Comment and Discussion

Glenn D. Rudebusch: This paper by David Backus and Jonathan Wright examines a timely topic of interest to macroeconomists, financial economists, and the general public of long-term savers and investors. They investigate the recent episode of continuing low long-term interest rates—a behavior that appears to some to be a "conundrum" given that short-term rates worldwide have been rising. For example, in the United States, while the Federal Reserve raised the federal funds rate from 1 percent in June 2004 to 5¼ percent in December 2006, the rate on ten-year U.S. Treasury notes actually edged down, on balance, from 4.7 percent to 4.6 percent. This directional divergence between short- and long-term rates is at odds with historical precedent and appears even more unusual given other economic developments at the time, such as a solid economic expansion, a falling unemployment rate, rising energy prices, and a deteriorating federal fiscal situation, all of which have been associated in the past with higher long-term interest rates rather than lower.

Of course, determining whether recent long-term interest rate movements truly represent a puzzle requires a theoretical framework that takes into account the various factors that affect long-term rates. The paper takes a joint macro-finance perspective on this problem, which, as much recent research suggests,[1] is a promising strategy that can capture two broad sets of determinants of long-term rates. In particular, from a macroeconomic perspective, the short-term interest rate is a policy instrument under the direct control of the central bank, which adjusts that rate to achieve its macroeconomic stabilization goals. Therefore financial market participants' understanding of central bank behavior, along with their views of

1. See, for example, Diebold, Piazzesi, and Rudebusch (2005).

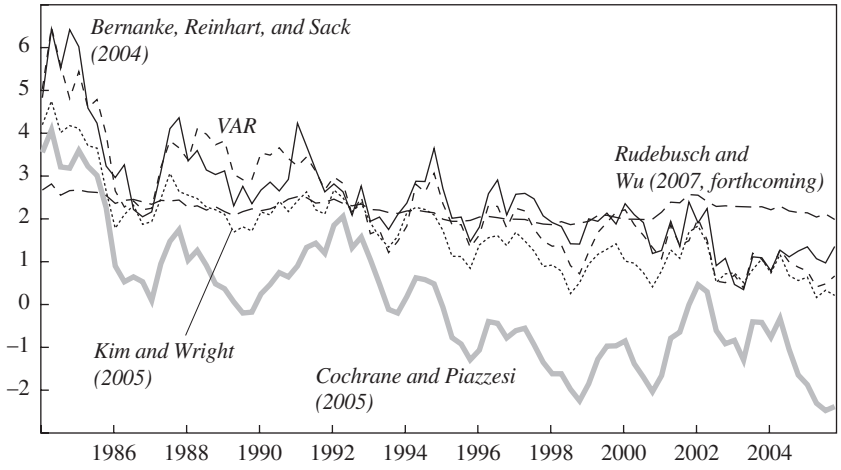
the future direction of the economy, will be an important element in forming their expectations of future short-term rates, which, in turn, will be key in pricing longer-term bonds. For example, the widespread view over the past few years that the Federal Reserve had inflation pretty well in hand has undoubtedly helped hold down long-term bond rates. In addition, a finance perspective, which stresses the importance for bond pricing of investor perceptions of risk, is also likely to be a crucial element in assessing whether there is any bond rate conundrum. Indeed, many have suggested that a reduction in the risk premium is responsible for recent low bond rates. Such a reduction may be attributable to changes in the amount of risk or to changes in the pricing of that risk, and numerous factors have been suggested that could have induced such changes.

The paper identifies a declining term premium, and in particular a declining inflation risk premium, as the proximate source of the recent fall in long-term interest rates. This seems reasonable, but in some sense one can interpret the authors' analysis as showing that there has been no conundrum. The estimated term structure models in the paper seem to fit the recent episode as well as the earlier sample (their figures 9 and 10); that is, the recent episode is not so puzzling that it requires a shift in model coefficients or produces unusually large residuals. The analysis in the paper has essentially defined the "conundrum" away. Of course, such a conclusion would require that the authors had the correct model of interest rates and the term premium, which is far from certain. It seems useful to examine other term structure representations in order to evaluate the robustness of the authors' conclusions; therefore my figure 1 plots five different measures, taken from the literature, of the term premium in the zero-coupon nominal ten-year U.S. Treasury yield:[2]

—*VAR measure:* This is obtained from a standard, three-variable, macroeconomic vector autoregression (VAR), comprising four lags each of the unemployment rate, quarterly inflation in the consumer price index, and the three-month Treasury bill rate. This VAR can be used in each quarter to forecast the short-term rate over the next ten years, which, after averaging, provides one estimate of the risk-neutral ten-year rate. The difference between the observed ten-year rate and that risk-neutral rate provides an estimate of the term premium.

