

Essay

Empirical Forecasting Methods: Beyond Extrapolation

J. Scott Armstrong*

Why Forecasting?

Beginning my career in 1960 as an industrial engineer at Eastman Kodak in Rochester, New York, it seemed apparent to me that forecasting errors were costly to the firm and that forecasting practices were deplorable. The forecasting literature, while useful, was at a primitive stage. In short, forecasting represented a great opportunity.

While working at Xerox in 1964, I developed their first forecasting system for inventory control. At Polaroid, I built a multinational forecasting system for Polaroid photographic products in 1966. This latter work provided the data for my Ph. D. thesis on forecasting at the Sloan School, MIT. It led to my long-term goal of improving forecasting methodology.

I hope to obtain findings that are useful to practitioners and researchers. An ideal study for me is one where managers or researchers believe method X is the best way to solve a problem, but method Y proves more effective. Forecasting provides this opportunity because it allows for different methods to be tested against actual outcomes.

My primary interest lies in comparative validation research. This has led me to findings that are sometimes contrary to prevailing wisdom. For example, in a paper that I published in the *Journal of Business* in 1978, I found that although well-known econometricians believed that econometric models produced more accurate short-term forecasts (than extrapolation or judgmental methods), they were unable to provide em-

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pirical support for their belief. In fact, the existing evidence did not support such a belief.

There are a number of reasons. One is arrogance. People deceive themselves That their judgment is more accurate than quantitative models. Second is laziness. Most managers do not keep up to date on the latest methods. Third is a belief in magic. They pay for consultants who provide smoke and mirrors. Finally there is convenience. This is the way we have always done it.

Finding Problems

I keep a list of possible problems that seem worth studying and discuss them with people. Some attract little interest. Others seem to capture people's imagination, so they are pursued. I am interested in problems that may have broad implications despite their lack of popularity. One such area involves predicting how parties will act in a situation involving conflict.

Occasionally, other people suggest interesting problems. For example, in the early 1970s, I was paid by an unnamed source to develop methods to forecast when leaders of foreign countries might encounter serious illness or death. Presumably this would affect their ability to negotiate with the U.S. Some years later, I found that I had worked for the CIA.

Forecasting does not have a home in universities. Its methods come from statistics, economics, cognitive psychology, and organizational behavior. Forecasting problems are found in finance, human relations, production, accounting, marketing, insurance, real estate, and so on. My own forecasting research has involved personnel selection, annual earnings, sales, store choice, retail site location, and outcomes of conflicts.

As a professor of marketing, much of my forecasting work involves marketing. To show the value of theory in consumer behavior, I examined whether academic researchers could use theories to predict the outcomes of research studies published in the *Journal of Consumer Research*. The results were disappointing - high school students made more accurate predictions than did the academicians. On the other hand, these results were interesting.

Much of my teaching involves advertising management. In 1994, I began a project to determine whether expert systems can produce better forecasts of the sales effect of advertisements. Initial indications are that the answer is yes. Information on this project can be found at <http://>

www-marketing.wharton.upenn.edu/~esap.

Finding Solutions

The ultimate aim of research is to produce useful findings. Forecasting research has produced many such findings and I have been involved with some of them.

The US Navy Personnel Research and Development Center offered to support my research at the time that I was working with a Ph.D. student, Fred Collopy. We began our research on Rule-based Forecasting (RBF), an expert system that integrates judgment and statistical extrapolation. Using RBF to select and combine extrapolation forecasts for annual time series, we achieved accuracy that was superior to the current leading strategy of using equally-weighted forecasts. The rules were published in *Management Science* in 1992 and a summary of the research to date is provided in “Rule-based Forecasting” in my book *Principles of Forecasting* (Kluwer 2001).

In our efforts to calibrate rules for RBF, we found that commonly used error measures posed problems in the development and testing of rule-based forecasting. As a result, we proposed error measures for comparing extrapolation methods. Our favored measure for comparing the accuracy of extrapolation methods is the Relative Absolute Error (RAE). For summarizing across series, we recommend the Median RAE. These findings were published in the *International Journal of Forecasting* in 1992.

