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Technical Report

NOTE ON FORECASTING TECHNIQUES

by
O.S. Gupta

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INDIAN INSTITUTE OF MANAGEMENT
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To

Chairman (Research)
IIMA

Technical Report

Title of the report ... NOTE ON FORECASTING TECHNIQUES.....

Name of the Author .....Dr. G. S. Gupta.....

Under which area do you like to be classified? .Forecasting.....

ABSTRACT (within 250 words)

.....The Note on Forecasting Techniques discusses (a) the need for forecasts, (b) the alternative forecasting techniques, and (c) the alternative measures of Forecast's inaccuracy. The discussion of each forecasting technique is illustrated with examples. It concludes that expert judgement plays a role in obtaining forecasts for any variable, using any technique; this role is less significant if statistical techniques are used than if other techniques are used. Furthermore, the note recommends obtaining alternative forecasts, based on alternative assumptions about the future, against obtaining a single forecast for any variable under forecasting.

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Please indicate restrictions if any that the author wishes to place upon this note .....

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Date 6th September 1973

Signature of the Author

Indian Institute of Management
Ahmedabad

NOTE ON FORECASTING TECHNIQUES

by

G. S. Gupta *

Introduction

Planning is gaining popularity at all levels of human organisation: individual or personal, firm, industry and the government. Further, a successful planning at any level entails three things:

(a) Passive forecasts: It is quite impossible for an unit, say, a firm to make plans unless it has some view of the problems which lie ahead and so forecasts have to be made which will indicate what is likely to happen in the absence of any action by the firm;[1]

(b) Setting of objectives: Before any plan can be laid, an organisation must have formulated some objectives; and

(c) Actual forecasts: Given the availability of a passive forecasts and given that some company objectives have been formulated, the firm has to be able to forecast what will be the outcome of pursuing these objectives by means of the policy instruments within its controls - e.g. the variation of prices and advertising expenditure to achieve short term ends, and in the long run changes in product quality and diversification into new fields.

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[1] Forecasting is defined as of describing future events precisely.

Technical note prepared by Prof. G.S. Gupta

*I am grateful to Prof. P.N. Misra for some useful discussion.

Thus, forecasting is an integral part of planning process. No management can escape from forecasting, for every business decision necessarily rests upon some forecast of future conditions. Not to forecast, therefore, is really to assume or forecast indefinite continuation of the status quo. To expect or forecast no change in these days of dynamic change seems very short sighted and unrealistic. Thus, the firm has no choice between forecasting and not forecasting; the area of choice only concerns the way the forecast is made, who does it, and what resources are devoted to it. However, correct forecasting is not usually possible because of the uncertainty which inevitably attaches to the future. None of us knows exactly what will happen to him next year, next month, next day, and even in the next moment. This is the paradox of forecasting: we all have to do because we are going to spend the rest of our life in the future, but we can do it only imperfectly because of the uncertainty attached to the future. By forecasting we only try to minimise the impact of uncertainty, for forecasting is only a means of attempting to reduce uncertainty of the future and not of eliminating it.

Before we discuss the various forecasting techniques, it may be noted that forecasting is only one technique of management decisions, the other techniques which facilitate decision making are operations research techniques and discounted cash-flow analysis. A forecast of industry's product demand alone may be enough to answer the question, "Is this market big enough." However, most investment problems are more complex. They require the use of operations research techniques to decide the optimum-size of the new plant, and the use of discounted cash flow analysis to arrive at the probable rate of return and to compare alternative investment projects. In this note we shall confine our discussion to various forecasting techniques.

Forecasting Techniques

Since forecasts play an important role in decision making, it is crucial to use the best available technique to minimise the forecast inaccuracy. However, there is no unique method which can always guarantee the best result. Furthermore, the choice of a method is often dictated by data availability and/or by urgency of forecasts. Many times forecasters are forced to use less-reliable method, for the required data for the use of more reliable method are not always available. If the

use of better techniques is time consuming and the forecasts are urgently needed, forecasts are made on the basis of easy and less reliable techniques. Therefore, it is important to know all the various techniques of forecasting. In what follows, we review the various forecasting techniques and note their advantages and limitations.

