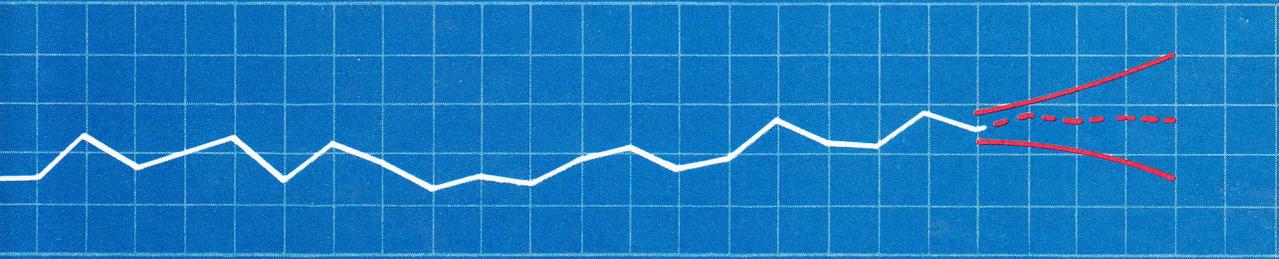
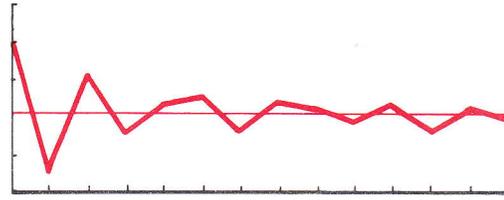


Forecasting



with TIMES



Every day, you and your executives must reach decisions on a number of crucial issues. How much raw material to order? Should advertising be increased? Should the production schedule be changed? Labor force? All these decisions require making the most difficult kind of judgment: what the future will be.

Lambda Corporation has developed a novel and powerful computer-based aid to forecasting, called TIMES, which is described briefly here.



An orderly succession of observations of the past, such as monthly sales of a product, is called a *time series*. Whenever we attempt to predict on the basis of observed time series data, we must assume that past history is *relevant* to future behavior, for otherwise one guess about the future is about as good as any other. But no matter how carefully we examine the past, the future in general cannot be determined entirely; if it could, no investor would lose money and no company would produce too much or too little of its products. Reality? Somewhere in between. The future *is* going to be something like the past, but in ways that are not simple to predict.

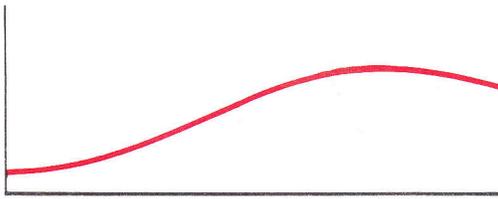
In the past, a number of techniques have been used for forecasting. In some instances, "smoothing" procedures have been used by rote. In other cases, elaborate statistical procedures have been used to determine functions that "fit the data well." "Fitting the data" is presumed to be evidence that the function embodies the essential nature of the process, and therefore

that extending the function into the future should produce reasonable forecasts. Sometimes such techniques actually do produce reasonable forecasts. This fact, coupled with the approval that generally is given to any result supported by statistical procedures, has led to a general acceptance of the "fit-the-data" criterion.

It seems almost too obvious to point out, however, that the criterion for developing a forecaster should be, not that it *fit past data well*, but that it *forecast the future well!* In technical terms, we would like to be able to develop a forecaster having minimum forecast error "variance" (the standard measure of prediction error); we shall here refer to such a forecaster as an *optimal* forecaster. Just recently, a very general technique has been developed for generating forecasts that satisfy this criterion of optimality.

The application of this new technique introduces, however, a whole new dimension of complexity into the forecasting problem: In order to determine an optimal forecaster, it is first necessary to determine a statistically appropriate representation, or model, of the time series. Understandably, there is a tremendous difference between finding a model that "fits past data" and finding one that exhibits the essential statistical properties of a particular time series. The statistical analysis required to implement the new technique is considerable and complex. It is for this reason that Lambda's TIMES program was developed.