2. These measures are described in detail in Rudebusch, Sack, and Swanson (2007).

Figure 1. Five Estimates of the Ten-Year Term Premium, 1984–2005



Source: Rudebusch, Sack, and Swanson (2007).

—*Bernanke-Reinhart-Sack measure:* A potential shortcoming of using a VAR to estimate the term premium is that it does not impose consistency between the yield curve at a given point in time and the VAR's projected time path of yields over time. Such pricing consistency is imposed in the model of Ben Bernanke, Vincent Reinhart, and Brian Sack (BRS),[3] which attaches a no-arbitrage model of the term structure to a VAR and provides an estimate of the term premium.

—*Rudebusch-Wu measure:* No-arbitrage restrictions can also be imposed on top of a New Keynesian macroeconomic model, as in the model of Rudebusch and Tao Wu (RW),[4] which provides another estimate of the term premium.

—*Kim-Wright measure:* Don Kim and Wright estimate the term premium using a standard, no-arbitrage, dynamic latent factor model from finance (with no macroeconomic structure underlying the factors).[5] In models of this kind, risk-neutral yields and the term premium are determined

3. Bernanke, Reinhart, and Sack (2004).
4. Rudebusch and Wu (2007, forthcoming).
5. Kim and Wright (2005).

by latent factors that are themselves linear functions of the observed bond yield data. This measure is the closest to the versions considered in the present paper.

—*Cochrane-Piazzesi measure:* John Cochrane and Monika Piazzesi analyze one-year-holding-period excess returns for a range of Treasury securities.[6] Their primary finding is that a single factor—a particular combination of current forward rates—predicts a considerable portion of these excess returns for Treasury securities. These, in turn, together with the one-year risk-free rate, imply an expected set of zero-coupon yields one year ahead (since the only way to generate expected returns on zero-coupon securities is through changes in yield). By iterating forward, one can compute the expected excess return for each of the next ten years, thereby yielding a measure of the term premium on the ten-year security.

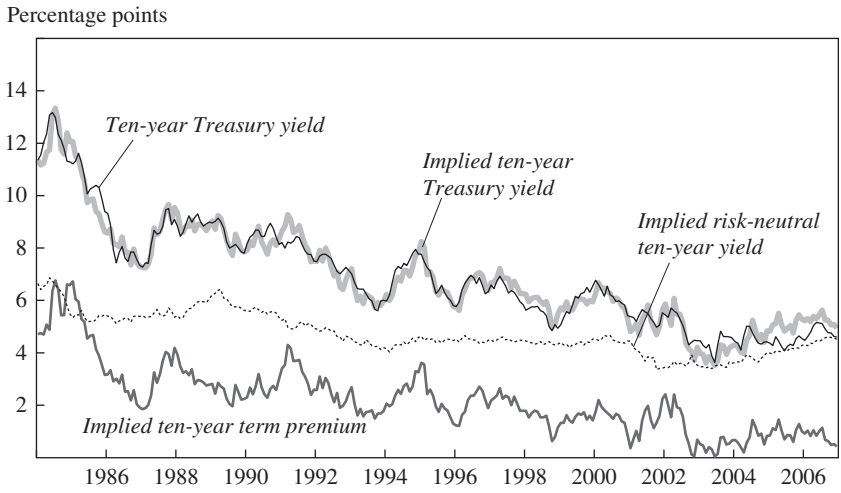
All five of these measures of the term premium show declines over the past few years and are generally consistent with the conclusions of Backus and Wright. However, these various measures also illustrate the considerable uncertainty that should be attached to any measure of the term premium. This caveat is worthy of elaboration; therefore I next consider in detail the implications of the results of the BRS and RW models for the recent behavior of long-term rates.[7]

