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# Economic Letter

*Insights from the*  
FEDERAL RESERVE BANK OF DALLAS

## Accounting For the Bond-Yield Conundrum

by Tao Wu

Long-term interest rates tend to rise as monetary policymakers increase short-term interest rates. This relationship didn't hold, however, during the recent U.S. monetary policy tightening cycle. Between June 2004 and June 2006, the Federal Open Market Committee increased the federal funds rate 17 times—going from 1 percent to 5.25 percent. Yet, long-term interest rates declined or stayed flat until early 2006.

This divergence between short- and long-term interest rates caught many economists, investors and central bankers by surprise. In his Feb. 16, 2005, congressional testimony, former Federal Reserve Chairman Alan Greenspan characterized the behavior of long-term interest rates since June 2004: "For the moment, the broadly unanticipated behavior of world bond markets remains a conundrum. Bond price movements may be a short-term aberration, but it will be some time before we are able to better judge the forces underlying recent experience."

*This conundrum has prompted a great deal of discussion regarding both its magnitude and the factors behind it. However, a compelling and broadly accepted explanation has yet to be reached.*



*Based on past performance, the 10-year bond yield seemed to be off track in mid-2005, possibly by 130 basis points or more.*

Since then, this conundrum has prompted a great deal of discussion regarding both its magnitude and the factors behind it. However, a compelling and broadly accepted explanation has yet to be reached.

The correct understanding and quantification of the conundrum have direct implications for monetary policy, which largely impacts economies as long-term interest rates respond to changes in central banks' target rates. Persistent changes in the relationship between short- and long-term interest rates will affect the timing and impact of monetary policy actions.

### The Conundrum Period

During the previous three monetary policy tightening cycles—1988–89, 1994–95 and 1999–2000—the 10-year Treasury yield responded to increases in the federal funds rate target by rising an average 26 basis points for every 100-basis-point increase in the target (*Chart 1*).

In the tightening episode that started June 30, 2004, however, the 10-year Treasury yield showed a dis-

tinctly different pattern. During the 12 months following the initial federal funds rate increase, this long-term bond yield declined by about 80 basis points as short-term rates rose rapidly. Based on past performance, the 10-year bond yield seemed to be off track in mid-2005, possibly by 130 basis points or more.

Such a decline appeared even more puzzling in light of other pressures in the economy, such as a robust expansion, rising energy prices and a falling federal fiscal deficit. All had put upward pressure on long-term interest rates in the past.

Some analysts have suggested the conundrum occurred because the bond market expected very rapid federal funds rate increases at the beginning of the tightening. When the Federal Open Market Committee (FOMC) instead moved in 17 consecutive 25-basis-point steps, it surprised the market from the downside and bond yields were adjusted downward to be consistent.

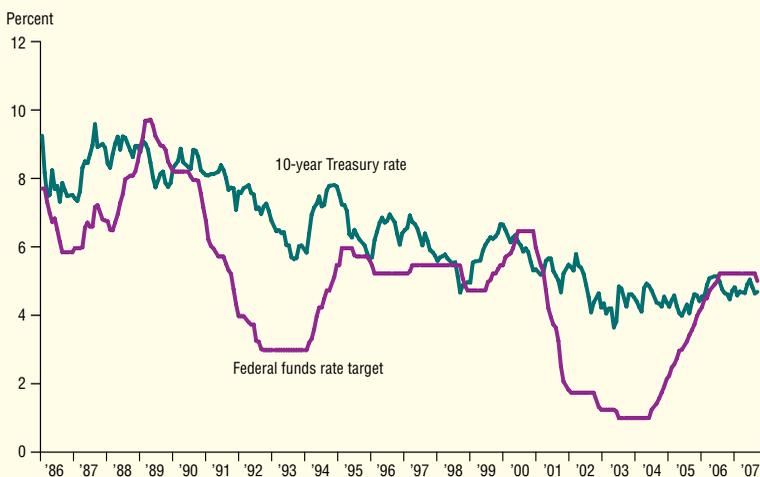
This explanation, however, contradicts the general impression that U.S. monetary policy's transparency has improved considerably the past two decades. During the most recent monetary policy tightening, the FOMC's actions were well anticipated. After the first increase, for example, the federal funds futures market and the Eurodollar futures market correctly anticipated almost every quarter-point increase in the federal funds rate for the next 12 to 18 months (*Chart 2*). Thus, it doesn't seem plausible that the long-term interest rate declines that followed the early-stage tightening arose from a misperception of monetary policy intention.

