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Time varying biases and the state of the economy

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ABSTRACT

This paper aims to investigate whether a forecast is optimal, given the information available when it is made. Going beyond the papers that study forecast errors based on the model of Nordhaus (1987), we use a time-varying procedure to forecast revisions and to account for the possibility that the duration of the state may also affect the bias. Three testable hypotheses are presented to help researchers test the optimality of forecasts, with the ultimate aim of determining whether these biases depend on the underlying economic state and whether they are persistent for the duration of the state. Corresponding bias-corrected forecasts can then be made based on these results. The empirical study finds that the one-quarter-ahead official forecast of GDP growth in Taiwan does indeed suffer from state-dependent biases: a persistent under-estimation bias in the relatively good state, and an under-reaction bias that decays with duration in the relatively bad one. Eliminating these biases in the forecast can remove over 44.0% of the variation in forecast errors, and pseudo out-of-sample experiments further support the fact that the resulting bias-corrected forecasts are markedly better than those made by Taiwan's government or using other competing models.

1. Introduction

Given the available information, conventional theory suggests that the optimal forecast, in the sense of minimized expected mean squared forecast errors (MSFE), must be the "rational expectation" of the target variable. The optimal forecast is unbiased because the induced forecast error has a zero mean, and efficient because the error is unpredictable and orthogonal to the components of the given information set when the forecast is made.

There are two conventional types of regression models proposed in the literature for investigating whether a forecast is optimal. One focuses on the relationship between realized and forecasted values directly (e.g., Mincer & Zarnowitz, 1969), while the other turns to the properties of the forecast errors (e.g., Holden & Peel, 1990 and Nordhaus, 1987). Note that the parameters of these two types of models are assumed (implicitly) to be constant over time, and thus the implied bias (non-zero mean of the forecast error) of a forecast is time-invariant; see e.g. Artis and Marcellino (2001), Gavin and Mandal (2003), Holden and Peel (1990), Loungani (2001), Mincer and Zarnowitz (1969), and Nordhaus (1987).

However, many studies analyzing survey data have shown that the forecast performance can be correlated strongly with the underlying economic conditions; see for example Chauvet and Guo (2003), Döpke (2001), Fildes and Stekler (2002), Grunberg and Modigliani (1954), Messina, Sinclair, and Stekler (2015), Sinclair, Joutz, and Stekler

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(2010), Sinclair, Stekler, and Carnow (2015), and Swanson and van Dijk (2006). This empirical evidence reveals that the bias of a forecast could be time-varying, and may depend on the underlying economic state and its duration.

To explain the possible time-varying bias of a forecast, Messina et al. (2015) and Sinclair et al. (2010, 2015) modify the models of Holden and Peel (1990), Mincer and Zarnowitz (1969), and Nordhaus (1987) by introducing a state variable whose values are identified for the corresponding target periods *ex post*. In essence, they aim to investigate whether the forecasts incorporate the knowledge of the "future state" of the economy that was available at the time when the forecast was made. Therefore, their models cannot be used to infer whether the forecast is actually optimal. Moreover, they neglect the possibility that the duration of the state may also help to explain the forecast error.

Going beyond the studies mentioned above, this paper proposes a new framework for investigating whether the forecast is optimal by extending the regression model of Nordhaus (1987). Since the proposed model accounts for the possibility that the underlying economic state and its duration may also affect the bias, we demonstrate how these time-varying biases of a forecast can be detected given the information set available at the time when the forecast is made. The innovative features of the proposed model, which cannot be found in previous works considering a series of published forecasts, are that it can help researchers to (1) test the conventional rationality of a forecast; (2) ascertain whether the existing biases depend on the underlying state of the economy when the forecast was made; (3) determine whether these biases remain persistent even when the duration of that economic state lengthens; and (4) construct a feasible bias-corrected forecast with a lower MSFE once the forecast has been published (which is useful for the real-time analysis in particular).

The framework proposed here is used to analyze the real GDP growth (one-quarter-ahead) forecast from the Taiwan government. The analysis is based on 105 real-time data vintages in Taiwan, and shows that this forecast suffers from time-varying biases that depend on the underlying economic state and its duration. Specifically, the Taiwan government tends to under-estimate GDP growth in relatively good states, and this bias is persistent. On the other hand, in relatively bad economic states, the government under-reacts to the received news; however, this bias disappears as the time in the state lengthens. Moreover, neither the official forecast nor other forecasts made using competing models substantially outperform the proposed bias-corrected forecast in pseudo out-of-sample experiments with Taiwan's GDP growth forecasts.

