Finance and Economics Discussion Series
Divisions of Research & Statistics and Monetary Affairs
Federal Reserve Board, Washington, D.C.

The Fed's Asymmetric Forecast Errors

Andrew C. Chang

2018-026

Please cite this paper as:
Chang, Andrew C. (2018). "The Fed's Asymmetric Forecast Errors," Finance and Economics Discussion Series 2018-026. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/FEDS.2018.026.

The Fed's Asymmetric Forecast Errors

Andrew C. Chang*

February 15, 2018

Abstract

I show that the probability that the Board of Governors of the Federal Reserve System staff's forecasts (the "Greenbooks") overpredicted quarterly real gross domestic product (GDP) growth depends on both the forecast horizon and also whether the forecasted quarter was above or below trend real GDP growth. For forecasted quarters that grew below trend, Greenbooks were much more likely to overpredict real GDP growth, with one-quarter ahead forecasts overpredicting real GDP growth more than 75% of the time, and this rate of overprediction was higher for further ahead forecasts. For forecasted quarters that grew above trend, Greenbooks were slightly more likely to underpredict real GDP growth, with one-quarter ahead forecasts underpredicting growth about 60% of the time. Unconditionally, on average, Greenbooks overpredicted real GDP growth.

JEL Codes: C53; D23; E03; E17

Keywords: Asymmetric Forecast Errors; Federal Open Market Committee; Forecast Accuracy; Greenbook; Monetary Policy; Real-Time Data

*Chang: Senior Economist, Division of Research and Statistics, Board of Governors of the Federal Reserve System. 20th St. NW and Constitution Ave., Washington DC 20551 USA. +1 (657) 464-3286. a.christopher.chang@gmail.com. https://sites.google.com/site/andrewchristopherchang/

†The views and opinions expressed here are ours and are not necessarily those of the Board of Governors of the Federal Reserve System. I thank Stephanie Aaronson, Aditya Aladangady, Felix Galbis-Reig, Paul Lengermann, Jeremy B. Rudd, Riccardo Trezzi, and seminar participants at the Board for helpful comments. I thank Emily G. Massaro for research assistance. Any errors are mine.

1 Introduction

The Board of Governors of the Federal Reserve System staff (the "staff") prepare a detailed projection of the US economy for meetings of the Federal Open Market Committee, called the *"Greenbooks"*. The academic literature has examined whether Greenbooks contain superior predictive power compared to private forecasters, time-series models, or the "market consensus".[1] In this paper, I take a different view and ask one question that remains surprisingly unanswered: what are the conditional probabilities that Greenbooks overpredicted quarterly real gross domestic product (GDP) growth when the forecasted quarter ended up growing at either above or below trend?

I depart from conventional measures of forecast accuracy, such as root mean squared error, because Greenbook forecasters may exhibit non-differentiable loss functions due to, among other things, psychological biases that affect their forecasts. These biases are well known in the psychological literature and they can affect master forecasters just as easily as novice psychics (Kahneman and Tversky, 1979).

Using Greenbook forecasts over 54 years, I find the probability that Greenbooks overpredicted real GDP growth depends on both the forecast horizon and also whether the forecasted quarter grew above or below trend. Conditional on a forecasted quarter that grew below trend, Greenbooks were much more likely to overpredict real GDP growth, with one quarter ahead forecasts overpredicting real GDP growth more than 75% of the time. This rate of overprediction is higher for further ahead forecasts. Conditional on a forecasted quarter that grew above trend, Greenbooks were slightly more likely to underpredict real GDP growth, with one-quarter ahead forecasts underpredicting growth about 60% of the time. This rate of underprediction is about the same for further ahead forecasts. I cautiously interpret these results as Greenbooks having an asymmetric loss function for real GDP growth forecast errors.

[1] Examples include Faust and Wright (2009), Arai (2014), Ericsson et al. (2015), and Chang and Hanson (2016).