### The Usual Suspects

In principle, bond yields can be divided into two components. One is the long-term real interest rate, which consists of an expected future real interest rate, plus a risk premium to cover the uncertainties of its future changes. The other is an inflation component, which depends on the

Chart 1

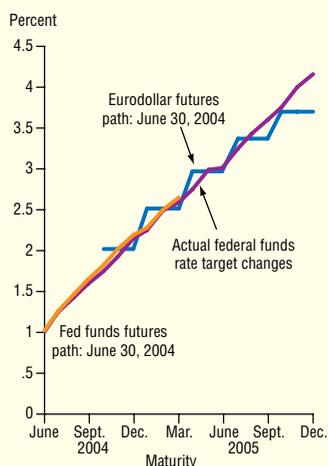
## Federal Funds Rate Target and 10-Year Treasury Yield



SOURCE: Haver Analytics.



## Chart 2 Monetary Policy Tightening Was Well Anticipated



SOURCE: Haver Analytics.

expected future inflation rate, plus a premium compensating investors for the uncertainties of future inflation. Changes in long-term bond yields should reflect variations in long-term real interest rates, long-run inflation expectations or risk premiums.<sup>1</sup>

With this in mind, it's worthwhile to review some changes in the economy and financial markets that might be relevant to the conundrum. In particular, market participants have cited the following factors as lowering risk premiums, putting downward pressure on long-term interest rates.

### Foreign official purchases.

Many market participants have suggested that substantial increases in foreign official purchases of U.S. Treasury securities in recent years have substantially depressed long-term Treasury yields.<sup>2</sup> In particular, Asian central banks built up their holdings of foreign reserves and kept their currency values low relative to the dollar to boost exports to the U.S.

Faced with a rapid accumulation of dollar assets from record-high

trade surpluses, Asian central banks invested many of these reserves in U.S. Treasury bonds, exerting downward pressure on Treasury yields (*Chart 3*). Some economists estimate such pressures on the 10-year Treasury yield at 40 to 120 basis points.

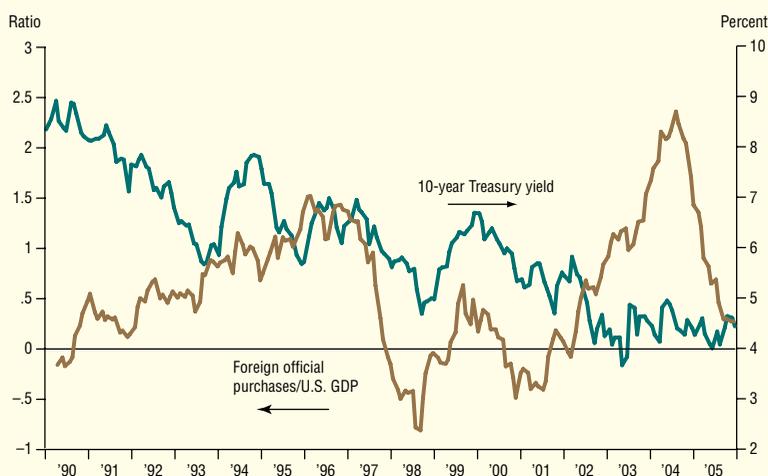
More generally, a global savings glut has arisen from surges in revenues for oil and commodity exporters, the rapid income growth of high-saving East Asian households and the reduction in fiscal deficits by several Latin American countries. These developments have added to the net supply of loanable funds to increasingly open world financial markets, helping hold down long-term interest rates in the U.S. and other advanced nations.

**Increased demand by pension funds.** Some analysts argue that declining bond yields may partly owe to higher demand for longer-duration Treasury securities as a result of proposed corporate pension reforms.

In particular, U.S. pension funds might be required to match the maturities of their assets and liabilities. This concern may have encouraged them to increase their holdings of longer-

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## Chart 3 Foreign Official Purchases and 10-Year Treasury Yield



SOURCES: Haver Analytics; Federal Reserve Board.



*Foreign official purchases of U.S. Treasury securities, increased demand for Treasury securities by pension funds, decreased macroeconomic uncertainty and declines in asset price volatility are among the reasons long-term Treasury yields have fallen.*

duration Treasuries ahead of any regulatory changes, suppressing long-term Treasury yields. Some analysts also cite U.K. pension reforms, which have been associated with unusually low yields on British bonds.

