TEACHING HOW TO INTEGRATE MANAGERIAL EXPERIENCE AND JUDGMENT INTO A DECISION SUPPORTING SALES FORECASTING MODEL

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ABSTRACT

Instruction in model building and forecasting often emphasizes the technical without regard to how the model can be best utilized in supporting business decisions. In practice, model results are often modified or recombined according to managerial experience and judgment. To effectively utilize models the student needs to learn not only how to use available forecasting systems, but how and under what circumstances to adjust model results in accordance with managerial experience and judgment. The methodology introduced in this paper permits the integration of managerial insights into a market model and illustrates how model forecasting and decision supporting performance is improved.

INTRODUCTION

As computer based modeling systems become more available and more widely applied, we as teachers find that we are encouraging students to become ever more computer literate and to learn how to apply statistical modeling packages to business decisions.

Unfortunately, the needs of students to gain technical mastery of the computer systems and to grasp a basic understanding of the supporting mathematics often lead to a concentrated emphasis on the technical without regard to how the model can be best utilized in supporting business decisions. In practice, model results are often modified or recombined according to managerial experience and judgment. To effectively utilize models the student needs to learn not only how to use available forecasting systems, but how and under what circumstances to adjust model results in accordance with managerial experience and judgment.

In the following paper, a methodology is developed which shows students in a simple graphic style how to integrate managerial experience into a decision supporting forecasting model. The mathematics is reduced to a minimum and the integration of knowledge into the model is emphasized. The example shown in the following paper could be covered in one or two class sessions.

INTEGRATING EXPERIENCE AND JUDGMENT INTO THE MARKET MODEL

How best can we incorporate qualitative knowledge into a model framework? Reflect for a moment on how often you have heard individuals state their qualitative understanding in terms of maximum or minimum boundaries or limits. Examples might be "Our market share is at least 50% now." or "We know that their product lasts more than 10 years longer than ours."

Note that the above statements can be written mathematically as inequalities: "Market share $\geq$ 50%" or "Difference in product life $\geq$ 10 years". Examples of "less than or equal to" inequalities might be "We can not sell more than 50 units per month" (monthly sales $\leq$ 50 units) or "Our motor driven lawn mower can not exceed 10 mph" (speed $\leq$ 10 mph).

It would seem that people often state their knowledge in terms of limits or boundaries. In this paper, the experience and judgment of the company's sales manager and his staff are cast into terms that can be described mathematically as inequalities.

Once the qualitative information is expressed in terms of inequalities, the information can be integrated mathematically as a set of boundary conditions, or at least, as restrictions in the model framework.

In the following discussion, only one relationship of the model is presented. (For readers who wish a fuller treatment of the model and its development, they are referred to Hebein (1990).

FRAMEWORK OF APPLICATION

A manufacturer of non corrosive piping systems has successfully introduced a new product into the petroleum market (primarily retail gasoline outlets including convenience stores with pumps) several years earlier. Growth in sales has been better then expected and production facilities are near capacity.

The sales manager has been asked to prepare a three year sales forecast. Based upon the outlook for sales, the company will assess its need for new capacity and its longer term market strategy.

The product, non corrosive piping systems, is used to connect gasoline underground storage tanks with the gasoline pumps in retail gas stations (referred to as petroleum marketing outlets--PMO's--by the industry).

Unfortunately, the petroleum marketing industry has been contracting. Table 1 shows that the number of gas stations has contracted by 34% since 1977. Note the change in industry mix. Convenience store gas outlets (C-Store outlets) are expanding but not as fast as gas stations are contracting. The sales manager's fear is that sales opportunities are shrinking and that sales growth could drop significantly.

STUDENT ASSIGNMENT

At this point the students are requested to develop their own forecast of company sales. Most of the students use some linear mathematical approach such as log normal OLS to extrapolate a forecast. Since company sales have been increasing at a compound rate of 39% for the last 10 years (Table 1), students generally produce a forecast of continued 30-40% or so per year compound growth.

Once the forecast assignment is complete, the instructor reminds the students that the industry is shrinking. Can they be certain of their forecast? To place company sales into perspective, the students are asked to prepare a forecast of industry sales. Since no time series of industry sales is available, the students must construct one. To help the students begin, the instructor notes the relationship between changes in stock and sales. Assuming one unit of stock per unit of product, the change in stock is equal to product sales less replacements of worn out units. Once the students understand the relationship between changes in stock of PMO's, system replacements, and total industry sales, they are able to ascertain the relative position of the product in the industry and its likelihood of continued sales growth. Essentially, the students develop a limited structural model of the industry.

