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# The Calculation and Presentation of Management Information from Comparative Budget Analysis

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The British system of university funding offers an opportunity for the detailed analysis of unit costs and marginal costs and the comparative assessments of expenditure patterns and priorities for a group of 95 institutions with similar objectives, in which each has autonomy in resource allocation.

This paper explores one system of analysis and invites critical discussion of techniques, their advantages and disadvantages, and it draws attention to the inevitable uncertainty involved in any such comparative assessment.

## University Funding

At the end of every financial year, each university (and its federated constituents in the cases of the Universities of Wales and London) returns detailed information on its student loads, incomes, and expenditures (on what is known as the *Form 3 Return*) to the University Grants Committee (UGC), which is the interface between the universities and government funds. The UGC uses the information as a basis for recommending to the government the level of funding required by the university system in future years, and the UGC decides on the annual allocation to each of the universities. The full-time chairman, a distinguished academic, is supported by a secretariat of administrators with expertise in such fields as statistics and quantity surveying. The committee members, who are not there to represent their own universities, are all part-time, and a large majority of the twenty are practicing academics.

Although the UGC is clearly pivotal in the funding determinations, it has maintained a mainly non-interventionist stance until recently. How a university allocates its received funds is still notionally its own prerogative, although the UGC now gives precise guidance on total student loads and makes recommendations on departmental closures and expansions. Although a university may disregard UGC advice, it may thereafter suffer a self-inflicted financial burden.

Because of institutional financial autonomy, it is right that the UGC calls for an accurate and detailed accounting of the stewardship of public moneys and, in turn, the universities can expect to be required to demonstrate rigour in their disbursement of funds.

The UGC gives little direct guidance, and the universities must do such comparative analyses as they can in order to ensure that their expenditure pattern is consistent with their academic objectives and without undue profligacy. Conversely, a university would wish to ensure that its staff and students are not underprivileged in comparison with their peers. The independent Committee of Vice-Chancellors and Principals publishes what has become known as the *Tress Brown Index* which assesses trends in inflation in university costs and also indicates the percentage breakdown of university expenditure among a variety of headings. Thus a university finance officer will know the percentage of total expenditure in British universities devoted to the Library, and so on. This is clearly a "broad brush" approach because total expenditure is dependent upon the mixture of disciplines taught—an arts-based institution being much cheaper than one dominated by science and technology.

To aid such analyses, the UGC tabulates the contents of *Form 3* for all universities and sends each what is known as the *"Form 3 Outturn."* The Outturn is necessarily historical, but it can be updated for inflation by the use of the Tress Brown Index (see Silver and Yeomans, 1982, and Taylor, 1983a). Subsequently much of the information is published annually in *University Statistics: Volume 3—Finance* (UGC/USR).

### The Nature of the Data Base

For each of the 95 institutions, income is quantified for about 45 sources and the 4,000+ sums of money are avidly scanned by every institution to make sure that it is not missing a trick. It is to the expenditure side that universities turn for their comparisons with their peers in order to give a perspective to their own resource allocations. It must be emphasised that this perspective should not be used to determine allocations, which ought to be based on academic grounds, and not by attaching a value to a British average, which can have no intrinsic merit.

For each of the institutions, departmental expenditure is accounted for in each of 18 subject categories (shortly to be increased to 39 "cost centres") under the following headings:

1. Salaries of Academic and Related Staff
2. Other Salaries and Wages
3. Other Departmental and Laboratory Expenditure
4. Expenditure from Research Grants and Contracts
5. Expenditure from Income for Other Services Rendered
6. Expenditure on Equipment.

For each of the subject categories, the full-time equivalent (FTE) student loads are listed by institution under these headings:

1. Undergraduates
2. Taught Course Postgraduates
3. Research Postgraduates.

Each of these is also divided between full-time and part-time enrolled students. This is a large quantity of information (= 2 x 18 x 95), shortly to be increased to 12 x 39 x 95 = 44,460 values.

In addition to these departmental loads and expenditures, the Form 3 Outturn details non-departmental expenditures under 54 other headings for each university, ranging from its expenditure on bookbinding to the maintenance of athletic facilities, which adds another 5,000+ to the total data bank.

Such a mass of data can only be handled realistically by a computer. Programmes have been written to do the analyses, and this paper focuses on the problems of interpretation.

The UGC tries to ensure uniformity among the returns by defining types of students and the elements contributing to a given expenditure. As every institution is autonomous in its allocation of resources and its accounting practices, there is some ambiguity in the data included in the Form 3 Return, but they are the best that are available and analyses have to take cognisance of the inherent uncertainty.

### How Much Does a Student Cost?

A student in a laboratory-based subject is likely to be more expensive than a classroom-based student. Similarly, a research student on a doctoral programme is likely to be more expensive than an undergraduate in the same subject. This topic has been explored before (Taylor, 1982).

In the UGC's report *University Development 1962/67* there was a hint that the UGC used "weightings" of one FTE for all undergraduates, two FTEs for each arts-based postgraduate (other than postgraduate certificate-of-education students) and three FTEs for each science-based postgraduate. Recruitment of postgraduates was thus encouraged in universities, and it was not long before expenditure patterns within universities reflected these differential weightings. More recently, broad-brush recommendations about postgraduate weightings have rightly been abandoned by the UGC.

Many universities still use weightings, and examples are given in Taylor (1983b), although there are indications that some universities are progressively abandoning them in their present form in favour of a much more pragmatic approach. Any strict numerical factor tends to facilitate evasion of the need for academic justification for specific action.

There is a need for comparisons however, and to discount the differential costs associated with different levels of study and different disciplines must seriously devalue those comparisons. Hence, it is argued that there is a case for weightings, not only to aid judgements about resource allocation but also for the retrospective analyses of the ways in which the peer group has allocated resources. Only by the use of weightings is it possible to distil from such a mass of data the collective wisdom of the other universities in the system.

If all universities had the same proportions of students by level of study in each subject category, weightings would be superfluous because comparable answers would be derived from division of the total expenditure by the unweighted student load. However, there is wide variation in the proportions of students by level of study and this simple calculation must be rejected.

### Equipment Expenditure

As a specific example, consider departmental equipment expenditure. In one institution, in order to encourage the recruitment of postgraduate research students, the equipment fund allocation process applies a weighting such that each research student is considered to be worth five undergraduates in the same subject, and the equipment budget of the university is distributed accordingly. The weighting makes no distinctions between subjects although it is acknowledged that an undergraduate physicist demands a greater unit of expenditure on equipment than an undergraduate linguist, for example, and the budget division has an appropriate undergraduate unit allocation for each subject.

This gives a clue about the potential for variation in satisfaction of subject demands. The undergraduate unit can vary by subject and the postgraduate weightings can vary among subjects—although in the example quoted above, it was a uniform x 5 for research studies, irrespective of subject.

