Geoffrey B. Isherwood and Socrates Rapagna

An Algorithm *
for Cost Analysis
of a University Faculty

The climate of accountability that increasingly surrounds university financing led to this study of the way in which funds were actually reaching students and programs within a particular university faculty. Concentrating on operating funds (mainly salaries) and on the numbers of students in courses, Isherwood and Rapagna were able to show differences in costs between departments, between graduate and undergraduate studies, and between degrees and diplomas of various "levels". The initial steps in achieving these results are the definition of the cost unit and the construction of the cost model; these are so defined as to be applicable not only to repetition of the cost analysis with the same faculty in the future, but also to other faculties engaged in quite different areas of teaching.

> Higher education is entering an era of crisis due to dwindling enrolments and rising costs, a crisis of public confidence, and a crisis of student disenchantment.[1]

The view expressed above is one reported from many colleges and universities across North America. At the same time it seems fair to note that university administrators have not used management science techniques to any great extent. Whether this omission is due to a lack of knowledge, a priority concern for political issues in the university, the "academic mind", or a skepticism for untried methods is not the concern of this paper.

Out of a series of studies on one university faculty, there grew an interest among both administrator and staff groups in exploring the faculty's annual fiscal operation. As at many universities, there had been a history of secrecy surrounding faculty fiscal matters. Some staff members felt that inequities had developed in department allocations and in the treatment of individuals. There arose a need to look at past practice and to look at the faculty's present fiscal structure. However,

---

*An "algorithm" is a precisely stated procedure applicable in the same way to all instances of a problem.

it was not clear how to proceed. There was concern that individual privacy concerning salary should be preserved, but that all other fiscal matters should be open to scrutiny. A committee of professors, termed the Costs Committee, was elected to develop a method of cost analysis and to conduct one such analysis. The purpose of this paper is to describe the method developed, to present some selected data derived from the cost analysis, and to look at the utility of the costing procedure within a university framework.

From the outset, the Costs Committee was faced with a conceptual problem because of the complexity of interaction between departments and programs within the faculty. Some programs had their own directors and drew services from many departments; several departments served both graduate and undergraduate programs; and some departments serviced one program only. It was in this complex of departments and programs that the cost analysis was to be performed.

Five major questions emerged that led to the development of the algorithm:

1. What are the factors to be involved in this cost analysis?
2. What is the basic cost unit to be employed?
3. What are the faculty organization units to be used in the cost analysis?
4. What means can be used to allocate staff costs among diverse services?
5. What means can be used to permit comparisons between the various faculty units and degrees?

General funding

Funding of the faculty's work comes from several sources. The major inputs are operating funds, overhead funds, capital funds, and research grants.

Faculty Annual Funding = Operating + Overhead + Capital + Research

Operating funds are distributed annually to cover the costs of staff salaries, administration of the faculty, materials and supplies of a consumable nature, staff travel, support of field activities (student teaching and internships) and the like. The university distributes these funds based on a formula that works from enrolments and a "tradition-based", per-student allocation. The great majority of these funds are fixed; that is, staff salaries take about ninety percent of the operating funds, and salaries are set on a university-wide basis through management-staff negotiations. Overhead funds are not distributed directly to faculties, but are given to other university units which then provide services for the faculties. Included here are fuel funds, maintenance funds, security funds, library funds and so on.

Capital funds are distributed to faculties based upon requests and funds available, and are for items having long-term use. For faculties requiring extensive "hardware", the capital budget can be large, but for this faculty, it is small. If capital budgets are to be used in a cost analysis, the value of items purchased should be pro-rated over their useful life.

Finally, the faculty is able to attract research funds from a number of sources. These funds typically support individual professors or teams of professors and their students who are working on projects. Most of the funds are directed to the projects, and while under the administration of the university are not used for faculty operations *per se*.