2 Data

I use Greenbook quarterly real GDP forecasts from 1967 to 2011, the last year that Greenbook data are available. I consider Greenbook forecasts from a one-quarter backcast to a five-quarter ahead forecast (therefore the latest Greenbook in my dataset contains a GDP forecast of the first quarter of 2013). For actual GDP, I use the Bureau of Economic Analysis's (BEA) first-release estimates. The BEA second-, third-, and October 2017 estimates all give similar results. All data come from the Federal Reserve Bank of Philadelphia real-time data center (Croushore and Stark, 1999).[2] Following the recommendations of Chang and Li (2017, Forthcoming-a), replication files for this paper can be found on my website.[3]

3 Forecast Errors

Figure 1 shows the probabilities that the Greenbooks overpredicted real GDP growth, given that the economy turned out to experience below-trend real GDP growth. I define trend as a 5-year moving average, but my results are similar using a 10-year moving average or looking at forecasts conditioned on being above or below zero real GDP growth. The horizontal axis of Figure 2 is the forecast horizon in quarters, where $t = 0$ indicates a "nowcast" of the current quarter, $t = -1$ indicates a one-quarter "backcast", and $t = 1$ indicates one-quarter ahead forecast.

The probability that Greenbooks overpredicted real GDP growth, given that the forecasted quarter turned out to experience below-trend GDP growth, rises monotonically with the forecast horizon. For current quarter "nowcasts", given the current quarter ended up below trend, the Greenbook overpredicted GDP about 65% of the time. This probability rises

[2]Available at: https://www.philadelphiafed.org/research-and-data/real-time-center/real-time-data/ for GDP and https://www.philadelphiafed.org/research-and-data/real-time-center/greenbook-data for Greenbooks. Downloaded on November 28th, 2017. The BEA October 2017 estimates were the latest estimates available on this date.

[3]https://sites.google.com/site/andrewchristopherchang/research

monotonically to just below 90% for five-quarter ahead forecasts.

Figure 2 shows the probabilities that Greenbooks overpredicted real GDP growth, given that the forecasted quarter turned out to be above trend. For current quarter "nowcasts", this probability is about 40 percent, and is about stable throughout the rest of the forecast horizon.

Importantly, the probabilities that Greenbooks overpredicted real GDP growth depend on whether the forecasted quarter grew above or below trend. Except for one-quarter "backcasts", this difference in conditional probabilities is statistically significant. The pattern is also stable across data vintages and robust to using only Greenbooks since 1990.[4]

4 Possible Explanations for Asymmetric Forecast Errors

4.1 Uninformed Greenbook Forecasts

One hypothesis as to why the Greenbook forecasts exhibit asymmetric forecast errors around trend is that the Greenbooks are completely uninformed about the future state of the economy, so they forecast a naive trend growth rate. However, I do not find this hypothesis to be credible.

By the law of total probability, the unconditional probability that Greenbooks overpredicted real GDP growth can be decomposed into equation (1).

$$\begin{aligned} Pr(Overprediction) \;=\; & Pr(Overprediction \mid AboveTrendGrowth) * Pr(AboveTrendGrowth) + \\ & Pr(Overprediction \mid BelowTrendGrowth) * Pr(BelowTrendGrowth) \end{aligned} \tag{1}$$

Assuming that Greenbooks had symmetric loss for unconditional overprediction (the outcome of equation (1)) then Greenbooks should have overpredicted fifty percent of the

[4]The fact that real GDP growth rates are skewed to the left does not affect my findings because I am counting whether forecasts are either above or below trend and ignoring the magnitude of the forecast error.

time. However, as shown in Figure 3, past "nowcasts" of the current quarter Greenbooks overpredicted more often than they underpredicted real GDP growth. Furthermore, if Greenbooks were also completely uninformed in addition to having symmetric loss for unconditional overprediction, then a reasonable forecasting strategy to ensure that the probability of overprediction is fifty percent would have been to forecast trend growth, as the probability of above trend growth is approximately equal to the probability of below trend growth of fifty percent.[5] But this strategy would imply that $Pr(Overprediction \mid AboveTrendGrowth)$ would be close to zero and that $Pr(Overprediction \mid BelowTrendGrowth)$ would be close to one, which is not what the data in Figures 1 and 2 show. Therefore, complete uninformativeness cannot explain my findings.