ESTIMATING INDUSTRY PRODUCT SALES

Mathematically, the relationship between sales and changes in stock can be described as one equation with two unknowns:

$$NB_t = R_t + \Delta PMO \quad (1)$$
$$= r_t\, PMO_t + \Delta PMO \quad (2)$$

with t = 1978, 1979,..., 1987; r_t = estimated average annual rate of removal of existing units; NB_t = new builds (new PMO's and replacement of existing units); ΔPMO = change in the number of petroleum marketing outlets (stock); and R_t = units of stock which are permanently removed or replaced by non corrosive product.

Equation (2) above has two unknowns, NB_t and r_t. The equation is indeterminate. To define the range of acceptable values of r_t, a value of r_t is selected and NB_t calculated. The company's market knowledge can be utilized to develop constraints on the range of NB_t. Before formulating the constraints in mathematical terms, we will discuss each constraint and the its rationale.

First, an acceptable value for r_t must generate removals of sufficient number that new builds are positive (select $r_t \mid NB_t \geq 0$). Intuitively, one can imagine years where new builds are zero, but it is impossible for new builds (which includes new construction and replacements) to be negative (less than none). Since annual changes in PMO's are usually negative (the number of outlets is declining), removals must be large enough to generate a positive value for each year in the time series of new builds. Mathematically, we can state the first inequality as: $NB_t \geq$ zero

Second, the replacement rate r_t must be sufficiently large to require new builds sufficient to match increases in the convenience store gas units (C-Stores). In other words, if all new builds are convenience stores, new builds must equal the increase in C-Stores. If removals are greater than zero, new builds must exceed the increase in C-Stores. That is, $NB_t \geq \Delta$ C-Store Outlets.

Finally, r_t must be constrained to a level which generates estimates of new builds that are consistent with product sales and market share. For example, if product sales are 100 units, and market share is 33%, than an r_t which suggests a new build level of 300 units is consistent with company information. The constraint will be expressed as a range of values bracketed as inequalities: min $MS_t \leq S_t$ / (r_t PMO + ΔPMO) $\leq$ max MS_t

Table 1
Available Data

YEAR	COMPANY SALES ($000'S)	ESTIMATED COMPANY MARKET SHARE (%)	GAS STATION OUTLETS (UNITS)	CONVENIENCE STORES (UNITS)	CONVENIENCE STORE OUTLETS (UNITS)
1973	305.0	35.0			
1974	1643.0	35.0			
1975	1870.0	35.0			
1976	465.0	36.0			
1977	422.0	37.0	176,465		
1978	686.0	38.0	170,628		
1979	659.0	39.0	164,790		
1980	1279.0	40.0	158,020	39,000	17,160
1981	2172.0	41.0	151,250	39,000	18,330
1982	3071.0	42.0	144,690	50,000	24,555
1983	3938.0	43.0	136,570	53,000	28,164
1984	5802.0	44.0	132,080	58,000	31,528
1985	6518.0	44.3	124,600	60,000	32,064
1986	8936.0	45.1	120,510	64,000	34,656
1987	11809.0	45.5	115,870	70,000	39,200

where MS_t is product market share of non corrosive piping sales; and S_t is sales of noncorrosive piping.

At this point, a time series of new builds is calculated for alternative values of r_t. Each simulated time series of new builds (NB_t) is then evaluated for its conformance to the constraints listed in the inequalities above.

In the classroom, a series of charts are used to make the evaluation more easily followed. Unfortunately, because of length constraints, the charts can not be included here. In the charts, selected values of r_t and the corresponding simulation of new builds are portrayed graphically. Each chart shows the relationship between new builds, removals, and changes in C-Store outlets across the 1978-1987 time period. In graphical form, violation of a constraint by a simulation of new builds is easily observable. Examination of the charts indicates that the simulation techniques lead to an r_t of 7% for the period 1978-1985, and an r_t of 5% for the period of 1986-1987.

