INTRODUCTION TO FORECASTING

This text is concerned with methods used to predict the uncertain nature of business trends in an effort to help managers make better decisions and plans. Such efforts often involve the study of historical data and the manipulation of these data in the search for patterns that can be effectively extrapolated to produce forecasts.

In this text, we regularly remind readers that sound judgment must be used along with numerical results if good forecasting is to result. The examples and the cases at the end of the chapter emphasize this point. There are more discussions of the role of judgment in this chapter.

THE HISTORY OF FORECASTING

In a book on the history of risk, author Peter Bernstein (1996) notes that the development of business forecasting in the seventeenth century was a major innovation. He writes:

> forecasting—long denigrated as a waste of time at best and a sin at worst—became an absolute necessity in the course of the seventeenth century for adventuresome entrepreneurs who were willing to take the risk of shaping the future according to their own design.

Over the next 300 years, significant advances in data-based forecasting methods occurred, with much of the development coming in the twentieth century. Regression analysis, decomposition, smoothing, and autoregressive moving average methods are examples of data-based forecasting procedures discussed in this text. These procedures have proved to be highly effective and routinely appear in the menus of readily available forecasting software.

Along with the development of data-based methods, the role of judgment and judgmental approaches to forecasting has grown significantly over the last 25 years. Without any data history, human judgment may be the only way to make predictions about the future. In cases where data are available, judgment should be used to review and perhaps modify the forecasts produced by quantitative procedures.

With the proliferation of powerful personal computers and the availability of sophisticated software packages, forecasts of future values for variables of interest are easily generated. However, this ease of computation does not replace clear thinking. Lack of managerial oversight and improper use of forecasting techniques can lead to costly decisions.

New forecasting procedures continue to be developed as the need for accurate forecasts accelerates.[1] Particular attention is being paid to the forecasting process in organizations with the need to coordinate objectives, methods, assessment, and interpretation.

IS FORECASTING NECESSARY?

In spite of the inherent inaccuracies in trying to predict the future, forecasts necessarily drive policy setting and planning. How can the Federal Reserve Board realistically adjust interest rates without some notion of future economic growth and inflationary pressures? How can an operations manager realistically set production schedules without some estimate of future sales? How can a company determine staffing for its call centers without some guess of the future demand for service? How can a bank make realistic plans without some forecast of future deposits and loan balances? Everyone requires forecasts. The need for forecasts cuts across all functional lines as well as all types of organizations. Forecasts are absolutely necessary to move forward in today's ever-changing and highly interactive business environment.

This text discusses various ways of generating forecasts that rely on logical methods of manipulating data that have been generated by historical events. But it is our belief that the most effective forecaster is able to formulate a skillful mix of quantitative forecasting and good judgment and to avoid the extremes of total reliance on either. At one extreme, we find the executive who, through ignorance and fear of quantitative techniques and computers, relies solely on intuition and feel. At the other extreme is the forecaster skilled in the latest sophisticated data manipulation techniques but unable or unwilling to relate the forecasting process to the needs of the organization and its decision makers. We view the quantitative forecasting techniques discussed in most of this text to be only the starting point in the effective forecasting of outcomes important to the organization: Analysis, judgment, common sense, and business experience must be brought to bear on the process through which these important techniques have generated their results.

Another passage from Bernstein (1996) effectively summarizes the role of forecasting in organizations.

> You do not plan to ship goods across the ocean, or to assemble merchandise for sale, or to borrow money without first trying to determine what the future may hold in store. Ensuring that the materials you order are delivered on time, seeing to it that the items you plan to sell are produced on schedule, and getting your sales facilities in place all must be planned before that moment when the customers show up and lay their money on the counter. The successful business executive is a forecaster first; purchasing, producing, marketing, pricing, and organizing all follow.

TYPES OF FORECASTS

When managers are faced with the need to make decisions in an atmosphere of uncertainty, what types of forecasts are available to them? Forecasting procedures might first be classified as long term or short term. Long-term forecasts are necessary to set

[1]A recent review of the current state of forecasting is available in a special issue of the *International Journal of Forecasting*, edited by R. J. Hyndman and J. K. Ord (2006).

the general course of an organization for the long run; thus, they become the particular focus of top management. Short-term forecasts are needed to design immediate strategies and are used by middle and first-line management to meet the needs of the immediate future.