4.2 Asymmetric GDP Source Data Quality

A second hypothesis that could explain the Greenbook's asymmetric forecast errors around trend is that the real-time data that the staff used to forecast real GDP growth were of different quality when the economy was above trend vs. when it was below trend. For example, suppose that when the economy was below trend that the data the staff used to forecast real GDP growth were of poorer quality relative to the quality of the data when the economy was above trend. If this data quality story was the case then, relatively speaking, the staff had a poor signal about what the economy was doing when the economy was growing below trend, so the natural response would have been to produce a more naive forecast that was closer to, though still below, trend. However, I also do not find this hypothesis to be credible.

Although real-time data quality are unobservable, one way to infer real-time data quality is to look at BEA revisions to real GDP growth. The argument for studying revisions is that the BEA both receives and incorporates new source data into its GDP estimate well

[5]The probabilities of above trend growth and below trend growth are approximately equal regardless of using either a 5 year or 10 year moving average as trend, and also are approximately equal across data vintages.

after it publishes its first-release estimate of real GDP growth in the month after the quarter closes. BEA revisions to GDP occur years after the BEA publishes its first-release estimate (Landefeld, Seskin, and Fraumeni, 2008; Chang and Li, Forthcoming-b). If the source data that the BEA receives after it publishes its first-release estimate of real GDP growth improve on its earlier source data, and if this improvement in source data is different for when the economy is above vs. below trend, then we should expect revisions to GDP growth that are different depending on whether the economy was above or below trend.

To check for different revisions, I compute revisions between the BEA first-release and October 2017 estimates for both when the first-release estimates were above and below trend. The average magnitude of these revisions are approximately the same for when the economy was above vs. below trend, which casts doubt on the asymmetric GDP source data quality hypothesis.[6]

4.3 Asymmetric Loss

A third hypothesis for explaining the Greenbook's asymmetric forecast errors is that Greenbooks have an asymmetric loss function. I cannot test this hypothesis directly, but my negative results for uninformed forecasts in section 4.1 and for asymmetric GDP source data quality in section 4.2 leave asymmetric loss open as a possibility for explaining my findings.

5 Conclusion

I document two findings about Greenbook forecasts.

First, I find evidence that the probability that Greenbooks overpredict quarterly real GDP growth depends on whether the forecasted quarter grew either above or below trend. The probability of overprediction conditional on a quarter growing below trend is higher than the same probability conditional on the quarter growing above trend. This difference is

[6] I also compute the difference between second- or third-release estimates and the October 2017 estimates, which gives similar results.

statistically significant and could suggest that Greenbooks have an asymmetric loss function.

Second, I find different forecast-horizon dependence of mistakes in Greenbook forecasts of real GDP growth depending on whether the economy was above or below trend. Over forecast horizons, the Greenbook probability of overpredicting real GDP growth conditional on the economy that was below trend increases with the forecast horizon, but for an economy that was above trend this probability of overprediction is about flat.

A caveat to my results is that I treat the Greenbook forecasts as unconditional, as does most of the literature. However, Greenbook forecasts are conditioned on assumed monetary policy. Treating the forecasts as unconditional gives valid results when either the difference between the assumed policy and the Greenbook staff's unconditional expectation for policy are close or the feedback from economic variables to policy is minimal (Faust and Wright, 2008).

