An Overview of Forecasting Methodology

http://www.statpac.org/research-library/forecasting.htm

Most people view the world as consisting of a large number of alternatives. Futures research evolved as a way of examining the alternative futures and identifying the most probable. Forecasting is designed to help decision making and planning in the present.

Forecasts empower people because their use implies that we can modify variables now to alter (or be prepared for) the future. A prediction is an invitation to introduce change into a system.

There are several assumptions about forecasting:

1. There is no way to state what the future will be with complete certainty. Regardless of the methods that we use there will always be an element of uncertainty until the forecast horizon has come to pass.

2. There will always be blind spots in forecasts. We cannot, for example, forecast completely new technologies for which there are no existing paradigms.

3. Providing forecasts to policy-makers will help them formulate social policy. The new social policy, in turn, will affect the future, thus changing the accuracy of the forecast.

Many scholars have proposed a variety of ways to categorize forecasting methodologies. The following classification is a modification of the schema developed by Gordon over two decades ago:

Trend extrapolation - These methods examine trends and cycles in historical data, and then use mathematical techniques to extrapolate to the future. The assumption of all these techniques is that the forces responsible for creating the past, will continue to operate in the future. This is often a valid assumption when forecasting short term horizons, but it falls short when creating medium and long term forecasts. The further out we attempt to forecast, the less certain we become of the forecast.

The stability of the environment is the key factor in determining whether trend extrapolation is an appropriate forecasting model. The concept of "*developmental inertia*" embodies the idea that some items are more easily changed than others. Clothing styles is an example of an area that contains little inertia. It is difficult to produce reliable mathematical forecasts for clothing. Energy consumption, on the other hand, contains substantial inertia and mathematical techniques work well. The developmental inertia of new industries or new technology cannot be determined because there is not yet a history of data to draw from.

There are many mathematical models for forecasting trends and cycles. Choosing an appropriate model for a particular forecasting application depends on the historical data. The **study of the historical data is called exploratory data analysis**. Its purpose is to identify the trends and cycles in the data so that appropriate model can be chosen.

The most common mathematical models involve various forms of *weighted smoothing* methods. Another type of model is known as *decomposition*. This technique mathematically separates the historical data into trend, seasonal and random components. A process known as a "turning point analysis" is used to produce forecasts. ***ARIMA*** models such as adaptive filtering and Box-Jenkins analysis constitute a third class of mathematical model, while ***simple linear regression and curve fitting*** **is a fourth.**

The common feature of these mathematical models is that historical data is the only criteria for producing a forecast. One might think then, that if two people use the same model on the same data that the forecasts will also be the same, but this is not necessarily the case. Mathematical models involve smoothing constants, coefficients and other parameters that must be decided by the forecaster. To a large degree, the choice of these parameters determines the forecast.

It is vogue today to diminish the value of mathematical extrapolation. Makridakis (one of the gurus of quantitative forecasting) correctly points out that judgmental forecasting is superior to mathematical models, however, there are many forecasting applications where computer generated forecasts are more feasible. For example, large manufacturing companies often forecast inventory levels for thousands of items each month. It would simply not be feasible to use judgmental forecasting in this kind of application.

Consensus methods - Forecasting complex systems often involves seeking expert opinions from more than one person. Each is an expert in his own discipline, and it is through the synthesis of these opinions that a final forecast is obtained.

One method of arriving at a consensus forecast would be to put all the experts in a room and let them "argue it out". This method falls short because the situation is often controlled by those individuals that have the best group interaction and persuasion skills.

A better method is known as the Delphi technique. This method seeks to rectify the problems of face-to-face confrontation in the group, so the responses and respondents remain anonymous. The classical technique proceeds in well-defined sequence. In the first round, the participants are asked to write their predictions. Their responses are collated and a copy is given to each of the participants. The participants are asked to comment on extreme views and to defend or modify their original opinion based on what the other participants have written. Again, the answers are collated and fed back to the participants. In the final round, participants are asked to reassess their original opinion in view of those presented by other participants.

The Delphi method general produces a rapid narrowing of opinions. It provides more accurate forecasts than group discussions. Furthermore, a face-to-face discussion following the application of the Delphi method generally degrades accuracy.

Simulation methods - Simulation methods involve using analogs to model complex systems. These analogs can take on several forms. A *mechanical analog* might be a wind tunnel for modeling aircraft performance. An equation to predict an economic measure would be a *mathematical analog*. A *metaphorical analog* could involve using the growth of a bacteria colony to describe human population growth. *Game analogs* are used where the interactions of the players are symbolic of social interactions.