Most of this paper is *deductive* on the matter of weightings, but can any *inductive* comment be made about weightings, particularly as they relate to the equipment budget? An undergraduate biologist makes an appreciable use of relatively expensive equipment such as spectrophotometers, pH-meters, and assorted electronic equipment. In like vein, the postgraduate research student of biology often commands the dedicated use of a range of expensive equipment, but his unit of expenditure is unlikely to be five times as high as that of the undergraduate. Their needs are not dissimilar. It may be that a postgraduate research student weighting of x 2 would be more appropriate than x 5.

What about students of management studies? At the moment, most undergraduates have little need for equipment except for occasional access to a computer—probably provided by a separately funded university computer unit—and the rest of his course is "chalk and talk" and classroom based. Not so the postgraduate research student in management studies. He probably has a need for sophisticated computer facilities under his personal control and, relatively, his demands are expensive. Inductively, it could be argued that the appropriate weighting for the postgraduate research student in management studies is nearer to x 25 undergraduates than the x 5 described above. There is little doubt that such a high weighting would be regarded as unrealistic, or even preposterous, by many in universities. Is it though?

In the comparisons which follow, London University is excluded because its costs are exceptional and its large size makes it an *outlier*, giving it undue influence on any correlations (Green and Chatfield, 1977). Siau, Rousseeuw, and Bingen (1985) proposed a robust regression technique based upon least median squares for reducing the influence of such outliers and contaminations.

The London and Manchester Business Schools are also disregarded as having exceptional costs because of atypical student loads and their small sizes. The two remaining exclusions are Oxford and Cambridge because there is a substantial financial input/output from the colleges which escapes report in the Form 3 Returns.

Equipment expenditure in 1981-82, together with the FTE student loads in the "business management" subject category, are shown in Table 1. Only those universities which offer the subject are listed.

**Table 1**

**1981-82 Equipment Expenditure and FTE Student Loads in Business Management in Selected British Universities**

| University | Equipment Expenditure £s | FTE Student Loads u/gs | p/gC | p/gR | Total |
|---|---|---|---|---|---|
| Aston | 63,548 | 641 | 362 | 26 | 1,029 |
| Bath | 30,556 | 226 | 31 | 101 | 358 |
| Bradford | 74,186 | 312 | 128 | 34 | 474 |
| City | 15,876 | 166 | 213 | 22 | 401 |
| Durham | 4,057 | 19 | 29 | 2 | 50 |
| Lancaster | 9,096 | 252 | 156 | 29 | 437 |
| Leeds | 3,416 | 191 | 30 | 1 | 222 |
| Loughborough | 15,965 | 387 | 15 | 14 | 416 |
| U.M.I.S.T. | 8,796 | 662 | 39 | 86 | 787 |
| Salford | 2,365 | 269 | 12 | 9 | 290 |
| Sheffield | 4,960 | 466 | 16 | 11 | 493 |
| Edinburgh | 13,038 | 304 | 35 | 13 | 352 |
| Glasgow | 9,243 | 43 | 85 | 10 | 138 |
| Heriot-Watt | 3,031 | 267 | 45 | 4 | 316 |
| Stirling | 9,087 | 143 | 10 | 11 | 164 |
| Strathclyde | 36,230 | 532 | 220 | 27 | 779 |
| Totals | 303,450 | 4,880 | 1,426 | 400 | 6,706 |

Notes: £s = British pounds; u/gs = undergraduate; p/gC = taught course postgraduate; p/gR = research postgraduate. Source: UGC Form 3 Outturn.

The elementary approach to these data would be to derive an unweighted unit expenditure thus:

£303,450/6,706 = £45.25 per FTE student.

The Bath load of 358 FTEs would therefore be "entitled" to £45.25 each, giving a total of £16,200 instead of the £30,556 actually spent.

It would quickly and correctly be argued that this is a naive approach, and to counter it, a scatter diagram as shown in Figure 1 would be produced. This illustrates the variation in the relationship between expenditure and the unweighted FTE load.

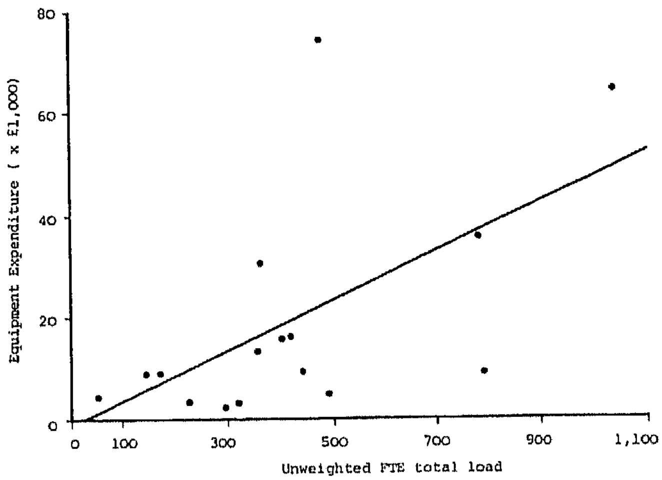



Figure 1. Scatter diagram of 1981-82 equipment expenditure in business management in selected universities—against unweighted student FTE load.

The regression line for the best fit (by "least squares") is shown in Figure 1. The equation for the line is this: £ Equipment expenditure = (FTE load x 48.81) - 1,492, and the indication for the Bath expenditure becomes £16,000 (with a standard error of £4,700), and the 95% confidence limits for the estimate of £16,000 are ± $£10,100.

The principal of the regression calculation is to minimise the sum of the squares of the vertical deviations from the line, and in spite of the apparent uncertainty, it is the best fit obtainable from the unweighted data. The correlation coefficient is quite high at 0.579, with 14 degrees of freedom, giving support to the acceptance of the relationship.

The School of Management Studies in Bath would rightly protest that the exercise disregards the costliness of their research students who represent almost one third of their total student load. Indeed, a quarter of all of the research FTEs in Table 1 are in the Bath

School. They would argue that the regression calculation grossly undervalues this fact and that they would be more fairly treated if postgraduate research students were weighted by an arbitrary multiplier, such as x 5.

One way forward is to calculate the partial regression in which three weightings are estimated: for u/gs, p/gCs, and p/gRs. In this example, it gives the following equation:

£ Equipment expenditure = (u/gs x 7.828)+ (p/gCs x 132.124)+(p/gRs x 180.061) + 301.158

The standard errors of the three coefficients are these:

| | |
|---|---|
| u/g | 27.498 |
| p/gC | 48.072 |
| p/gR | 169.056 |

The sizes of the standard errors are indicative of the great uncertainty, but see the comment that follows.

