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Interfaces with Other Disciplines

Analytical debiasing of corporate cash flow forecasts

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ABSTRACT

We propose and empirically test statistical approaches to debiasing judgmental corporate cash flow forecasts. Accuracy of cash flow forecasts plays a pivotal role in corporate planning as liquidity and foreign exchange risk management are based on such forecasts. Surprisingly, to our knowledge there is no previous empirical work on the identification, statistical correction, and interpretation of prediction biases in large enterprise financial forecast data in general, and cash flow forecasting in particular. Employing a unique set of empirical forecasts delivered by 34 legal entities of a multinational corporation over a multi-year period, we compare different forecast correction techniques such as Theil's method and approaches employing robust regression, both with various discount factors. Our findings indicate that rectifiable mean as well as regression biases exist for all business divisions of the company and that statistical correction increases forecast accuracy significantly. We show that the parameters estimated by the models for different business divisions can also be related to the characteristics of the business environment and provide valuable insights for corporate financial controllers to better understand, quantify, and feedback the biases to the forecasters aiming to systematically improve predictive accuracy over time.

1. Introduction

Cash flow forecasts play a pivotal role in corporate financial management tasks. For instance, the forecasts are used in liquidity management to ensure solvency and in foreign-exchange risk management to identify and hedge exposures resulting from foreign business activities. Inaccurate forecasts are an unreliable basis for corporation-wide financial plans and can lead to liquidity shortages, uncovered currency risks or increased hedging costs. In large multinational companies, cash flow forecasts are prepared for individual subsidiaries from different countries and distinct business divisions. The cash flows are predicted by local financial managers who report the forecasts to the corporation's central finance department, where corporation-wide financial plans are derived from all delivered forecasts.

Since the cash flow forecasts are typically generated by human experts with different backgrounds, attitudes and individual forecasting procedures, the forecasts are likely to be biased by behavioral or political dimensions, overall leading to reduced forecast accuracy. Biased judgmental forecasting and decision-making are phenomena observed in many contexts. In numerous studies and laboratory experiments significant biases are found regularly in various forecasts, decreasing the accuracy and negatively influencing business performance (Leitner & Leopold-Wildburger, 2011). For instance, in a study by Lawrence, O'Connor, and Edmundson (2000), errors in sales forecasts of three manufacturing-based companies were attributed mainly to inefficiencies and biases. In another study, Enns (2002) analyzed the influence of biased and uncertain demand forecasts on production scheduling and found that biases significantly influence lateness of the delivery to the customer.

There are several empirical studies providing further strong evidence for the existence of cognitive biases in expert forecasting, such as the well-known anchoring and adjustment. Hogarth and Makridakis (1981) and Lawrence, Goodwin, O'Connor, and Oenkal (2006) provide extensive overviews of judgmental forecasting and its heuristics and biases. Although the effect can be mitigated and reduced with adequate decision support systems (George, Duffy, & Ahuja, 2000; Remus & Kottemann, 1995), it is regularly observed that information provided by decision support systems is undervalued and biases can therefore only be partly removed (Bhandari, Hassanein & Deaves, 2008; Lim & O'Connor, 1996). Overall, it is likely that corporate cash flow forecasts in multinational companies are also biased and that these biases influence decision models.

For instance, Gormley and Meade (2007) consider the problem of corporate-wide cash balance management using short-term cash flow forecasts. Based on data from a large international company, the authors show that transactional costs strongly depend on the accuracy of the cash flow forecasts used as input for financial planning.

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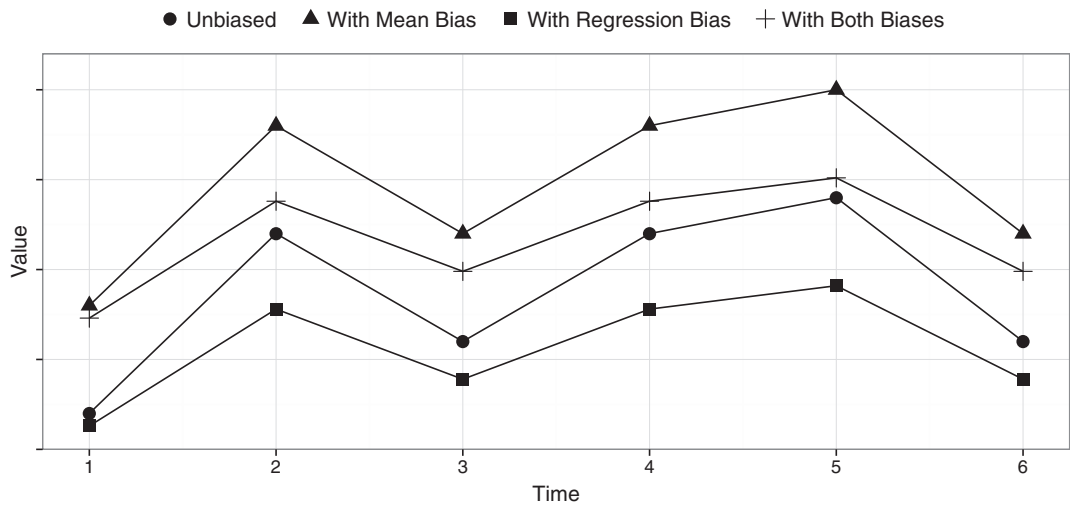