**Decreased macroeconomic uncertainty.** Because long-term bond yields are closely related to short-term interest rates and other macroeconomic fundamentals (both present and expected), declines in macroeconomic uncertainty since the early 1980s may have put downward pressure on long-term interest rates.

The Great Moderation of the American business cycle, as described by Fed Chairman Ben Bernanke, has been linked to decreased uncertainty about inflation, real growth and real interest rates.

**Declines in asset price volatility.** The deepening global integration of financial markets, coupled with the introduction of new financial instruments the past two decades, may have played a role in reducing the magnitude of economic fluctuations and mitigating their effect on long-term investors. Consequently, less-volatile asset prices—in this case, Treasury bond prices—have ostensibly worked to lower risk premiums and bond yields.

### **A Macro-Finance Analysis**

Determining the impact of these factors on the conundrum requires a rigorous framework. Given the various forces at work, a joint macroeconomic and finance analysis is the most desirable.

A macroeconomic perspective calls for an examination of the relationship between current and future economic fundamentals and the Fed's monetary policy. It recognizes that long-term interest rate movements reflect markets' expectations of the future federal funds rate, which the Fed adjusts to achieve its inflation and economic stabilization goals.

A finance perspective entails quantifying changing investor perceptions of risks for bond pricing, both

in the amount of interest rate risks and changes in the pricing of those risks. It recognizes that reductions in risk premiums are likely a part of the conundrum.

In a 2006 article, Glenn Rudebusch, Eric Swanson and Tao Wu provide a good example of such a macro-finance approach.<sup>3</sup> The analysis is based on two different models. The first is a vector autoregression-based model developed by Bernanke, Vincent Reinhart and Brian Sack (BRS) in 2004.<sup>4</sup> The second is a New Keynesian-based model that Rudebusch and Wu (RW) developed about the same time.<sup>5</sup>

Both models incorporate important linkages between interest rates and macroeconomic fundamentals. They also impose the standard no-arbitrage restriction from financial analysis to model the variations of term premiums across all bond maturities and over time. However, these models have technical specifications that differ in important ways, such as the short-run effect on interest rates and the economy. Analysis drawing from both may very well yield more robust explanations for the conundrum and other aspects of interest rate behavior.

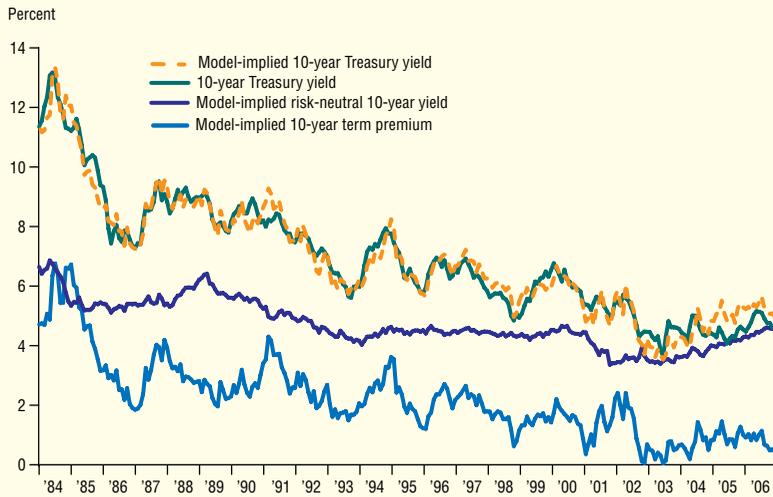
Both models account for the generally downward trend in the 10-year bond yield over the past two decades (*Charts 4A, B*). The risk-neutral component—the sum of long-run inflation expectations and the expected real interest rate—falls considerably over the same period. So does the associated risk premium in BRS. This is consistent with the Great Moderation interpretation that the U.S. economy has become much less volatile and inflation has gradually stabilized at low levels.

Nevertheless, the estimations also yield notable prediction errors in the most recent monetary tightening cycle (*Charts 5A, B*). Both models overpredicted the 10-year Treasury yield by 50 to 75 basis points in the second half of 2004 and almost all of 2005.