My figure 2 shows the ten-year zero-coupon U.S. Treasury yield from 1984 through 2006 together with the BRS model decomposition of that yield. The risk-neutral rate implied by the BRS model is the model's estimated yield on a riskless ten-year zero-coupon bond, the implied ten-year Treasury yield is the model's estimated yield on the same bond after accounting for risk, and the implied term premium is the difference between the two. The BRS model does not match the data perfectly, and so the model's residuals—the difference between the model predictions taking into account risk and the data—are graphed in figure 3. Despite the model's excellent fit to the data overall, the recent period of low ten-year yields is one episode that the model notably fails to fit. From mid-2004 through the end of 2006, the model overestimates the ten-year Treasury yield by around 50 basis points on average. Figures 4 and 5 present the analogous pair of graphs for the ten-year bond yield decomposition implied by the RW model. Again the fit of the model to the data is excel-

6. Cochrane and Piazzesi (2005).

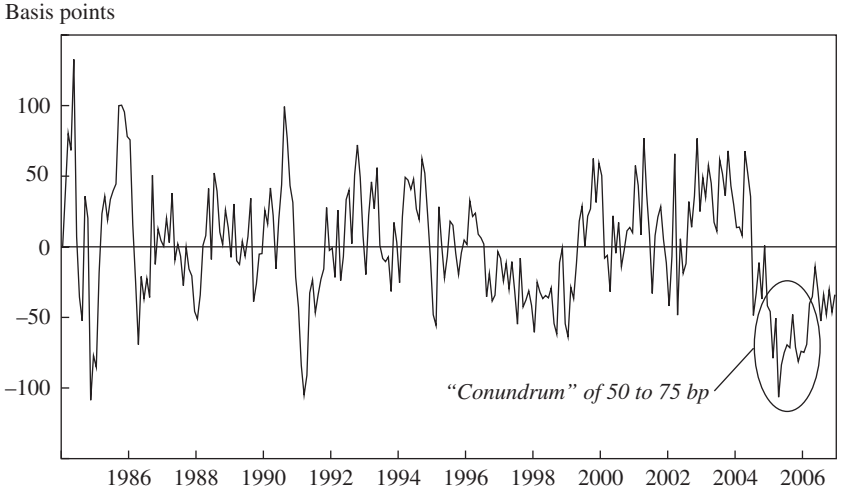
7. This discussion is based on the analysis of Rudebusch, Swanson, and Wu (2006).

Figure 2. Decomposition of the Ten-Year Treasury Yield, 1984–2006: Bernanke-Reinhart-Sack Model[a]



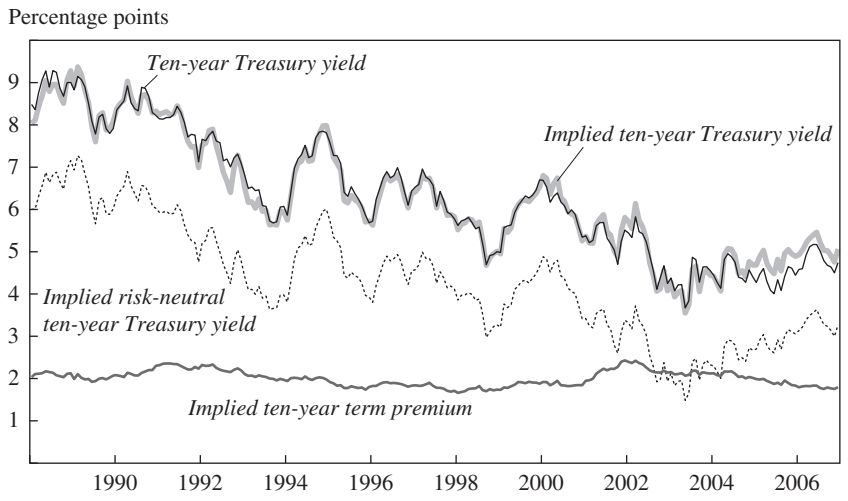
Source: Rudebusch, Swanson, and Wu (2006).
a. Bernanke, Reinhart, and Sack (2004).