The three coefficients are, in effect, weightings to be applied to the loads and for the convenience and comprehension of decision-makers can be converted in relation to undergraduates thus:

| | |
|---|---|
| Undergraduate | = x 1 |
| Course postgraduate | = (132.124/7.828) = x 17 |
| Research postgraduate | = (180.061/7.828) = x 23 |

If these weightings are applied to the student loads shown in Table 1 and then a linear regression analysis performed, the equation simplifies to this:

£ Equipment expenditure = (wtd FTEs x £7.783) + 325.

This indicates a Bath expenditure of £24,300 (standard error = £4,244) and 95% confidence limits for the Bath weighted student load of ± £9,100.

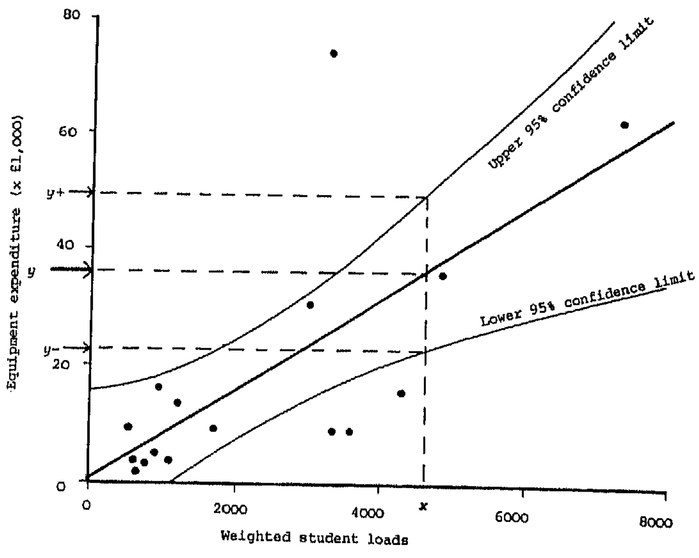



Figure 2. Scatter diagram of 1981-82 equipment expenditure in business management in selected universities—against weighted student FTE load and together with the regression line and its 95% confidence limits.

The correlation coefficient is improved, as might be expected, to 0.705, and it is likely that this is the best obtainable fit between observed and actual expenditure for the universities tabulated. The scatter diagram is shown in Figure 2. A closer and perhaps more useful fit could be obtained by the exclusion of the Bradford point, which could be exceptional, although this comment is qualified below.

Partial regression analysis, where appropriate, clearly facilitates comparative analysis within a subject category, although there will be different weightings for each expenditure heading (i.e., there will be appropriate weightings for academic staff expenditure, support staff expenditure, and yet others for consumable expenditure, etc.). As a technique, it offers an estimate of the collective judgements of British university decision-making. In the example Bradford seems to be aberrant, but such aberrations are not unexpected—especially in equipment expenditure which might call for the purchase of an expensive computer in one year, with little expenditure in other years as compensation. The analysis benefits from calculation through an inflation-compensated time series or running mean. In this way volatility is suppressed. In any event, the wide tolerance suggested by the confidence limits would impose little restraint on a determined head of school arguing his budgetary needs.

On the face of it, partial regression analyses are sufficient to obtain the best fit between expenditure and weighted student load, whilst providing an indication of the appropriate weightings to be applied for level of study, but unfortunately there are occasions when it does not work! Sometimes one or more of the regression coefficients are negative, suggesting that each added student makes the expenditure less, which any head of department will forcefully point out is a nonsense.

Under these circumstances an "empirical" weighting is sought. It sets the conditions that the weightings are positive (i.e., each student incurs additional expenditure), that undergraduates are x 1, and that course and research postgraduates are independently weighted by integer factors equal to or greater than one up to a maximum of x 150. The upper limits of weighting may seem to be so high that the whole relationship is dominated by expenditure in support of postgraduates; in fact, such may well be appropriate.

An iterative computer programme tests the suitability of partial regression for every expenditure heading and stores the indicated weighting values on file for subsequent use, provided they are positive. If this condition is not fulfilled, the computer performs repeated regression analyses in which the weighting value of course postgraduates is changed and the weighting value of research postgraduates is changed. The programme then "homes in" on weighting values which give the highest correlation coefficient. This is illustrated in Figure 3, in which the stippled plane is a correlation value of zero. The height above the line is the correlation coefficient given at the coordinates by postgraduate course and research postgraduate weightings. The computer then files the weightings maximising the correlation. In the case of equipment expenditure in 1981-82 for management studies, the weighting values found by this empirical method correspond with those found by partial regression (*i.e.*, p/gC x 17 and p/gR x 23), as might be expected.

The mathematical purist may suggest that this represents a rather cavalier dismissal of propriety. However, as has been demonstrated earlier (Taylor, 1982) the estimation of Great Britain (GB) average unit costs is not unduly sensitive to the applied weightings, which represent only the "fine tuning" of a substantially correct estimation. The pragmatist has to do the best he can under the circumstances and accept the compromise forced upon him. His defence has to be that peer review is desirable for the conduct of his affairs and for the benefit of the institution, and it works, provided there is due recognition of the inherent uncertainties—for example, by being guided by the location in quartiles of ranking league tables. These uncertainties again prompt the important *caveat* that resource allocation should not be driven by the GB average or its approximation.

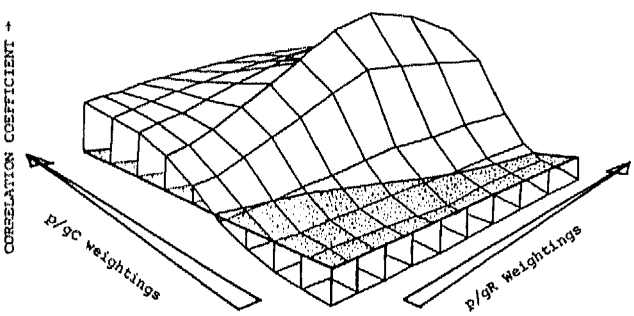



Figure 3. An illustration of an iterative computer programme that tests the suitability of partial regression.

## Discussion

When all of the original data from the Form 3 Outturn are on computer file, the computer has the marathon task of doing the regressions for each expenditure heading in order to get the best fit for weighting factors for level of study.

For some expenditure headings, level of study or even unweighted student load may not be appropriate. For example, "cleaning and custody" is more a function of usable area, and this is taken into account. Each student "commands" the provision of a usable area, depending upon his subject and his level of study. The undergraduate biologist needs 5.2 $m^2$ of laboratory and associated space, whereas the p/g research biologist needs 15.0 $m^2$ of such space. They each generate a demand for 4.35 $m^2$ of space to provide the office and research accommodation for the academics appointed to teach them. There are analogous needs for administrative space, recreational space, etc., right down to a share of the garage space in which the groundsman keeps his tractor.