Figure 1: The Probability that Greenbooks Overpredicted Real GDP Growth Given the Forecasted Quarter Grew Below Trend

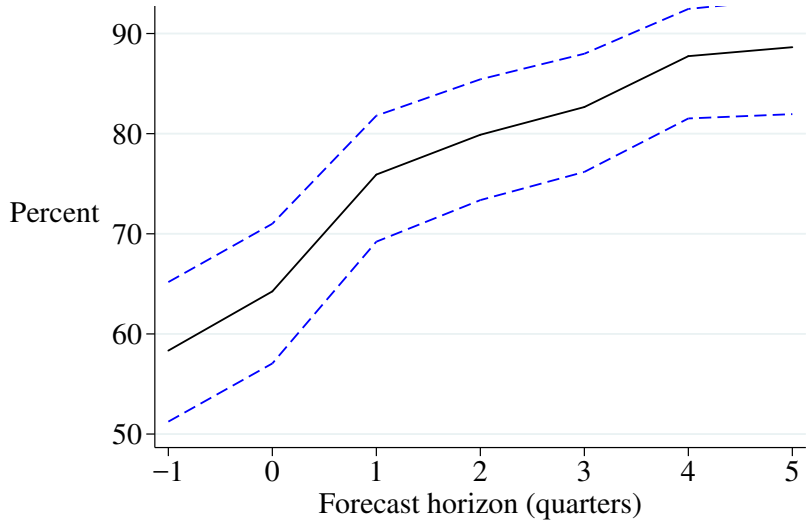
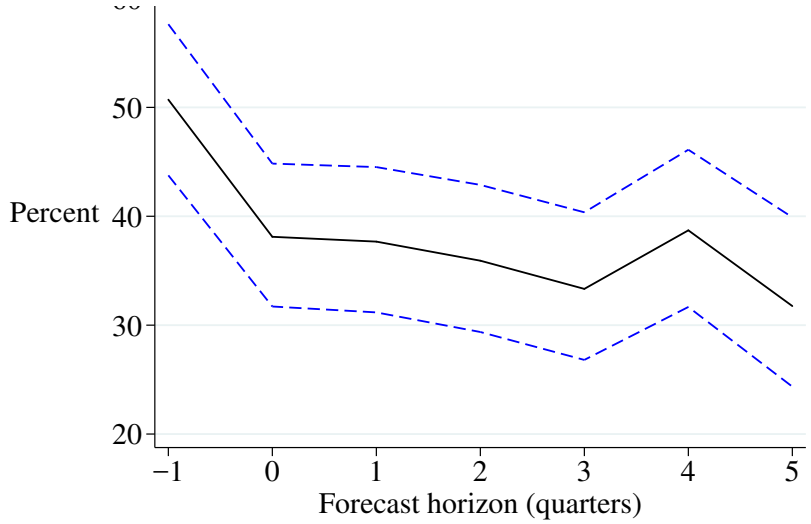
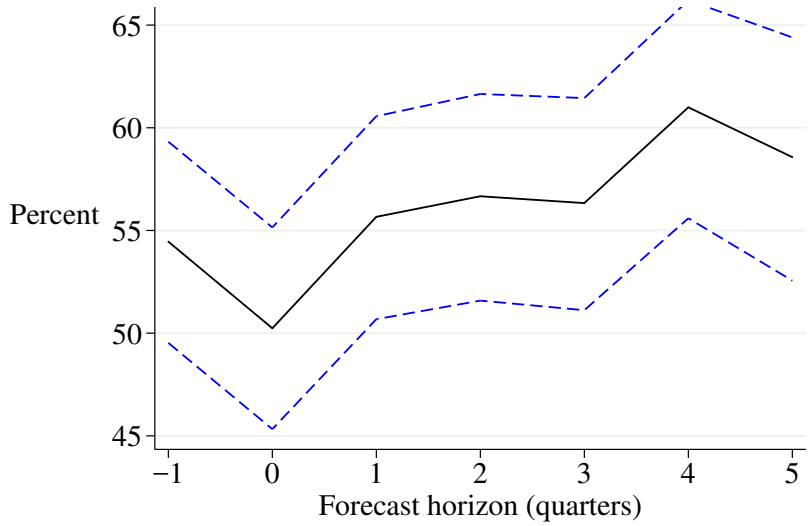