It was decided to look only at the annual operating funds for the cost analysis. The decision was largely pragmatic. Overhead funds were difficult to assess. While one might get a global estimate of their value, it would be difficult to allocate them to departments and programs. Capital funds were excluded from the analysis because of the difficulty in pro-rating the value of goods and the fluctuation in capital allocations on a year-to-year basis among departments. Finally, research funds were excluded from the analysis because they were not under the control of the university but under the control of individual professors working with granting agencies. It was decided to treat the overhead funds, the capital funds and the research funds as "givens". While the operating funds were largely fixed, their allocation to various faculty departments and programs was not fixed. That is, the assignment of professors to programs and departments was within the scope of faculty control. It was this "allocation of resources" that was under scrutiny in the cost analysis.

It became apparent that the cost analysis should be developed on an annual basis. This would not only provide an annual review of expenditures but would also permit trend analysis, if desired, at a later date. Also, the analysis would then conform to the university budget and staffing cycle.

Developing the cost model

A study of the faculty budgeting practice led to the classification of *operating funds* into three main groupings:

1. Professorial activities — teaching, research, supervision, counselling, and administration funds (TRSCA).
2. Materials and supplies funds (MS)
3. General Budget funds (GB)

Operating funds = TRSCA + MS + GB

TRSCA are the funds that support staff salaries or the various activities in which professors are involved. All staff members were

asked to complete a Workload Analysis Form and to indicate how they spent their time (based upon 100%) in each of the five activities (TRSCA) by teaching unit (TU). The "teaching unit" was a concept developed for this study to include both the typical faculty department and any other unit that offered courses or program services to students.

Staff members were not asked to report their salaries. In order to maintain confidentiality on salary, it was decided to estimate the salary of a professor according to his rank. That is, the cost of a professor would be the average cost of all professors of that rank. This procedure introduced error in exchange for confidentiality. However, after inspecting the distribution of salaries by rank for assistant, associate and full professors, it became evident that few salaries deviated more than fifteen percent from the average salary for a given rank. Furthermore, since the salary distributions by rank tended to be normal, it was anticipated that some error reduction would occur when salary costs were aggregated. While this procedure was not ideal, it was deemed acceptable.

It should also be noted that professors, in estimating their time in a given activity, were likely to inject error into the analysis. Without keeping a log on every staff member one would probably not get a clear indication of the time spent on the activity. No consideration was given to the "quality" of the work done under TRSCA.

The Materials and Supplies fund allocations, in contrast, were precisely reported by the Dean. The General Budget funds were also precisely reported, and they were in part precisely allocated to the appropriate teaching units and in part pro-rated over teaching units where the allocations had not been originally specified. Some error in allocation would enter the model here, but it would be very difficult to estimate. Taken together, the MS and GB allocations amounted to about ten percent of the operating funds.

The cost unit

After some discussion, the Costs Committee decided the most appropriate cost unit would be "one student in a three-credit course". This cost unit would be termed a "student unit". The university serves its clients through courses; courses are combined to form programs. Students pay tuition based on the courses in which they enrol and the university allocates its resources to support courses. The "course" thus provides an interface between the client and the organization, and most courses are offered on a three-credit basis.

It should be noted in passing that while students pay the same fees for each course they take (excluding special fees), faculties allocate resources to courses on a differential basis. Some courses are termed "money-makers": they support other, more expensive, faculty and university offerings. In addition, courses come in many forms, ranging from individual tutorials through seminars for discussion purposes and large group lectures to monograph and thesis work.

While the number of students enrolled in a course could be determined in a number of ways, pragmatics prevailed again and some error was injected into the analysis. Student registrations in courses were used, instead of the actual enrolments. In a future analysis, it might be best to use the number of students who received grades. By using enrolments, course counts are probably a little inflated and course costs are probably underestimated.

