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NEW PRODUCT SALES FORECASTING USING A GROWTH CURVE MODEL

Douglas G. Bonett, Department of Statistics, University of Wyoming

Abstract

A logistic growth curve model for new product sales forecasting is proposed as an alternative to the traditional subjective forecasting methods. The parameters of the logistic growth curve model are redefined to represent meaningful growth characteristics that may more easily be specified by expert panels.

Introduction

A large number of quantitative methods have been developed for the purpose of forecasting the value of some variable at a future point in time. Introductory reviews of these methods can be found in Makridakis and Wheelwright (1978) and Cleary and Levenbach (1982).

The quantitative methods involve the analysis of a historical time series of data. The analysis process involves a model fitting procedure and a rule for extrapolating current values of the variable into the future. Single and multiple equation regression models and autoregressive-moving average models are perhaps the most widely used quantitative models and given a sufficiently large historical data base, these models can yield very accurate forecasts.

Forecasting the future sales of a new product involves special problems since no historical data may be available. Various subjective forecasting methods, such as the methods of executive jury or sales force composites, have been used with varying degrees of success to forecast new product sales (Reichard, 1966; Wheelright & Makridakis, 1980).

In this paper, a logistic growth curve model will be defined that can be used to forecast new product sales. The parameters of the growth curve model will be redefined in terms of 1) the maximum number of sales per month, 2) the length of time for sales to grow from 10% to 90% of maximum, and 3) the number of sales in the first month. The advantage of defining the parameters in this way is that the executive staff and sales personnel will be able to subjectively specify expected values for these parameter values. When the subjective information has been specified in this form, sales estimates can be computed for any future point in time. Furthermore, as monthly sales figures becomes available, the information can be used to modify the subjective guesses of the growth curve parameters to give ongoing revisions of sales forecasts.

The Growth Curve Model

A logistic growth curve model is defined as

$$Y(t) = M/(1 + A[\exp(-Bt)]) \qquad (1)$$

where Y(t) is the number of sales in month t, M is the maximum number of sales per month, A is the intercept, and B is the slope. The application of growth curve models for forecasting purposes has been described by Ayres (1969), Cetron (1969), and Chambers, Mullick, and Smith (1971).

If the values of parameters of the logistic growth curve can be specified, then Equation (1) can be used to generate a forecast of the sales in any future month. However, it will be very difficult for sales personnel or an executive panel to subjectively specify the values of either A or B. In Appendix A it is shown that the slope can be defined in terms of the length of time for sales to grow from 10% to 90% of maximum. This is a quantity that usually can be specified by an expert panel. Letting G represent this period of time, we show in Appendix A that

$$B = 2[\log(.9/.1)]/G. \quad (2)$$

Thus, if one can specify G, then the value of B follows from Equation (2). In addition, it can be shown (see Appendix A) that the intercept can be defined in terms of the number of sales during the first month. Let F denote the number of sales in the first month then

$$A = [(M/F) - 1]/[(\exp(-B)]. \quad (3)$$

Thus, if one can specify F, M and G, then the value of A follows from Equation (3) with B computed from Equation (2). Table 1 gives hypothetical sales forecasts for a product believed to have maximum monthly sales of 1000 units with the number of sales in the first month equal to 50 or 100 and the number of months for sales to grow from 10% of maximum (1000) to 90% of maximum equal to 12 or 18 months.

The sales forecasts given in Table 1 were generated from a micro-computer program written in BASIC. This program is reproduced in Appendix B. A compiled version of the program for the IBM personal computer and compatibles can be obtained by sending a 5 1/4 diskette to the author.

Updating Sales Forecasts Based on Actual Sales Data

Equation (1) can be used to generate sales forecasts based solely on subjective guesses for M, F, and G. After the first month of sales data have been obtained, F is no longer an unknown quantity and the actual first month sales may be used in place of the guessed value of F to produce a revised forecast using the subjective guesses of only M and G. For example, if the initial guesses for M, G, and F are 1000, 12, and 50 respectively, then the resulting forecasts are given in the first column of Table 1. Suppose that the first month sales are actually 100 rather 50 units but we still believe that G=12 and M=1000. The revised forecast using F=100, G=12, and M=1000 are shown in the third column of Table 1. As additional months of actual sales data become available, the predicted and actual sale figures should be compared to asses the appropriateness of the subjective guesses for M and G. Comparing the predicted and actual sales figures involves computing the difference between these two quantities and then computing a summary goodness of fit statistic such as the sum of the squared differences or the sum of the differences ignoring negative signs. Although it is possible to solve mathematically for the values of M and G that minimize the sum of the squared differences between actual and predicted sales values, the methods involve rather complicated computations. Using the program in Appendix B, it is a simple task to find revised values of M and G through trial and error that give forecasts that more closely match the actual data. As actual monthly sale data become available, subjective guesses regarding the values of M and G may be modified in the light of new information and the sales forecast for future months can be revised accordingly.

