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Term Structures of Inflation Expectations and Real Interest Rates

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Abstract

I use a statistical model to combine various surveys to produce a term structure of inflation expectations—inflation expectations at any horizon—and an associated term structure of real interest rates. Inflation expectations extracted from this model track realized inflation quite well, and in terms of forecast accuracy, they are at par with or superior to some popular alternatives. The real interest rates obtained from the model follow Treasury Inflation-Protected Securities rates as well.

Key Words:

Inflation expectations | Nelson–Siegel model | State-space methods | Surveys

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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 commonly followed surveys. The same goes for the core versions. Since GDP price deflator is only available quarterly, it is not a very appealing measure. Finally, most financial contracts that use inflation use some variant of CPI inflation.

2 Patton and Timmermann (2011) and Knüppel and Vladu (2016) also discuss this issue and provide a solution that uses approximations.

3 Two other papers used a reduced-form approach. Ajello, Benzoni, and Chyruk (2012) used the nominal yields at a given point in time to forecast inflation at various horizons using a dynamic term structure model that has inflation as one of the factors. The important distinction of this article relative to some others is that the authors separately modeled the changes in core, energy, and food prices because, as they show, each of these components has different dynamics. Mertensy (2016) set out to extract trend inflation (long-run inflation) from financial variables and surveys. His data consist of long-horizon surveys, realized inflation measures, and long-term nominal

yields. He uses a reduced-form factor model with a level and uncertainty 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 $-S_t$. The three factors are labeled as such because, as Diebold, Rudebusch, and Aruoba (2006) demonstrated, $L_t=y_t(\infty), S_t=y_t(\infty)-y_t(0)$ (with the definition adopted in this article), and the loading on C_t starts at zero and decays to zero affecting the middle of the yield curve where the maximum loading is determined by the value of λ.

8 For an extensive survey, see Diebold and Rudebusch (2013).

9 In practice, this turns out to be a very minor issue. See footnote A-5 in the online appendix (supplementary material).

10 In Section 3.2, I consider a VAR(1) containing all three factors as an alternative. I show that model selection criteria point to the independent AR(3) specification, and I use this as the benchmark.

11 See, for example, Diebold, Rudebusch, and Aruoba (2006) for the details of estimating the NS model; Aruoba, Diebold, and Scotti (2009) for a specific example

with a state-space model with many missing observations; and Durbin and Koopman (2012) for a textbook treatment of both.

12 It is important to note that by decomposing the nominal rate this way, I implicitly include the inflation risk premium in rt(τ). 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, which is about 22 log points, means that the benchmark model fits the data better, indicating that capturing higher order autoregressive dynamics is much more important than cross-factor correlations.

16 The actual inflation measure is the appropriate difference of the natural logarithm of CPI, as extracted from Federal Reserve Economic Data (FRED) in July 2016, with the FRED code CPIAUCSL. The RMSEs for the model forecast differ across panels only due to differences in the samples used in comparisons with the alternative models.

17 I also compared the model forecast with a simpler no-change forecast, one that assumes that the forecast of any horizon is equal to the annual inflation at the point of the forecast. The model forecast is superior to this forecast, and this is statistically significant for all horizons.

18 Lucca and Schaumburg (2011) provided a good summary of these problems and some others that make TIPS and swap rates noisy indicators of inflation expectations.

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.