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Selection of Sales Forecasting Technique using a Tool of Zero-One Integer Goal Programming

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Abstract

Sales forecasting is one of the most crucial inputs to a firm's decision making process. The achievement of the organizational goal depends upon the selected sales forecasting techniques that will give the necessary information to pursue these goals. Since the sales forecast is crucial to a firm's success it is important that the right technique is selected to generate forecasts. Because of the importance of technique selection the overall purpose of this study is to propose and demonstrate a methodology for improving the sales forecasting technique selection process by using a tool of zero-one integer goal programming.

Methodology: *The methodology of zero-one integer goal programming is used to suggest which sales forecasting technique should be used for given sales forecasting situation. The possible way of setting up the goal program is to use the evaluation criteria as goals to achieve. In order to test the significance of goal programming approach a comparison is made between the protocol results and predicted results by using the percentage estimates of rank order of techniques.*

Practical Implications: *The use of goal programming formulation provides a formal, logical way of thinking about decision making process. This should increase the understanding of this problem area and increase the quality of decisions. Since goal programming is an optimization technique it gives a more normative approach to decision-making and emphasizes such activities as sensitivity analysis and measurement.*

Keywords: *Sales Forecasting Techniques, Goal Programming, Evaluation Criteria*

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1. INTRODUCTION

Sales forecasting is one of the most crucial aspects of planning for almost all companies. The importance of selection of sales forecasting technique has increased due to the increase in the number of sales forecasting techniques used by companies. The functions of various departments are dependent on the sales forecast. Sales forecasting has become one of the crucial inputs to a firm's decision making process. The achievement of the organizational goal depends upon the selected sales forecasting techniques that will give the necessary information to pursue these goals. Each technique differs in characteristics-therefore, some techniques may be more useful for certain goals than others. Since the sales forecast is crucial to a firm's success it is important that the right technique is selected to generate forecasts. Because of the importance of technique selection the overall purpose of this study is to investigate the sales forecasting selection process. Even though the forecasting technique selected depends on the situation, it usually is possible for more than one technique to be used for forecasting in the situation.

2. LITERATURE REVIEW

Historically, modeling and forecasting sales data is one of the major research efforts and many theoretical and heuristic methods have been developed in the last several decades. The available traditional quantitative approaches include heuristic methods such as time series decomposition and exponential smoothing as well as time series regression and autoregressive and integrated moving average **(ARIMA)** models that have formal statistical foundations. Nevertheless, their forecasting ability is limited by their assumption of a linear behavior and thus, these are not always satisfactory. There has been a great deal of discussion in economic literature about applications of various forecasting models for forecasting desired issues. Several time series forecasting techniques such as naive models to **ARCH and GARCH** and further advanced model have been applied to explain forecasting performance of preferred variables. The explanatory methods make projections of the future by modeling the relationship between same series and other series. Under such methods, any changes in inputs will affect the output of the system in a predictable way, assuming the relationship is stable.

Linear programming was developed by **Dantzig** in the early 1940s. However this methodology only allowed one to look at accomplishing one objective at a time. Goal programming was introduced by **Charnes and Cooper** in **1961**. This technique was first viewed as a means for approaching unsolvable linear programming problems. Goal programming is a methodology that can be used when the decision maker is faced with a problem having a single goal with multiple sub-goals. It is also appropriate in cases having multiple goals and sub-goals.

Some of the main assumptions with respect to goal programming are as follows:

- The function may be linear or nonlinear. Non-linear functions are transformed to linear approximations.
- Variables may be continuous, integer, and/or zero-one.
- The decision maker can establish preemptive priorities for each objectives or groups of objectives.
- All decision variables must be non-negative.

