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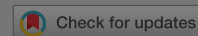
Articles

Term Structures of Inflation Expectations and Real Interest Rates

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The author is grateful to Tom Stark for extensive discussions about the Survey of Professional Forecasters and providing feedback regarding the derivations in the Appendix ([supplementary material](#)), to Dongho Song for help with the unobserved-components stochastic-volatility model, to Jonathan Wright for sharing some of the forecasts from Faust and Wright ([2013](#)) and helpful discussions, to Frank Diebold and Frank Schorfheide for helpful comments, and to the editor, the associate editor, and two anonymous referees for their comments that helped sharpened the message of the article. The author was a consultant for the Federal Reserve Bank of Minneapolis when an earlier version of this article was written and is a visiting scholar at the Federal Reserve Bank of Philadelphia. The views expressed herein are those of the author and not necessarily those of the Federal Reserve Banks of Minneapolis and Philadelphia or the Federal Reserve System.

Notes

- 1 My analysis focuses on CPI inflation as opposed to, for example, personal consumption expenditures (PCE) price index inflation, gross domestic product (GDP) price deflator inflation, or any of the “core” versions that strip out energy and food prices. PCE inflation has been released since the mid-1990s, but it has been scarcely included in the literature. Since GDP price deflator inflation is more reliable than PCE inflation, I use GDP price deflator inflation. Finally, real GDP growth is not inflation.
- 2 Patton (2012) discusses this issue and provides a detailed review.
- 3 Two other studies have used the same data as I used. Gürk (2012) uses the data for various horizons using a different method. The results are similar. The results are similar as they show, each in its own way, that the data set out to be consistent with the hypothesis. His data consist of nominal yields. He uses a factor that

captures stochastic volatility in the trend process. My results regarding long-run inflation expectations are similar to his.

4 Gospodinov and Wei (2016) extended the model in D’Amico, Kim, and Wei (2018) to include information from derivative markets and oil futures, which they argue improves the forecasting performance of the model. Abrahams et al. (2016) also used real and nominal bond yields for a similar purpose, though, they use observable factors to adjust TIPS yields for liquidity.

5 For example, Haubrich, Pennacchi, and Ritchken (2012) used survey data that are similar to mine as well as swap and nominal yield data, and their forecast accuracy is worse than what I obtain, primarily because it is more volatile.

6 They showed that the relationship between macroeconomic surprises and yields that is strong before the crisis weakens or disappears after 2008.

7 The original NS model starts with the assumption that the forward rate curve is a variant of a Laguerre polynomial, which results in the function in (1) when converted to yields. As such, it has no economic foundation, unlike some of the papers cited in the introduction that contain asset-pricing models. The slope factor in Diebold, Rudebusch, and Aruoba (2006) is defined as $-St$. The three factors are labeled as such because, as Diebold, Rudebusch, and Aruoba (2006) demonstrated, $St \rightarrow St(0) = St(0)$ (with the definition $St(0) = St(0)$) and decays to zero as $t \rightarrow \infty$. The intercept factor is determined by the value of $St(0)$.

8 For an example of how to use the model, see the online appendix.

9 In practice, the model is estimated using the data in the online appendix.

10 In the online appendix, I show that the model can be estimated using the data in the online appendix. I use this model to estimate the parameters of the model.

11 See, for example, Diebold, Rudebusch, and Aruoba (2006) for an example of how to use the model. Koopman (2012) for an example of how to use the model.



12 It is important to note that by decomposing the nominal rate this way, I implicitly include the inflation risk premium in $r_t(\tau)$. However, this is not crucial as it is natural for the ex-ante real rate to include this risk. The debate on the size of the inflation risk premium is far from settled in the literature. See, for example, D'Amico, Kim, and Wei (2018), Duffee (2018), and Haubrich, Pennacchi, and Ritchken (2012).

13 In all figures, the two National Bureau of Economic Research (NBER) recessions in the sample are shown with gray shading, and September 2008 is shown with a vertical line. The latter is arguably the height of the financial crisis, and significant changes occur in both the inflation forecasts and the financial variables introduced later. Also, where relevant, I use red dashed lines to denote pointwise 95% confidence bands.

14 In fact, since TIPS break-even rates are defined as the difference between nominal yields and the TIPS rate, and I define my ex-ante real rate as the difference between the nominal yields and my inflation expectations, the difference between TIPS yields and my real interest rate is by construction equal to the difference between the break-even rate and my inflation expectations. Note that I do not show a TIPS rate for the 6-month and 1-year maturities since Gürkaynak, Sack, and Wright (2010) cautioned against using their model to generate TIPS rates for maturities lower than two years.

15 The two models have the same number of parameters, and thus the difference in the log-likelihood is due to the different fit of the models to the data. The model fits the data better, and the difference in log-likelihood is much more important than the difference in the number of parameters.

16 The average inflation rate is calculated as the logarithm of the average of the CPI, as estimated by the FRED compiler, and the logarithm of the average of the CPI with the FRED compiler. The difference is only due to the different treatment of the data.

17 I assume that the point of view is statistically significant. The point of view is statistically significant. The point of view is statistically significant.

18 Lucca (2015) shows that the point of view is statistically significant. The point of view is statistically significant.

19 Both of these papers start their estimations prior to the introduction of the respective financial asset, using only nominal yields. As such, their reported inflation expectations can be considered as being related to TIPS and swaps only after 1999 for TIPS and 2004 for swaps. The forecasts of D’Amico, Kim, and Wei (2018) are graciously provided by the Federal Reserve Board. The forecasts of Haubrich, Pennacchi, and Ritchken (2012) are available from the website of the Federal Reserve Bank of Cleveland (www.clevelandfed.org). The forecasts of other studies cited in the Introduction are not publicly available; therefore, I am not able to use them in this comparison.

20 As Campbell, Shiller, and Viceira (2009) noted, following the failure of Lehman Brothers in September 2008, a large amount of TIPS bonds flooded the market as Lehman’s holdings were being sold, followed by large institutional investors. This depressed the price, increased the TIPS yields, and with little change in the nominal yields led to a large decline in break-even rates.

Further reading ⓘ

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