International Journal of Forecasting 34 (2018) 163–180

Contents lists available at ScienceDirect

International Journal of Forecasting

journal homepage: www.elsevier.com/locate/ijforecast

# Forecasting from time series subject to sporadic perturbations: Effectiveness of different types of forecasting support

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ARTICLE INFO

*Keywords:*
Forecasting support
Judgmental adjustment
Time series
Promotions
Sales

ABSTRACT

How effective are different approaches for the provision of forecasting support? Forecasts may be either unaided or made with the help of statistical forecasts. In practice, the latter are often crude forecasts that do not take sporadic perturbations into account. Most research considers forecasts based on series that have been cleansed of perturbation effects. This paper considers an experiment in which people made forecasts from time series that were disturbed by promotions. In all conditions, under-forecasting occurred during promotional periods and over-forecasting during normal ones. The relative sizes of these effects depended on the proportions of periods in the data series that contained promotions. The statistical forecasts improved the forecasting accuracy, not because they reduced these biases, but because they decreased the random error (scatter). The performance improvement did not depend on whether the forecasts were based on cleansed series. Thus, the effort invested in producing cleansed time series from which to forecast may not be warranted: companies may benefit from giving their forecasters even crude statistical forecasts. In a second experiment, forecasters received optimal statistical forecasts that took the effects of promotions into account fully. This increased the accuracy because the biases were almost eliminated and the random error was reduced by 20%. Thus, the additional effort required to produce forecasts that take promotional effects into account is worthwhile.


## 1. Introduction

Business forecasters use both unaided judgmental forecasting and forecasting aided by formal statistical forecasts (Sanders & Manrodt, 2003). The latter approach may become increasingly common as users become more familiar with the sorts of software that provide forecasting support. As a result, forecast support systems have great potential for improving forecast performances. However, there are various factors that prevent this potential from being realised fully. Forecasters tend to ignore the 'advice' provided by a formal forecast, or take it into account too little (Goodwin, Fildes, Lawrence, & Nikolopoulos, 2007; Lim & O'Connor, 1996; Önkal, Goodwin, Thomson, Gönul, & Pollock, 2009). That is, even when they do take it into account, they do not assign enough weight to it. Consequently, the improvement in accuracy that it produces is generally small, albeit somewhat greater when the series are complex and the formal forecasts are of a higher quality

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https://doi.org/10.1016/j.ijforecast.2017.09.007
0169-2070/

(Goodwin & Fildes, 1999; Goodwin, Fildes, Lawrence, & Stephens, 2011; Lim & O'Connor, 1995; Trapero, Pedregal, Fildes, & Kourentzes, 2013).

The picture is more complex in the case of series with sporadic perturbations, such as those associated with promotions. Goodwin and Fildes (1999) showed that, in this situation, statistical forecasts tend to be helpful in normal periods, but not in those that are subject to promotions. However, the statistical forecasts they used did not take the effects of promotions into account, but were based on the baseline time series cleansed of the effects of promotions. Recently, forecasting models that do allow for the effects of promotions have been developed (Huang, Fildes, & Soopramanien, 2014; Kourentzes & Petropoulos, 2016; Trapero et al., 2013). However, given that there is a considerable lag between the development of more sophisticated statistical models and their implementation by practitioners (Lawrence, 2000; Sanders & Manrodt, 2003), it is likely to be some time before they have any impact on business practice.

Even in the case of relatively simple models, there appears to be a gap between the formal forecasts used in experimental studies and those used in business practice. In experimental studies, formal forecasts are based on non-promotional periods only (e.g., Goodwin & Fildes, 1999); in other words, they are calculated from the baseline series cleansed of promotion effects. In non-experimental studies, on the other hand, formal forecasts do not take into account whether past periods contain promotions (Fildes, Goodwin, Lawrence, & Nikolopoulos, 2009; Trapero et al., 2013). Hence, if we are interested in considering the relevance of experimental results to business practice, we need to ask whether the potential advantage of using judgmentally adjusted statistical forecasts rather than unaided judgment depends on the type of statistical forecast used.

