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ABSTRACT

This comparative study is broadly divided into two parts. The first presents a simple approximate internationally data-based university overall mathematical resource model derived from an original analysis of a 15-university international sample from the CERI (Center for Educational Research and Innovation) 1968/1969 Information Survey. It provides a method of estimation of staff and costs at departmental (or equivalent structure) level in terms of twelve broad subject areas and these are then used to derive staff, areas, recurrent and some capital expenditures at the overall university level. The results of a typical example are given. The second part presents a generalized conceptual/data-based methodology for the calculation of university departmental academic, supporting and administrative staff by broad subject area and geographical region. The methodology has been specifically formulated to accommodate different types of student programmes and the method is illustrated by example to a typical British University. Included are relevant observations on international university comparative data derived from the CERI survey. (Author)

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IN HIGHER EDUCATION
- CENTRE FOR EDUCATIONAL RESEARCH
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COMPARATIVE STUDIES IN COSTS AND RESOURCE REQUIREMENTS FOR UNIVERSITIES

by

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(Note by the Secretariat)

This report was prepared by Professor Keith Legg as a consultant to the Centre during January - July 1971. It constitutes one of the in-house research activities carried out as part of the Programme on Institutional Management in Higher Education. It is based on the University Information Survey conducted by the Centre with his advice. It provides a method of estimation of staff and costs at departmental (or equivalent structure) level in terms of 12 broad subject areas and these are then used to derive staff, areas, recurrent and some capital expenditures at the overall university level. The results of a typical example are given.

The report then presents a generalized conceptual/data-based methodology for the calculation of university departmental academic, supporting and administrative staff by broad subject area and geographical region. The methodology has been specifically formulated to accommodate different types of student programmes and the method is illustrated by example to a typical British university.

COMPARATIVE STUDIES IN COSTS AND RESOURCE REQUIREMENTS FOR UNIVERSITIES.

This report has been prepared by Professor Keith Legg, Head of the Department of Transport Technology, The University of Technology, Loughborough, England, and Consultant to CERI.

The paper is broadly divided into two parts. The first presents a simple approximate internationally data-based university overall mathematical resource model derived from an original analysis of a 15-University international sample from the CERI 1968/1969 Information Survey. It provides a method of estimation of staff and costs at departmental (or equivalent structure) level in terms of 12 broad subject areas and these are then used to derive staff, areas, recurrent and some capital expenditures at the overall university level. The results of a typical example are given.

The second part presents a generalized conceptual/data-based methodology for the calculation of university departmental academic, supporting and administrative staff by broad subject area and geographical region. The methodology has been specifically formulated to accommodate different types of student programmes and the method is illustrated by example to a typical British University.

The paper includes relevant observations on international university comparative data derived from the CERI survey.

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CHAPTER 1. AN APPROACH TO UNIVERSITY PLANNING

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1. The General Approach

Systematic evaluation of the university function has been a much-neglected subject. Universities have become so closely associated with the term "academic freedom" that attempts to formalise their function have invariably been resisted on the basis of violation of this ancient heritage. Such resistance can, however, be justified quite easily on the grounds of the complexity of the problem involving as it does the human equation of young people during their most intellectually formative years. However, the need for and rapid growth of higher education demands the application of the most sophisticated management principles to the organization and running of universities if the present confusion is not to degenerate into chaos. Thus in recent years there has been a growth in research activity in this area with particular emphasis on a systems approach. The majority of work has concentrated on descriptive model techniques which, although probably more acceptable to the average academic, limit the degree of comparative analysis that can be made and tend to be of a localized nature. Formulae are regarded with suspicion and, if not firmly controlled, can lead to complicated detail and rigid application. Nevertheless, the analytical approach provides considerable flexibility, particularly for a generalized overall system, and if used within its limitations can provide broad guidelines whilst obviating the principle that "whoever shouts loudest gets most!".

With these considerations in view a simple mathematical approach to academic planning was developed at the University of Loughborough, and has become accepted as a good management aid for those aspects of staff and space on which it concentrates. Principally it serves as a guide for equitable provision across the university for existing commitments and the determination of future requirements conforming to University policy.