To compare faculty units, one would have to aggregate course costs. For example, to compare Department (Teaching Unit) X with Department (Teaching Unit) Y, one would calculate as follows:

$$\text{Unit X} = \sum \frac{(\text{TRSCA} + \text{MS} + \text{GB}) \text{ for all courses }_x}{(\text{Students in all courses)}_x}$$

$$\text{Unit Y} = \sum \frac{(\text{TRSCA} + \text{MS} + \text{GB}) \text{ for all courses }_y}{(\text{Students in all courses)}_y}$$

Two computer programs were written to solve these equations. One program was to determine "counts", the number of student units, and the other program sorted and allocated costs to the various teaching units. Taken together, along with a sorting feature in each program, one was able to complete the cost analysis.[2]

The cost analysis

Given this cost model, it was not readily apparent which comparisons should be made in analysing the faculty. A second faculty committee, the Committee on Planning and Priorities, collaborated with the Costs Committee, and three major questions emerged. (Other analyses were also completed, but are not reported here.)

1. What is the cost by teaching unit for undergraduate studies?
2. What is the cost by teaching unit for graduate studies?
3. What is the cost by level of instruction (graduate or undergraduate) and by degree or diploma?

Undergraduate studies. Table 1 contains information related to the question, "What is the cost by teaching unit (TU) for undergraduate studies?" In all the following analyses, it was decided to rely upon a cost/student ratio as the prime means of analysis. This ratio is determined by dividing the proportion of the costs in the TU by the proportion of the student units in the TU.

$$\text{C/S Ratio} = \frac{\text{Proportion of the costs in the TU}}{\text{Proportion of the student units in the TU}}$$

where,

$$\text{Proportion of the costs in the TU} = \frac{\text{Total Cost of the TU}}{\text{Total Cost of all TU's}}$$

Proportion of the students in the TU =

$$\frac{\text{Number of Students in the TU (N)}}{\text{Total Number in all TU's}}$$

TABLE 1

THE COST BY TEACHING UNIT FOR UNDERGRADUATES RANKED BY THE COST/STUDENT RATIO

Teaching Unit[1]	N[2]	Cost per Student($)[3]	Total Cost ($1000)[4]	Proportion[5] Cost	N	C/S Ratio
A	8	1250	10	.004	.001	4.00
B	207	711	147	.054	.016	3.38
C	19	440	8	.003	.001	3.00
D	502	324	163	.060	.038	1.58
E	346	286	99	.037	.026	1.42
F	73	253	18	.007	.006	1.17
G	1697	245	416	.153	.130	1.18
H	302	230	70	.026	.023	1.13
I	577	229	132	.049	.044	1.11
J	690	226	156	.058	.053	1.09
K	388	211	82	.030	.030	1.00
L	44	209	9	.003	.003	1.00
M	1207	202	244	.090	.092	0.98
N	605	199	120	.044	.046	0.96
O	695	193	134	.049	.053	0.92
P	502	184	92	.034	.038	0.89
Q	200	174	35	.013	.015	0.87
R	714	170	121	.045	.055	0.82
S	1839	167	307	.113	.141	0.80
T	1591	161	256	.094	.122	0.77
U	388	142	55	.020	.030	0.67
V	479	78	37	.014	.037	0.38
Totals	13073		2711			

1. *Actual department (or teaching unit) names have been represented by letters.*
2. *N = the number of student units (one student in a three-credit course).*
3. *Cost per Student ($) = the cost for one student unit.*
4. *Total Cost ($1000) = N times Cost per Student ($).*
5. *Proportions of Cost or of N are of totals for all TUs (see bottom line).*

The range in the C/S ratio is from a high of 4.00 for TU (or Department) A, to a low of 0.38 for TU (or Department) V; in effect, the most expensive undergraduate cost per student is over 10 times the least expensive cost per student. However, the most expensive offering has only 8 student units so that the total cost is small. Between TU F (C/S=1.17) and TU T (C/S=0.77), there is only a factor of 1.5 in the ratios (1.17

divided by 0.77). That is to say, the costs per student for TU's lying be-
tween F and T are very similar, and these TU's account for 85 percent
of the undergraduate student units.