The advantage of goal programming is rather than attempting to maximize or minimize an objective function directly, the algorithm seeks to minimize the deviations from each goal subject to the constraints imposed by the entire goal set. The deviational variables around each goal can be both positive and negative. That is, a goal can be underachieved or over-achieved. The algorithm first seeks to minimize the deviation from the highest priority goal. Next, the algorithm looks at the second highest priority goal and attempts minimization of the deviations subject to the constraints imposed by the first priority goal. This algorithm continues through the entire goal set with higher priority goals constraining the lower priority objectives. Consequently, it is very doubtful that all goals will be completely achieved in a goal programming solution.

3. GOAL PROGRAMMING TECHNIQUE

The goal programming algorithm consists of the objective or achievement function and a set of goal constraint equations. The achievement function contains the deviational variables weighted by their preemptive priority coefficients. The goal constraint equations express the relationship between the decision variables and the desired goal levels.

The complete specification of the linear goal program is as follows:

Find: $\bar{X}=(X_1, X_2 \ldots\ldots X_{12})$ **so as to minimize**

$$\bar{a}=\{P_1.g_1(\bar{n}, \bar{p}), P_2.g_2(\bar{n}, \bar{p}), \ldots P_k.g_k(\bar{n}, \bar{p})$$

Such that: $\sum_{j=1}^{j} C_{i,j}.x_j + n_i - p_i = b_i$ **for i = 1,2, …m**

$$\bar{x}, \bar{n}, \bar{p} \geq \bar{0}$$

The rules for minimizing the deviational variables (n_i and p_i) in the achievement function are as follows:

$b_i = (n_i$ **and** $p_i)$

$b_i \geq (n_i)$

$b_i \leq (p_i)$

Where the positive deviation (for goal i) is designated by p_i and the negative by n_i. The deviation from each goal are minimized with respect to the preemptive priority weight (P_j) assigned to the goal, b_i is the goal value for goal i, $C_{i,j}$ is the coefficient associated with variable j in the i^{th} objective, $g_k(\bar{n}, \bar{p})$ is a linear function of the deviation variables, P_k is the priority associated with $g_k(\bar{n}, \bar{p})$, K = m, i.e., the number of preemptive priorities are equal to or less than the total number of objectives.

4. OBJECTIVE OF THE STUDY

The primary objective of this study is to propose and demonstrate a methodology for improving the sales forecasting technique selection process by using a tool of zero-one integer goal programming. The secondary objective is to gain a greater understanding of the selection process

from the view point of practitioners in order to make recommendations to improve this process.

5. RESEARCH METHODOLOGY

Type of study: This study can be best classified as a descriptive research design. There are also some aspects of this study that are exploratory and will provide the initial information to indicate future research direction.

Sampling and sample selection: The purposive sampling method is used to collect the sample. The sample consisted of respondents from ten fast moving consumer goods companies. All ten companies requested confidentiality as a requirement for their participation.

Instrument: Self-administered questionnaire was used for getting the response from the forecasters in order to select the sales forecasting technique using a tool of zero-one integer goal programming approach.

(a). Selection of Sales forecasting Techniques: The following sales forecasting techniques are considered in this study:

- Moving Average
- Single Exponential Smoothing
- Holt Exponential Smoothing
- Winter's Exponential /Smoothing
- Decomposition Method
- ARIMA method
- Regression Method
- Econometric Method
- Jury of Executive opinion
- Sales force Composite method
- Delphi method

(b). Selection Criteria for Sales forecasting techniques: The following criteria are used to evaluate the performance of above mentioned sales forecasting techniques:

- Predictive strength of the model
- Time span
- Volume of initial data required
- Characteristics of initial data
- Forecast cost
- Complexity of the model
- Number of variables
- Correlation among variables

(c). Scales: Seven-point scales are used for the goal programming task since a greater degree of discrimination is needed for evaluating a sales forecasting technique.

A methodology using zero-one integer goal programming is used to select a forecasting technique based on evaluation criteria (such as predictive strength of the model, time span, forecast cost etc.). Goal programs will be run for each respondent using the parameters provided by the respondent. Actual choice of technique will be compared with the choice of technique predicted using the goal programming strategy. A comparison will be made with the proportion of correct predictions given from a random model.