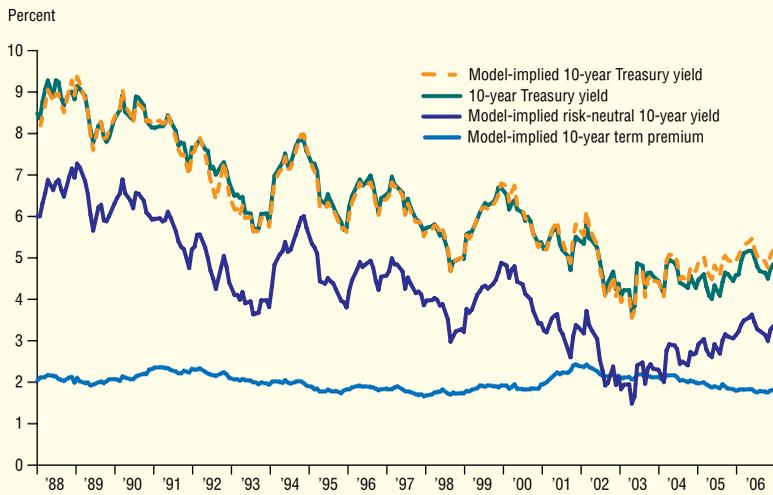
Chart 4

## Models Account For 10-Year Bond-Yield Trend

### A. Bernanke–Reinhart–Sack



### B. Rudebusch–Wu



SOURCE: Author's estimates.

*Both macro-finance models find evidence of a substantial and persistent conundrum in long-term bond yields in 2004 and 2005 that can't be accounted for by changes in macroeconomic fundamentals.*

The models failed to closely track the 10-year bond yield on a few other occasions as well — in 1997–99, for instance. But the prediction errors in 2004–05 are substantially larger and much more persistent than in previous episodes.

In other words, both macro-finance models find evidence of a

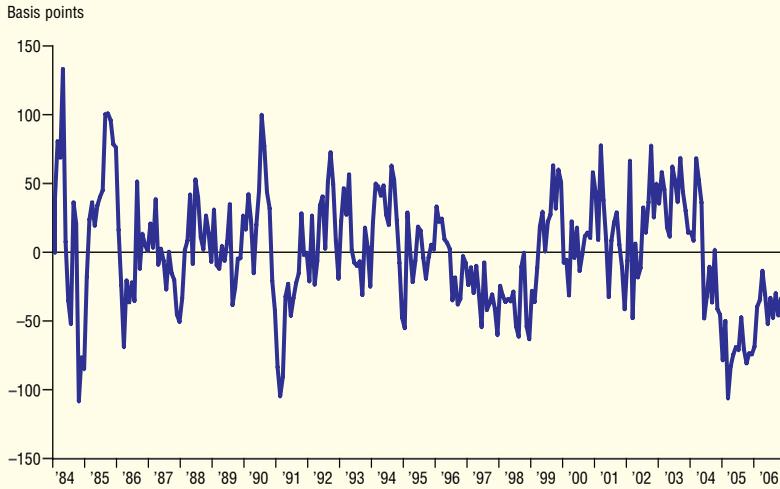
substantial and persistent conundrum in long-term bond yields in 2004 and 2005 that can't be accounted for by changes in macroeconomic fundamentals and estimated declines in risk premiums implied by such changes. Yet, the magnitude of the conundrum is much smaller than what a simple correlation analysis would suggest.



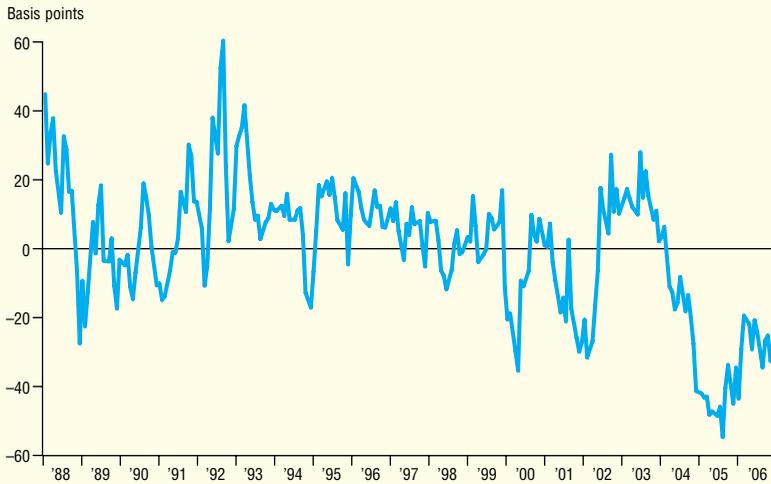
Chart 5

## Models Overpredict 10-Year Treasury Yield in Conundrum Period

### A. Bernanke–Reinhart–Sack



### B. Rudebusch–Wu



NOTE: Charts depict variations in bond yields not explained by the models.