TU B is an expensive unit in that it has a high C/S ratio (3.00); yet
it has few student units (19) so it is not costly to operate. Both TU D and
TU E have moderately high C/S ratios (1.58 and 1.42 respectively) and
large registrations (502 and 346, respectively) and are more expensive to
operate. TU's U and V have low C/S ratios (0.67 and 0.38, respectively)
and large registrations (388 and 479, respectively) making them true
"money makers".

Of some interest is the relationship between N (Student Units) and
the two cost measures, the cost per student and the C/S ratio. The
correlation (Pearson product-moment) between N and the cost per
student is −.36, and between N and C/S is −.41. This implies a slight
tendency to an economy of scale. TU's with higher enrolments tend to
be slightly less costly.

TABLE 2

THE COST BY TEACHING UNIT FOR GRADUATE STUDENTS RANKED BY THE COST/STUDENT RATIO

| Teaching Unit* | N | Cost per Student ($) | Total Cost ($1000) | Proportion | | C/S Ratio |
				Cost	N	
M	14	5848	82	.079	.010	7.90
N	6	1065	6	.006	.004	1.50
O	78	987	77	.075	.056	1.34
C	301	896	270	.262	.217	1.21
I	92	727	67	.065	.066	0.98
K	44	655	29	.028	.032	0.88
T	394	632	249	.242	.284	0.85
V	246	594	146	.142	.177	0.80
D	28	488	14	.014	.020	0.70
S	186	478	89	.086	.134	0.64
Total	1389		1029			

*The non-alphabetical order of Teaching Units is due to the use of the same labels
for units as in Table 1.*

Graduate studies. Table 2 contains information related to the ques-
tion, "What is the cost by teaching unit for graduate studies?" The range
in C/S ratios is from a high of 7.90 to a low of 0.64; the most expensive
graduate cost per student is 12 times the least expensive cost per student.
However, the two highest TU's by C/S ratio have only 20 student units
(1%) between them. TU O has a C/S ratio of 1.34 and that is only 1.7
times the C/S ratio of TU V. This implies a relatively even distribution
of resources between six of the ten TU's. TU's O and C, by virtue of their
C/S ratios (1.34 and 1.21, respectively) and their student units (78 and

301, respectively) are the most expensive graduate units to maintain. Also, TU's S and perhaps V, by virtue of their C/S ratios (0.64 and 0.80, respectively) and their student units (186 and 246, respectively) are below the average for graduate studies; they are "money-makers".

The correlation between N and cost per student is −.35, while the correlation between N and the C/S ratio is −.34. As with the undergraduate offerings, there is a slight economy of scale with graduate offerings.

TABLE 3

			Cost per Student ($)	Total Cost ($1000)	Proportion Cost	N	C/S Ratio
Level	Degree	N					
Graduate		1365	731	998	.273	.097	2.81
	MA	172	1092	188	.051	.012	4.25
	MEd	1161	676	785	.215	.082	2.62
	PhD	10	585	6	.002	.001	2.00
	DEd	22	872	19	.005	.002	2.50
Undergraduate		12724		2654	.727	.903	0.81
	Bachelor						
Full-time	Program A	3625	219	793	.217	.257	0.84
	Program B	686	215	148	.041	.049	0.84
	Program C	1958	221	432	.118	.139	0.85
	Diploma						
	Program D	2625	179	469	.128	.186	0.69
	Program E	2831	202	571	.156	.201	0.78
	Program F	146	277	40	.011	.010	1.10
Part-time	All	852	237	201	.055	.060	0.92
	Grand Totals	14089		3652			

Levels and degrees. Table 3 contains information related to the question, "What is the cost by level of instruction (graduate or undergraduate) and by degree or diploma?". There are 12,724 (90%) undergraduate student units and 1,365 (10%) graduate student units. The total cost of undergraduate offerings is 2.654 million dollars (73%), while graduate costs are 0.998 million dollars (27%). The cost of a graduate student is 3.5 times the cost of an undergraduate one (2.81 divided by 0.81).