These "norm" spaces have been identified for every type of student by discipline and level of study, and the computer calculates the total usable area in each university from its declared student load in Form 3. This is then the basis for determining the unit cost of "cleaning and custody" for the premises. In other words, the regression analysis is appropriate to its interpretation.

In the ultimate, very little judgement is needed to achieve the best comparison. For example, the "management studies equipment" expenditure explored above has used the FTE loads of universities. The FTE loads include part-time students who typically conduct their research outside the university, with equipment paid for by their employer or someone else. Part-time students would therefore be discounted in the analysis because they do not generate the same demand for expenditure. Such considerations ramify throughout the whole analysis, but once the judgement is argued out, the computer programmes need little amendment thereafter.

Eventually, when the computer has determined the weighting and other associated factors, the computer starts the equally time-consuming task of analysing the expenditure patterns of all universities. For example, it starts off by giving the education student loads the appropriate weightings for academic staff expenditure and, by regression, determines the GB average expenditure for each university corresponding to its exact student load. It continues the analysis by *excluding* each university, in turn, from the regression so that the average is calculated from the peer group; the university in question cannot influence the distribution. Its actual expenditure is then compared statistically by a "student's-t" test, with the peer population indication of the average expenditure for its student population. The basic theory of regression analysis has been described by Schefler (1969) among many others, and its translation to provide fixed costs from the intercept and marginal unit costs from the slope of the regression line are discussed more fully in the text that follows. The methodology of using confidence limits can also be deduced from Schefler.

The results of all of these analyses for all universities are accumulated on file in the computer so as to enable the construction of "Taylor Squares," as have been illustrated elsewhere (Farrant & Taylor, 1983). An example of usage is given below. Every expenditure heading is treated in this way until the whole of the Form 3 expenditures have been analysed.

The regression shown in Figure 2 for equipment expenditure can be converted into a "weighted unit cost" curve as is illustrated in Figure 4, in which the expenditure has been divided by the student load. The curve becomes asymptotic to the slope in the equation which is the marginal cost of adding one student. The fixed cost (the constant in the equation) is independent of student load, and the curvature of the figure results from the numbers of students among whom this fixed cost is shared. The methodology was well described by Pickford (1975). The undergraduate marginal unit cost can be converted to the postgraduate course or postgraduate research student marginal cost by using the appropriate weighting.

Some universities are known to adopt a regression analysis as guidance for the allocation of resources, although any weighting factors used tend to be arbitrarily chosen rather than estimated as described in this paper. The use of regression analysis is valuable in that it offers a method of compensating for economies of scale. One university has reported that it looks for a 10% deviation from the regression line as indicative that action is appropriate. The adoption of an arbitrary 10% "trigger for action" is questionable and appropriate for only two distinct population sizes. Regression analysis can support arguments based on equity, but the adop-

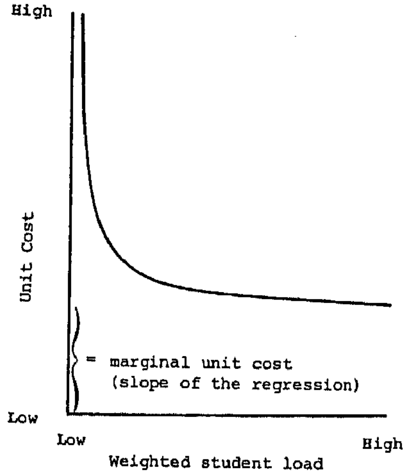



Figure 4. Curve of weighted unit costs.

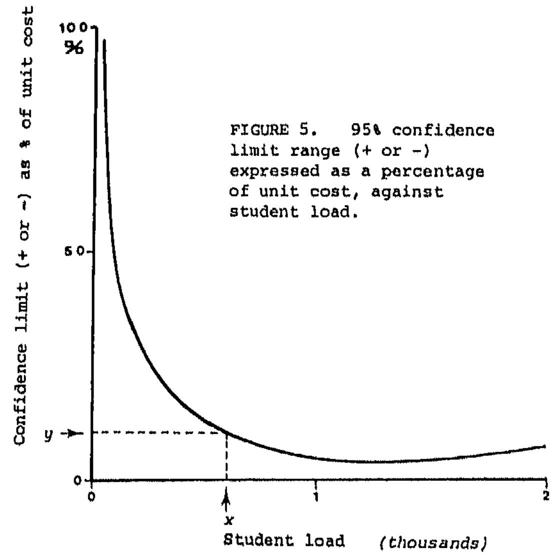



Figure 5. 95% confidence limit range (+ or -) expressed as a percentage of unit cost—against student load.

tion of a 10% threshold could result in considerable inequity. The choice of ±10% may have resulted from misinterpretation of the methods described by Pickford (1975).

If the points in the scatter diagram fall exactly on a straight line, which is most unlikely in university expenditures, the threshold has no relevance. In practice, variations in expenditure patterns will lead to uncertainty about the position of the regression line. Figure 2 shows a regression line accompanied by its upper and lower 95% confidence limits as curved lines.

There are two points to notice. Firstly, a vertical line drawn from $x$ on the student load axis can be taken to the regression line and reflected to the expenditure axis to give the best estimate of the mean expenditure $y$, as shown by the large arrow. Secondly, if horizontal lines are drawn from the $x$ interceptions of the confidence limits, $y+$ and $y-$ result.

Although $y$ is the best estimate, its uncertainty is such that it is possible to say only that the actual value is likely to be between $y+$ and $y-$ for 95% of such analyses. Because the confidence limits are curves, the interval between $y+$ and $y-$ varies with student load; hence, the adoption of any arbitrary deviation such as 10% can be highly deceptive.

Figure 5 shows the consequence of the curved confidence limits in a regression analysis. The confidence limit (+ or -) is expressed as a percentage of the unit cost at each student load. It will be seen that the adoption of an arbitrary limit of 10% (indicated by $y$) would be compatible with a unique student load, in this example 600. At any other student load, its adoption as a threshold could lead to an erroneous conclusion. Furthermore, this curve is particular to one population of students and expenditures, so its use in a general sense is excluded.

Figure 5 also illustrates a minimum in the relationship. Beyond a student load of about 1,200, the confidence limit as a percentage of unit cost begins climbing again, and there will be another student load at which 10% is an appropriate assessment.

The uncertainties indicated by regression equations are often large, and in the whole spectrum of a university's expenditure, perhaps only two or three comparisons show a statistically significant difference from the GB average for its student load. As there could be more than 150 such comparisons for each institution, chance is likely to result in a few indications of significant difference where none exist. For instance, in any normal distribution, one in twenty samples is likely to indicate a difference with an attached probability of $p<0.05$. On the other hand, some institutions show a significant difference in as many as one-third of all analyses, which fact could justifiably prompt enquiry. Even then, any consequential adjustments should be made so as to defend academic need, or the baby may be thrown out with the bathwater.