SOURCE: Author's estimates.

market volatility: the implied volatility in the longer-term U.S. Treasury market from the Merrill Lynch MOVE index; the implied volatility from Eurodollar options for uncertainty about the near-term path of monetary policy; and the VIX measure of implied volatility from S&P 500 index options for uncertainty in the stock market.

- Two measures of macroeconomic volatility: an eight-quarter trailing standard deviation of the real gross domestic product (GDP) growth rate to proxy output uncertainty and a 24-month trailing standard deviation of core personal consumption expenditure (PCE) deflator inflation to proxy inflation uncertainty.

- A measure of foreign government and central bank purchases of U.S. Treasury securities: the 12-month change in custodial holdings by the New York Fed for all foreign official institutions, normalized by the total stock of U.S. Treasury debt held by the public.

All these series are natural candidates for omitted variables that could affect long-term bond yields. For instance, less volatility in the longer-term Treasury market tends to make Treasury securities more attractive relative to other assets and drive long-term bond yields down. Similarly, reduced uncertainty about future monetary policy tends to lower the risks of holding long-term bonds and lead to lower risk premiums.

Another possibility is that an increase in stock market volatility enhances the safety appeal of Treasury bonds, driving their prices up and their yields down. Lower macroeconomic volatility and increased foreign purchases of U.S. Treasuries also depress the term premium and lower long-term bond yields.

Statistical analysis reveals how these factors differ in their effect on long-term bond yields (*Table 1*). The most significant factor is the large drop in the implied volatility of longer-term Treasury securities, with a 1 point decline in the index reducing

Both macro-finance models focus only on macroeconomic fundamentals and their associated risk premiums; they don't examine special factors that might have affected the premiums. A natural next step involves determining

which of those factors could have contributed to the conundrum in 2004–05.

To this end, Rudebusch, Swanson and Wu sought to quantify those factors by examining:

- Three measures of financial

the 10-year Treasury yield by 0.5 to 1.2 basis points.

Increases in stock market volatility also tend to reduce long-term Treasury yields, although such effects aren't always statistically significant. Less uncertainty about real growth and inflation—in particular, uncertainty about inflation—significantly decreases long-term Treasury yields.

Interestingly, foreign official purchases of U.S. Treasuries—the most important factor many market participants and the financial press cited for keeping long-term bond yields low during the conundrum period—don't have a significant effect on long-term Treasury yields.

Even the coefficient estimate's sign is "wrong." The press had conjectured a negative correlation between foreign official purchases and long-term Treasury yields, but the data indicate a positive relationship.

To add to the confusion, the relationship between foreign official purchases and Treasury yields hasn't been consistent over the past two decades. Controlling for macroeconomic determinants of long-term bond yields reveals that the correlation is significantly positive between 1987 and 2000 and negative only since 2002.<sup>6</sup>

### Dissecting the Conundrum

How much of the conundrum can these factors explain? One way to answer this question is to break down the regression results from the declines in 10-year Treasury yields. Focusing on the 12 months following the initial monetary tightening in June 2004 isolates the period when the conundrum was most apparent.

The actual decline in 10-year Treasury yields over those 12 months is approximately 90 basis points (*Table 2*).<sup>7</sup> Both models suggest that a

substantial part of it stems from model-implied term premiums. The RW model also identifies a decline in the risk-neutral component of the 10-year rate, primarily reflecting a decline in long-run inflation expectations.

However, a large portion of the bond-yield declines remains unexplained by macroeconomic fundamentals and associated risk premiums. Changes in the model residuals are nearly 87 basis points in the BRS model and 32 basis points in the RW model.

These residuals can be decomposed using six measures of volatility and foreign purchases. The fall in implied volatility of longer-term Treasuries accounts for the greatest fraction of the conundrum, or more than a third of the unexplained residuals from both models. Declines in the uncertainty of real GDP growth also contribute to the conundrum, accounting for about 10 percent of the model residuals.

Inflation volatility doesn't change substantially in those 12 months and has essentially no effect. The three remaining factors aren't statistically significant and account for relatively small changes in bond yields during the period.

Half or more of the model residuals—49 basis points in the BRS model and 23 basis points in the RW model—remain unexplained after the six variables are taken into account. These may be related to such factors as pension fund reforms or abnormal changes in risk appetites that aren't considered in the analysis.

Despite its incomplete results, the macro-finance approach provides a useful perspective for disentangling the conundrum.

