LTIPLE LINEAR REGRESSION VIEWPOINTS
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BUDGET ALLOCATIONS AT MSU: LINEAR REGRESSION POLICY CAPTURING ANALYSIS

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ODUCTION:

Within higher education circles, the 1960's are already being wistfully re-
ed to as the "golden decade". During these halcyon years the major problem
ng most established universities was how to take advantage of the available
; to achieve maximum growth. MSU was no exception to this phenomenon. The
cupation with growth left little room for concerns about efficiency, and
was reflected in the University's management style. Ample funds relieved
al administrators of the need to make hard allocation decisions. At MSU,
nly requirement placed on departments and colleges by the Provost was one of
ding him with a general account of what they were doing. The format of this
al report" was left completely open and the units typically used this oppor-
y to portray their accomplishments and lever for more funds by hinting at
achievements were just around the corner. With the start of the 1970's, con-
ned budgets suddenly materialized. The economic problems that plagued nation-

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al and state governments alike put the large, state supported, research oriented universities under a double loss as both state appropriations and federally-sponsored research funds began to lag. At MSU it became immediately obvious that the annual report provided neither the information nor the mechanism by which the Provost could make allocation decisions. This situation provided the impetus to develop a university-wide system called the Annual Evaluation and Report (AER), which combined the functions of program evaluation, academic planning, unit budgeting, and fund allocation.

THE PROBLEM:

Under the AER process, the allocation of new funds was procedurally dependent upon the results of a very detailed analysis of unit, department, and college data. Obviously, no allocation process can operate totally on quantitative data and so the admission of highly subjective judgments into the allocation process was essential; however, the amount by which the subjective considerations offset the quantified information is not easily controlled or even determined. This then is the issue at hand. How closely have fund allocations followed the recommendations resulting only from an examination of hard data? Before taking this question on directly, it was necessary to take into consideration some artifacts of the AER procedure itself in order to develop a series of reasonable hypotheses.

PRELIMINARY CONSIDERATIONS

Although data pertaining to every academic unit are thoroughly analyzed, and judgments are made as to the need for further staffing and support, the final allocations from the Provost are not made on a department by department basis.

er, the allocation decisions are made at the college level. In cases where the departments within a college are consistently high or consistently low eed for additional resources, the aggregation of these departmental judgments he college level will result in a similar, clear-cut indicator. However, the departmental needs and performances are widely divergent within one col-, the final allocation decision that can develop from a synthesis of such a d pattern is much more subjective and unpredictable. Another complexity of relations between departments and their colleges is the fact that although cations are made to the college on the basis of specific departmental needs, AER procedure does not restrict the dean's flexibility in reallocating funds is/her departments. Thus there is no mechanism to ensure that the departments ive the funds that central administrators intended for them.

Out of consideration of the above, what might have been our original question e., the degree of match between allocations to departments and departmental --now expands into a series of questions:

1) Over a period of 5 years how well can we predict department budget increases from the key data elements reflecting upon the operation of the department?
2) Does our predictive ability increase if we know what college a department belongs to?
3) How well are college budget increases predicted from the college level data?
4) Does there seem to be a halo effect associated with the allocation process, i.e., does knowledge of a unit's (department or college) previous year's allocation enhance the predictive power of the data?

METHOD:

McNeil, Kelly, and McNeil discuss policy capturing (pp. 405-419) as an application of multiple linear regression. The process involves seeking variables which correlate with the results of some decision making process. They present, by way of example, Christal's fable "Selecting a Harem", the point of which (stated far more amusingly in the original than here) is that if a characteristic adds to the ability to predict the decision, then it must have been considered in the making of the decision. We have, in the AER process, a clear set of decisions (change in budget) and a group of "characteristics" which were intended to be a part of the decision making process. We know beforehand the explicit components of the budgeting policy and procedure. From these known elements we can, by induction, make several assumptions regarding the patterns by using regression techniques. Each of the four questions calls for some statistical evidence that the known elements of the budget policy have the effects which should most obviously occur. Our intention was to adopt the McNeil, Kelly, McNeil-Christal approach to this situation by referencing each question in terms of a full and restricted model to determine to what degree (if any) available information influenced the decision makers.