Figure 3. Unexplained Portion of the Ten-Year Treasury Yield, 1984–2006: Bernanke-Reinhart-Sack Model



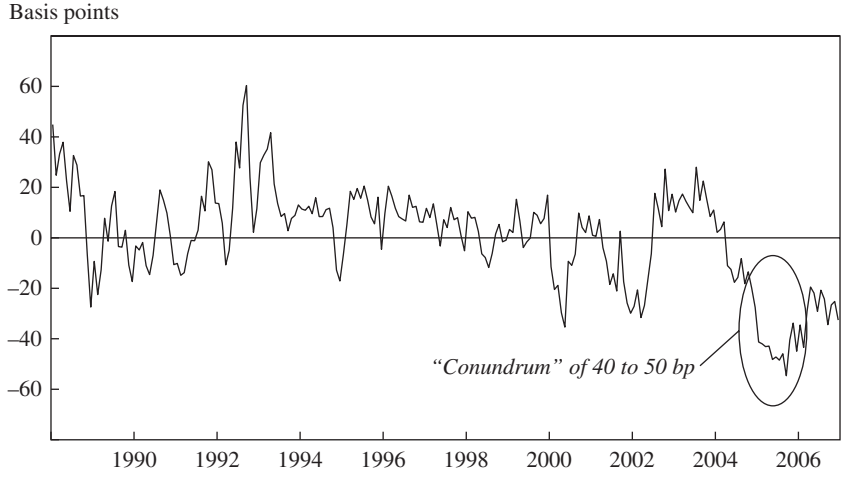
Source: Rudebusch, Swanson, and Wu (2006).

Figure 4. Decomposition of the Ten-Year Treasury Yield, 1988–2006: Rudebusch-Wu Model[a]



Source: Rudebusch, Swanson, and Wu (2006).
a. Rudebusch and Wu (2007, forthcoming).

Figure 5. Unexplained Portion of the Ten-Year Treasury Yield, 1988–2006: Rudebusch-Wu Model



Source: Rudebusch, Swanson, and Wu (2006).

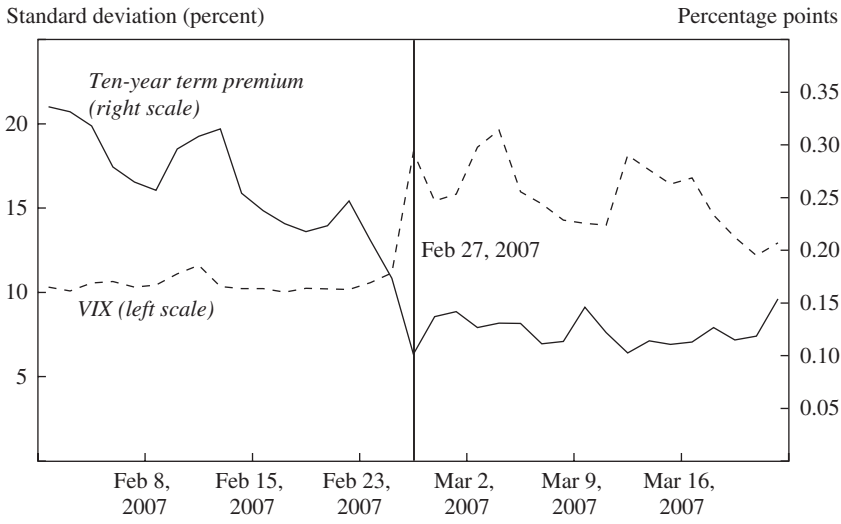
lent, which is all the more remarkable given that the RW model was not optimized to fit the ten-year yield at all (indeed, the five-year yield is the longest maturity used in the estimation, and the estimation sample ends in 2000).