The several forecasting techniques, roughly in the ascending order of sophistication and perhaps the accuracy of their forecasts, are the following:

1) Historical Analogy Method
2) Trend Method
3) End-Use Method
4) Survey Method
5) Regression Method
6) Leading Indicators Method
7) Simultaneous Equations Method

Methods (2), (5) and (7) are jointly referred to as Statistical method. Method (2) is also known by names Time Series method or Extrapolation method. Methods (5) and (7) together are also known as Model Building methods. An another name of method (6) is Barometric method. As will be seen later, some of these techniques are more subjective than others, although expert judgement plays some role in each of them.

These various methods can be used to forecast almost any variable. For example, they are used in forecasting demand for various products and services, investment, advertisement expenditure, costs, prices, profits, etc. However, it is the demand forecasting which concerns the business firm most. Therefore, without the loss of generality, we shall illustrate the use of these techniques for demand forecasting. A brief discussion of each of these techniques is now in order.

(1) Historical Analogy Method

Under historical analogy method, forecasting is attempted on the principle of country comparisons. It involves two stages: (a) selection of a country (A) which sometimes in the past (Period T*), particularly

with respect to the industry (I) the demand of whose product is under forecasting, was in the same stage of development as the country (B) for which forecasts are being made at present (period T); and (b) forecasting of the demand for industry I's product in country B in periods T + 1, T + 2, . . . , T + n on the basis of the actual demand of that industry's product in country A in periods T* + 1, T* + 2, . . ., T* + n, respectively.

To illustrate its application, let the present (1973) stage of India's development with respect to the demand for cement is same as that of U.S.A. in 1940. Then, the demand for Cement in India in 1974 and 1975 by this method will be forecasted as equal to the cement demand in U.S.A. in 1941 and 1942, respectively.

Advantages

The only advantage of this method is that it neither requires any time series data nor the use of any statistical technique.

Limitations

i) It is very difficult, if not impossible, to find the country A in period T*, which had witnessed the same economic structure and the stage of development as country B in Period T. This is difficult because the various countries even at different times differ with respect to natural resources, demographic structure, economic structure, tests and preferences, etc.

ii) Even if it is possible to find the country A, the future trends in the demand of industry I's product in country B may differ from the trends in the demand of this industry's product in country A in periods subsequent to period T*, for the increase in knowledge, technological changes etc.

Due to these limitations, many writers and forecasters, not to speak of using it, do not even include it among the forecasting techniques.

(2) Trend Method

Trend method is the simplest, yet often a useful method of forecasting. The use of this technique requires just the extrapolation of

historical data on the assumption that the variable under forecasting will follow along its already established path. Thus, the trend method relies on the constancy in the pattern of past movements of some time series.[2] The use of this technique involves two stages of work: (a) determination of the appropriate trend curve and the values of its parameters (intercept and slope)[3]; and (b) derivation of forecasts with the help of the estimated trend line or curve.

Some of the most suitable alternative trend curves for business forecasting are the following:

(i) Aritnmetic (linear) trend: $Y = a + bT$, where Y is the variable under forecasting; T is the trend variable which takes a value of zero in the first period, 1 in the second period, 2 in the third period, and so on; and a (intercept) and b (slope) are parameters. This trend line assumes that change will be a constant absolute amount (=b) every period.

(ii) Exponential (Semi-log) trend: $Y = ae^{bT}$ or $\log_e Y = \log_e a + bT$. The semi-log trend assumes a constant growth rate (= b) each period.

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[2] A time series is an ordered sequence of events such as the demand for an industry's product recorded monthly.

[3] A crude version of this technique is called as Graphical method of forecasting. Under this method, instead of mathematically determining the trend curve the forecaster projects subjectively the graph of the variable's historical data to future periods and then reads out its value in the production period.

