COLOR TV INDUSTRY SALES FORECASTING : AN INPUT TO CORPORATE PLANNING

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ABSTRACT

This case teaches the state of the art in spectral time series analysis and forecasting methodology. It changes the way this type of problem is viewed. As input to its strategic planning activities, RCA, a large American corporation must determine the future direction of the color TV market. The case shows how to improve on past efforts by using the "Moving Window Spectral Method (MWS)" [1] to analyze and forecast each cyclical component in the historical data separately. The aggregate forecast is obtained by combining the component forecasts. The MWS method is the only method that will perform this analysis automatically.

CASE

The operations research planning meeting of a large corporation was convened to review the demand forecast for color television sets. From the looks on their faces Paul (Director of SIS) and Newton (Director of OR) still had considerable doubts about the future direction of the color television market, and therefore, the company's share. The estimated number of households for 1985 is now 84.5 million, and the household penetration is expected to reach 90%. It is almost that now.

Barry (Senior OR Analyst) remarked that : "the forecast for industry color television purchase rate, the percentage of households purchasing color TV sets, does appear to be on the high side." "Perhaps we are not quite sure where we want to be regarding a long term forecasting model," said Russell (Manager of OR) . "I think we have made good progress towards a technical short term forecasting model. The impact of peripheral devices such as video cassette recorders may impair the long term forecasting capability of our model," he continued. "I have been saying that all along ," said Steve P. (Senior OR Analyst). "Our technical models are all black box representations. I can see their applications being limited to short term inventory planning. My preference is for an econometric model." "All mathematical models are really black box until we interpret them, " Raj (Senior OR Scientist) reminded the group. Steve S. (Manager OR) offered a suggestion : "Following up on what Russell observed, we should expect color TV sales to be stimulated by VCR and home video game machine sales. Our customers have been using the TV set as a monitor for viewing in connection with these devices." "I agree," said Russell, ". . . otherwise there would have been the normal tendency toward market saturation." " It is not even clear what the cause and effect relationship between the TV and VCR is , " said Barry ." "Don't you think our data on color TV purchase rates is highly aggregated ?" asked Steve P. Well . . . we have been discussing ways of decomposing Color TV sales into component buyer segments, according to level of maturity," answered Barry. Steven P. followed up: " and how about breaking out the screen sizes too."

" Well, Russell ?," questioned Newton. Russell responded: "We have taken various time domain analysis approaches including moving averages, autoregressive models and exponential smoothing. Tammy (OR Analyst) has been running the regression analysis computer program. More recently, we have been looking at a product diffusion model. One method that we have not tried is spectral analysis. I understand that there is a new computer program called FOURCAST. It is based on the Multivariate Moving Window Spectral (MWS) Method." "I am interested in seeing how that method will model seasonal patterns and other market dynamics," requested Raj. " It appears that this particular method of spectral analysis can be carried out with little historical data," commented Jack (Senior OR Analyst). "Good," said Russell because that is all the data we have." "I can set up the micro computer operation ," offered Ray (Manager OR).

"Now why didn't I think of that," said Newton. "That is a frequency domain approach isn't it ? It certainly is a decomposition method , and if it is multivariate, then it could be used to develop a hybrid econometric/time series model. Modeling with spectral analysis will synthesize most of the exponential effects of the various buyer segments, represented in the aggregate data. Didn't this come up in discussions with Denis R. (University Professor)?" "Yes," answered Paul re-lighting a cigar, "he has been doing research in this area. In fact, he has agreed to join our team during the summer, and assist us in hammering out a forecast."
SIS - Strategic Information Systems. OR - Operations Research