The two models' implied decompositions into the expected short-term rate and the term premium are very different. In the RW model the term premium is relatively constant over 1988–2006, hovering around the 2 percent level, with little high-frequency variation but a notable cyclical movement. Furthermore, the RW model attributes most of the variation in the ten-year yield over time to changes in the expected future path of short-term rates. By contrast, the BRS model attributes most of the high-frequency variation in the ten-year yield to changes in the term premium component, with the risk-neutral component generally trending smoothly downward. The differences between the estimates of the ten-year term premium in these two models largely reflect different assumptions about the long-run persistence of movements in the nominal short-term rate. The BRS model is based on estimates of a macroeconomic VAR that is specified in levels. The smoothly downward-trending risk-neutral rate from the BRS model is essentially a VAR projection of the future path of the short-term rate that reverts to its sample mean fairly quickly. In the RW model the future path of short-term interest rates is instead affected greatly by highly persistent changes in the perceived value of the central bank's target for inflation, which allows significant variation in the risk-neutral ten-year yield. Obviously, then, estimates of the ten-year term premium are very sensitive to assumptions about the long-run properties of the short-term rate.[8] However, such long-run properties are difficult to determine,[9] and so, once such specification uncertainty is accounted for, the confidence intervals associated with any term premium estimate are quite substantial.

Still, despite their differences, the BRS and RW models are largely in agreement that there is, in fact, a conundrum. Specifically, the recent level of long-term bond yields is substantially lower, on the order of 30 to 80 basis points, than can be explained by either of these models. Of course, documenting the conundrum, especially as a sequence of large residuals of the same sign, is only one step toward explaining it. Rudebusch, Eric Swanson, and Wu examined several popular explanations for the conun-

8. Kozicki and Tinsley (2001).
9. Rudebusch (1993).

Figure 6. S&P 500 Volatility Index (VIX) and Ten-Year Term Premium, 2007



Source: Federal Reserve Board and Chicago Board Options Exchange.

drum by regressing the BRS and RW macro-finance models' residuals on various proxies for uncertainty or volatility, and they found that most of the conundrum remained unexplained.[10] Backus and Wright have to take a somewhat different strategy because their finance yield-curve representations are so flexible that the residuals in fitting yields are apparently minuscule. Therefore they employ a two-step strategy, regressing an estimate of the term premium on macroeconomic variables, and it is only in this final regression that a bond yield conundrum can be said to emerge. Specifically, the large recent residuals from their second-stage regression, which are apparent in their figure 11, suggest that *if* the authors have the correct term structure model, then the conundrum is an unusually low term premium relative to macroeconomic fundamentals.

It is important to stress that even if the explanatory power of these second-stage regressions had been higher, we are still some distance away from a model that integrates the various explanations of recent low long-term rates into an underlying asset pricing model. Only such a unified

10. Rudebusch, Swanson, and Wu (2006).

one-step formulation can provide a complete and compelling accounting of the recent episode. To give some sense of how much we do not understand, figure 6 plots daily data on the Kim-Wright term premium along with the VIX measure of implied volatility from options on the S&P 500 index as a measure of uncertainty in the stock market. Backus and Wright note that the decline in the VIX measure of financial market risk is broadly consistent with the fall in the term premium. Unfortunately, as the daily data show, this correlation does not always hold. On February 27 of this year, when financial markets were shaken by surprising news on durable goods orders and drops in Chinese equity prices, the implied volatility jumped, but the term premium fell. Of course, one could speculate that although financial risk had clearly risen, the price attached to that risk fell even more as funds flowed into the bond market in a "flight to quality." However, such speculation shows that much remains unknown about movements in the term premium and in bond rates more generally.

General discussion: Benjamin Friedman called attention to the decomposition, in the authors' figure 10, of the nominal forward rate into expected inflation and an inflation risk premium as well as the expected future real interest rate and a real term premium. He found it striking that the estimate of expected inflation had gone up rather than down with the advent of the present Federal Reserve chairman, noting that it was inconsistent with the common explanation of the long-term yield conundrum, namely, that market participants find credible the assurances that inflation is going to remain in check over the long term. The rise in expected long-run inflation should be particularly surprising to those economists who believe that an explicit inflation target should keep inflation expectations in check. To Friedman this evidence, which suggests that market participants are not convinced that inflation will remain low, made the current low level of nominal long-term rates even more puzzling.

Gregory Mankiw remarked that the paper did not so much crack the forward rate conundrum as recharacterize it as a term premium conundrum. He suggested that the next step is to explain the behavior of such premiums. He also suggested that if they are to be interpreted as risk premiums, they should be related to some measure of risk. He reminded the panel of a Brookings paper he had presented twenty-one years ago, in which he had tried but failed to find a relationship between term premiums and the risks captured in second moments.