An another version of the trend method is called as Auto-Regressive method. Under this method the variable under forecast (Y) is regressed on its past values: $Y_t = a + b\,Y_{t-1} + c\,Y_{t-2} + \ldots$ Since the past values are known, the value in the next period can be forecasted using the estimated auto-regressive model.

(iii) Second and higher degree polynomials trend. The second degree polynomial is called a parabola. Its equation is $Y = a + bT + cT^2$. The characteristic of a parabola is that its slope $\left(\frac{dY}{dT}\right)$ changes direction once and once only - from positive to negative or vice versa. The shape and location with respect to the axes will vary according to the values of the constants a, b, and c. A useful method of detecting whether a second degree polynomial will fit a series is to examine the second differences ($\Delta'' Y = \Delta' Y_t - \Delta' Y_{t-1}$). If these are approximately constant the second degree polynomial will fit. This method can be generalised for a parabola of the nth degree: the nth differences will be constant. Thus, to determine the appropriate polynomial, we only need to examine the differences of different orders.

(iv) Cobb-Douglas (Double-log) Trend: $Y = aT^b$ or $\log_e Y = \log_e a + b \log_e T$. The double-log trend assumes a constant elasticity (= b) every period. When the second difference of the logarithms of Y ($\Delta' \log Y_t - \Delta' \log Y_{t-1}$) are approximately constant, this is the appropriate trend.

Both theoretical and empirical considerations help in the selection of the most appropriate growth curve. Theoretically, logic might support a particular growth pattern. Empirically, the curve that best fits the past movement of the data (i.e. the one which guarantees the highest R^2) is the most appropriate curve. The constants of these trend curves can be estimated by least squares method and the chosen estimated trend equation can then be used for forecasting purposes.

To illustrate, the estimated appropriate trend line for scheduled commercial banks' demand deposits (Y) in India is $Y = 572.15 + 43.28\ T$, $R^2 = .99$; where deposits are measured in crores of rupees and $T = 0, 35$ (1961 I = 0, 1961 II = 1, 1961 III = 2, . . . , 1969 IV = 35). This yields the forecasts for demand deposits in 1970 I = 572.15 + (43.28) (36) = 2130.23, in 1970 II = 572.15 + (43.28) (37) = 2173.51, and so on. Thus, knowing the estimated line (curve) we can forecast any future value of Y.

Advantages

The main advantage of this method is that it can be used easily and quickly, for it does not require the knowledge of economic theory and the market, and also that it requires the time series data only on the variable whose future values are to be forecasted. Nevertheless, since many time series follow a particular trend, it often yields good results. Therefore, to the credit of this technique it is sometime said that wonder goes where knowledge fails.

Limitations

i) The trend method is based on the principle that history repeats itself one hundred per cent. It assumes that the trend curve which best fits the past data will also be the appropriate curve for the future. In other words, it suffers from the limitations that the values of the parameters of the trend curve will remain constant in the prediction period.

ii) For this method to yield good results, it is usually necessary to have a long time series of the variable under forecasting. Thus, the method is not available for, say, forecasting demand for new products or for products with relatively short existence.

In spite of these limitations, the trend method is recommended for obtaining quick forecasts and as a preliminary to the use, and for comparing with the results of the sophisticated techniques.

3) <u>End-Use Method</u>

Forecasts under end-use method for, say, steel demand in 1975 are obtained by summing all probable aggregate demands of all the users (consumers) of steel in 1975. The forecasts are arrived at after going through the four steps: (a) identify all the possible uses (for instance input to other industries, direct consumption demand, exports and imports) of the product whose forecasting is being attempted; (b) obtain the input-output coefficients with respect to the product whose demand forecasting is being attempted and the industries using this product as input; (c) obtain the desired or

targeted levels of output of its (the product whose demand is being forecasted) all consuming industries, and its probable demands for final consumption and exports net of imports in the prediction period; and (d) derive its inter-industry demand and add the same to its probable demands for final consumption and exports net of imports in the prediction period to yield the forecasts of aggregate demand for the product.