Summary

Growth curve models have been successfully applied in a variety of forecasting applications. The usefulness of growth curve models in the present context is based on an assumption that the growth of sales is similar to the growth of living organisms in competition with other organisms in a limited space. The logistic growth curve model defined here has been widely used to describe the growth of living organisms and thus provides a useful alternative to the traditional subjective forecasting of new product sales.

If a product is introduced in different regions and the growth pattern is believed to differ across regions, then different growth curves should be specified for each individual region. Monthly forecasts are then generated for each individual region and summed within each month to give an aggregate forecast.

To apply the logistic growth model in a subjective manner requires expert guesses regarding the values of the parameters of the model (i.e., the asymptote, slope, and intercept). The slope and intercept represent quantities that would be very difficult for an expert panel to specify. In this paper, these quantities have been translated into growth characteristics for which an expert panel may have specific opinions. Thus, the translations of the logical model parameters into the alternative growth characteristics makes possible the use of a logistic growth curve model with subjective information. Whenever subjective forecasts are made, there is usually some disagreement among the members of the expert panel. It may be useful in these situations to define different scenarios that represent, for example, best, average, and worst cases for each of the three growth characteristics and then compute forecasts under each scenario.

References

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Table 1

Monthly Sales Forecast Under Different Growth Assumptions

Month	M=1000 units G=12 months F=50 units	M=1000 units G=18 months F=50 units	M=1000 units G=12 months F=100 units	M=1000 units G=18 months F=100 units
1	50.0	50.0	100.0	100.0
2	70.6	63.0	138.1	124.2
3	98.7	79.0	187.7	153.3
4	136.4	98.7	250.0	187.7
5	185.5	122.6	324.7	227.8
6	247.2	151.4	409.5	273.6
7	321.4	185.5	500.0	324.7
8	405.9	225.2	590.5	380.3
9	496.3	270.6	675.3	439.3
10	587.0	321.4	750.0	500.0
11	672.1	376.8	812.3	560.7
12	747.2	435.6	861.9	619.7
13	810.0	496.3	900.0	675.3
14	860.1	557.1	928.5	726.4
15	898.7	616.2	949.3	772.2
16	927.5	672.1	964.3	812.3
17	948.6	723.5	975.0	846.7
18	963.8	769.6	982.5	875.8
19	974.6	810.0	987.8	900.0
20	982.3	844.8	991.5	919.9
21	987.6	874.2	994.1	936.2
22	991.4	898.7	995.9	949.3
23	994.0	918.8	997.1	959.8
24	995.8	935.3	998.0	968.3
25	997.1	948.6	998.6	975.0
26	998.0	959.3	999.1	980.3
27	998.6	967.8	999.3	984.5
28	999.0	974.6	999.5	987.8
29	999.3	980.0	999.7	990.4
30	999.5	984.3	999.8	992.5
31	999.7	987.6	999.9	994.1
32	999.8	990.3	999.9	995.4
33	999.9	992.4	999.9	996.4
34	999.9	994.0	1000.0	997.1
35	999.9	995.3	1000.0	997.8
36	1000.0	996.3	1000.0	998.3

Appendix A

Reparameterization of Slope and Intercept Parameters

Let F denote the sales for the first month (t=1) so that Equation (1) becomes F = M/(1 + A[exp(-B)]) and M/F = 1 + A[exp(-B)]. Solving for A gives

$$A = (M/F - 1)/\exp(-B), \quad \text{(A1)}$$

the result of Equation (2). Now write the percent of maximum (P) as

$$P = Y/M = 1/(1 + A[\exp(-Bt)]) \quad \text{(A2)}$$

and solving for t gives

$$t = [\log(AP) - \log(1 - P)]/B. \quad \text{(A3)}$$

The number of months for sales to reach 10% and 90% of maximum is defined by setting P = .10 and P = .90 respectively in Equation (A3). Subtracting Equation A1 with P = .10 from Equation (A3) with P = .90 defines the number of months for sales to grow from 10% to 90% (G) and gives

$$G = 2[\log(.9/.1)]/B \quad \text{(A4)}$$

which is the result of Equation (3).

Appendix B

BASIC Program for New Product Sales Forecasting

```
10 print "Maximum sales ...";:input M
15 print "Number of months to grow from 10% to 90% of max ...";:input G
20 print "Number of sales in first month ...";:input F
25 print "Number of months to forecast ...";:input N
30 dim Y(999)
40 B=(2*log(.9/.1))/G
45 A=((M/F)-1)/exp(-B)
50 for t=1 to N
55   Y(t)=M/(1+A*(exp(-B*t))
60 next t
65 cls
70 print "Month    Sales"
75 print "--------------"
80 for t=1 to N
85   print using "####";t;
90   print using "#######.#";Y(t)
95 next t
```