Mankiw was also surprised by the authors' finding of an empirical relationship between forward rates and dispersion in expectations. He cautioned against interpreting this as evidence of a risk premium, noting that dispersion is a measure of disagreement, not a measure of uncertainty. For example, all would agree that the expected outcome of a roll of dice is seven even though the actual outcome is quite uncertain, ranging from two to twelve. Disagreement must have something to do with varying information sets or different interpretations of similar information. Unfortunately, economics lacks good models of disagreement.

Richard Cooper regarded the label "term premium" as misleading and drew parallels to the panel's discussion of the paper by Oliner, Sichel, and Stiroh in this volume, where some had criticized what they saw as the reification of the productivity residual. The label "term premium" simply denotes the unexplained residual from the estimation and should be referred to as such.

Eswar Prasad suggested looking at asset markets other than the market for U.S. Treasury securities to learn about the importance of Asian central banks' behavior in holding down long-term rates. He noted that the Chinese authorities are putting similar amounts of money into agency bonds, such as Ginnie Maes, as into Treasury bonds. Although there is no good measure of term premiums for agency bonds, Prasad believed it could be informative to compare the behavior of those markets with that of the Treasury market. He observed further that if one assumes U.S. and foreign industrial bonds to be close substitutes, any future announcement of a revaluation of China's currency should have had effects on those markets as well. An asymmetric response of term premiums on U.S. and foreign bond markets to the announcement that the Chinese central bank intends to diversify away from dollars into other currencies would provide further evidence of the importance of foreign bank behavior to U.S. interest rates.

References

Ang, Andrew, and Monika Piazzesi. 2003. "A No-Arbitrage Vector Autoregression of Term Structure Dynamics with Macroeconomic and Latent Variables." *Journal of Monetary Economics* 50, no. 4: 745–87.

Ang, Andrew, Geert Bekaert, and Min Wei. 2007 (forthcoming). "The Term Structure of Real Rates and Expected Inflation." *Journal of Finance.*

Beechey, Meredith. 2007. "A Closer Look at the Sensitivity Puzzle: The Sensitivity of Expected Future Short Rates and Term Premia to Macroeconomic News." Finance and Economics Discussion Paper 2007-06. Washington: Board of Governors of the Federal Reserve System.

Bekaert, Geert, Seonghoon Cho, and Antonio Moreno. 2005. "New-Keynesian Macroeconomics and the Term Structure." Working Paper 11340. Cambridge, Mass.: National Bureau of Economic Research (May).

Bernanke, Ben S., Vincent R. Reinhart, and Brian P. Sack. 2004. "Monetary Policy Alternatives at the Zero Bound: An Empirical Assessment." *BPEA,* no. 2: 1–78.

Berner, Richard, and David Miles. 2006. "The Term-Premium Case for Higher Yields." Morgan Stanley Global Economic Forum (January 20).

Cochrane, John H., and Monika Piazzesi. 2005. "Bond Risk Premia." *American Economic Review* 95, no. 1: 138–60.

_____. 2006. "Decomposing the Yield Curve." Unpublished. Graduate School of Business, University of Chicago (November).

Dai, Qiang, and Kenneth J. Singleton. 2002. "Expectation Puzzles, Time-Varying Risk Premia, and Affine Models of the Term Structure." *Journal of Financial Economics* 63, no. 3: 415–41.

D'Amico, Stefania, Don H. Kim, and Min Wei. 2007. "TIPS from TIPS: The Information Content of Treasury Inflation-Protected Security Prices." Washington: Federal Reserve Board (March).

Diebold, Francis X., Monika Piazzesi, and Glenn D. Rudebusch. 2005. "Modeling Bond Yields in Finance and Macroeconomics." *American Economic Review* 95, no. 2: 415–20.

Duffee, Gregory R. 2002. "Term Premia and Interest Rate Forecasts in Affine Models." *Journal of Finance* 57, no. 1: 405–43.

Duffie, Darrell, and Rui Kan. 1996. "A Yield-Factor Model of Interest Rates." *Mathematical Finance* 6, no. 4: 379–406.

Gallmeyer, Michael F., Burton Hollifield, and Stanley E. Zin. 2005. "Taylor Rules, McCallum Rules and the Term Structure of Interest Rates." *Journal of Monetary Economics* 52, no. 5: 921–50.

