An Affine Term Structure Model with Fed Chairs' Speeches

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Abstract

This paper analyzes the impact of the sentiment expressed in speeches by Fed Chairs on bond yields, using an affine term structure model, similarly to the framework developed in Ang and Piazzesi (2003). The speeches by Fed Chairs are evaluated using finBERT (Huang, Wang, Yang, 2022) to generate three sentiment factors: negative, neutral, and positive. The variance decomposition analysis indicates that sentiment factors account for a considerable portion of the variance in short-term and long-term yield forecasts. Also, the inclusion of sentiment factors is helpful to improve out-of-sample forecast performance for relatively longer-term yields.

Introduction

Central bank communication plays an important role in financial market conditions. Leombroni et al. (2021), Swanson and Jayawickrema (2023), Swanson (2023) and many other papers show that central bank communication, especially ECB president or Fed chair's speeches have a significant effect on bond yields using high frequency data. This paper extracts factors which capture the tone in the speeches by the chairs of the Federal Reserve System using finBERT. Incorporating the sentiment factors to an affine term structure model for U.S. Treasury bonds with macroeconomic variables, I analyze the contribution of macroeconomic and sentiment factors as well as latent factors to yield determination. Also, I compare the forecast performance in Treasury bond yields. The sentiment of central bank communication is measured by a finBERT model developed by Huang, Wang, and Yang (2023). FinBERT models are a class of BERT models which are additionally pre-trained with financial communication documents. The model by Huang, Wang, and Yang is trained by corporate reports (10-K & 10-Q), earnings call transcripts, and analyst reports. Using this model, I construct the sentiment factors for each speech by the Fed chairs during 2001—2022 using sentiment scores and macroeconomic variables. Incorporating the sentiment factors as additional observed factors to an affine term structure model with macroeconomic variables (see Ang and Piazzesi, 2003), I estimate parameters of the term structure model and conduct variance decomposition to see the contribution of each factor. Moreover, I implement out-of-sample forecast to compare the forecast performance.

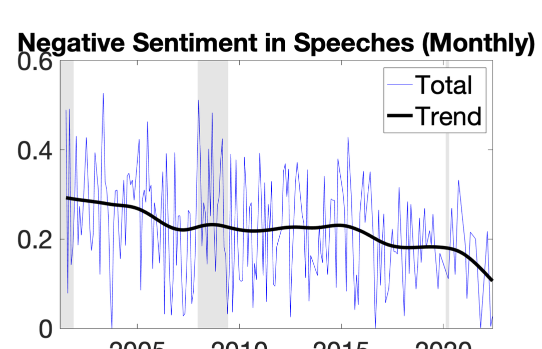

Figure 1. Negative Sentiment in Speeches.

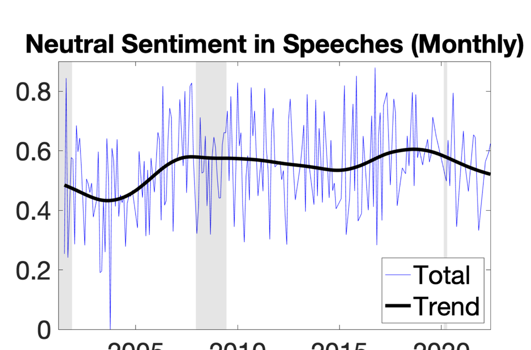

Figure 2. Neutral Sentiment in Speeches.

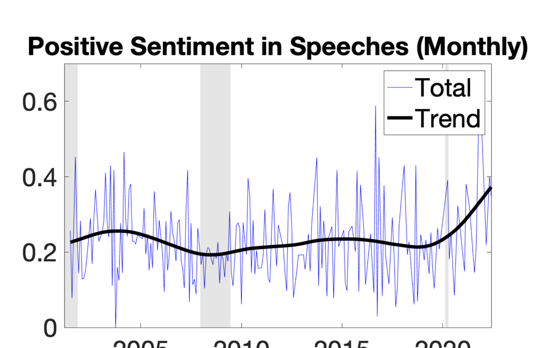

Figure 3. Positive Sentiment in Speeches.