### Examples of Usage

The computer prints out two tables for each expenditure heading. Table 2 shows such a print-out for "library salaries and wages" expenditure in 1982-83. In the case of the University of Bath, the actual expenditure of £333,430 is compared with the GB average for the FTE load of 3,720 students. Spending was at 81.8% of the GB level. Column "t1" suggests that the difference may be significant when measured by the standard error of the mean prediction, but "t2" indicates that the expenditure is consistent with the variation of the peer population.

Although Table 2 gives information in a form which is useful for reference, it is not particularly helpful as a means of conveying information on relativities; hence, the computer sorts the universities in rank order of their percentage relationship with the GB average, highlighting any selected university. Table 3 is the result. At a glance, it reveals that Bath expenditure at 81.8% is in the bottom quartile. If students and staff complain that they have to queue too long for counter service, they may have a justified complaint. On the other hand, other tables printed out suggest that Bath spends more than average on books and a lot more than average on periodicals. The message is obvious: A slower counter service is offset by a better selection opportunity.

At the end of the analysis there are many hundreds of similar tables covering all aspects of the university's affairs. Decision-makers in the university can call on analyses which draw together indications from the Tables. Let us suppose that departmental heads in the imaginary "University of Whitby" complain that they have too few support staff (technicians and clerical staff).

According to the Form 3 Outturn for 1982-83, the University of Whitby spent £1,554,584 on departmental support (non-teaching) staff. The tables of unit costs derived as described above suggest that, for the mixture of students by subject and by level of study, their GB peers would have spent £2,078,527 as shown in Table 4.

The final column suggests that there has been little attempt to use peer review in the past for the allocation of support staff.

## Table 2

### Comparative Expenditures for Salaries and Wages in the Libraries of British Universities for the 1982-83 Session

Library 1982-83  Page 19a  BATH

Expenditure heading - Salaries and wages
Weightings - u/g x 1  p/gC x 1  p/gR x 1

| University | Expend | GB exp. | % of GB | t1 | t2 | Load | -----COSTS----- Marginal | Fixed |
|---|---|---|---|---|---|---|---|---|
| Aston | 338549 | 405131 | 69.8 | -8.6 | -1.3 | 4507 | 96.6 | 49775 |
| BATH | 333430 | 407565 | 81.8 | -3.9 | -0.7 | 3720 | 96.5 | 48399 |
| Birmingham | 711616 | 937581 | 75.9 | -7.4 | -2.1 | 9034 | 100.0 | 33890 |
| Bradford | 437655 | 508081 | 86.1 | -4.2 | -0.6 | 4763 | 96.8 | 46890 |
| Bristol | 753000 | 728433 | 103.4 | 1.2 | 0.2 | 7062 | 96.8 | 45163 |
| Brunel | 406347 | 336460 | 120.8 | 3.2 | 0.6 | 3036 | 97.4 | 40639 |
| Cambridge | 1955497 | 1216422 | 160.8 | 15.3 | 6.2 | 12088 | 96.9 | 44850 |
| City | 292062 | 314754 | 92.8 | -1.0 | -0.2 | 2775 | 96.7 | 46325 |
| Durham | 659685 | 507700 | 129.9 | 9.2 | 1.4 | 4811 | 97.1 | 40582 |
| East Anglia | 469426 | 457233 | 102.7 | 0.7 | 0.1 | 4258 | 97.0 | 44386 |
| Essex | 304134 | 366427 | 83.0 | -3.0 | -0.6 | 3296 | 96.5 | 48311 |
| Exeter | 597242 | 527113 | 113.3 | 4.2 | 0.6 | 4992 | 97.0 | 43111 |
| Hull | 593160 | 582018 | 101.9 | 0.7 | 0.1 | 5545 | 96.9 | 44686 |
| Keele | 354210 | 321599 | 110.1 | 1.4 | 0.3 | 2869 | 97.2 | 42786 |
| Kent | 443432 | 450645 | 98.4 | -0.4 | -0.1 | 4185 | 96.9 | 45135 |
| Lancaster | 437137 | 491561 | 88.9 | -3.2 | -0.5 | 4596 | 96.8 | 46591 |
| Leeds | 927138 | 1129287 | 82.1 | -4.7 | -1.8 | 10898 | 101.0 | 28222 |
| Leicester | 596080 | 511654 | 116.5 | 5.0 | 0.8 | 4836 | 97.0 | 42517 |
| Liverpool | 785299 | 818908 | 95.9 | -1.3 | -0.3 | 7969 | 97.3 | 43870 |
| L.G.S.B.S. | 104242 | 68014 | 153.3 | 1.0 | 0.3 | 239 | 96.9 | 44850 |
| London | 7855620 | 4567244 | 172.0 | 12.1 | 11.2 | 46661 | 96.9 | 44850 |
| Loughborough | 522762 | 594401 | 87.9 | -4.2 | -0.6 | 5653 | 97.1 | 45769 |
| M.B.S. | 109599 | 69856 | 156.9 | 1.1 | 0.3 | 258 | 96.9 | 44850 |
| Manchester | 971292 | 1168593 | 83.1 | -4.3 | -1.7 | 11278 | 101.2 | 27261 |
| U.M.I.S.T. | 235852 | 503033 | 46.9 | -16.8 | -2.6 | 4664 | 96.5 | 53066 |
| Newcastle | 755288 | 792741 | 95.3 | -1.5 | -0.3 | 7699 | 97.3 | 43942 |
| Nottingham | 839281 | 739133 | 113.5 | 4.6 | 0.9 | 7202 | 96.2 | 46379 |
| Oxford | 3431645 | 1285525 | 266.9 | 40.7 | 17.8 | 12801 | 96.9 | 44850 |
| Reading | 670145 | 592388 | 113.1 | 4.6 | 0.7 | 5668 | 96.8 | 43875 |
| Salford | 366361 | 470833 | 77.8 | -6.0 | -0.9 | 4369 | 96.6 | 48622 |
| Sheffield | 861011 | 826325 | 104.2 | 1.3 | 0.3 | 8082 | 96.6 | 45933 |
| Southampton | 698102 | 651783 | 107.1 | 2.5 | 0.4 | 6275 | 96.7 | 44779 |
| Surrey | 279041 | 375934 | 74.2 | -4.8 | -0.9 | 3303 | 96.3 | 50080 |
| Sussex | 691598 | 453367 | 152.5 | 14.2 | 2.3 | 4276 | 97.6 | 35849 |
| Warwick | 605370 | 566969 | 106.8 | 2.3 | 0.3 | 5396 | 96.9 | 44179 |
| York | 397805 | 381215 | 104.4 | 0.8 | 0.1 | 3476 | 97.0 | 43983 |
| Aberystwyth | 344556 | 356983 | 96.5 | -0.6 | -0.1 | 3216 | 96.8 | 45559 |
| Bangor | 359083 | 325050 | 110.5 | 1.5 | 0.3 | 2905 | 97.2 | 42719 |
| Cardiff | 575000 | 569770 | 100.9 | 0.3 | 0.0 | 5416 | 96.9 | 44850 |
| St. David's | 101147 | 117574 | 86.0 | -0.5 | -0.1 | 735 | 96.7 | 46526 |
| Swansea | 470936 | 411451 | 114.5 | 3.1 | 0.5 | 3800 | 97.2 | 42090 |
| W.N.S.Med. | 94393 | 119304 | 79.1 | -0.7 | -0.2 | 745 | 96.5 | 47386 |
| UWIST | 328043 | 316324 | 103.7 | 0.5 | 0.1 | 2806 | 97.0 | 44095 |
| Aberdeen | 759135 | 579426 | 131.0 | 10.9 | 1.7 | 5558 | 96.7 | 42237 |
| Dundee | 392473 | 364008 | 107.8 | 1.4 | 0.3 | 3303 | 97.1 | 43273 |
| Edinburgh | 1321747 | 1010964 | 130.7 | 8.3 | 2.9 | 10347 | 91.2 | 67311 |
| Glasgow | 1241857 | 1063040 | 116.8 | 4.2 | 1.6 | 10752 | 93.4 | 59087 |
| Heriot-Watt | 182024 | 350370 | 52.0 | -7.9 | -1.5 | 3088 | 95.7 | 54837 |
| St. Andrew's | 464695 | 375568 | 123.7 | 4.4 | 0.8 | 3442 | 97.5 | 40135 |
| Stirling | 330901 | 309453 | 109.5 | 1.3 | 0.3 | 2743 | 97.2 | 42919 |
| Strathclyde | 679278 | 728705 | 93.2 | -2.3 | -0.4 | 7038 | 97.3 | 44243 |