INPUT DATA

NO	DATE	CTVPR	PRICEIND	INCOM
1	9/15/77	1.225	5.400	2.098
2	10/15/77	1.231	5.591	2.099
3	11/15/77	1.391	5.643	2.102
4	12/15/77	1.954	5.136	2.108
5	1/15/78	1.524	5.542	2.109
6	2/15/78	0.808	5.367	2.125
7	3/15/78	0.938	5.066	2.151
8	4/15/78	1.167	5.341	2.162
9	5/15/78	1.013	5.231	2.165
10	6/15/78	0.890	5.357	2.161
11	7/15/78	1.173	5.348	2.170
12	8/15/78	1.097	5.318	2.176
13	9/15/78	1.339	5.337	2.183
14	10/15/78	1.398	5.193	2.197
15	11/15/78	1.447	5.006	2.200
16	12/15/78	2.095	4.668	2.209
17	1/15/79	1.570	5.153	2.211
18	2/15/79	0.870	5.150	2.216
19	3/15/79	1.100	5.128	2.222
20	4/15/79	1.160	5.084	2.213
21	5/15/79	1.080	4.859	2.207
22	6/15/79	0.890	4.749	2.200
23	7/15/79	1.250	5.099	2.218
24	8/15/79	1.030	4.745	2.216
25	9/15/79	1.300	4.918	2.207
26	10/15/79	1.410	4.874	2.212
27	11/15/79	1.410	4.778	2.216
28	12/15/79	1.930	4.322	2.213
29	1/15/80	1.410	4.736	2.235
30	2/15/80	0.840	4.524	2.227

31	3/15/80	0.920	4.533	2.214
32	4/15/80	1.040	4.638	2.194
33	5/15/80	0.870	4.474	2.180
34	6/15/80	0.930	4.319	2.183
35	7/15/80	1.130	4.527	2.205
36	8/15/80	0.970	4.522	2.206
37	9/15/80	1.120	4.585	2.210
38	10/15/80	1.230	4.579	2.228
39	11/15/80	1.310	4.572	2.236
40	12/15/80	1.840	4.127	2.251
41	1/15/81	1.360	4.262	2.246
42	2/15/81	0.790	4.096	2.241
43	3/15/81	0.920	4.320	2.242
44	4/15/81	1.050	4.161	2.239
45	5/15/81	0.930	4.095	2.230
46	6/15/81	0.990	4.167	2.236
47	7/15/81	1.140	4.025	2.259
48	8/15/81	0.990	3.963	2.266
49	9/15/81	1.160	4.194	2.263
50	10/15/81	1.210	4.091	2.265
51	11/15/81	1.314	3.737	2.255
52	12/15/81	1.828	3.582	2.242
53	1/15/82	1.450	3.218	2.240
54	2/15/82	0.770	3.177	2.244
55	3/15/82	0.970	3.078	2.253
56	4/15/82	1.030	3.854	2.273
57	5/15/82	1.020	3.847	2.264
58	6/15/82	0.990	3.510	2.246
59	7/15/82	1.200	3.730	2.267
60	8/15/82	1.000	3.901	2.262
61	9/15/82	1.180	3.656	2.261
62	10/15/82	1.250	3.716	2.265
63	11/15/82	1.510	3.593	2.279
64	12/15/82	2.150	3.139	2.285
65	1/15/83	1.740	3.599	2.291
66	2/15/83	0.970	3.538	2.285
67	3/15/83	1.130	3.486	2.297
68	4/15/83	1.250	3.570	2.300
69	5/15/83	1.160	3.521	2.310
70	6/15/83	1.080	3.548	2.317
71	7/15/83	1.430	3.349	2.348
72	8/15/83	1.150	3.406	2.341
73	9/15/83	1.420	3.389	2.351
74	10/15/83	1.420	3.351	2.377
75	11/15/83	1.610	3.288	2.390
76	12/15/83	2.740	2.842	2.407
77	1/15/84	1.840	3.332	2.432
78	2/15/84	1.100	3.203	2.450
79	3/15/84	1.330	3.205	2.458
80	4/15/84	1.410	3.190	2.461
81	5/15/84	1.240	3.227	2.460
82	6/15/84	1.220	3.029	2.465
83	7/15/84	1.520	3.319	2.477
84	8/15/84	1.290	3.203	2.480
85	9/15/84	1.430	3.076	2.485
86	10/15/84	1.630	2.976	2.480
87	11/15/84	1.850	2.930	2.481
88	12/15/84	2.990	2.605	2.492

Notes on Input Data

CTVPR- Residential color television industry purchase rate (%).
PRICEIND- Industry color television real average price ($hundreds, base year 1982).
INCOM- Real disposable personal income ($thousand billions, base year 1982)

Question

Use the historical data provided (on diskette) [1] to develop a model that can be used to forecast industry color television sales for 1985. Management is interested in knowing the impact of any relevant variables[3][4]. How can management incorporate the model as a strategic planning tool.