Greenspan, Alan. 2005. "Testimony of Chairman Alan Greenspan: Federal Reserve Board's Semiannual Monetary Policy Report to the Congress." Washington: Board of Governors of the Federal Reserve (February 16).

Gross, Bill. 2005. "I've Got to Admit It's Getting Better, Getting Better all the Time." PIMCO *Investment Outlook* (March) (www.pimco.com/LeftNav/Featured+Market+Commentary/IO/2005/March_IO_2005.htm).

Gürkaynak, Refet S., Brian P. Sack, and Eric T. Swanson. 2005. "The Sensitivity of Long-Term Interest Rates to Economic News: Evidence and Implications for Macroeconomic Models." *American Economic Review* 95, no. 1: 425–36.

Gürkaynak, Refet, Brian P. Sack, and Jonathan H. Wright. 2006. "The US Treasury Yield Curve: 1961 to the Present." Finance and Economics Discussion Paper 2006-28. Washington: Board of Governors of the Federal Reserve System (June).

Kim, Don H. 2004. "Inflation and the Real Term Structure." Working paper. Washington: Board of Governors of the Federal Reserve.

Kim, Don H., and Athanasios Orphanides. 2005. "Term Structure Estimation with Survey Data on Interest Rate Forecasts." Finance and Economics Discussion Paper 2005-48. Washington: Board of Governors of the Federal Reserve System (October).

Kim, Don H., and Jonathan H. Wright. 2005. "An Arbitrage-Free Three-Factor Term Structure Model and the Recent Behavior of Long-Term Yields and Distant-Horizon Forward Rates." Finance and Economics Discussion Paper 2005-33. Washington: Board of Governors of the Federal Reserve System (August).

Kozicki, Sharon, and Peter A. Tinsley. 2001. "Shifting Endpoints in the Term Structure of Interest Rates." *Journal of Monetary Economics* 47, no. 3: 613–52.

Kroszner, Randall S. 2006. "Why Are Yield Curves So Flat and Long Rates So Low Globally?" Remarks presented at the meeting of the Institute of International Bankers, New York, June 16.

Lehman Brothers. 2007. "Outlook 2007: The Conundrum Runs Its Course." *Global Weekly Interest Rate Strategy* (December 21).

Lu, Biao, and Liuren Wu. 2006. "Systematic Movements in Macroeconomic Releases and the Term Structure of Interest Rates." Paper presented at the annual meeting of the European Finance Association, Zurich, August 23–26.

Ludvigson, Sydney C., and Serena Ng. 2006. "Macro Factors in Bond Risk Premiums." New York University (August).

Macaulay, Frederick R. 1938. *Some Theoretical Problems Suggested by the Movements of Interest Rates, Bond Yields and Stock Prices in the United States since 1856.* Cambridge, Mass.: National Bureau of Economic Research.

Rudebusch, Glenn D. 1993. "The Uncertain Unit Root in Real GNP." *American Economic Review* 83, no. 1: 264–72.

Rudebusch, Glenn D., Brian P. Sack, and Eric T. Swanson. 2007. "Macroeconomic Implications of Changes in the Term Premium." Federal Reserve Bank of St. Louis *Review* 89, no. 4: 241–69.

Rudebusch, Glenn D., Eric T. Swanson, and Tao Wu. 2006. "The Bond Yield 'Conundrum' from a Macro-Finance Perspective." *Monetary and Economic Studies* 24, no. S-1: 83–109.

Rudebusch, Glenn D., and Tao Wu. 2007. "Accounting for a Shift in Term Structure Behavior with No-Arbitrage and Macro-Finance Models." *Journal of Money, Credit, and Banking* 39, no. 2–3: 395–422.

_____. 2007 (forthcoming). "A Macro-Finance Model of the Term Structure, Monetary Policy, and the Economy." *Economic Journal.*

Shiller, Robert J. 1979. "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure." *Journal of Political Economy* 87, no. 6: 1190–1219.

Warnock, Francis E., and Veronica Cacdac Warnock. 2006. "International Capital Flows and U.S. Interest Rates." Working Paper 12560. Cambridge, Mass.: National Bureau of Economic Research (October).