6. FINDING AND ANALYSIS

The objective of this study is to propose and demonstrate a methodology for improving the sales forecasting technique selection process by using a tool of zero-one integer goal programming. For the requirement of this study two basic methods are used. The first is to use protocol analysis: The respondent is asked to give the decision strategy he is using to choose a technique for a particular sales forecasting scenario. The second is to use a goal programming strategy to predict the preparer's choice of sales forecasting technique for a given forecasting situation. The goal programming strategy prediction is performed by using the technique evaluation criteria mentioned above. A comparison is made between the protocol results and the prediction results that follow. The prediction results are obtained by trying to predict - using a goal programming strategy- the sales forecasting techniques chosen by the preparers for a sales forecasting scenario. This is done by using the technique evaluation strategy. The prediction results are more complicated and there are several ways in which these might be analyzed.

Measures on each of these criteria are given for each of the techniques in **Table 1**.

Table 1: Evaluation criteria measurement for the Sales Forecasting Techniques

Criteria	Sales Forecasting Techniques											
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	Goal Range
G_1	1	1	2	2	4	5	6	7	6	4	5	≤ 7
G_2	1	1	2	2	5	6	6	7	6	4	5	≤ 7
G_3	1	1	2	2	4	6	6	7	5	4	4	≤ 7
G_4	1	1	2	2	4	6	6	7	5	4	4	≤ 7
G_5	1	1	2	2	3	5	6	7	5	4	4	≤ 7
G_6	1	1	2	2	4	5	6	7	4	3	3	≤ 7
G_7	1	1	2	2	4	6	6	7	5	4	4	≤ 7
G_8	1	1	2	2	4	6	6	7	6	4	5	≤ 7

For predictive strength of the model (G_1) a subjective estimate is given for each technique. These estimates are based on the responses received from the respondent for sales forecasting technique's performance on the basis of various criteria. For e.g., the technique X_1(Moving Average) is given a 6 for predictive strength of the model. A goal attainment value of 7 has been given for this situation. Since the inequality for this equation is 'less than or equal', the negative

deviation n_1 will be minimized. The equation for G_1 (predictive strength of the model) is as follows:

$$\mathbf{G_i = \sum_{j=1}^{11} C_{1,j}.\ X_j + n_1 + p_1 = b_1}$$

$$G_1 = 1X_1 + 1X_2 + 2X_3 + 2X_4 + 4X_3 + 5X_6 + 6X_7 + 7X_8 + 6X_9 + 4X_{10} + 5X_{11} + n_1 - p_1 = 7$$

If only X_1(Moving Average) is used the value of X_1 will equal 1 and all other variables X_2 to X_{11} will equal 0. Thus G_1 (Predictive Strength of the model) will achieve a value of 6. Consequently, the negative deviation (n_1) will take a value of 1 and G_1 will be underachieved by this amount (since goal attainment value $b_1 = 7$).

The equation for G_2 (Time span) is as follows:

$$G_2 = 1X_1 + 1X_2 + 2X_3 + 2X_4 + 5X_5 + 6X_6 + 6X_7 + 7X_8 + 6X_9 + 4X_{10} + 5X_{11} + n_2 - p_2 = 7$$

The equation for G_3 (Volume of initial data required) is as follows:

$$G_3 = 1X_1 + 1X_2 + 2X_3 + 2X_4 + 4X_5 + 6X_6 + 6X_7 + 7X_8 + 5X_9 + 4X_{10} + 4X_{11} + n_3 - p_3 = 7$$

The equation for G_4 (Characteristic of initial data) is as follows:

$$G_4 = 1X_1 + 1X_2 + 2X_3 + 2X_4 + 4X_5 + 6X_6 + 6X_7 + 7X_8 + 5X_9 + 4X_{10} + 4X_{11} + n_4 - p_4 = 7$$

The equation for G_5 (Forecast costs) is as follows:

$$G_5 = 1X_1 + 1X_2 + 2X_3 + 2X_4 + 3X_5 + 5X_6 + 6X_7 + 7X_8 + 5X_9 + 4X_{10} + 4X_{11} + n_5 - p_5 = 7$$

The equation for G_6 (Complexity of the model) is as follows:

$$G_6 = 1X_1 + 1X_2 + 2X_3 + 2X_4 + 4X_5 + 5X_6 + 6X_7 + 7X_8 + 4X_9 + 3X_{10} + 3X_{11} + n_6 - p_6 = 7$$

The equation for G_7 (Number of variables) is as follows:

$$G_7 = 1X_1 + 1X_2 + 2X_3 + 2X_4 + 4X_5 + 6X_6 + 6X_7 + 7X_8 + 5X_9 + 4X_{10} + 4X_{11} + n_7 - p_7 = 7$$

The equation for G_8 (Correlation among variables) is as follows:

$$G_8 = 1X_1 + 1X_2 + 2X_3 + 2X_4 + 4X_5 + 6X_6 + 6X_7 + 7X_8 + 6X_9 + 4X_{10} + 5X_{11} + n_8 - p_8 = 7$$

An Illustration using the Algorithm:

Find X_1, X_2, X_3, and X_4 so as to minimize

Min $\bar{a} = \{p_1 (n_1 + n_2), p_2 (n_3)\}$

G_1: $2X_1 - X_2 + n_1 - p_1 = 0$

G_2: $X_1 + X_2 + X_3 + X_4 + n_2 - p_2 = 2$

G_3: $-3X_1 - X_2 - 4X_3 - X_4 + n_3 - p_3 = -6$

$X_1, X_2, X_3, X_4 = 0, 1$

$\bar{n}, \bar{p} \geq \bar{0}$

Solution: $X_1 = 1, X_2 = 0, X_3 = 0, X_4 = 1, \bar{a} = (0, 0)$

In order to compare the protocol results and predicted results with some standard of performance the percentage will be compared with what would have been obtained from a random model. The expected percentage for a random model and the observed percentage from prediction for the evaluation criteria are given in **Table 2**.

Evaluation Criteria

Sales Forecasting Technique	Rank	Protocol results (%)	Predicted results (%)
Moving Average	1	100	100
Single Exponential Smoothing	1	100	100
Holt Exponential Smoothing	2	100	100
Winter's Exponential Smoothing	2	100	100
Decomposition Method	4	97	98
ARIMA method	6	98	96
Regression Method	6	96	96
Econometric Method	7	99	100
Jury of Executive opinion	5	94	97
Sales force Composite method	4	96	93
Delphi method	4	97	95

From the above table it is seen that the protocol results (%) are closer to the predicted results (%) using zero-one integer goal programming approach. Thus it seems from the above results that the goal programming strategy is making a significant contribution in predicting the preparer's choices for selecting the sales forecasting techniques.

It also seems from the research findings that the preparer finds it appropriate to directly incorporate in the decision making based on evaluation criteria. The possibility still exists that by only looking at prediction, the preparer may be using another type of choice strategy that happens to give the same results as the goal programming strategy.

From the above results it is found that the use of goal programming in sales forecasting techniques selection is a reasonable approach to follow in modeling the sales forecasting technique selection process. It also appears that preparers are predominantly using several technique evaluation criteria rather than taking corporate goals into consideration when selecting a sales forecasting technique.

7. CONCLUSION

Goal programming is not viewed here as only a mathematical algorithm but as a cognitive process of decision making. The goal programming methodology looks at deviations from specified goals. This is very similar to specifying minimum and/or maximum acceptable levels on dimensions depending on how the deviations are minimized. A goal programming formulation places the evaluation process into a broader perspective. This may increase the understanding of the problem at hand. Since goal programming is an optimization technique it gives a more normative approach to decision-making and emphasizes such activities as sensitivity analysis and measurement.