Goodwin and Fildes (1999) argued that the benefit of providing statistical forecasts should be greater when they are based on data that have been cleansed of promotional effects. Referring to the estimated level of sales when a promotion does not run as the *baseline* value, they point out that this is because the baseline values provided by that type of statistical forecast can be accepted without any adjustment when no promotions are planned. Moreover, the past differences between promotional and non-promotional periods can be used directly as a basis for assessing the size of the adjustment that is needed when promotions are planned.

In what follows, we address the following questions. First, does the use of a judgmentally-adjusted statistical forecast provide an advantage over the use of unaided judgment? Second, is any such advantage greater when statistical forecasts are based on past data that have been cleansed of promotional effects? Third, does any benefit that may be derived from the provision of statistical forecasts depend on features of either the data series (i.e., the ratio of promotional to non-promotional periods) or the periods to be forecast (i.e., whether a promotion is planned)? Finally, can people make good use of 'ideal' statistical forecasts that make allowance for the effects of promotions (cf., Huang et al., 2014; Kourentzes and Petropoulos, 2016; Trapero et al., 2013)? In other words, if their goal is to maximize the forecasting accuracy, do they adopt these forecasts without any adjustment?

## 2. Development of hypotheses

In their survey, Fildes and Goodwin (2007) found that 75% of respondents indicated that they used judgment when making forecasts, with 25% saying that they used unaided judgment and 50% saying that they used a combination of judgment and statistical forecasting (averaging, judgmental adjustment). Over recent years, the use of statistical software has become more pervasive in business settings, and therefore the proportion of forecasters using a combinatorial approach has increased: it had risen to 55% by 2014 (Fildes & Petropoulos, 2015).

Judgmental adjustment does not always improve statistical forecasts, as people tend to make *unnecessary* adjustments even when they have no additional information (Goodwin, 2000; Lawrence, Goodwin, O'Connor, & Önkal, 2006). This may be because they discern patterns in noise (Fildes et al., 2009), because they are too optimistic and place excess weight on positive signals (Bovi, 2009; Durand, 2003; Kotteman, Davis, & Remus, 1994), or because they want to feel ownership of their forecasts (Önkal & Gönul, 2005). They also tend to be overconfident in the accuracy of their forecasts (Arkes, 2001; Bovi, 2009; Lawrence et al., 2006), perhaps because a self-serving attribution bias causes them to overestimate the importance of their own judgment relative to that of the statistical forecast (Hilary & Hsu, 2011; Libby & Rennekamp, 2012).

All of these studies have focused on whether judgmentally-adjusted forecasts are better or worse than raw statistical forecasts. The underlying issue was whether forecasters should be allowed to make adjustments to statistical forecasts and, if they should, whether there is anything that can be done to ensure that their adjustments are beneficial (Goodwin et al., 2011). In contrast, our primary aim here is to investigate the value of providing a formal forecast in order to increase the forecasting accuracy. Thus, our main focus is on whether judgmentally-adjusted statistical forecasts are better or worse than unaided judgmental forecasts.[1] For us, the underlying aim is to quantify the benefit of providing forecasters with forecasting support (operationalized in this paper as the provision of a statistical forecast, including historic forecasts). Such support has been assumed to be beneficial (Alvarado-Valencia & Barrero, 2014) because it reduces the processing demands imposed on forecasters (Fildes & Goodwin, 2013). Furthermore, combining forecasts from more than one source outperforms the results of a single forecasting method (Armstrong, 2001), particularly when the two methods are independent and rely on different information. The complementary nature of judgment and statistical methods means that their combination should be especially beneficial (Blattberg & Hoch, 1990). Therefore:

[1] However, we will also report comparisons between judgmentally adjusted forecasts and raw statistical forecasts in Section 5.