To illustrate the end-use method of forecasting, let us use it to forecast steel demand in India in 1975. For simplicity assume that steel is used as input in only four industries: I_1, I_2, I_3 and I_4, that it is used for final consumption and exports, and that it can be imported. Further, assume that the input-output coefficients of steel in its four consuming industries are a_1, a_2, a_3 and a_4, respectively. Then, if in the prediction period 1975 the desired or targeted levels of output of the four industries are X_1, X_2, X_3 and X_4, respectively, and C_s, E_s and I_s are its probable levels of final consumption, exports and imports, respectively; forecast of aggregate steel demand in 1975 is given by

$$D_s = a_1 X_1 + a_2 X_2 + a_3 X_3 + a_4 X_4 + C_s + E_s - I_s$$

$$= \sum_{i=1}^{4} a_i X_i + C_s + E_s - I_s$$

Advantages

The data required for its application are relatively easy to obtain; it requires no time series data. The input-output coefficients are usually known and they seldom change significantly, and the desired or targeted levels of output of consuming industries, and probable demand for final consumption and exports net of imports are usually available from the individual industries' and national plans; (ii) use of this technique supposedly yields good results, for it can take care of anticipated technological, structural and other changes;[4]

[4] Expected technological changes can be incorporated by changing the concerned input-output coefficients.

(iii) it yields sector-wise forecasts. That is in the process of obtaining forecast of aggregate demand, the forecaster obtains the demand by the individual consuming industries, by the final consumers and by exporters and importers.

Limitations

i) The targeted or desired levels of outputs of different consuming industries very often differ from their actual productions in the prediction period.

ii) This method entails the use of some other forecasting techniques to arrive at the probable final demand and exports net of import demand in the prediction period.

iii) It is quite tedious and time consuming.

In spite of its virtues because of its severe limitations, its use has been rather limited.

4) Survey Method

It was noted at the beginning of this note that forecasts are necessary for a reasonable planning. It was also seen in the discussion of the end-use method that planning helps forecasting. Under the survey method, forecasting is based exclusively on planning.

Survey method can conveniently be discussed in two parts: Complete Enumeration Survey method and Sample Survey method.

4 A) Complete Enumeration Survey Method

The complete enumeration survey method goes much deeper than the end-use method. Under this method, aggregate demand forecasts are obtained by aggregating the probable demands of all individual consumers in the production period. It thus involves two stages: (a) obtain the probable demands of all consumers; and (b) sum the individual probable demands to obtain the market demand.

To illustrate, if there are n consumers and the probable demands of them are $D_1, D_2, \ldots, D_n$, then the forecasts for market demand are given by $\sum_{i=1}^{n} D_i$.

Advantages

The principal merit of this method is that under this method the forecaster does not introduce any bias of his own, he just collects the information and aggregates. If the expectations of all incividual consumers prove to be 100% correct, the forecast for market demand will also be 100% correct.

Limitations

Its use is just not feasible, particularly for those products which are consumed by a large community. Because of this limitation, its restricted version, i.e., sample survey method is recommended.

4B) Sample Survey Method

Under the sample survey method, the forecaster selects a few consuming units out of a whole lot and then by gathering probable demands of these selected units, he infers forecasts of aggregate demand. Thus, the application of this method necessitates to go through three steps: (a) select the representative sample, (b) obtain the probable demands by the selected sample units; and (c) translate the demand of the sample units into the demand of the whole population.

To illustrate, let there be 100 consumer units and we select a sample of 10 units out of these whole lot. Further, assume that the probable demands in the prediction period of these selected units are $D_1, D_2, \ldots, D_{10}$, respectively. Then the forecasts for aggregate demand is given by $\sum_{i=1}^{10} n_i D_i$ where $\sum_{i=1}^{10} n_i = 100$ and n_i is the number of consuming units in group i, the demand of each of which is assumed to be equal to D_i.