Notes: Average excludes Cardiff, London, Oxford, Cambridge, and the Business Schools. Source: UGC Form 3 Outturn.

## Table 3

### Comparative Expenditures for Salaries and Wages in the Libraries of British Universities for the 1982-83 Session— Arranged in Rank Order of their Percentage Relationship with GB Average Expenditure

Salaries and wages
Weightings - u/g x 1  p/gC x 1  p/gR x 1

| Serial | University | FTE Load | Actual Unit Cost £ | Average Unit Cost £ | % of G.B. Average | Student's t1 | t2 |
|---|---|---|---|---|---|---|---|
| 1 | Oxford | 12,801. | 268.1 | 100.4 | 266.9 | 40.7 | 17.8 |
| 2 | London | 46,661. | 168.4 | 97.9 | 172.0 | 12.1 | 11.2 |
| 3 | Cambridge | 12,088. | 161.8 | 100.6 | 160.8 | 15.3 | 6.2 |
| 4 | M.B.S. | 258. | 424.8 | 270.8 | 156.9 | 1.1 | 0.3 |
| 5 | L.G.S.B.S. | 239. | 436.2 | 284.6 | 153.3 | 1.0 | 0.3 |
| 6 | Sussex | 4,276. | 161.7 | 106.0 | 152.5 | 14.2 | 2.3 |
| 7 | Aberdeen | 5,558. | 136.6 | 104.3 | 131.0 | 10.9 | 1.7 |
| 8 | Edinburgh | 10,347. | 127.7 | 97.7 | 130.7 | 8.3 | 2.9 |
| 9 | Durham | 4,811. | 137.1 | 105.5 | 129.9 | 9.2 | 1.4 |
| 10 | St. Andrew's | 3,442. | 135.0 | 109.1 | 123.7 | 4.4 | 0.8 |
| 11 | Brunel | 3,036. | 133.8 | 110.8 | 120.8 | 3.2 | 0.6 |
| 12 | Glasgow | 10,752. | 115.5 | 98.9 | 116.8 | 4.2 | 1.6 |
| 13 | Leicester | 4,836. | 123.3 | 105.8 | 116.5 | 5.0 | 0.8 |
| 14 | Swansea | 3,800. | 123.9 | 108.3 | 114.5 | 3.1 | 0.5 |
| 15 | Nottingham | 7,202. | 116.5 | 102.6 | 113.5 | 4.6 | 0.9 |
| 16 | Exeter | 4,992. | 119.6 | 105.6 | 113.3 | 4.2 | 0.6 |
| 17 | Reading | 5,668. | 118.2 | 104.5 | 113.1 | 4.6 | 0.7 |
| 18 | Bangor | 2,905. | 123.6 | 111.9 | 110.5 | 1.5 | 0.3 |
| 19 | Keele | 2,869. | 123.5 | 112.1 | 110.1 | 1.4 | 0.3 |
| 20 | Stirling | 2,743. | 123.6 | 112.8 | 109.5 | 1.3 | 0.3 |
| 21 | Dundee | 3,303. | 118.8 | 110.2 | 107.8 | 1.4 | 0.3 |
| 22 | Southampton | 6,275. | 111.3 | 103.9 | 107.1 | 2.5 | 0.4 |
| 23 | Warwick | 5,396. | 112.2 | 105.1 | 106.8 | 2.3 | 0.3 |
| 24 | York | 3,476. | 114.4 | 109.7 | 104.4 | 0.8 | 0.1 |
| 25 | Sheffield | 8,082. | 106.5 | 102.2 | 104.2 | 1.3 | 0.3 |
| 26 | UWIST | 2,806. | 116.9 | 112.7 | 103.7 | 0.5 | 0.1 |
| 27 | Bristol | 7,062. | 106.6 | 103.1 | 103.4 | 1.2 | 0.2 |
| 28 | East Anglia | 4,258. | 110.2 | 107.4 | 102.7 | 0.7 | 0.1 |
| 29 | Hull | 5,545. | 107.0 | 105.0 | 101.9 | 0.7 | 0.1 |
| 30 | Cardiff | 5,416. | 106.2 | 105.2 | 100.9 | 0.3 | 0.0 |
| | **G.B. Average** | **308,514.** | **124.6** | **0.0** | **100.0** | | |
| 31 | Kent | 4,185. | 106.0 | 107.7 | 98.4 | -0.4 | -0.1 |
| 32 | Aberystwyth | 3,216. | 107.1 | 111.0 | 96.5 | -0.6 | -0.1 |
| 33 | Liverpool | 7,969. | 98.5 | 102.8 | 95.9 | -1.3 | -0.3 |
| 34 | Newcastle | 7,699. | 98.1 | 103.0 | 95.3 | -1.5 | -0.3 |
| 35 | Strathclyde | 7,038. | 96.5 | 103.5 | 93.2 | -2.3 | -0.4 |
| 36 | City | 2,775. | 105.2 | 113.4 | 92.8 | -1.0 | -0.2 |
| 37 | Lancaster | 4,596. | 95.1 | 107.0 | 88.9 | -3.2 | -0.5 |
| 38 | Loughborough | 5,653. | 92.5 | 105.1 | 87.9 | -4.2 | -0.6 |
| 39 | Bradford | 4,763. | 91.9 | 106.7 | 86.1 | -4.2 | -0.6 |
| 40 | St. David's | 735. | 137.6 | 160.0 | 86.0 | -0.5 | -0.1 |
| 41 | Manchester | 11,278. | 86.1 | 103.6 | 83.1 | -4.3 | -1.7 |
| 42 | Essex | 3,296. | 92.3 | 111.2 | 83.0 | -3.0 | -0.6 |
| 43 | Leeds | 10,898. | 85.1 | 103.6 | 82.1 | -4.7 | -1.8 |
| **44** | **BATH** | **3,720.** | **89.6** | **109.6** | **81.8** | **-3.9** | **-0.7** |
| 45 | W.N.S.Med. | 745. | 126.7 | 160.1 | 79.1 | -0.7 | -0.2 |
| 46 | Salford | 4,369. | 83.9 | 107.8 | 77.8 | -6.0 | -0.9 |
| 47 | Birmingham | 9,034. | 78.8 | 103.8 | 75.9 | -7.4 | -2.1 |
| 48 | Surrey | 3,303. | 82.5 | 111.1 | 74.2 | -4.8 | -0.9 |
| 49 | Aston | 4,507. | 75.1 | 107.6 | 69.8 | -8.6 | -1.3 |
| 50 | Heriot-Watt | 3,088. | 58.9 | 113.5 | 52.0 | -7.9 | -1.5 |
| 51 | U.M.I.S.T. | 4,664. | 50.6 | 107.9 | 46.9 | -16.8 | -2.6 |