Arising out of this early work at Loughborough, CERI/OECD conducted an international survey of 80-universities in 1970/1971, with an objective of providing a data basis for further analytical investigation. From the total survey, 15-universities submitting the most complete returns were selected for more intensive analysis. The methods of data processing are detailed in reference 6.

Analysis of the 15-university sample is the basis for the simple overall university model. This data facilitated the evaluation of relationships between student enrolment, staff and space requirements, and recurrent and capital expenditure. Although the final model stands independent of the data analysis, its application depends upon knowledge of the model constants. One source of this knowledge is the survey.

In addition to the initial data-based model, a more conceptual model is developed at the departmental level. Both the overall model and the departmental model are based on definitions of the academic staff function related to teaching. Though research and other duties of academic staff are not explicitly included, the selection of teaching can be justified on the grounds that it is the "raison d'être" of the university. In any case, the use of an average teaching load parameter takes into account, implicitly, time devoted to these other activities.

The extended data-based methodology of the overall university model can assist in a wide range of problems, between as well as within, universities. Applied to individual institutions, using their own initial data, it would be useful in simple planning, forcasting and resource allocation between departments, and at university level. Applied nationally or internationally it facilitates comparative inter-institutional studies of the different resource elements, for the planning of resource needs for new institutions and growth of existing ones.

Specific approximate individual studies e.g. comparative approximate costs per student in broad subject areas could be aided, at any of these levels, by application of the methodology.

The second, more conceptual framework for determining departmental requirements enables a more exact assessment of absolute levels of resource needs. Modification to make it operative as a sub-model for the overall university model is possible.

2. A Simple Data-Based Model for Overall University Resource Allocation

This overall university model develops a series of relationships, expressed algebraically, between the component elements of the university. Its essential purpose is to aid in resource allocation within and between universities. With this in mind values of parameters, necessary for model solutions, are provided from the university survey.

A simple explanation of the methodology is set out in diagram I (section numbers refer to appropriate points in the model Chapter 2). It commences at the departmental level where input data on student enrolment, classified into 1st degree and higher degree, is required. Each department is classified into one of ten broad subject areas. At this point academic staff requirements for each department can be defined. Academic staff numbers determine supporting staff requirements (technical, administrative etc.), and annual recurrent expenditure at the departmental level.

To procede from this stage to the overall university it is necessary to make several assumptions. The simplest set, utilized here, is that all students and academic staff are attached to a particular department. In a specific context different assumptions re the relationship of departmental students and staff and overall university numbers may be more appropriate. These can be incorporated without undue difficulty under the present assumption the sum of departmental students and academic staff equal the corresponding university figures.

Relationships can now be developed at the university level. Administrative, library, technical and other staff are expressed in terms of total academic staff. Simple algebraic substitutions enable university annual recurrent expenditure, and its components, to be expressed similarly.

University space requirements are categorized into various groups according to function. These are, broadly, net university building floor area, gross university building area, recreational facilities, and car parks. The first category is further subdivided into teaching rooms, laboratories, academic and administrative staff offices, library and "other" areas. Each of these components is evaluated independently, and all are reducable to expressions in which academic staff is the only independent factor.

University used land area is the sum of gross building area, recreational and car park areas. In order to assess the total site requirement from this, building density and 'environmental desirability' factors are introduced.

To convert these capital requirements into monetary terms, it is necessary to know the cost per square unit of the different types of provisions. If growth is envisaged, the percentage growth rate of the student populated must.