Advantages

The principal advantage of the sample survey method is that it neither requires any time series data nor the use of any statistical technique. Further, if the sample is properly chosen, it yields good results.

Limitations

(i) It is highly subjective. The two forecasters working with different samples of the same population invariably arrive at different forecasts.

(ii) It is observed that sampling error gets smaller and smaller with every increase in sample size. This temptation renders the method tedious and expensive.

(iii) It is subject to large errors, for survey entails the services of many field workers, all of whom can only rarely be always accurate.

(5) Regression Method

Under regression technique, forecasts are made on the basis of an estimated relationship between the forecast (dependent) variable and its explanatory (independent) variables.

The philosophy behind this method is that it assumes that the functional relationship that best explains the past behaviour of the forecast variable will hold equally true in the prediction period. Its use essentially involves five steps of work: (a) Identify the variables which appear to have determined the forecast variable (Y) in the past. This is done on the basis of the principles of economic theory; (b) determine the most appropriate form of the functional relationship. The most popular forms found in the literature are linear, exponential and

Cobb-Douglas. This is done on the basis of both economic theory and empirical testing; (c) estimate the functional relationship between the forecast variable and its determining variables (causes). This is attempted by statistical (least squares) technique, using past time series and/or cross-section data.[5] The measure of the strength of this dependence relationship is provided by the coefficient of determination (R^2), which measures the percentage of total variation of the dependent variable that is explained by its explanatory variables. Thus, higher the R^2 better is the equation for forecasting purposes; (d) forecast the values of the determining variables (X_1, X_2, . . . X_n) in the prediction period. This is often done first on the basis of the trend method of forecasting and then by adjusting the resulting forecasts subjectively on the basis of the forecaster's expected changes in the prediction period; and (e) obtain the final forecasts by feeding the forecasts of X_1, X_2, . . . X_n into the estimated functional relationship.

To illustrate its working, the private non-bank sector's demand function for scheduled commercial banks' credit, estimated from time series data for the period 1948-49 through 1967-68 is

$$(Cr)_t = -921.34 + 0.3020\,(Y_{na})_t + 0.0267\,(Ya)_t - 87.25\,(i_1)_t + 79.06\,(i_g)_1$$
$$\qquad\qquad (5.27)\quad (9.40)\qquad\quad (1.47)\qquad\quad (1.96)\qquad\quad (0.87)$$

$$\bar{R}^2 = 0.9966, \quad DW = 1.29$$

where Cr = bank credit (Rs. crores)

Y_{na} = nominal non-agricultural income (Rs. crores)

Ya = nominal agricultural income (Rs. crores)

i_1 = loan rate (%)

i_g = yield on government bonds (%)

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[5] Time series data refer to the same population at different sequential points of time, e.g. national income in the years 1951, 1952, 1953, and so on; while cross-section data refer to the different populations at the same point of time, e.g. incomes of states Rajasthan, U.P., M.P., Gujarat, etc. in 1973.

Subscript t stands for the time period; t-values are in parentheses; $\bar{R}^2$ is coefficient of determination adjusted for degrees of freedom; and DW is Durbin-Watson statistic.

The trend (linear) method yields the forecasts for Y_{na} = 13910.12, Ya = 15214.99, i_1 = 8.52, and i_g = 5.61 in the prediction period 1968-69. Forecast for Cr in 1968-69 are thus given by

$$(Cr)_{1968-69} = -921.34 + 0.3020\ (13910.12) + 0.0267\ (15214.99) - 67.25\ (8.25) + 79.06\ (5.61)$$

$$= 3385.92$$

Advantages

(i) The regression method not only provides the forecasts, as the other methods discussed so far, but it also explains the variations in the forecast variable in the past. In other words, it is both prescriptive and descriptive.

(ii) It is neither mechanistic as the trend method nor is very subjective as the sample survey method. Though there is a possibility of two forecasters choosing two slightly different forecasting equations to obtain different forecasts, the differences in their forecasts will rarely be significant; the difference may, however, be significant if any or both of them are not using the trend method in forecasting the values of the explanatory variables.