Data

I use the speeches and Congressional testimony (henceforth "speeches") by Fed chairs from December 2001 to June 2022. During this period, Chair Alan Greenspan gave 117 speeches; Chair Ben Bernanke, 234 speeches; Chair Janet Yellen, 57 speeches; Chair Jerome Powell, 46 speeches. Using Huang, Wang, and Yang (2023)'s finBERT model, I compute the sentiment scores for each speech and compile monthly data using the last speech of the month. If there is a month without a speech, I interpolate the missing value. Figure 1,2, and 3 show the changes in negative, neutral and positive scores over time.

For macroeconomic variables, I use percentage changes of the PCE, the PPI for finished goods, and Case-Shiller U.S. National Home Price Index and extract the first principal component to form an inflation measure. A real activity measure is based on the first principal component extracted from the growth rate of the number of job openings for total nonfarm from JOLTS, the unemployment rate, the employment-population rate, and the growth rate of industrial production. All inflation and growth rates are annualized monthly rate.

I use data on bond yields of maturities 1, 3, 12, 36, 60, and 120 months from December 2001 to June 2022. All bond yields are based on constant maturity Treasury yields as reported in the FRED database of the Federal Reserve Bank of St. Louis. I choose 1, 36, 120 month yields as key rates representing short, medium, and long ends of the yield curve.

Model & Results

I estimate a discrete-time term structure model similar to Ang and Piazzesi (2003). The model combines three sentiment factors S_t with the principal components for the inflation measure π_t and the real activity measure y_t as observable factors along with three latent factors F_t.

$$[\pi_{t+1}\ y_{t+1}\ S_{t+1}\ F_{t+1}]' = c + \rho \cdot [\pi_t\ y_t\ S_t\ F_t]' + \Sigma u_{t+1}$$
$$i_t^n = A_n + B_n \cdot [\pi_t\ y_t\ S_t\ F_t]' + \Sigma_e u_t^e$$

The three sentiment factors (S_t) are residuals after regressing the sentiment scores on the macroeconomic principle components. For identification and estimation, I follow conventional restrictions and use MCSE by Hamilton and Wu (2012).

Figure 4 shows the response of annualized yield to one SD increase in each factor. Positive sentiment shock seems to lower short-term bond yields while negative and neutral sentiment shocks seem to lift shot-term bond yields. Table 1 (and 2) summarize the relative contribution of each factor to forecast variances for 1-month (120-month) ahead forecast. Sentiment factors explain 77-88% of the 1-month ahead forecast variance while they explain 46-60% in 120-month ahead forecast variance. In the latter, the role of macro factors becomes more significant.

Also, I perform 1-month ahead out-of-sample forecast over 24 months by expanding windows to compare bond yield forecasting performance between the macro model of Ang and Piazzesi (2003) and the model with sentiment factors. For 120-month (60-month) bond yield, the root mean squared errors (RMSEs) are 0.1170 for the macro model and 0.0288 for the model with sentiment factors (0.3878, and 0.1919). Including sentiment factors seems to improve the out-of-sample forecasting performance for long-term yields relative to the macro model.