Within graduate studies, the M.A. degree is the most expensive. 82% of the student units are in M.Ed. programs which have a C/S ratio of 2.62. Within undergraduate studies, the C/S ratios are very similar for all bachelor degree and diploma options. They range from a high

of 1.10 to a low of 0.69, with four of the six options clustering around a C/S ratio of 0.80. Undergraduate part-time student costs are low, with a C/S ratio of 0.92.

"Meaning" and "utility"

There remains the need to explore the usefulness of such an analysis as this. Two main points will now be discussed: the "meaning" of a cost analysis, and its "utility".

A cost analysis is a collection of expenditures arrayed in one or more perspectives. The choice of arrays is dependent upon the organizational structure of the faculty, the kind and type of programs offered, and the insights of the analysts; the choice has both rational and non-rational elements. In this study, a Cost/Student ratio was developed as the prime means of comparison between faculty teaching units, degrees, and diplomas. The use of this ratio permits comparison between large and small units and allows one to see whether economies of scale are present within the faculty offerings. It becomes evident that some faculty units are "expensive", while others might be termed "money-makers". However, while differences in the allocation of funds to sub-units within a faculty may be evident, one cannot assume that they should be "corrected". Differences in allocation of funds occur because of conscious choice. Moreover, the cost analysis reports the findings for only one year and must be seen as a relatively static analysis. A cost analysis can also be seen as a mirror image of the "program budget". The "program budget" is used as a basis for allocating funds to specific programs within a faculty, while a cost analysis studies the spending of funds within a faculty. One is prior to the fact; the other, after. It might be redundant to have both a program budget and a cost analysis within the same faculty. The meaning of a cost analysis needs to be supplemented by its utility for the given faculty.

It appears that the major utility of a cost analysis as a management tool may be to raise questions about present operations and future goals for the institution. However, within the university setting, severe constraints are placed on the ability of management to shift funds from one program to another, because of personnel commitments. Most of the faculty budget is typically devoted to staff salaries. (In the case under study, ninety percent of the funds were consumed by salary.) Given a staff with a high percentage of people on tenure, a dean would have difficulty shifting funds. It seems fair to note that tenured staff build in a "system inertia" that limits a faculty's ability to shift funds. Therefore, while a cost analysis may raise significant questions about present operations, a highly tenured staff may inhibit the response of a faculty to desired change. The utility of a cost analysis as a tool for change may be very limited.

A second use of a cost analysis may be to help sub-units within the faculty to argue for increased funding. A faculty unit that is low on the totem pole may seek to increase its support at the expense of the

more expensive units. This may be particularly true if both units are engaged in roughly the same activities. In this way, the cost analysis may serve a political purpose within the faculty.

A third use may be to encourage more collegiality in the management of the faculty. The opening up of faculty costs to all faculty members may be seen as a move by management to remove the mystique surrounding budgetary matters and to encourage broad support for faculty growth and development.

In the case presented, one might provide a summary description of this faculty as one committed to a low-cost emphasis on extensive bachelor and diploma programs and a high-cost emphasis on a small number of graduate programs, predominantly at the masters level. Within undergraduate programs, most teaching units have similar costs. Within graduate programs, most teaching units also have similar costs, but the M.A. degree is more expensive than the other degrees. This analysis shows the present state of affairs. The analysis might also be seen as representing the tradition within the faculty. A series of decisions in past years, largely related to staffing, has determined the present faculty patterns.

The meaning and the utility of a cost analysis tend to merge. That is, a cost analysis is largely a "management tool" that may have utility in helping a faculty to shape its future within typical staffing constraints. The cost analysis, in and of itself, is useless. Not until those responsible for the commitment of funds use it in their decision-making processes, along with other information and goals about faculty development, does it have meaning.

REFERENCES

1. Shroeder, Roger G. and Adams, Carl R., "The Effective Use of Management of Science in University Administration", *Review of Educational Research,* 46 (Winter, 1976), p. 117.

2. For further information on the algorithm, including the computer programs developed for the analysis, consult the authors.