(iii) It is easy to apply provided, of course, the data for a good sample size are available.

Limitations

(i) The principal limitation of the regression method of forecasting is that it requires the use of some other method in forecasting the values of the explanatory variables in the prediction period. To the extent, forecasts of the values of explanatory variables are wrong, the forecasts based on the regression method will be wrong.

(ii) The forecast equation used in this method is true on average for the past and it may not exactly be true for the prediction period. This limitation becomes severe particularly in the fact of structural change. Thus, to the extent the true values of the parameters differ from their respective actual values, the forecasts will be wrong.

(iii) The forecasts under this method assume that the forecast equation holds exactly in the prediction period. To the extent it is stochastic, i.e. the disturbance term is non-zero, the forecasts will be wrong.

In fact, no forecast is 100% correct and so the only severe limitation of this method is (i) above.

6) Leading Indicator Method

Leading indicators are the variables which move up or down ahead of some other variables. The use of these indicators for forecasting purposes involves two stages: (a) identification of the appropriate leading indicators and (b) determination of the relationship between the leading indicator and the variable under forecasting. The last step requires the measurements of the lead period and of the relation between the two said variables. This is accomplished with the aid of regression analysis.

To illustrative, let Y be the variable to be forecasted, X be its leading indicator. If the relation between these two variables is found to be, say, $Y_t = 1.5 + 0.9\ X_{t-2}$, the forecasts for Y are $Y_{t+1} = 1.5 + 0.9\ X_{t-1}$ and $Y_{t+2} = 1.5 + 0.9\ X_t$. Thus knowing the present and the past values of X, we can forecast the next two years' values of Y.[6]

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[6] A forecasting method very similar to the leading indicators method is the forecastings with the aid of anticipatory data. Under this method, forecasts of future values of a variable are obtained on the basis of anticipations about that variables future movements. For example, loans of a bank in the next period may be forecasted on the basis of the effective loan requests pending with that bank; capital consents and loans sanctioned may be used to predict investment in corporate sector (see Rangarajan C. (1970): Forecasting Capital Expenditure in Corporate Sector, Economic and Political Weekly, Vol. V, No. 51 (Dec. 18), pp. 2049-51).

Advantages

The only advantage which could be attributed to this method is that it overcomes the regression technique's problem of forecasting the values of the independent variables in the prediction period.

Limitations

i) It is not always possible to find out a leading indicator for every variable under forecasting.

ii) Lead period is often not constant over time.

iii) Relationship between the leading indicator and the forecasting variable often varies with time.

Because of these rather severe limitations, the leading indicator method has rarely been used in forecasting.

(7) Simultaneous Equations Method

The simultaneous equations method of estimation overcomes the main limitation of the regression method by specifying a complete model which can be solved into reduced (forecasting) form equations.[7] The reduced form equations contain only one endogenous variable and one or more predetermined variables, whose values in the prediction period can easily be forecasted. For, the predetermined variables are either policy variables (such as government expenditures, tax rates, government securities with the non-government sectors, bank rate, etc.), lagged endogenous variables, or some non-policy exogenous variables (such as population, weather, etc.). Under this method, the appropriate model can be developed to almost completely overcome the problem of forecasting independent variables. The application of this method involves the following sequential steps of work: (a) specify the complete model. This is done on the principles of economic theory; (b) estimate the complete model from the past time series and/or cross-section data. This is attempted with the aid of the appropriate statistical technique, such as Two-Stage Least Squares (2SLS) methods; (c) solve the model algebraically into its reduced form; (d) forecast the values of the predetermined variables in the prediction period, and (e) obtain forecasts for the endogenous variables by feeding the forecasts of predetermined variables into the estimated reduced-form equations.

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[7] A reduced-form equation is one which expresses an endogenous variable in terms of only predetermined variables and parameters.