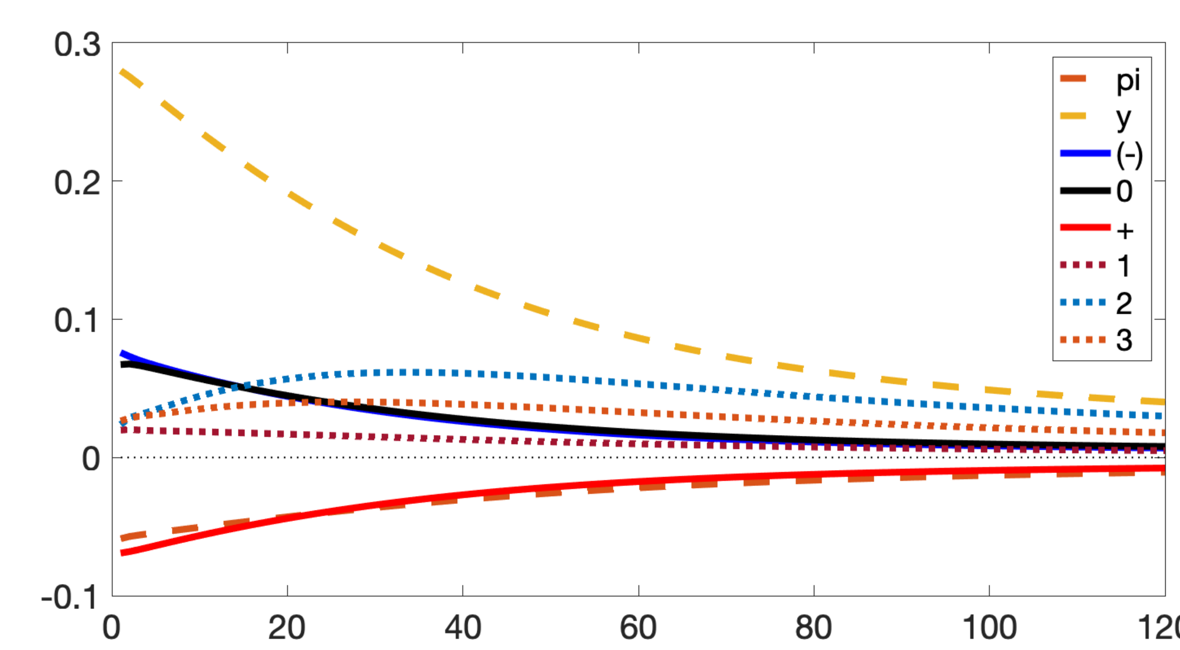

Figure 4. Annualized Yield Responses (%) for Each Bond Maturity to One SD Factor Shocks.

1-month ahead forecast contribution	Short end	Middle	Long end
Macro factors	0.1197	0.1570	0.1973
Sentiment factors	0.8797	0.8328	0.7700
Latent factors	0.0006	0.0102	0.0327
120-month ahead forecast contribution	**Short end**	**Middle**	**Long end**
Macro factors	0.4019	0.4703	0.5370
Sentiment factors	0.5981	0.5294	0.4622
Latent factors	0.000026	0.0003	0.0007

Conclusions

This paper analyzes the impact of negative, neutral and positive sentiments in speeches by Fed Chairs on bond yields. Sentiment factors are constructed using sentiment scores by finBERT (Huang, Wang, Yang 2023). They seems to play a key role in yield determination, and including them shows better out-of-sample forecasting performance relative to the macro model of Ang and Piazzesi (2003). This analysis, however, relies on the performance of the finBERT score system and shares its limitations. There exists room for improvement in sentiment analysis by finBERT, considering the Fed chairs' euphemism.

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References

1. 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(4):745–787.
2. Hamilton, James D. and Jing Cynthia Wu. 2012. "Identification and estimation of Gaussian affine term structure models." Journal of Econometrics 168(2):315–331.
3. Huang, Allen H., Hui Wang and Yi Yang. 2023. "FinBERT: A Large Language Model for Extracting Information from Financial Text." Contemporary Accounting Research 40(2):806–841.
4. Leombroni, Matteo, Andrea Vedolin, Gyuri Venter and Paul Whelan. 2021. "Central bank communication and the yield curve." Journal of Financial Economics 141(3):860–880.
5. Swanson, Eric T. 2023. "The Importance of Fed Chair Speeches as a Monetary Policy Tool." AEA Papers and Proceedings 113:394–400.
6. Swanson, Eric and Vishuddhi Jayawickrema. 2023. "Speeches by the Fed chair are more important than FOMC announcements: An improved high-frequency measure of us monetary policy shocks." Unpublished Manuscript.
7. Board of Governors of the Federal Reserve System (U.S.) . 2023. "Market Yield on U.S. Treasury Securities at 10-Year (5-year, 3-year, 1-year, 3-month, 1-month) Constant Maturity, Quoted on an Investment Basis [GS10, GS5, GS3, GS1, GS3M, GS1M], Monthly.". retrieved from FRED, Federal Reserve Bank of St. Louis, May, 2023.