In 1989, I was invited to lecture about forecasting methods to epidemiologists in Shanghai and Beijing, China. To prepare for this visit, Fred Collopy and I applied our methods to data on epidemics. We concluded that traditional extrapolation methods were not appropriate for this field. Instead, extrapolation methods should be tailored to the “causal forces.” Causal forces are used to structure an expert’s domain knowledge about the net direction of the forces acting on a time series. We proposed five categories (growth, decay, supporting, opposing, and regressing), and tested their use for the selection of extrapolation methods. We found that the assumptions commonly made for exponential smoothing are sometimes inappropriate.

Communication Problems

I am interested not only in doing research on forecasting, but also in communicating the findings. Why is it that people involved with fore-

casting research in a field such as economics are unaware of relevant research done in another field such as psychology? This lack of communication across fields is a major barrier to progress. Sometimes people in one field "discover" a method years after it has been discovered in another field. This happened, for example with studies of judgmental bootstrapping.¹

I am especially interested in research that challenges existing beliefs and procedures. Commonly used peer review procedures inhibit the publication of innovative findings, as I have shown in my review of published empirical research on journal peer review. (See my paper in *Science and Engineering Ethics* in 1997. Full-text of this paper is available at <http://hops.wharton.upenn.edu/forecast>). These research findings led us to develop reviewer and author guidelines to encourage the publication of controversial findings, first at the *Journal of Forecasting* and then at the *International Journal of Forecasting*.

Much has been learned about forecasting over the last half century. To summarize this knowledge, I have been working on an edited book that draws upon the talents of about 40 researchers from various disciplines. This book, *Principles of Forecasting: A Handbook for Researchers and Practitioners*, is designed to provide a comprehensive summary of knowledge and to present it so that the findings can be used by practitioners. In addition, the book might guide further research. Information about this project is available at <http://hops.wharton.upenn.edu/forecast>. Publication by Kluwer Academic Publishers is expected in 2001.

The Future

What is the future for forecasting methods? Perhaps the most fruitful area involves developing methods to more effectively integrate judgment and statistical methods. This includes combining forecasts, rule-based forecasting, judgmental bootstrapping, econometric methods, and expert systems.

Given that many researchers of forecasting methods are committed to empirical testing of competing hypotheses, I have high expectations about progress in forecasting. The recent movement toward reporting conditions should help in developing generalizations from the research.

The big challenge, it seems, is having the persistence to gain recognition for ideas and methods. For example, I believe that the work on causal forces represents one of my most important research contributions.

Although it is inexpensive to implement, it has yet to attract much attention.

In particular, I have been trying to gain acceptance for my research on role-playing. Role-playing can improve forecast accuracy in conflict situations. This could produce better negotiations and reduce the likelihood of such things as strikes, wars, and failed negotiations between companies. Surely these are important problems. For example, if the Argentine generals had role played the takeover of the Falkland Islands, would they have made a different decision? If Britain had role played the situation, would they have decided to sell the Falklands, as proposed some years before the invasion? In my studies, the percentage of correct predictions for five situations increased from 16% with unaided judgment to 56% for role playing. Nevertheless, I encountered much resistance in getting this research published. Eventually my studies were published in various places. Full text of the latest summary of this research is available in my book, *Principles of Forecasting*.

Although communication of findings is difficult, the future is promising. The Internet has reduced the cost of publishing. In effect, all papers submitted to journals can be published. At the same time, the Internet has improved the ability to find relevant papers. It is currently inexpensive to do on-line searches of journal publications using SSCI and OVID, and to access full-text papers. Furthermore, the capability now exists to provide continuing peer review. This will help readers decide what to read and how much faith to place in the findings.

The communication problems will eventually be solved by software. When one has to make a forecast, the software will guide her through all the procedures. These procedures could use the latest research findings.

Notes

1. To address the communication issue, I set out to write a book that would integrate findings from various fields. This book, *Long-Range Forecasting*, (John Wiley: 1985, 2nd ed) became a major reference work in forecasting, and both editions (1978 and 1985) received favorable reviews. According to Cox (*International Journal of Forecasting*, 1987, Pp. 515-527), it became the most frequently cited book on forecasting methods.

INVITATION FOR AUTHORS

The *Journal of Futures Studies* (JFS) is published by the Educational Development Center, Tamkang University, Tamsui, Taipei, Taiwan. The editors invite contributors in the areas of foresight, forecasting, long-range planning, visioning and other related areas. Contributors should be based on the critical and/or empirical research in the field of Futures Studies. The journal attempts to attract contributors who can offer distinctive viewpoints on a broad range of future-oriented issues. Contributors also should comply with the following guidelines:

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