Forecasts might also be classified in terms of their position on a micro–macro continuum, that is, in terms of the extent to which they involve small details versus large summary values. For example, a plant manager might be interested in forecasting the number of workers needed for the next several months (a micro forecast), whereas the federal government is forecasting the total number of people employed in the entire country (a macro forecast). Again, different levels of management in an organization tend to focus on different levels of the micro–macro continuum. Top management would be interested in forecasting the sales of the entire company, for example, whereas individual salespersons would be much more interested in forecasting their own sales volumes.

Forecasting procedures can also be classified according to whether they tend to be more quantitative or qualitative. At one extreme, a purely qualitative technique is one requiring no overt manipulation of data. Only the "judgment" of the forecaster is used. Even here, of course, the forecaster's "judgment" may actually be the result of the mental manipulation of historical data. At the other extreme, purely quantitative techniques need no input of judgment; they are mechanical procedures that produce quantitative results. Some quantitative procedures require a much more sophisticated manipulation of data than do others, of course. This text emphasizes the quantitative forecasting techniques because a broader understanding of these very useful procedures is needed in the effective management of modern organizations. However, we emphasize again that judgment and common sense must be used along with mechanical and data-manipulative procedures. Only in this way can intelligent forecasting take place.

Finally, forecasts might be classified according to the nature of the output. One must decide if the forecast will be a single number best guess (a *point forecast*), a range of numbers within which the future value is expected to fall (an *interval forecast*), or an entire probability distribution for the future value (a *density forecast*). Since unpredictable "shocks" will affect future values (the future is never exactly like the past), nonzero forecast errors will occur even from very good forecasts. Thus, there is some uncertainty associated with a particular point forecast. The uncertainty surrounding point forecasts suggests the usefulness of an interval forecast. However, if forecasts are solely the result of judgment, point forecasts are typically the only recourse. In judgmental situations, it is extremely difficult to accurately describe the uncertainty associated with the forecast.

MACROECONOMIC FORECASTING CONSIDERATIONS

We usually think of forecasting in terms of predicting important variables for an individual company or perhaps for one component of a company. Monthly company sales, unit sales for one of a company's stores, and absent hours per employee per month in a factory are examples.

By contrast, there is growing interest in forecasting important variables for the entire economy of a country. Much work has been done in evaluating methods for doing this kind of overall economic forecasting, called *macroeconomic forecasting*. Examples of interest to the federal government of the United States are the unemployment rate, gross domestic product, and prime interest rate. Economic policy is based, in part, on projections of important economic indicators such as these. For this reason,

there is great interest in improving forecasting methods that focus on overall measures of a country's economic performance.

One of the chief difficulties in developing accurate forecasts of overall economic activity is the unexpected and significant shift in a key economic factor. Significant changes in oil prices, inflation surges, and broad policy changes by a country's government are examples of shifts in a key factor that can affect the global economy.

The possibility of such significant shifts in the economic scene has raised a key question in macroeconomic forecasting: Should the forecasts generated by the forecasting model be modified using the forecaster's judgment? Current work on forecasting methodology often involves this question.

Theoretical and practical work on macroeconomic forecasting continues. Considering the importance of accurate economic forecasting to economic policy formulation in this country and others, increased attention to this kind of forecasting can be expected in the future. A good introductory reference for macroeconomic forecasting is Pindyck and Rubinfeld (1998).

CHOOSING A FORECASTING METHOD

The preceding discussion suggests several factors to be considered in choosing a forecasting method. The level of detail must be considered. Are forecasts of specific details needed (a micro forecast)? Or is the future status of some overall or summary factor needed (a macro forecast)? Is the forecast needed for some point in the near future (a short-term forecast) or for a point in the distant future (a long-term forecast)? To what extent are qualitative (judgment) and quantitative (data-manipulative) methods appropriate? And, finally, what form should the forecast take (point, interval, or density forecast)?

The overriding consideration in choosing a forecasting method is that the results must facilitate the decision-making process of the organization's managers. Rarely does one method work for all cases. Different products (for example, new versus established), goals (for example, simple prediction versus the need to control an important business driver of future values), and constraints (for example, cost, required expertise, and immediacy) must be considered when selecting a forecasting method. With the availability of current forecasting software, it is best to think of forecasting methods as generic tools that can be applied simultaneously. Several methods can be tried in a given situation. The methodology producing the most accurate forecasts in one case may not be the best methodology in another situation. However, the method(s) chosen should produce a forecast that is accurate, timely, and understood by management so that the forecast can help produce better decisions.

The additional discussion available in Chase (1997) can help the forecaster select an initial set of forecasting procedures to be considered.