Key Steps

Data, Plot, Transform, Model, Forecast, Inverse Transform [5][6][7].

Key Related Ideas

Transformation[5][6][7], Spectrum, Cycles, Frequency[2], Time Series, Trend, Regression, Historical, Forecast, Parameters, Statistical inference, Prediction interval, Extrapolation, Interactive forecasting, Strategic planning, t-test[1][2], F-test[1], Decomposition, Analysis of Variance (ANOVA)[8,9], Stationary, mean, variance, probability distribution, mean absolute percentage error, frequency response, impulse response, moving window[10].

APPENDIX

Courses & Levels

This case is suitable for graduate & senior undergraduate courses in production & operations management, management science, operations research, econometrics, business forecasting and strategic management.

Scope

RCA's portfolio of business activities includes research, design and the manufacture of color television sets. As input to strategic planning activities, insight into the future direction of the color TV market is required. The color TV is an integral part of the instructional, news and entertainment industries, a closed circuit monitor, and now a device which is ancillary to other prime movers such as video games. RCA faces local and significant foreign competition from other producers of consumer electronic devices. The RCA Operations Research (OR) team has already acquired historical data from the Electronics Industry Association of America.

Several time domain forecasting methodologies have been employed by OR Analysts at RCA. Historical data was analyzed primarily in terms of its trend, and possibly a seasonal effect. Some dynamics of the data may have been overlooked.

RCA wants to explore new methodologies designed to better estimate and thereby discover other components which may be embedded in the data. Spectral analysis will represent periodic components in the data. The case is intended to show that the way

to improve on past efforts is to analyze and forecast each cyclical component separately. The aggregate forecast is obtained by summing the component forecasts. The case incorporates the state of the art "Moving Window Spectral Method (MWS)." It is the only method that will perform this analysis automatically. This approach may be classified as a frequency domain method. The computer program FOURCAST [1] carries out this procedure, so that neither the instructor nor the student is required to do any programming. The program and the historical data are provided on a diskette. No keyboard data entry is required. The student may therefore focus on problem definition, and on applying the method to the data.

Discussion Question and Answers

The question that was asked in the case presentation is open ended. As a senior undergraduate student, there are several concepts wherein you may apply your statistical training. In doing so it is unlikely that all facets of the Moving Window Spectral Methodology will be utilized. The case will however provide useful exposure to the methodology, particularly the important concept of decomposition.

As a graduate student majoring in quantitative methods, you are expected to answer the question in great depth, with thoughtfulness and specificity. By making use of technical tools (e.g. statistical & other inference) many observations regarding the characteristics of the data, potential models, analysis of variance, and parameter estimates are possible. Use is to be made of the frequency domain, as well as the time domain characteristics of the data.

The Moving Window-Spectral Model

Let Y(t), t=1,2,.....,n represent a time series. In order to estimate a forecasting model, a moving window of length T is defined in the time domain (1). The moving window is used to generate sequences of observations in the time domain, each sequence containing an observation of length T on the input and output processes and for each frequency in the frequency domain (2) as follows [1][2].

The general discrete time domain AR(T) model relating the model variables is given by

$$Y_i(t) = \sum_{j=1}^{N} \sum_{k=1}^{T} Y_j(t-k)\, B_{ij}(k) + E_i(t) \qquad (1)$$

where N = the number of variables in the model

$B_{ij}(k)$ = system parameter, coefficient of Y_j in equation i, lagged k time periods.

$E_i(t)$ = the unobservable error term in ith equation.

i = 1,2,3,...,N. t=T+1,T+2,...,n.

Transforming the time domain model to the frequency domain yields

$$Y_{mi}(w) = \sum_{j=1}^{n} Y_{m-1,j}(w)\, B_{ij}(w) + E_{mij}(w) \qquad (2)$$

for m=2,3,..,n-T+1,and where the frequency $-\pi \le w \le \pi$.

Y(w) is the frequency domain counter part of Y(t) and B(w) is the spectral density function of the impulse response function B(t).

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