To cite an example, a simple demand-supply model for scheduled banks' credit, estimated from time series data for the period 1948-49 to 1967-68 by 2SLS method is

Demand Equation

$$(Cr)_t = -969.16 + 0.3064\ (Y_{na})_t - 0.0275\ (Ya)_t - 106.22\ (i_1)_t + 107.64\ (i_g)_t$$
$$\qquad\qquad (3.89)\ (8.27) \qquad\qquad (1.40) \qquad\qquad (1.31) \qquad\qquad (0.77)$$

$$\bar{R}^2 = 1.00, \quad DW = 1.53$$

Supply Equation

$$(Cr)_t = -710.16 + 0.7052\ (DD)_t + 0.1571\ (TD)_t + 0.1538\ (B)_t + 114.88\ (i_1)_t$$
$$\qquad\qquad (5.25)\ (4.76) \qquad\qquad (1.17) \qquad\qquad (2.01) \qquad\qquad (4.13)$$

$$\bar{R}^2 = 0.9956, \quad DW = 1.47$$

where

DD = demand deposits (Rs. crores)

TD = time deposits (Rs. crores)

B = number of banking offices (pure numbers)

and the other notations have the same meaning as before.

Cr and i_1 are the endogenous variables, the rest are exogenous variables.

The model's solution into its reduced form is

$$(Cr)_t = -844.78 + 0.3388\,(DD)_t + 0.0755\,(TD)_t + 0.0739\,(B)_t + 0.1592\,(Y_{na})_t + 0.0143\,(Ya)_t + 55.93\,(i_g)_t$$

$$(i_1)_t = -1.1714 - 0.0032\,(DD)_t - 0.0007\,(TD)_t - 0.0007\,(B)_t + 0.0014\,(Y_{na})_t + 0.0001\,(Ya)_t + 0.4868\,(i_g)_t$$

The model can be extended to endogenize Y_{na}, Ya, DD, TD, etc. and if that is done the problem of their forecasts will not arise. In other words, the model can be developed which will give only those variables in the right hand side of the reduced form which can easily be forecasted. However, to illustrate the working of the simultaneous equations method of forecasting, the above simple model has been chosen. Because of this simplicity, the forecasting of the values of Y_{na}, Ya, DD, TD, etc. in the prediction period is seen as a problem. Subject to this limitation, the trend (linear) method is used to forecast the values of the predetermined variables. The forecasts obtained for the prediction period 1968-69 are

DD = 1961.85, TD = 2249.75, B = 7130,

Y_{na} = 13910.12, Ya = 15214.99 and i_g = 5.61

Feeding these values in the reduced form equations, we obtained the following forecasts for endogenous variables Cr and i_1 in the prediction period 1968-1969:

$$(Cr)_{1968-69} = -844.73 + 0.3383\,(1961.85) + 0.0755\,(2249.75) + 0.0739\,(7130) + 0.1592\,(13910.12) + 0.0143\,(15214.99) + 55.93\,(5.61)$$

$$= 3262.3$$

$$(i_1)_{1968-69} = 1.1714 + 0.0032\,(1961.85) - 0.0007\,(2249.75) - 0.0007\,(7130) + 0.0014\,(13910.12) + 0.0001\,(15214.99) + 0.4869\,(5.61)$$

Advantages

The simultaneous equations method of forecasting possesses all the advantages of the regression method. Furthermore, if one is not worried about the size of the model, it can almost eliminate the regression method's major problem of forecasting the values of the independent variables in the prediction period. Provided the data are available, one should not really be concerned with the model's size, for computer is there to help the forecasters to estimate and solve the model.

Limitations

It is subject to limitations (ii) and (iii) of the regression method. However, as noted above, these are not severe. The main obstacle to its application is the unavailability of the data for a good sample. In developed countries like U.S.A., U.K., Canada, where long time series data are easily available, this method is the most popular one. In India also the data constraint is becoming weaker and weaker with the passage of time and so the simultaneous equations method of forecasting has good prospects.