FORECASTING STEPS

All formal forecasting procedures involve extending the experiences of the past into the future. Thus, they involve the assumption that the conditions that generated past relationships and data are indistinguishable from the conditions of the future.

A human resource department is hiring employees, in part, on the basis of a company entrance examination score because, in the past, that score seemed to be an important predictor of job performance rating. To the extent that this relation continues to

hold, forecasts of future job performance—hence hiring decisions—can be improved by using examination scores. If, for some reason, the association between examination score and job performance changes, then forecasting job performance ratings from examination scores using the historical model will yield inaccurate forecasts and potentially poor hiring decisions. This is what makes forecasting difficult. The future is not always like the past. To the extent it is, quantitative forecasting methods work well. To the extent it isn't, inaccurate forecasts can result. However, it is generally better to have some reasonably constructed forecast than no forecast.

The recognition that forecasting techniques operate on the data generated by historical events leads to the identification of the following five steps in the forecasting process:

1. Problem formulation and data collection
2. Data manipulation and cleaning
3. Model building and evaluation
4. Model implementation (the actual forecast)
5. Forecast evaluation

In step 1, problem formulation and data collection are treated as a single step because they are intimately related. The problem determines the appropriate data. If a quantitative forecasting methodology is being considered, the relevant data must be available and correct. Often accessing and assembling appropriate data is a challenging and time-consuming task. If appropriate data are not available, the problem may have to be redefined or a nonquantitative forecasting methodology employed. Collection and quality control problems frequently arise whenever it becomes necessary to obtain pertinent data for a business forecasting effort.

Step 2, data manipulation and cleaning, is often necessary. It is possible to have too much data as well as too little in the forecasting process. Some data may not be relevant to the problem. Some data may have missing values that must be estimated. Some data may have to be reexpressed in units other than the original units. Some data may have to be preprocessed (for example, accumulated from several sources and summed). Other data may be appropriate but only in certain historical periods (for example, in forecasting the sales of small cars, one may wish to use only car sales data since the oil embargo of the 1970s rather than sales data over the past 60 years). Ordinarily, some effort is required to get data into the form that is required for using certain forecasting procedures.

Step 3, model building and evaluation, involves fitting the collected data into a forecasting model that is appropriate in terms of minimizing forecasting error. The simpler the model is, the better it is in terms of gaining acceptance of the forecasting process by managers who must make the firm's decisions. Often a balance must be struck between a sophisticated forecasting approach that offers slightly more accuracy and a simple approach that is easily understood and gains the support of—and is actively used by—the company's decision makers. Obviously, judgment is involved in this selection process. Since this text discusses numerous forecasting models and their applicability, the reader's ability to exercise good judgment in the choice and use of appropriate forecasting models will increase after studying this material.

Step 4, model implementation, is the generation of the actual model forecasts once the appropriate data have been collected and cleaned and an appropriate forecasting model has been chosen. Data for recent historical periods are often held back and later used to check the accuracy of the process.

Step 5, forecast evaluation, involves comparing forecast values with actual historical values. After implementation of the forecasting model is complete, forecasts

are made for the most recent historical periods where data values were known but held back from the data set being analyzed. These forecasts are then compared with the known historical values, and any forecasting errors are analyzed. Some forecasting procedures sum the absolute values of the errors and may report this sum, or they divide this sum by the number of forecast attempts to produce the average forecast error. Other procedures produce the sum of squared errors, which is then compared with similar figures from alternative forecasting methods. Some procedures also track and report the magnitude of the error terms over the forecasting period. Examination of error patterns often leads the analyst to modify the forecasting model.

MANAGING THE FORECASTING PROCESS

The discussion in this chapter serves to underline our belief that management ability and common sense must be involved in the forecasting process. The forecaster should be thought of as an advisor to the manager rather than as a monitor of an automatic decision-making device. Unfortunately, the latter is sometimes the case in practice, especially with the aura of the computer. Again, quantitative forecasting techniques must be seen as what they really are, namely, tools to be used by the manager in arriving at better decisions. According to Makridakis (1986):

> The usefulness and utility of forecasting can be improved if management adopts a more realistic attitude. Forecasting should not be viewed as a substitute for prophecy but rather as the best way of identifying and extrapolating established patterns or relationships in order to forecast. If such an attitude is accepted, forecasting errors must be considered inevitable and the circumstances that cause them investigated.

