows may cause less informed traders to demand a higher rate of return.

References

Benninga, Simon, and Aris Protopapadakis. 1983. "Nominal and real interest rates under uncertainty: The Fisher theorem and the term structure." *The Journal of Political Economy* 91, 856–867.

Chu, Quentin C., Cheng F. Lee, and Deborah N. Pittman.1995. "On the inflation risk premium." *Journal of Business, Finance, and Accounting* 22, 881–892.

Chu, Quentin C., Deborah N. Pittman, and Linda Q. Yu. 2003. "Real rates, nominal rates, and the Fisherian link." *International Review of Financial Analysis* 12, 189–205.

Chu, Quentin C., Deborah N. Pittman, and Linda Q. Yu. 2004. "Information content of maturing TIIS." *The Journal of Fixed Income* 13, 90–99.

Chu, Quentin C., Deborah N. Pittman, and Linda Q. Yu. 2005. "Information risk in TIPS market: An analysis of nominal and real interest rates." *Review of Quantitative Finance and Accounting* 24, 235–250.

Chu, Quentin C., Deborah N. Pittman, and Jeng-Hong Chen. 2007. "Inflation or disinflation? Evidence from maturing US Treasury Inflation-Protected Securities." *Applied Economics* 39, 361–372.

Chu, Quentin C., Deborah N. Pittman, and Linda Q. Yu, 2011. "When do TIPS prices adjust to information?" *Financial Analysts Journal* 67, 59–73.

D'Amico, Stefania, Don H. Kim, and Min Wei. 2008. "Tips from TIPS: The Informational Content of Treasury Inflation-Protected Security Prices." *Bank for International Settlements working papers*, No. 248.

Dudley, William C., Jennifer Roush, and Michelle Steinberg Ezer. 2009. "The case for TIPS: An examination of the costs and benefits." *Economic Policy Review*, Federal Reserve Bank of New York 15, 1–15.

Easley, David. and Maureen O'Hara. 2004. "Information and the cost of capital." *Journal of Finance* 59, 1553–1583.

Grieves, Robin and Michael W. Sunner. 1999. "Fungible STRIPS for the U.S. Treasury's inflation-indexed securities." *Journal of Fixed Income* 9, 55–62.

Katz, Michael and Christopher Palazzolo. 2010. "Inflation in 2010 and beyond? Practical considerations for institutional asset allocation." AQR Capital Management, LLC., Greenwich, Connecticut.

Kaul, Gautam. 1987. "Stock returns and inflation: The role of the monetary sector." *Journal of Financial Economics* 18, 253–276

Pennachi, George G. 1991. "Identifying the dynamics of real interest rates and inflation: Evidence using survey data." *Review of Financial Studies* 4, 53–86.

Roll, Richard. 1996. "U.S. Treasury inflation-protected bonds: the design of a new security." *Journal of Fixed Income* 6, 9–28.

Roll, Richard. 2004. "Empirical TIPS." *Financial Analysts Journal* 60, 31–53.

Sack, Brian. 2000. "Deriving inflation expectations from nominal inflation-indexed Treasury yields." *Journal of Fixed Income* 10, 6–17.

Sack, Brian and Robert Elsasser. 2004. "Treasury inflation-indexed debt: A review of the U.S. experience." *Economic Policy Review,* Federal Reserve Bank of New York, 10, 47–63.

Shen, Paul and Jonathan Corning. 2001. "Can TIPS help identify long-term inflation expectations?" *Economic Review*, Federal Reserve Bank of Kansas City, 86, 61–87.

United States General Accounting Office. 2009. "Treasury inflation protection securities should play a heightened role in addressing debt management changes." GAO 09–932.

Wilcox, David W.. 1998. "The introduction of indexed government debt in the United States." *Journal of Economic Perspectives* 12, 219–227.