Two models identify a bond-yield conundrum during the most recent monetary tightening cycle, albeit a smaller one than was presented by the financial press. The conundrum is heavily related to a substantial decline in the volatility of long-term bond prices. Contrary to many accounts, foreign

**Table 1**  
**Regressions of Model Residuals**

Independent variable	Bernanke-Reinhart-Sack		Rudebusch-Wu	
	Coefficient	(t stat)	Coefficient	(t stat)
Implied volatility on longer-term Treasury securities (Merrill Lynch MOVE index)	1.20	(5.47)	.49	(4.11)
Implied volatility on six-month-ahead Eurodollar futures (from options, in basis points)	-.23	(-1.35)	-.17	(-1.83)
Implied volatility on S&P 500 (VIX index)	-.33	(-.63)	-.50	(-1.73)
Realized volatility of quarterly GDP growth (trailing 8-quarter standard deviation, in percent)	15.40	(3.10)	3.90	(1.45)
Realized volatility of monthly core PCE price inflation (trailing 24-month standard deviation, in percent)	360.00	(2.18)	214.00	(2.39)
Foreign official purchases of U.S. Treasury securities (trailing 12-month total, as percent of U.S. debt in hands of public)	147.00	(.76)	38.00	(.04)
$\bar{R}^2$	.30		.14	

SOURCES: Haver Analytics; Federal Reserve Board.

Table 2

## Decomposition of Long-Term Bond-Yield Conundrum

Independent variable	Bernanke–Reinhart–Sack model	Rudebusch–Wu model
Observed change in 10-year yield (basis points), June '04–June '05, of which:	–93.3	–87.0
• Model-implied change in risk-neutral 10-year yield	13.1	–29.6
• Model-implied change in term premium	–19.9	–25.2
• Change in model residuals, of which:	–86.5	–32.2
▶ Change in implied volatility on longer-term Treasuries	–29.9	–12.2
▶ Change in realized volatility of core PCE inflation	1.1	.7
▶ Change in realized volatility of GDP growth	–11.6	–2.9
▶ Change in implied volatility of Eurodollar rate	7.0	5.1
▶ Change in implied volatility of S&P 500	1.2	1.7
▶ Change in foreign official purchases	–6.0	–1.6
▶ Unexplained by above	–48.6	–23.0

SOURCE: Author's construction.

official purchases of Treasury securities apparently play little or no role.

The bond-yield conundrum—falling long-term interest rates in the midst of monetary tightening—posed challenges to the Fed's monetary policy actions in 2004 and 2005. Will the opposite of the bond-yield conundrum occur now, with the Fed cutting the federal funds rate at a time of uncertainty about rising energy and food prices and long-run inflation stability? This question increases the importance of closely monitoring the relationship between long- and short-term rates.

*Wu is a senior economist in the Research Department of the Federal Reserve Bank of Dallas.*

### Notes

<sup>1</sup> "Globalization's Effect on Interest Rates and the Yield Curve," by Tao Wu, Federal Reserve Bank of Dallas *Economic Letter*, vol. 1, September 2006.

<sup>2</sup> "International Capital Flows and U.S. Interest Rates," by Francis Warnock and Veronica Warnock, International Finance Discussion Papers no. 840, Board of Governors of the Federal Reserve System, September 2005.

<sup>3</sup> "The Bond Yield 'Conundrum' from a Macro–Finance Perspective," by Glenn Rudebusch, Eric Swanson and Tao Wu, *Monetary and Economic Studies*, vol. 24, no. S-1, November 2006, pp. 83–109.

<sup>4</sup> "Monetary Policy Alternatives at the Zero Bound: An Empirical Assessment," by Ben Bernanke, Vincent Reinhart and Brian Sack, *Brookings Papers on Economic Activity*, Issue 2, 2004, pp. 1–78.

<sup>5</sup> "A Macro–Finance Model of the Term Structure, Monetary Policy, and the Economy," by Glenn Rudebusch and Tao Wu, *Economic Journal*, forthcoming.

<sup>6</sup> "The Long-Term Interest Rate Conundrum: Not Unraveled Yet?" by Tao Wu, Federal Reserve Bank of San Francisco *FRBSF Economic Letter*, April 29, 2005.

<sup>7</sup> Actual changes in the 10-year bond yield differ by a few basis points across the two models. The Bernanke–Reinhart–Sack model uses month-average yield data, while the Rudebusch–Wu model uses end-of-month yields.

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