Notes: Average excludes Cardiff, London, Oxford, Cambridge, and the Business Schools. Source: UGC Form 3 Outturn.

The penultimate column of Table 4 can be illustrated as a square in which the widths of the columns are proportional to the share of the total budget at the GB average level of expenditure for the mixture of students. This is illustrated in Figure 6.

However, Table 4 indicated that some schools of study were better endowed than the GB average and others were below average. The columns of Figure 6 can be extended or truncated accordingly, as shown in Figure 7. The average for the university as a whole was 74.8%, which is indicated by a dashed line.

As an indication of the priorities determined by the decision-makers in the university, the columns can be rearranged in rank order as is illustrated in Figure 8. If the square has 10 cm. sides, then 1 cm² = £20,785. The information given in Table 4 and illustrated in Figure 7 has been extracted from 18 subject tables analogous to Table 2.

If there is virement within the departmental budget, it is helpful to use similar summary tables to Table 4 for academic salaries and for consumable expenditures. This entails extracting information from a further 36 tables analogous to Table 2. The appropriate squares can be drawn and the tables can be summed so as to construct a square covering all departmental expenditure.

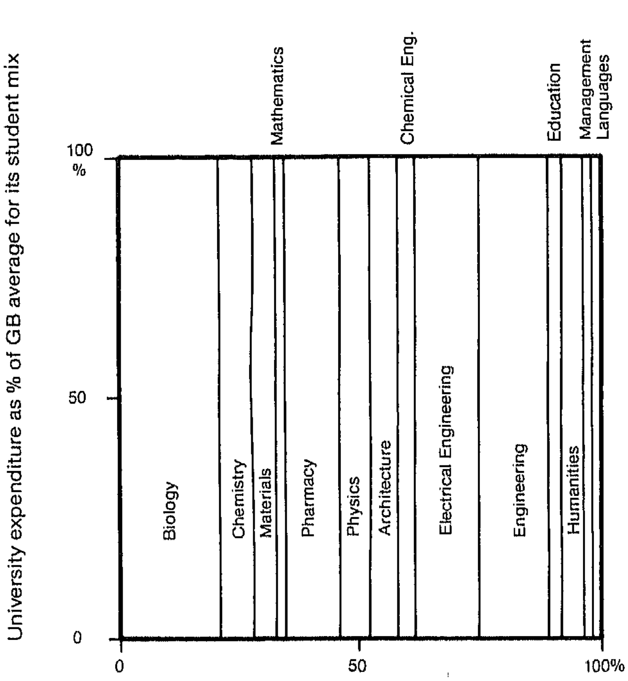
**Table 4**

**Expenditure on Departmental Support Staff in 1982-83 in the "University of Whitby" and the Theoretical Support-Staff Expenditure at the GB Average Level for the Mixture of Students**

| School of Study | Actual Expenditure £s | GB Average Expenditure £s | GB Average Expenditure % of total | Actual as % of GB Average |
|---|---|---|---|---|
| Biology | 270,971 | 428,056 | 20.6 | 63.3 |
| Chemistry | 154,717 | 142,128 | 6.8 | 108.9 |
| Materials | 73,091 | 96,071 | 4.6 | 76.1 |
| Mathematics | 31,848 | 39,876 | 1.9 | 79.9 |
| Pharmacy | 242,804 | 237,171 | 11.4 | 102.4 |
| Physics | 128,161 | 132,258 | 6.4 | 96.9 |
| Architecture | 62,119 | 118,920 | 5.7 | 52.2 |
| Chemical Eng | 43,642 | 73,294 | 3.5 | 59.5 |
| Electrical Eng | 153,349 | 277,961 | 13.4 | 55.2 |
| Engineering | 199,531 | 295,924 | 14.2 | 67.4 |
| Education | 54,144 | 50,992 | 2.5 | 106.2 |
| Humanities | 50,038 | 89,583 | 4.3 | 55.9 |
| Management | 53,012 | 43,872 | 2.1 | 120.8 |
| Languages | 37,157 | 52,421 | 2.5 | 70.9 |
| Totals | 1,554,584 | 2,078,527 | 100.0 | 74.8 |

*Note:* £s = British pounds.