Mathematical analogs are of particular importance to futures research. They have been extremely successful in many forecasting applications, especially in the physical sciences. In the social sciences however, their accuracy is somewhat diminished. The extraordinary complexity of social systems makes it difficult to include all the relevant factors in any model.

Clarke reminds us of a potential danger in our reliance on mathematical models. As he points out, these techniques often begin with an initial set of assumptions, and if these are incorrect, then the forecasts will reflect and amplify these errors.

One of the most common mathematical analogs in societal growth is the S-curve. The model is based on the concept of the logistic or normal probability distribution. All processes experience exponential growth and reach an upper asymptopic limit. Modis has hypothesized that chaos like states exist at the beginning and end of the S-curve. The disadvantage of this S-curve model is that it is difficult to know at any point in time where you currently are on the curve, or how close you are to the asymtopic limit. The advantage of the model is that it forces planners to take a long-term look at the future.

Another common mathematical analog involves the **use of multivariate statistical techniques**. These techniques are **used to model complex systems involving relationships between two or more variables**. Multiple regression analysis is the most common technique. Unlike trend extrapolation models, which only look at the history of the variable being forecast, **multiple regression models look at the relationship between the variable being forecast and two or more other variables.**

Multiple regression is the mathematical analog of a systems approach, and it has become the primary forecasting tool of economists and social scientists. **The object of multiple regression is to be able to understand how a group of variables (working in unison) affect another variable.**

The multiple regression problem of ***collinearity*** mirrors the practical problems of a systems approach. Paradoxically, **strong correlations between predictor variables create unstable forecasts**, **where a slight change in one variable can have dramatic impact on another variable**. In a multiple regression (and systems) approach, as the relationships between the components of the system increase, our ability to predict any given component decreases.

Cross-impact matrix method - Relationships often exist between events and developments that are not revealed by univariate forecasting techniques. The cross-impact matrix method recognizes that the occurrence of an event can, in turn, effect the likelihoods of other events. Probabilities are assigned to reflect the likelihood of an event in the presence and absence of other events. The resultant inter-correlational structure can be used to examine the relationships of the components to each other, and within the overall system. **The advantage of this technique is that it forces forecasters and policy-makers to look at the relationships between system components, rather than viewing any variable as working independently of the others.**

Scenario - The scenario is a narrative forecast that describes a potential course of events. Like the cross-impact matrix method, it recognizes the interrelationships of system components. The scenario describes the impact on the other components and the system as a whole. It is a "script" for defining the particulars of an uncertain future.

Scenarios consider events such as new technology, population shifts, and changing consumer preferences. Scenarios are written as long-term predictions of the future. A most likely scenario is usually written, along with at least one optimistic and one pessimistic scenario. The primary purpose of a scenario is to provoke thinking of decision makers who can then posture themselves for the fulfillment of the scenario(s). The three scenarios force decision makers to ask: 1) Can we survive the pessimistic scenario, 2) Are we happy with the most likely scenario, and 3) Are we ready to take advantage of the optimistic scenario?

Decision trees - Decision trees originally evolved as graphical devices to help illustrate the **structural relationships between alternative choices**. These trees were originally presented as a series of yes/no (dichotomous) choices. As our understanding of feedback loops improved, decision trees became more complex. Their structure became the foundation of computer flow charts.

Computer technology has made it possible create very complex decision trees consisting of many subsystems and feedback loops. Decisions are no longer limited to dichotomies; they now involve assigning probabilities to the likelihood of any particular path.

Decision theory is based on the concept that an *expected value* of a discrete variable can be calculated as the average value for that variable. The expected value is especially useful for decision makers because it represents the most likely value based on the probabilities of the distribution function. The application of Bayes' theorem enables the modification of initial probability estimates, so the decision tree becomes refined as new evidence is introduced.

Utility theory is often used in conjunction with decision theory to improve the decision making process. It recognizes that dollar amounts are not the only consideration in the decision process. Other factors, such as risk, are also considered.

Combining Forecasts

It seems clear that no forecasting technique is appropriate for all situations. There is substantial evidence to demonstrate that **combining individual forecasts produces gains in forecasting accuracy**. There is also evidence that adding quantitative forecasts to qualitative forecasts reduces accuracy. Research has not yet revealed the conditions or methods for the optimal combinations of forecasts.

Judgmental forecasting usually involves combining forecasts from more than one source. Informed forecasting begins with a set of key assumptions and then uses a combination of historical data and expert opinions. Involved forecasting seeks the opinions of all those directly affected by the forecast (e.g., the sales force would be included in the forecasting process). These techniques generally produce higher quality forecasts than can be attained from a single source.

Combining forecasts provides us with a way to compensate for deficiencies in a forecasting technique. By selecting complementary methods, the shortcomings of one technique can be offset by the advantages of another.