The use of goal programming for the sales forecasting technique selection process pinpoints critical measurements that should be made. For e.g., where currently only subjective estimates

could be given for certain goals, in the future it might be possible to set up some kind of objective measures to use in its place. The advantage of using such a model is points out that this type of measurement is needed. The use of a goal programming formulation also provides a formal, logical way of thinking about this decision process. This should increase the understanding of the problem area at hand and increase the quality of decisions.

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APPENDIX

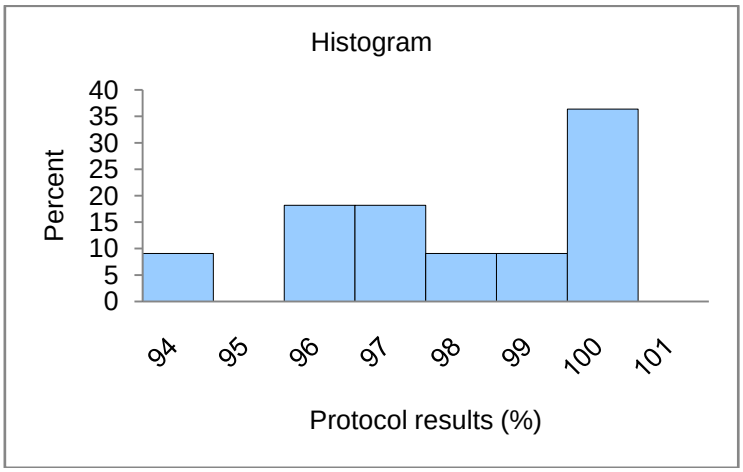
Correlation Matrix

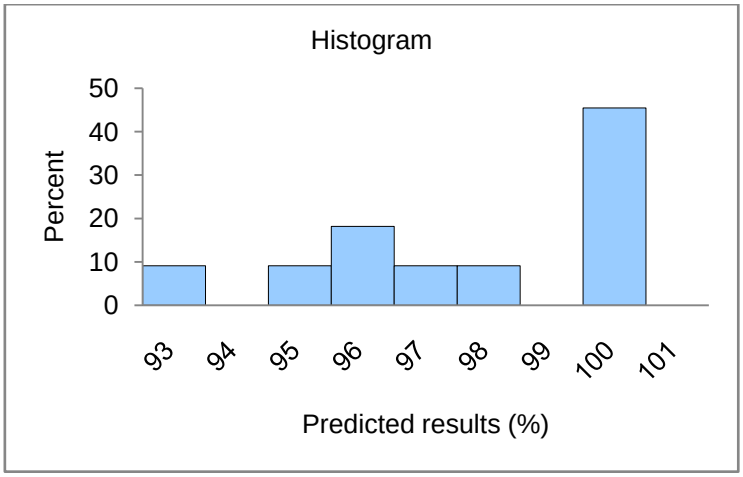
	Protocol results (%)	*Predicted results (%)*
Protocol results (%)	1.000	
Predicted results (%)	.750	1.000

11	sample size
± .602	critical value .05 (two-tail)
± .735	critical value .01 (two-tail)

Descriptive statistics	
Protocol results (%)	
count	11
mean	97.91
sample variance	4.29
minimum	94
maximum	100
range	6
skewness	-0.51
kurtosis	-0.79
coefficient of variation (CV)	2.12%
p-value	.3173
chi-square(df=1)	1.00

Descriptive statistics	
Predicted results (%)	
count	11
mean	97.73
sample variance	6.22
minimum	93
maximum	100
range	7
skewness	-0.61
kurtosis	-0.82
coefficient of variation (CV)	2.55%
p-value	.0313
chi-square(df=1)	4.64


Histogram
Percent
40
35
30
25
20
15
10
5
0
94
95
96
97
98
99
100
101
Protocol results (%)


Histogram
Percent
50
40
30
20
10
0
93
94
95
96
97
98
99
100
101
Predicted results (%)