Methodology for Determining Resource Needs for Overall University. (Chapter 2)

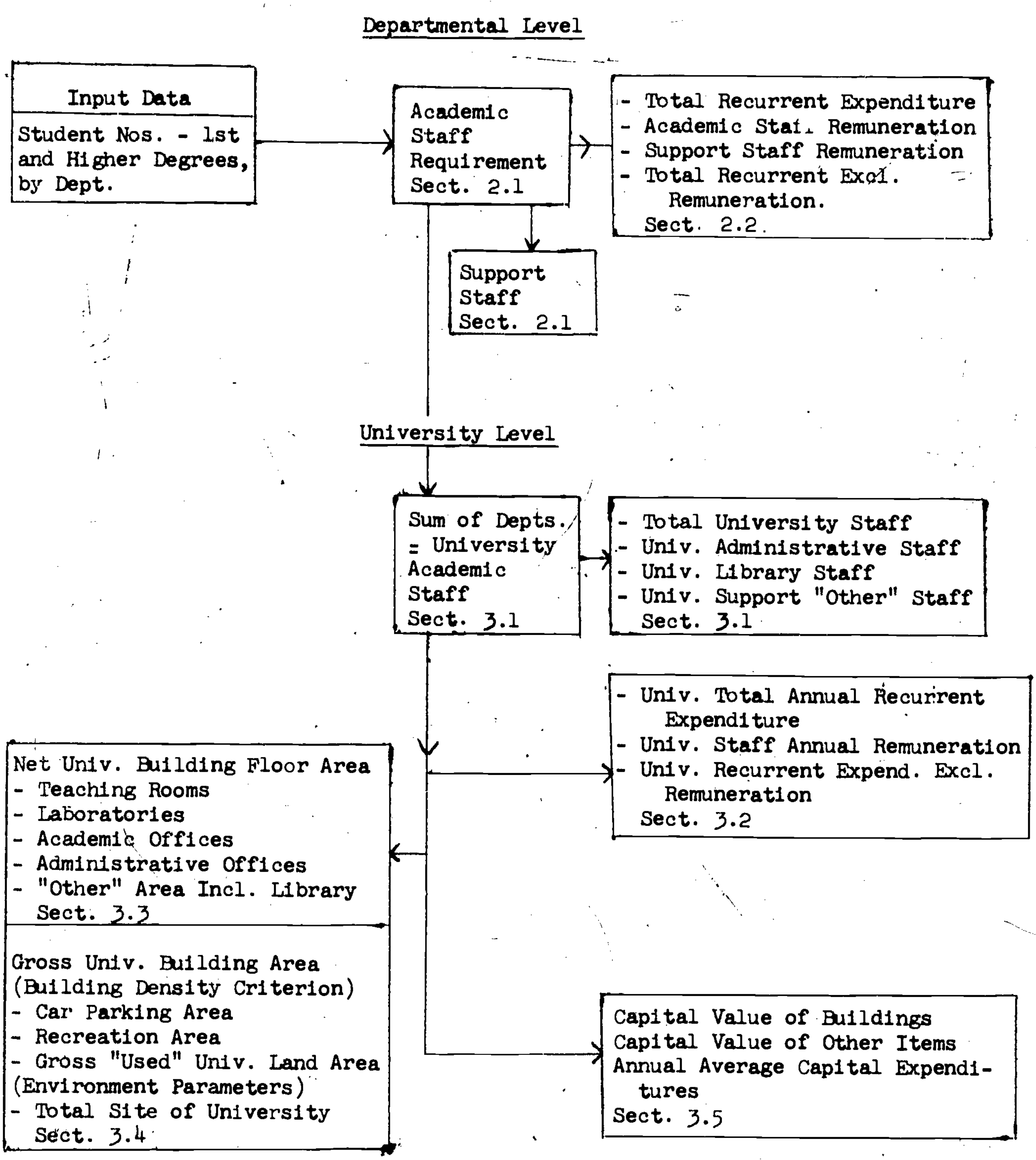

DIAGRAM I

The crucial element in the practical application of this methodology is a knowledge of the parameter values with the algebraic functions. Approximate values for these parameters were obtained from 15-university sample, and from the 80-university OECD survey. These values are presented in section 4 of Chapter 2. Due to the quantity of data a computer programme calculating these constants was written. The results of the 15-university sample are cross-tabulated by three regions - North America, United Kingdom and Europe, and by the ten broad subject areas divised. An overall average situation across all regions was also calculated as a basis for general comparison. These could be used as approximations in determining requirements of departments, by university personnel, and of universities, by national bodies. Approximations drawn from the large 80-university survey, classified into five regions plus an overall average, are also presented.