Seventy-two departments fit our criteria for complete data. We knew from the start that it could be difficult to find statistical significance for a small sample with large numbers of predictors. Indeed, we were aware as we started that at least one model would require that we use an N of 12, the number of colleges in our study. Since there was no way to increase the sample size (it was, save for departments and colleges deleted to eliminate reporting inconsistencies,

the same as the population), it seemed reasonable (meaning that we saw no alternative) to approach significance from the view of replication: "The proof is always in the prediction; and whether or not a finding from a small sample has meaning rests in empirical replication" (McNeil, Kelly, and McNeil, p. 352). We felt that our sets of annual data allowed for a kind of replication. If certain variables accounted for a large amount of R^2 in every year, and if the total R^2 was consistent, then we might claim to have at least trailed and treed the policy if not exactly to have captured it. (Trailed = R^2 .25, Treed = R^2f .50, Captured = R^2 over 75, by unilateral and rather arbitrary definition.)

Statistics were calculated by program REGRAN, a routine in the Veldman Library. It contrasts full and restricted models through the calculation of $F = \frac{(R^2_f - R^2_r)/dfn}{(1 - R^2_f)/dfd}$. The first column of Table 5 was calculated on SPSS because of the need to transform variables, an option we have not yet had time to build into Veldman.

The next two sections describe the details of the variables and the hypotheses used to answer each of the four policy questions.

THE MODEL VARIABLES:

Dependent Variables:

$B_i(t)$ = Unit's budget change, from your (t-1) to year t, expressed as a percentage of the total budget.

i = 1 for the model using departments as the units (hypotheses 1, 2, 4).

i = 2 for the model using colleges as the units (hypotheses 3, 4).

Independent Variables

$E_i(t)$ = Department enrollment change measured in Student Credit Hours (SCH).

$EP_i(t)$ = Department's enrollment change expressed as a percentage.

$R_i(t)$ = Outside grant and contract research funds attracted by the department.

$RF_i(t)$ = Outside grant and contract research funds per full time equivalent faculty (FTE) member in the department.

$P_i(t)$ = Department's published outputs per FTE.

$AAU_i(t)$ = Department's SCH/FTE workoad compared to AAU departments average workload. The comparison is expressed in terms of % change in faculty staff needed to match the AAU workloads.

$PBES_i(t)$ = Department's SCH/FTE workload compared to similar MSU departments average workloads in a manner identical to AAU(t).

$COL_k(t)$ = Membership variable indicating to which of the twelve colleges the department belongs. K = 1, 2, ... 11.

THE HYPOTHESES:

Hypothesis 1a, b, c, d, e: For each of the five budget years, certain AER variables are significant predictors of annual department budget change.

Full Model: $B_1(t) = A_0U + C_1E_1(t) + C_2W_1(t) + C_3R_1(t) + C_4RF_1(t) + C5SP_1(t) + C_6EP_1(t) + C_7AAU_1(t) + C_8PBES_1(t) + E$

Restricted Model: $B_1(t) = A_0U(t) + E \qquad t = 1, 2, 3, 4$

(Models 1, b, c, d, e, related to years t + 1(FY 1976), ... , 5 (FY 1980)

Hypothesis 2a, b, c, d, e: College membership is a significant predictor of annual department budget change over and above the effects of the AER variables.

Full Model: $B_1(t) = A_0U(t) + \ldots + C_8PBES_1(t) + D_kCol_k(t) + E$

$k = 1, \ldots, 11$

Restricted Model: $B_1(t) = A_0U(t) + \ldots + C_8PBES_1(t) + E$

$t = 1, \ldots, 5$

Hypothesis 3a, b, c, d, e: A subset of the predictors in Hypothesis 1 will significantly predict change in the college budget (given year).

Full Model: $B_2(t) = A_0U(t) + C_1E_2(t) + C_2W_2(t) + C_3R_2(t) + E$

Restricted Model: $B_2(t) = A_0U(t) + E \qquad t = 1, \ldots, 5$

Hypothesis 4a, b, c, d: The previous years' departmental budget changes are significant predictors of annual department budget change.

Department

Full Model: $B_1(t) = A_0U + C_1B_1(t-1)$

Restricted Model: $B_1(t) = A_0U(t) \qquad t = 2, 3, 4, 5$

College

Full Model: $B_2(t) = A_0U(t) = C_1B_2(t-1) + E$

Restricted Model: $B_2(t) = A_0U(t) + E$

Results

Table 1
Hypothesis 1
(8 Basic Predictors)

Year	R^2 Full	R^2 Restricted	F	P	dfn	dfd
1974	.0838	.00	.721	.6741	8	63
1975	.1611	.00	1.512	.1707	8	63
1976	.1931	.00	1.884	.0778	8	63
1977	.0502	.00	.416	.9071	8	63
1978	.2178	.00	2.192	.0394	8	63

Table 2
Hypothesis 2
(College Over and Above 8 Basic Predictors)