Given that, several key questions should always be raised if the forecasting process is to be properly managed:

- Why is a forecast needed?
- Who will use the forecast, and what are their specific requirements?
- What level of detail or aggregation is required, and what is the proper time horizon?
- What data are available, and will the data be sufficient to generate the needed forecast?
- What will the forecast cost?
- How accurate can we expect the forecast to be?
- Will the forecast be made in time to help the decision-making process?
- Does the forecaster clearly understand how the forecast will be used in the organization?
- Is a feedback process available to evaluate the forecast after it is made and to adjust the forecasting process accordingly?

FORECASTING SOFTWARE

Today, there are a large number of computer software packages specifically designed to provide the user with various forecasting methods. Two types of computer packages are of primary interest to forecasters: (1) general statistical packages that include regression analysis, time series analysis, and other techniques used frequently by

forecasters and (2) forecasting packages that are specifically designed for forecasting applications. In addition, some forecasting tools are available in Enterprise Resource Planning (ERP) systems.

Graphical capabilities, interfaces to spreadsheets and external data sources, numerically and statistically reliable methods, and simple automatic algorithms for the selection and specification of forecasting models are now common features of business forecasting software. However, although development and awareness of forecasting software have increased dramatically in recent years, the majority of companies still use spreadsheets (perhaps with add-ins) to generate forecasts and develop business plans.

Examples of stand-alone software packages with forecasting tools include Minitab, SAS, and SPSS. There are many add-ins or supplemental programs that provide forecasting tools in a spreadsheet environment. For example, the Analysis ToolPak add-in for Microsoft Excel provides some regression analysis and smoothing capabilities. There are currently several more comprehensive add-ins that provide a (almost) full range of forecasting capabilities.[2]

It is sometimes the case, particularly in a spreadsheet setting, that "automatic" forecasting is available. That is, the software selects the best model or procedure for forecasting and immediately generates forecasts. We caution, however, that this convenience comes at a price. Automatic procedures produce numbers but rarely provide the forecaster with real insight into the nature and quality of the forecasts. The generation of meaningful forecasts requires human intervention, a give and take between problem knowledge and forecasting procedures (software).

Many of the techniques in this text will be illustrated with Minitab 15 and Microsoft Excel 2003 (with the Analysis ToolPak add-in). Minitab 15 was chosen for its ease of use and widespread availability. Excel, although limited in its forecasting functionality, is frequently the tool of choice for calculating projections.

ONLINE INFORMATION

Information of interest to forecasters is available on the World Wide Web. Perhaps the best way to learn about what's available in cyberspace is to spend some time searching for whatever interests you, using a browser such as Netscape or Microsoft Internet Explorer.

Any list of websites for forecasters is likely to be outdated by the time this text appears; however, there are two websites that are likely to remain available for some time. B&E DataLinks, available at *www.econ-datalinks.org*, is a website maintained by the Business and Economic Statistics Section of the American Statistical Association. This website contains extensive links to economic and financial data sources of interest to forecasters. The second site, Resources for Economists on the Internet, sponsored by the American Economic Association and available at *rfe.org*, contains an extensive set of links to data sources, journals, professional organizations, and so forth.

FORECASTING EXAMPLES

Discussions in this chapter emphasize that forecasting requires a great deal of judgment along with the mathematical manipulation of collected data. The following examples demonstrate the kind of thinking that often precedes a forecasting effort in a real

[2]At the time this text was written, the Institute for Forecasting Education provided reviews of forecasting software on its website. These reviews can be accessed at *www.forecastingeducation.com/forecastingsoftwarereviews.asp*.

firm. Notice that the data values that will produce useful forecasts, even if they exist, may not be apparent at the beginning of the process and may or may not be identified as the process evolves. In other words, the initial efforts may turn out to be useless and another approach required.

The results of the forecasting efforts for the two examples discussed here are not shown, as they require topics that are described throughout the text. Look for the techniques to be applied to these data. For the moment, we hope these examples illustrate the forecasting effort that real managers face.

Example 1 Alomega Food Stores

Alomega Food Stores is a retail food provider with 27 stores in a midwestern state. The company engages in various kinds of advertising and, until recently, had never studied the effect its advertising dollars have on sales, although some data had been collected and stored for 3 years.

The executives at Alomega decided to begin tracking their advertising efforts along with the sales volumes for each month. Their hope was that after several months the collected data could be examined to possibly reveal relationships that would help in determining future advertising expenditures.

The accounting department began extending its historical records by recording the sales volume for each month along with the advertising dollars for both newspaper ads and TV spots. They also recorded both sales and advertising values that had been lagged for one and two months. This was done because some people on the executive committee thought that sales might depend on advertising expenditures in previous months rather than in the month the sales occurred.