Alternatively a university or national body could collect data to develop parameter values more closely related to their own context. The decision to do this would rest on whether the accuracy obtained merited the additional work involved. This would almost certainly require computer facilities, although the programme available at CERI could be of assistance. It would also necessitate that universities look closely at their own management data services. In this paper, methodology is emphasized rather than the accuracy of detail.

One further feature of the model is that, although it is built up logically step-by-step, functions enabling the calculation of particular requirements of immediate interest, can be extracted, without necessitating a great deal of computation at earlier stages.

3. A Conceptual Methodology for Departmental Requirements

An alternative, more-conceptualized departmental model which analyses the complex functions of a department as an entity, has been developed. This provides a complete methodology for determining departmental resource needs where the department is responsible for a whole range of different courses of study, where its staff teach in other departments, and where it turn benefits from staff external to the department.

The basis of this methodology is the generalized "programme of study" concept. A "programme of study" is those requirements which must be satisfied in order to qualify for a degree or diploma. From this concept is derived a general equation applicable to any course of study run by a department. This might be an undergraduate degree course, post-diploma research studies, short courses, etc. The departments student enrolment is classified into three groups - fundamental, advanced and higher.

From these categories it is possible to compare different programmes of study from different educational systems far more directly than with the simpler 1st degree/higher degree classification of the overall model. Each department can categorize its programmes of study more finely, and weightings of requirements for different levels of students can be more exact.

A programme of study under the auspices of one department, may be taught by academics attached to both that department and other departments. This service-teaching between departments is explicitly incorporated in the analysis by means of distribution factors. Thus the contribution by academic staff of any particular department to various programmes of study in accounted for in determing the departmental staff needs.

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Methodology for Determination of Departmental Requirements. (Chapter 3).