Evaluation of Forecasts Accuracy

Since no forecast is going to be 100% correct, a note on forecasting techniques should include the tests for measuring the accuracy of forecasts. The forecast accuracy tests compare the forecasts ($\hat{Y}_t$) with the realization (Y_t). Before we discuss the tests, it should be noted that there are two kinds of forecasts: ex ante forecasts and ex post (genuine) forecasts. Ex ante forecasts are the forecasts for the sample periods or cross-sections and ex post forecasts are for the future periods. The non-statistical forecasting methods, i.e., Historical Analogy, Leading Indicator, End-Use and Survey method can be used to yield only ex post forecasts while the statistical methods, i.e. Trend, Regression, and Simultaneous Equations method can be used to yield both ex ante and ex post forecasts. The alternative tests for evaluating the accuracy of ex ante forecasts are

(1) Coefficient of Determination Test

(2) Root Mean Squared Error Test

(3) Percentage Mean Absolute Error Test

The accuracy of ex post forecast which can be tested only after the prediction period has come, can be evaluated by the following test:

(4) Percentage Absolute Error Test

These various tests may now be discussed in brief.

(1) Coefficient of Determination (R^2) Test

The coefficient of determination is measured by

$$R^2 = \sum_{t=1}^{n} \frac{(\hat{Y}t - \bar{Y})^2}{\sum_{t=1}^{n} (Yt - \bar{Y})^2}$$

where $\bar{Y}$ = sample mean of Y

n = sample size

and subscript t stands for the period if time series data are used and for the particular cross-section if cross-section data are used.

Higher the R^2 better are the ex ante forecasts. This test is appropriate for evaluating the forecasts of the Trend and Regression methods. It is not useful for testing the accuracy of the ex ante forecasts of the Simultaneous Equations method.

(2) Root Mean Squared Error (RMSE) Test

The root mean squared error is measured by

$$\text{RMSE} \quad \frac{1}{n} \sum_{t=1}^{n} (Y_t - \hat{Y}_t)^{2}$$

The RMSE test is such that lower the RMSE better are the ex ante forecasts. This test is appropriate for evaluating the accuracy of ex ante forecasts of any statistical forecasting techniques.

(3) Percentage Mean Absolute Error (PMAE) Test

The percentage mean absolute error is measured by

$$PMAE = \frac{100}{n}\left[\sum_{t=1}^{n} \left|\frac{Y_t - \hat{Y}_t}{Y_t}\right|\right]$$

Lower the PMAE better are ex ante forecasts.

(4) Percentage Absolute Error (PAE) Test

The percentage absolute error is measured by

$$PAE = \frac{(100)\left|(Y_t - \hat{Y}_t)\right|}{Y_t}$$

t stands for the prediction period to which ex post forecast applies.

Lower the PAE better is the forecast.

These various tests can be used to evaluate the accuracy of forecasts both on absolute and comparative basis. That is, they can be used to evaluate the accuracy of forecasts of a particular forecasting technique and also to compare the accuracy of forecasts of different forecasting techniques; the latter for selecting the most appropriate forecasting technique from all of them.

Conclusion

Expert judgement plays a role in obtaining forecasts for any variable, using any forecasting technique. In statistical techniques, it perhaps plays a lesser role than in other techniques. The other point which may be noted here is that there are dangers in prescribing single number forecasts, i.e. assigning only one value to the forecast variable in the forecast time period. For, future cannot be seen precisely and so our single kind of assumptions about the future may very well turned out to be wrong. It is therefore, suggested that, again based on expert judgement, alternative forecasts should be obtained based on all possible alternative assumptions about the future. These alternative forecasts will enable the decision maker to better plan his business strategy. The decision maker would not be surprised if any one of his alternative forecasts proves to be approximately correct. Surely, there are more chances of one of the alternative forecasts to prove to be correct than the single forecast. Furthermore, he will have planned his next step for every alternative outcome. The various forecasting methods discussed above can be used to supply with alternative forecasts based on alternative assumptions about the future.

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