Year	R^2 Full	R^2 Restricted	F	P	dfn	dfd
1974	.2897	.0838	1.372	.2140	11	52
1975	.4110	.1611	2.006	.0463	11	52
1976	.2410	.1931	1.299	.9828	11	52
1977	.4385	.0502	3.270	.0021	11	52
1978	.3352	.2178	.835	.6076	11	52

Table 3
Hypothesis 3
College Level Data
Budget with Outside Dollars, Student Credit Hours, Enrollment as Predictors

Year	R^2 Full	R^2 Restricted	F	P	dfn	dfd
1974	.4086	.00	1.612	.2707	3	8
1975	.2843	.00	.927	.5223	3	8
1976	.6388	.00	4.127	.0559	3	8
1977	.1943	.00	.563	.6589	3	8
1978	.2537	.00	.793	.5369	3	8

Table 4
4a
Hypothesis 4
(Previous Budget Change - Department)

Year/ Predicted by	R^2 Full	R^2 Restricted	F	P	dfn	dfd
1978 by Prev. 4	.0990	.00	1.868	.1252	1	68
1978 by 1977	.0074	.00	.521	.5202	1	70
1977 by 1976	.0083	.00	.584	.5464	1	70
1976 by 1975	.0075	.00	.532	.5249	1	70
1975 by 1974	.0139	.00	.985	.6746	1	70

4b
(Effect of Previous Budget Change - College)

Year/ Predicted by	R^2 Full	R^2 Restricted	F	P	dfn	dfd
1978 by Prev. 4	.2621	.00	.533	.7190	4	6
1978 by 1977	.2238	.00	2.595	.1392	1	9
1977 by 1976	.0988	.00	.987	.6518	1	9
1976 by 1975	.1057	.00	1.063	.3307	1	9
1975 by 1974	.0933	.00	.926	.6366	1	9

DISCUSSION:

Variance accounted for by the eight predictors is fairly small, about 20% in the year it is largest (1976) (Table 1). We were concerned that this seemed to suggest that very little of the decision was based on the data. This concern lead to some manipulations which we shall describe further on and the "College over and above" hypothesis. In 1976 and 1978 the variance accounted for may be considered

Variance accounted for by college membership in addition to the other variables ranges from 28 to 44%, a considerable improvement (Table 2). F probabilities

in 1975 and 1977 are .0463 and .0021, respectively, which adds to the credibility of the pattern. The suggestion of these hypotheses seems to be that a department is more dependent on its collegiate affiliation than on its departmental merits in certain years. To some degree, experience and the data tell us that this is true. Inspection of weighting coefficients identified exactly those colleges which have received large budget increases because of very heavy enrollment demands. Apparently, in a given year, such conditions reduce the Provost's flexibility and leave less money to be distributed through the rest of the system. The most extreme form of the result would be the low productivity department in a high budget college receiving extra funds simply because they are available to the dean and the high productivity department in a college which is not at the positive end of the need cycle receiving a very small, or no, increase as the dean attempts to stretch the resources around his or her units.

The low R^2's for 1a through 1e motivated us to also build a model using curvilinear relationships. Using the ten most commonly recurring predictors, linear and curvilinear, across the five years as the predictors produced results which were not all that different from those obtained in 1a through 1e (Table 5). This would again seem to indicate that the department is often not the focal unit in this process.

Table 5

Year	10 Modified R^2	8 Original R^2
1974	.13445	.0838
1975	.11023	.1611
1976	.24694	.1931
1977	.10332	.0502
1978	.20089	.2178

Perhaps another point to consider is that it is likely that central administrators suffer from such intense information overload that they are forced to make their decisions on the basis of data aggregated in the most concise manner and to assume that deans will distribute funds in the most meaningful way. A promising route for future study would be to attempt to capture deans' policies.

The number of colleges was too small to allow us to test the hypothesis that the eight basic predictors aggregated at the college level accounted for larger amounts of variance than when aggregated at the department level (a fairly obvious corollary of the previous hypotheses). To test for the general idea, we chose three variables which appeared to be heavy contributors (outside dollars, student credit hours, enrollment) (Table 3); the results showed that even this small number of predictors accounted for fairly large proportions of variance at the collegiate level, which tends to confirm the previous results relative to collegiate influence and the role of the college in the decision making process.

Table 4 shows the results of tests to determine the "carry over" or "halo" effects of budget changes to subsequent years. Probabilities are very low; however, the patterns are consistent with the other results: little predictability at the department level, more at the collegiate level.

No one should be totally surprised that provosts or other budget level officials are forced by the complexity of their tasks to focus their decisions at the highest level possible. These findings may, however, confirm the suspicions and feelings of many department chairs that they are at the mercy of forces outside their control.

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