The rest of this paper is organized as follows. Section 2 introduces the methodology. Section 3 presents a relevant empirical study of forecast in Taiwan, and Section 4 draws conclusions.

2. Methodology

2.1. Optimal forecast and testable models

Let y_t be the realized GDP growth rate at time t, and $y^f_{t|t-h}$ be its h-step-ahead forecast published at time $t-h$ for $h > 0$. Accordingly, define the (one-step-ahead) forecast error as $e_t \equiv y^f_{t|t-1} - y_t$, where $e_t > 0$ indicates an over-prediction and $e_t < 0$ indicates an under-prediction.

Let Ω_t denote the information set available at time t; then, conventional forecasting theory claims that the optimal one-step-ahead forecast should be $\mathbb{E}[y_t|\Omega_{t-1}]$, the conditional expectation of y_t given the information set at time $t-1$, while minimizing the expected MSFE (see Patton & Timmermann, 2012, for example). It immediately follows that, if $y^f_{t|t-1}$ is optimal, the resulting forecast error e_t should satisfy the moment condition as

$$\mathbb{E}[e_t|\Omega_{t-1}] = 0, \tag{1}$$

which also implies that e_t should have zero mean (meaning that $y^f_{t|t-1}$ is unbiased) and be orthogonal to the variables in Ω_{t-1} (meaning that $y^f_{t|t-1}$ is efficient).

Holden and Peel (1990) propose the following simple regression to test for the unbiasedness of a forecast:

$$e_t = \mu + u_t, \tag{2}$$

where u_t is the zero-mean unpredictable disturbance at time $t-1$. Given this model, $\mu = 0$ implies that the forecast is unbiased, while a non-zero μ implies a biased forecast.[1] On the other hand, in an attempt to introduce some of the variables available in Ω_{t-1} into a test for the unbiasedness and efficiency of $y^f_{t|t-1}$, Nordhaus (1987) considers the model for the forecast error as

$$e_t = \alpha + \beta \cdot FR_{t-1} + u_t, \tag{3}$$

where the variable $FR_{t-1} \equiv y^f_{t|t-1} - y^f_{t|t-2}$ is known as the forecast revision, and measures the forecaster's adjustment of the forecast in response to the new information received between times $t-2$ and $t-1$.[2] The intercept α indicates the possibly systematic estimation error of the forecasts, and the slope β measures how all of the new information is incorporated into the forecast made at time $t-1$; thus, $\beta > 0$ ($\beta < 0$) reflects the forecaster's over-reaction (under-reaction) to the information received.[3] Thus, throughout this paper, we interpret positive values of α as an over-estimation bias and negative ones as an under-estimation bias, while a positive (negative) β indicates an over-reaction (under-reaction) bias. If the forecast is optimal, then the null that $\alpha = \beta = 0$ should not be rejected significantly by the observed data. In addition, from a model selection perspective, if the estimate of β is significantly non-zero, the model of Holden and Peel (1990) in Eq. (2) may not be appropriate for modeling e_t, since the variable FR_{t-1} can help to explain e_t statistically.

[1] Note, however, that an unbiased forecast does not necessarily imply that the forecast is efficient if the residual of the regression in Eq. (2) is serially correlated; see Gavin and Mandal (2003) and Joutz and Stekler (2000).

[2] For example, a positive revision occurs when the forecaster receives some good news about the economy. If the forecaster expects the news to have a larger impact on the economy, then there will be a larger revision to the forecast.

[3] In the literature, the intercept $\alpha > 0$ ($\alpha < 0$) can be interpreted as the behavioral bias of optimism (pessimism), while $\beta > 0$ ($\beta < 0$) captures the behavioral bias of over-reaction (under-reaction) to new information; see e.g. Amir and Ganzach (1998), Ashiya (2003), and Ehrbeck and Waldmann (1996). In particular, Ehrbeck and Waldmann (1996) establish a structural model, and Amir and Ganzach (1998) propose a theory to support these existing behavioral biases.