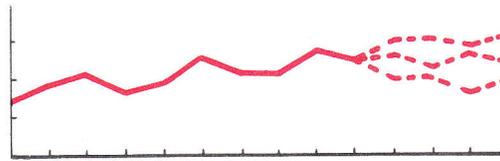
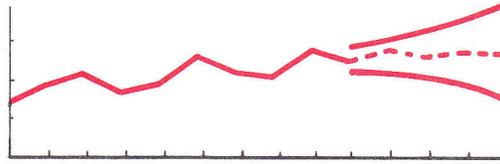
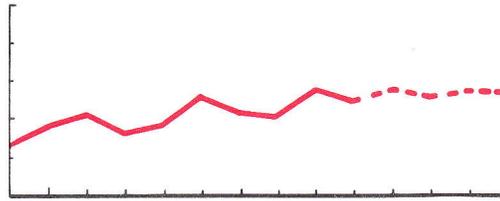
Using TIMES, the analyst develops, through a series of "tentative model" analyses, a model which is a statistically appro-



appropriate representation of the process generating the time series. The changes from one model to the next, more refined, model are guided by statistical tests; the requisite test statistics are computed by TIMES. The final model to be determined defines the minimum-variance forecaster used to generate forecasts. With the TIMES model, it is also possible to compute tolerance limits around the forecasts, which are necessary to provide the decision-maker with information about upside potential and downside risk. Additionally, the model can be used to simulate possible future "realizations" of the time series.

The forecaster defined by TIMES is used repeatedly as new data becomes available, to compute updated forecasts. It is *not* necessary to derive a new model (and hence a new forecaster) each time new data becomes available. Of course, the model should be checked periodically with more recent data to guard against model changes which should be made if the time series begins to exhibit statistical properties different from those characterizing the period employed in the original analysis.

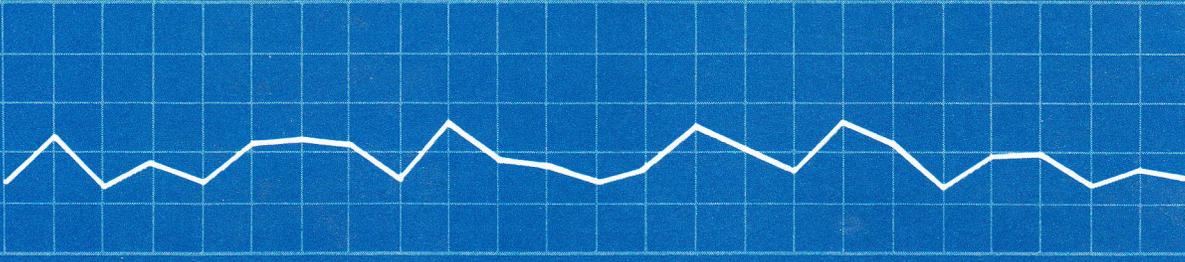
It is appropriate to ask whether or not the difference in criterion — "fit-the-data-well" vs. "minimum-variance" — makes any significant difference in the accuracy of the forecasts. The answer is an emphatic *yes*. Forecasts based on other techniques have up to twice the error variance of those based on the TIMES technique. The economic significance of this difference you can well imagine for your own company.



Lambda's TIMES program makes available all the power and sophistication of the new technique in the form of a program that operates on the IBM 360 computer. Because each firm differs from every other in its needs for forecasting and, indeed, in the statistical talent it can bring to bear, Lambda makes the package available in two ways:

Companies that have one major forecasting problem—say, one key product—may prefer to select the *Lambda analysis plan*. The client provides Lambda with the time series data in appropriate form, and in return receives a completed model and a computer program that will compute forecasts based on the model.

The *basic TIMES plan* provides the user with the complete package, including indoctrination and technical assistance during the development of the first model. This plan is best suited to companies which clearly recognize their need to develop and improve their forecasting capability on a continuing basis.



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TIMES is a product of Lambda Corporation, an operations research group specializing in developing computer systems for solving problems of critical importance to management. . .resource allocation, production scheduling, sales forecasting, information systems.