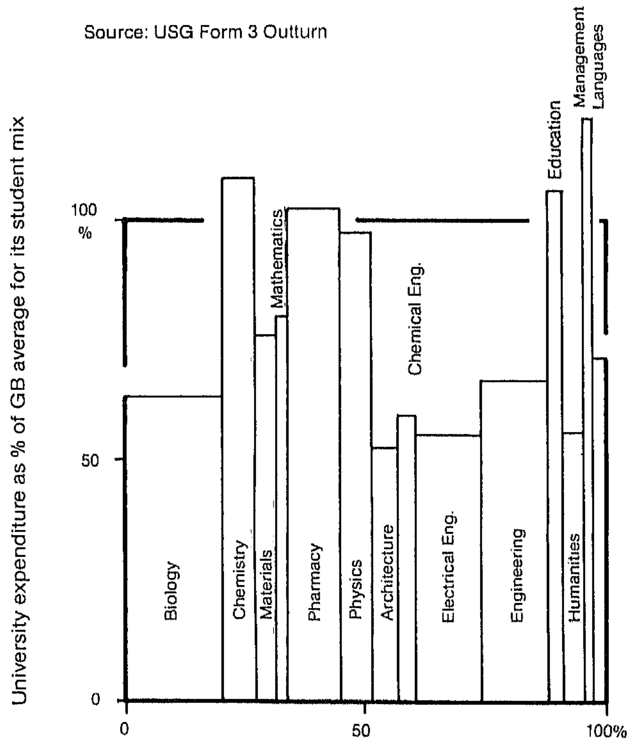
Analogous tables to Tables 2 and 3 are produced for all expenditures. The university positions in the Table 3 analogues, in terms of quartiles, enable the production of a matrix, as in Table 5, which illustrates the relationships in respect of support staff and consumable expenditures in schools. Should they choose, those schools on the diagonal from top left to bottom right may use their virement capability to move some way towards the average. From the Tables (such as Table 5) it is easy to attach specific sums of money as a measure of deviation from the GB average provision (or the average university provision, if judged to be more appropriate in the circumstances). Such deviations can be tabulated, together with confidence limits, as a backcloth for discussion of any reallocation of resources among schools in the University of Whitby. The academic




Cumulative percentage of university expenditure when at GB average

Figure 6. Square representing departmental support-staff expenditure at the "University of Whitby" if it were at the GB average level for its mixture of students.

Source: USG Form 3 Outturn




Cumulative percentage of university expenditure when at GB average

Figure 7. The extension or truncation of the columns in Figure 6, showing the actual departmental expenditure on support staff at the "University of Whitby".

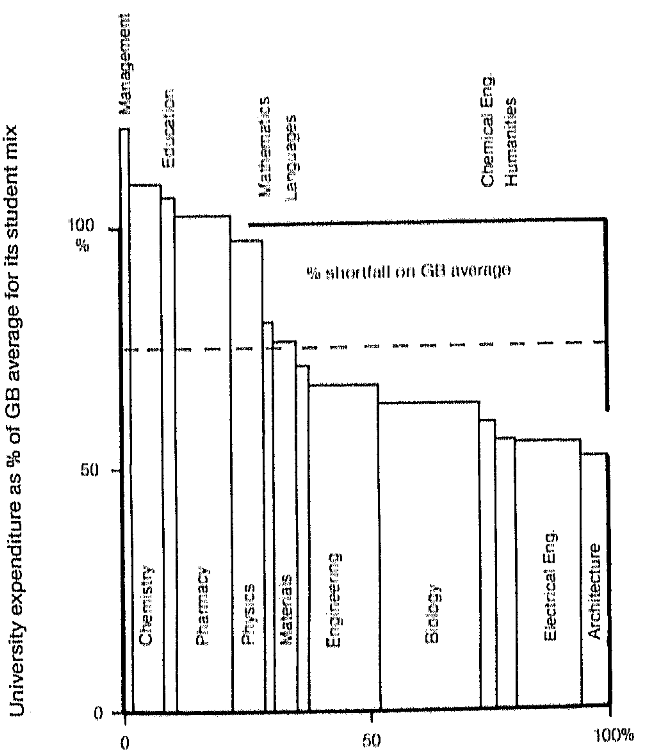
Source: UGC Form 3 Outturn

**Table 5**

**Distribution of Schools with Respect to Support Staff and Consumable Expenditures in 1981-82—against 86% of the GB Average**

| | School Support-Staff Expenditure | | | |
|---|---|---|---|---|
| | **Lower Quartile** | **Median** | | **Upper quartile** |
| **Upper Quartile** | *Biol. Sci.* (**-100**) (*+60*) net -40<br>*Arch & B.E.* (**-45**) (*+21*) net -24<br>*Engineering* (**-35**) (*+20*) net -15<br>*Mat. Sci.* (**-11**) (*+17*) net +6 | *Mathematics* (**-**) (*+6*) net +6<br>*Physics* (**-2**) (*+24*) net +22 | *Pharm. & P'col.* (**+50**) (*+64*) *net +114*<br>*Chemistry* (**+4**) (*+49*) net +53<br>*Education* (**+2**) (*+18*) net +20 | |
| **Median** | *Chem. Eng.* (**-12**) (*+2*) net -10 | *Mod. Langs.* (**-4**) (*+4*) net - | | |
| | *Elect. Eng.* (**-102**) (*-5*) net-107<br>*Human. & SS* (**-24**) (*-3*) net -27 | | *Management* (**+7**) (*-5*) net +2 | |
| **Lower Quartile** | | | | |

Notes: Bold figures in parentheses show over- or under-spend on support staff; italic figures in parentheses do likewise for consumables. Also shown is the net figure. All figures are in British pounds.




Cumulative percentage of University expenditure when at GB average

Figure 8. The rearrangement of columns in Figure 7 in order of size, suggesting the order of priority in the allocation of funds. (Note: The dashed line indicates the average level of support given by the university at 75% of the GB peer expenditure.

Source: UGC Form 3 Outturn

arguments would be mustered as would other reasons. For example, Pharmacy has a responsibility for the animal house which relieves Biological Sciences of expenditure, but is the size of the difference appropriate? Electrical Engineering is moving from heavy current studies towards microchips; do they really need the unit costs associated with the engineering subject category?

The UGC movement towards "cost centres" rather than the present broad-brush subject categories will enable much more finesse in analyses in the future, in that electrical engineers will be comparable with other electrical engineers rather than with the whole of engineering. Confidence limits are likely to be enlarged because sample sizes will be smaller, but this tendency will be more than offset by the greater homogeneity of the information—leading to greater precision in the estimation of the mean values. This will help Whitby's self-appraisal in the future. They are presently confined to the broad analysis offered as an example in this paper, but at least there is a perspective to their considerations.

Another example of the use of the unit cost analysis described in this paper is given in Taylor (1984) which sets out to identify the resource needs of sandwich (= co-operative) education.

In conclusion, it is suggested that the pattern of comparative expenditure determined by the method described above offers a perspective for resource allocation. It allows the construction of budgetary models for testing the financial outcomes of academic and recruitment hypotheses, and it provides an information base so as to insulate decision-makers against uninformed "special pleading."

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