Fig. 1. Examples of biases covered by Theil's method (without a random error component). The *unbiased*-line indicates a forecast exactly predicting the actual values at each point in time. The *with mean bias* curve shows forecasts exhibiting the same pattern as the actuals, but at a higher level, where the vertical distance corresponds to the mean bias. The *with regression bias* line slightly underestimates small values and strongly underestimates higher values, while the *with both biases* line shows both types of biases. When removing the mean bias in *with both biases*, the curve would match the *with regression bias* curve which can be corrected by removing the regression bias.

Unfortunately, while in general there is awareness of the importance of accurate financial forecasts for corporate planning and control (Graham & Harvey, 2001; Kim, Mauer, & Sherman, 1998), there is practically no research available that empirically analyzes corporate cash flow forecasts. This is particularly true regarding the identification, interpretation, and finally mitigation of judgmental biases in forecasts. Hence, corporate financial controllers have little guidance on how to assess and improve the quality of their heterogeneous cash flow forecasts. In our context, identification and removal of biases before the forecasts are used in corporation-wide planning activities could lead to increased financial efficacy.

In this paper we conduct an empirical analysis of statistical approaches to debiasing cash flow forecasts using a unique set of corporate cash flow forecasts with different horizons. The data are provided by a large international corporation and generated by experts from 34 legal entities in various countries over a period of six years and for several currencies. We analyze and discuss the impact of statistical correction methods for different estimation techniques and parameters.

To our knowledge, this is the first work to decompose, quantify, and correct cash flow forecast biases in corporate settings. More generally, we are not aware of *any empirical work* analyzing biases in large sets of heterogeneous enterprise financial forecast data. More important, we are not aware of scientific publications that analyze the parameters learned by correction models, although these might provide valuable insights.

Our research makes several contributions to the literature. First, we find that different types of biases exist in the empirical cash flow forecast data of our sample company. Second, we find that substantial improvements of forecast accuracy can be achieved by debiasing forecasts using statistical techniques. Third, we analyze and compare the parameters learned by the correction models and find significant differences between the respective parameters learned in different business environments. We show that the learned parameters can be related to the characteristics of the business the forecast has been generated in and argue that the parameters provide valuable insights for corporate financial controllers to better understand, quantify, feedback, and systematically mitigate biases over time.

2. Forecast debiasing methods

Many studies report successful debiasing of expert forecasts with statistical correction techniques. The most common approach is Theil's method (Theil, 1966), which is based on a decomposition of the mean squared error (MSE). For a time series of length T with actuals $A_1, \ldots, A_T$ and corresponding forecasts $F_1, \ldots, F_T$, the metric is defined as $\text{MSE} = \frac{1}{T}\sum(A_t - F_t)^2$.

With means $\bar{F}, \bar{A}$ and standard deviations s_F, s_A of the forecasts and actuals, and r as the correlation between forecasts and actuals, the MSE can be decomposed to

$$\text{MSE} = (\bar{A} - \bar{F})^2 + (s_F - r s_A)^2 + (1 - r^2)s_A^2$$

The three terms of this decomposition are commonly called mean bias, regression bias and random (unsystematic) error. The mean bias corresponds to a systematic under- or overestimation of the actual value. The regression bias covers a component of the forecasts which is (linearly) correlated to the actuals but nevertheless does not scale perfectly with actual values. For instance, a regression bias exists if small values are slightly and high values are substantially underestimated (or overestimated). The unsystematic part of the error results from an uncorrelated component which cannot be corrected using linear techniques. Both biases are illustrated in Fig. 1 where variations of a short time series with different combinations of biases are depicted.

The parameters for the debiasing of forecasts can be estimated by regressing the actuals on the forecasts: $A_t = \alpha + \beta F_t + \epsilon_t$ with residuals ϵ_t. α and β are estimated as a and b; the debiased forecast can then be calculated as $C_t = a + bF_t$. In the literature, different approaches to estimating a and b for forecast correction have been proposed and evaluated.

In Theil's method (Theil, 1966), ordinary least squares (OLS) estimation is used by solving:

$$\min \sum (A_t - C_t)^2 = \min \sum [A_t - (a + bF_t)]^2$$

Theil's method has been evaluated in numerous studies and for various applications. In an early study Moriarty (1985) corrected one single sales time series spanning six years. The author found mean biases in four of the six years and additional significant regression biases. Correction of biases led to a significant reduction of the mean squared error for two of the years. In contrast to the years for which the correction was advantageous, the other two years primarily exhibited a much lower mean bias. In a broader study, Elgers, Lo, and Murray (1995) corrected 6302 yearly earnings forecasts generated by analysts. The mean squared error of the forecasts could be reduced significantly. In an exploratory study, Shaffer (1998) analyzed 33 one-quarter-ahead forecasts of a macro-economical indicator generated