COMPARISON OF FORECAST SALES WITH ACTUAL SALES

Table 2 shows the company's sales forecast in current dollars for the integrated market model (which includes managerial experience and judgment) and a log linear model sales projection. In Table 3, the sales forecasts projected in late 1987 are compared to the actual sales achieved by the company in the period 1987-1989. For the year 1990, only the first half year is available. However, a full year prediction is made based upon the company's plan and recent sales activity.

The forecast error is calculated as the percent of actual sales ((forecast-actual)/actual) x 100. The relative closeness of the forecast based upon the integrated model to the actual sales tends to confirm the basic model structure and the company's understanding of the market. Note that the log linear forecast is substantially higher than the actual sales.

Although the forecast accuracy of the integrated model is encouraging, it is important to recognize that there are many possible sources of error and that countervailing errors may contribute to the accuracy of the forecast. For example, to make the forecast, assumptions had to be made estimating the inflation rate, the average sales size, and the market share size. A higher than expected rate of inflation (increased current dollar sales) could be offset by lower average sales size (lower current dollar sales).

However, despite the inherent problems of forecasting the future, the forecast accuracy of the integrated model was superior to the log linear model and sufficient to sustain the managerial confidence gained by the systematic inclusion of company experience and judgment.

SUMMARY AND CONCLUSIONS

The preceding paper has described a process which permits the systematic integration of qualitative information, such as experience and judgment, into a quantitative market model. The graphical exposition supported by simple mathematics permits students to access elements of large model construction and provides an example of how management experience and judgment can be used within a model framework.

Furthermore, note that the students are shown how helpful management experience can be in achieving a "reasonable" model solution. In fact, the model had satisfactory forecast accuracy and was accepted by company management as an important decision support tool for a major capital investment decision.

In this case, the company rapidly expanded its capacity. Prior to the development of the integrated market model, the company management had regarded the petroleum market as one of limited potential, with little prospects for real growth since the number of petroleum market outlets were declining.

The integrated model's forecast that sales could double in a four year period led to reconsideration of the petroleum market and substantial capital investment in the business. As indicated by Wright (1988), the trend is to evaluate forecasting models by their impact on decisions. If the bottom line for market models is their impact on firm profitability, then the integrated market model described in this paper was a success.

Also, it can be seen that by including experience and judgment into the model, the model maker, or

Table 2: Company Sales Forecast

YEAR	NEW BUILDS (UNITS)	INDUSTRY SALES (UNITS)	INDUSTRY SALES ($82)	INTEGRATED MODEL FORECAST COMPANY SALES ($82)	LOG LINEAR MODEL FORECAST COMPANY SALES ($82)
1986	7662	3473.05	$17,365,247.35	$7,831,726.56	$8,597,749.74
1987	7684	4417.68	$22,088,379.71	$10,050,212.77	$11,731,988.74
1988	9075	5898.75	$29,493,750.00	$13,567,125.00	$15,851,755.25
1989	9510	6466.8	$32,334,000.00	$15,520,320.00	$21,282,227.42
1990	9478	6634.25	$33,171,250.00	$16,884,166.25	$28,354,026.09

Table 3: Comparison of Forecast with Actual Sales

YEAR	ACTUAL COMPANY SALES (000'S)	INTEGRATED MODEL FORECAST COMPANY SALES ($000'S)	INTEGRATED MODEL FORECAST ERROR ((F-A)/A)*100 (%)	LOG LINEAR MODEL FORECAST COMPANY SALES ($000'S)	LOG LINEAR MODEL FORECAST ERROR ((F-A)/A)*100 (%)
1986	$8,936.0	$8,936.0	-----	$9,810.0	9.78
1987	$11,809.0	$11,809.0	-----	$13,785.1	16.73
1988	$17,300.0	$16,579.0	-4.35	$19,370.8	11.97
1989	$19,800.0	$19,857.2	0.29	$27,219.6	37.47
1990	$23,000.0	$22,768.7	-1.02	$38,249.6	66.30

student, is forced to learn about the business and more importantly, to establish meaningful communications with management. As indicated by Gross (1987-1988), part of the success of any forecasting model can be attributed to the inclusion of practitioner experience and market knowledge. In this example, the students learn how to build forecasts that include managerial knowledge.

Finally, the forecast achieved by the integrated model is relatively accurate (within 5%). As suggested by Liu (1987), it seems reasonable that the development of model structure which includes more information, such as company market knowledge and industry data, has a greater chance of making superior forecasts.

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