

"WHY COMBINING WORKS?"

by

Spyros MAKRIDAKIS*

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* Research Professor of Decision Sciences and Information Systems, INSEAD, Boulevard de Constance, 77305, Fontainebleau, France.

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Spyros MAKRIDAKIS

Research Professor, INSEAD

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Abstract

The purpose of this paper is to explore the reasons why combining works, discuss the implications involved and propose guidelines for improving the field of forecasting by exploiting the reasons that contribute to the success of combining.

Keywords: Time Series Forecasting; Forecasting Accuracy; Combining

There is little doubt that combining improves forecasting accuracy. This empirical finding holds true in statistical forecasting, judgmental estimates and when averaging statistical and subjective predictions (Clemen, 1989). In addition, combining reduces the variance of post-sample forecasting errors considerably (Makridakis and Winkler, 1983). The empirical findings are at odds with statistical theory and point out the need for major changes in our basic thinking and approach to statistical modelling and forecasting. As Clemen (1989) concludes "using a combination of forecasts amounts to an admission that the forecaster is unable to build a properly specified model. Trying ever more elaborate combining models seems to add insult to injury as the more complicated combinations do not generally perform all that well."

FACTORS THAT CONTRIBUTE TO MAKING COMBINING WORK

There are several factors that deteriorate the accuracy of individual forecasting methods and increase the size of errors. Combining works because it averages such errors. The following factors are a partial list that contribute to the empirical fact that the accuracy of combining is higher than those of the individual methods being combined:

1. Measuring the wrong thing: In forecasting we often need to estimate demand however demand data is rarely, if ever, available. Thus, instead of measuring demand we measure such things as orders, production, shipments or billings. However it is obvious that such proxies of apparent demand introduce systematic biases in measuring the "real" demand and therefore decrease accuracy of forecasting.
2. Measurement Errors: No matter what we try to measure there are always errors of measurement (including clerical and data processing errors) the size of which can be substantial and systematic. This is particularly true for disaggregate items but can be also observed on aggregate ones (e.g., GNP - see Morgenstern, 1963) whose magnitude range from plus of minus 10% to 15%. Measurement errors also include accounting changes, the way the data is kept, changes in definitions, and what is to be included in the different factors being used. Even if the size of measurement errors is in the neighborhood of 10%-15% (which is a minimum that applies to highly aggregate macroeconomic variables) it makes little sense to worry about better methods which are going to improve forecasting accuracy 5% or 10%.
3. Unstable or changing patterns or relationships: Statistical models assume that patterns and relationships are constant. However, this is rarely the case in the real world where special events and actions, fashions, cycles and so forth bring systematic changes and therefore introduce non-random errors in forecasting.

4. Models that minimize past errors: Available forecasting methods select the best model by a process that depends on how well a model minimizes one-step-ahead forecasting errors when tested against available data. However, such models are not necessarily **unbiased** in predicting future values (in particular when there are changes in patterns or relationship) and in forecasting more than one-step-ahead horizons.

CAN COMBINING BE IMPROVED?

Empirical evidence indicates that simple combining schemes (i.e., using a simple arithmetic average to combine several/many methods) are as accurate as elaborate ones. The following three factors have been found by this author to improve the accuracy of combining while maintaining the idea of using simple combining procedures:

1. Use sensible methods: Various forecasting methods can be checked empirically concerning their individual ability to accurately forecast. Alternatively, the findings of major empirical studies can be used to exclude methods which are consistently worse than others. Once empirical evidence has indicated a number of models which provide the most accurate results, combining can subsequently be restricted to these set methods only, thus excluding some which are clearly inferior (e.g., quadratic exponential smoothing for longer forecasting horizons).

2. Use complementary methods: Some methods are conservative in forecasting (for example, single exponential smoothing) while some others are over-reactive and/or extrapolate past trend in a way that assumes that such trends will continue uninterrupted during the future. By selecting methods which can cover a wide range of possibilities the user can combine methods which cover a wide range of outcomes and which when averaged can also average the forecasting errors of the methods being combined.

3. Use combining to elicit judgemental inputs: Instead of making judgemental estimates of future values this author has found it useful to ask decision makers to indicate the direction of future changes in trends. If the

subjective judgment of those involved is that the trend is going to slow down or become flat, then more weight can be given to a method like single exponential smoothing. Alternatively if decision makers feel that established trends will continue, then more weight can be given to linear smoothing. If the users are not certain the dampen trend model can be weighted more heavily. Thus, by the appropriate selection of forecasting methods to include in the combining (in particular if they are complementary) and by deciding on the appropriate weight of each (or alternatively which methods to combine) a way can be found to elicit the judgment and knowledge of decision makers while still harnessing the advantage of using objective and consistent approaches to forecasting.

COMBINING AND FORECASTING RESEARCH

In addition to more appropriate data geared towards forecasting applications the methods used to forecast must be also reconsidered. Methods that fit the past, extrapolate past patterns/relationships and are concerned with one-step-ahead forecasts are clearly not appropriate. Thus, a serious effort must develop towards new, creative alternatives that are not based on the fallacies of constancy of past patterns/relationships which has been the hidden but prevalent assumption of all statistical forecasting. Some initial attempts by this author (Makridakis 1990) to go beyond model fitting, and select methods based on their performance on more than one-step-ahead forecasts have produced encouraging results. Much more, however, must be done if forecasting is to become useful and relevant for actual, real-life applications.

The fact that the accuracy of combining outperforms the individual methods and/or subjective estimates being combined cannot be ignored and must be used to guide our search for improving forecasting accuracy. Effort must be concentrated on gathering the right data and minimizing measurement errors. Moreover, data must be adjusted to variations that are external to the generating process (e.g., a strike of some other highly unusual event).

CONCLUSIONS

Decision makers will benefit by accepting the empirical finding that combining improves accuracy and reduces the variance of forecasting errors. Similarly, forecasting researchers ought to test any new methods against a combination of existing ones. Unless their new method is proven to outperform the combination it should not be viewed favorably. Finally, forecasting experts must accept the limitations of available forecasting methods and those of the data being used and develop alternative approaches to forecasting which are more realistic and relevant to actual forecasting situations.

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