Figure 2: The Probability that Greenbooks Overpredicted Real GDP Growth Given the Forecasted Quarter Grew Above Trend



Description: The horizontal axis is the forecast horizon in quarters, where $t = 0$ indicates a "nowcast" of the current quarter. Actual real GDP growth is the BEA first-release. Figure 1 shows the probability that Greenbooks overpredicted real GDP growth given that the forecasted quarter grew below trend. Figure 2 shows the probability that Greenbooks overpredicted real GDP growth given that the forecasted quarter grew above trend. Trend is a five-year moving average of quarterly real GDP growth rates. Dashed blue lines are Clopper and Pearson (1934) 95% confidence intervals.
Interpretation: Greenbooks overpredicted real GDP growth more frequently when the forecasted quarter grew below trend than when the forecasted quarter grew above trend, suggesting Greenbooks may have an asymmetric loss function.

Figure 3: The Unconditional Probability that Greenbooks Overpredicted Real GDP Growth



Description: The horizontal axis is the forecast horizon in quarters, where $t = 0$ indicates a "nowcast" of the current quarter. Actual real GDP growth is the BEA first-release. Dashed blue lines are Clopper and Pearson (1934) 95% confidence intervals.
Interpretation: On average, Greenbooks overpredicted real GDP growth for forecasts past the current quarter.

References

Arai, Natsuki, "Using Forecast Evaluation to Improve the Accuracy of the Greenbook Forecast," International Journal of Forecasting 30:1 (2014), 12-19.

Chang, Andrew C., and Tyler J. Hanson, "The Accuracy of Forecasts Prepared for the Federal Open Market Committee," Journal of Economics and Business 83 (2016), 23-43. http://dx.doi.org/10.1016/j.jeconbus.2015.12.001.

Chang, Andrew C., and Phillip Li. "A Preanalysis Plan to Replicate Sixty Economics Papers that Worked Half of the Time," American Economic Review 107:5 (2017), 60-64.

Chang, Andrew C., and Phillip Li. "Is Economics Research Replicable? Sixty Published Papers from Thirteen Journals Say "Often Not"," Critical Finance Review (Forthcoming-a).

Chang, Andrew C., and Phillip Li. "Measurement Error in Macroeconomic Data and Economics Research: Data Revisions, Gross Domestic Product, and Gross Domestic Income," Economic Inquiry (Forthcoming-b).

Clopper, Charles J., and Egon S. Pearson, "The Use of Confidence or Fiducial Limits Illustrated in the Case of the Binomial," Biometrika 26:4 (1934), 404-413.

Croushore, Dean, and Tom Stark, "A Real-Time Data Set for Macroeconomists," Federal Reserve Bank of Philadelphia Working Paper 99-4 (1999).

Ericsson, Neil R., Steadman B. Hood, Fred Joutz, Tara M. Sinclair, and Herman O. Stekler, "Time-dependent Bias in the Fed's Greenbook Forecasts," JSM Proceedings, Business and Economics Statistics Section, Alexandria, Virginia, 1568-1582.

Faust, Jon, and Jonathan H. Wright, "Efficient Forecast Tests for Conditional Policy Forecasts," Journal of Econometrics 146 (2008), 293-303.

Faust, Jon, and Jonathan H. Wright, "Comparing Greenbook and Reduced Form Forecasts Using a Large Realtime Dataset," Journal of Business & Economic Statistics 27:4 (2009), 468-479. http://dx.doi.org/10.1198/jbes.2009.07214

Kahneman, Daniel, and Amos Tversky, "Intuitive Prediction: Biases and Corrective Procedures," Management Science 12 (1979), 313-327.

Landefeld, J. Steven, Eugene P. Seskin, and Barbara M. Fraumeni, "Taking the Pulse of the Economy: Measuring GDP," Journal of Economic Perspectives 22:2 (2008), 193-216.