The executives also believed that sales experienced a seasonal effect. For this reason, a dummy or categorical variable was used to indicate each month. In addition, they wondered about any trend in sales volume.

Finally, the executives believed that Alomega's advertising dollars might have an effect on its major competitors' advertising budgets the following month. For each following month, it was decided that competitors' advertising could be classified as a (1) small amount, (2) a moderate amount, or (3) a large amount.

After a few months of collecting data and analyzing past records, the accounting department completed a data array for 48 months using the following variables:

- Sales dollars
- Newspaper advertising dollars
- TV advertising dollars
- Month code where January = 1, February = 2, through December = 12
- A series of 11 dummy variables to indicate month
- Newspaper advertising lagged one month
- Newspaper advertising lagged two months
- TV advertising lagged one month
- TV advertising lagged two months
- Month number from 1 to 48
- Code 1, 2, or 3 to indicate competitors' advertising efforts the following month

Alomega managers, especially Julie Ruth, the company president, now want to learn anything they can from the data they have collected. In addition to learning about the effects of advertising on sales volumes and competitors' advertising, Julie wonders about any trend and the effect of season on sales. However, the company's production manager, Jackson Tilson, does not share her enthusiasm. At the end of the forecasting planning meeting, he makes the following statement: "I've been trying to keep my mouth shut during this meeting, but this is really too much. I think we're wasting a lot of people's time with all this data collection and fooling around with computers. All you have to do is talk with our people on the floor and with the grocery store managers to understand what's going on. I've seen this happen around here before, and here we go again. Some of you people need to turn off your computers, get out of your fancy offices, and talk with a few real people."

Example 1.2 Large Web-based Retailer

One of the goals of a large Internet-based retailer is to be the world's most consumer-centric company. The company recognizes that the ability to establish and maintain long-term relationships with customers and to encourage repeat visits and purchases depends, in part, on the strength of its customer service operations. For service matters that cannot be handled using website features, customer service representatives located in contact centers are available 24 hours a day to field voice calls and emails.

Because of its growing sales and its seasonality (service volume is relatively low in the summer and high near the end of the year), a challenge for the company is to appropriately staff its contact centers. The planning problem involves making decisions about hiring and training at internally managed centers and about allocating work to outsourcers based on the volume of voice calls and emails. The handling of each contact type must meet a targeted service level every week.

To make the problem even more difficult, the handling time for each voice call and email is affected by a number of contact attributes, including type of product, customer, and purchase type. These attributes are used to classify the contacts into categories: in this case, one "primary" category and seven "specialty" categories. Specific skill sets are needed to resolve the different kinds of issues that arise in the various categories. Since hiring and training require a 6-week lead time, forecasts of service contacts are necessary in order to have the required number of service representatives available 24 hours a day, 7 days a week throughout the year.

Pat Niebuhr and his team are responsible for developing a global staffing plan for the contact centers. His initial challenge is to forecast contacts for the primary and specialty categories. Pat must work with monthly forecasts of total orders (which, in turn, are derived from monthly revenue forecasts) and contacts per order (CPO) numbers supplied by the finance department. Pat recognizes that contacts are given by

$$\text{Contacts} = \text{Orders} \times \text{CPO}$$

For staff planning purposes, Pat must have forecasts of contacts on a weekly basis. Fortunately, there is a history of actual orders, actual contacts, actual contacts per order, and other relevant information, in some cases, recorded by day of the week. This history is organized in a spreadsheet. Pat is considering using this historical information to develop the forecasts he needs.

Summary

The purpose of a forecast is to reduce the range of uncertainty within which management judgments must be made. This purpose suggests two primary rules to which the forecasting process must adhere:

1. The forecast must be technically correct and produce forecasts accurate enough to meet the firm's needs.
2. The forecasting procedure and its results must be effectively presented to management so that the forecasts are used in the decision-making process to the firm's advantage; results must also be justified on a cost-benefit basis.

Forecasters often pay particular attention to the first rule and expend less effort on the second. Yet if well-prepared and cost-effective forecasts are to benefit the firm, those who have the decision-making authority must use them. This raises the question of what might be called the "politics" of forecasting. Substantial and sometimes major expenditures and resource allocations within a firm often rest on management's view of the course of future events. Because the movement of resources and power within an organization is often based on the perceived direction of the future (forecasts), it is not surprising to find a certain amount of political intrigue surrounding the forecasting process. The need to be able to effectively sell forecasts to management is at least as important as the need to be able to develop the forecasts.