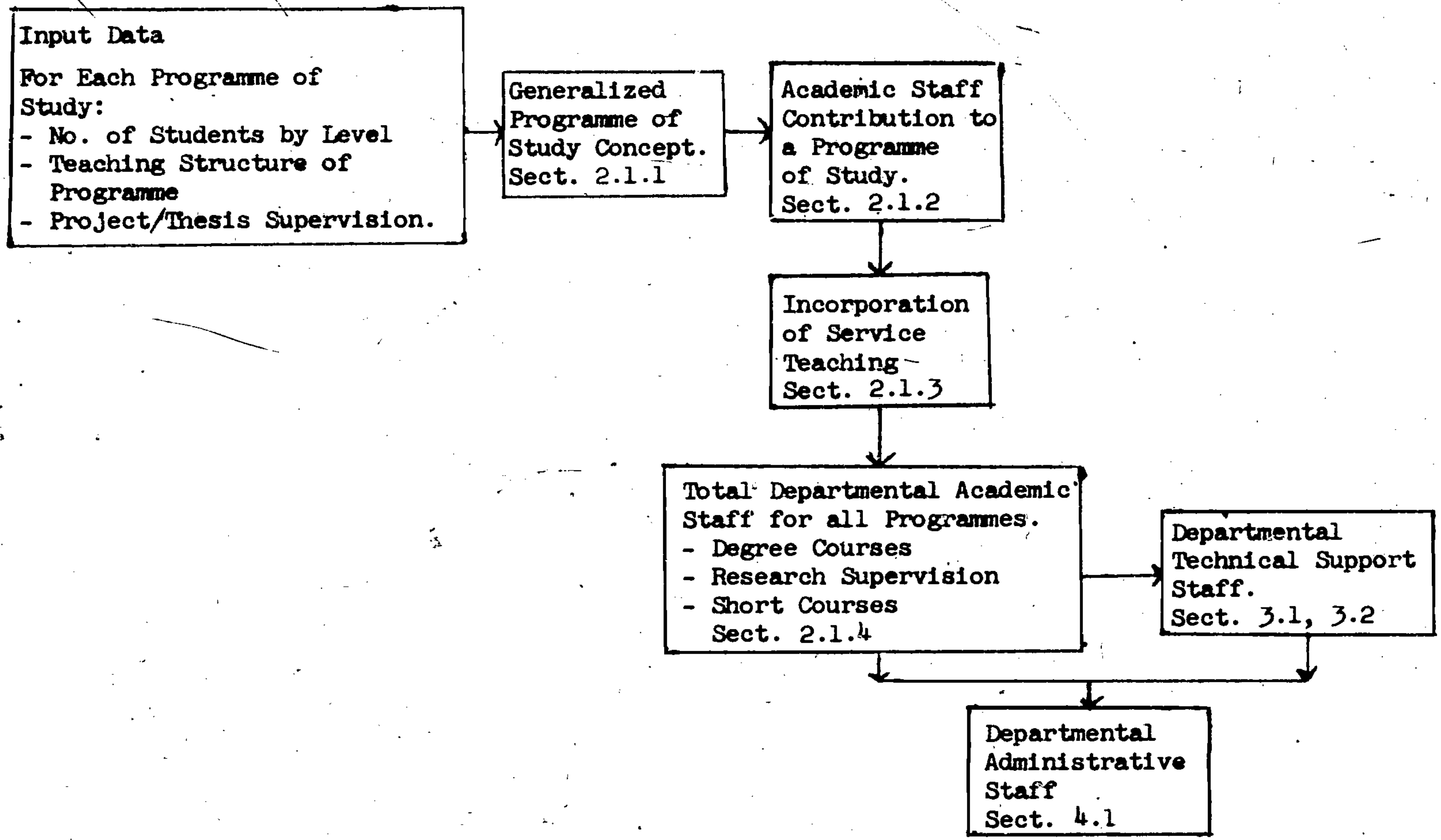

DIAGRAM II

Given the data on different levels of students, and the detailed structure of teaching of each programme of study, it is hence possible to obtain a more accurate assessment of the absolute academic staff requirements of any particular department. In addition a means of assessing the composition of this in terms of part-time and full-time staff is included.

Technical and other support staff (excluding administration) is postulated as a function of departmental support area, including laboratories and other working space necessary for the adequate functionning of the department. Although technical support staff is also related to academic staff, data from the 80-university survey suggests that this relationship is small. The method also enables, as a by-product, the assessment of departmental support area requirements.

Departmental administrative staff is related to total departmental academic and technical staff. Furthermore it is a reasonable assumption that the degree of administrative servicing is related to the level of responsibility of these other staff. Hence administrative staff are a function of departmental staff, weighted for differing levels of responsibility.

The framework of this more-conceptual departmental model is illustrated in Diagram II. Section numbers are included to facilitate reference to the detailed exposition in Chapter 3.

In addition to the two models, a good deal of data interpretation is included throughout, especially in Chapter 4. As well as providing insight for analytical investigation for the models, this information is useful in its own right.

The application of such management aids as these models would dearly be much simpler with completer facilities, due to the large quantity of data and calculation involved. In any case the compilation of such information is required for effective running of a university. Although it is an administrative task to set up the process, it is essential to involve academic staff at all levels and at all stages. This is particularly important in assessing the inputs of data.

The total methodology serves as an aid in the decision-making process, by providing information and assessment of resource needs. It is not a substitute for the policy making process itself.

CHAPTER 2. A SIMPLE DATA-BASED METHODOLOGY FOR THE DETERMINATION OF UNIVERSITY RESOURCE REQUIREMENTS.

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1. Introduction

The methodology for the determination of university resource requirements developed in this chapter is a set of simple data-based relationships. Analysis of the 15-university survey data revealed certain parameter values linking different variables (see Chapter 4, sections 2.2, 2.3 and 2.4). This allowed a first approximation of how the variables relate to one another.

In contrast to the more conceptual departmental model of Chapter 3, this methodology has potential utilization at the university, national and international levels. It does not allow an absolute value assessment of requirements of individual departments, but provides approximations for comparative purposes. However, with some further development the methodology of the mor conceptual departmental model could be utilized as input data, for absolute assessments of departments, within the overall university model. This would then replace the general departmental section 2 of the present chapter.

The model presented here, together with the sets of parameter values which could be utilized in practical evaluations, could assist in the following problems·

(i) Application to individual institutions, using their own initial data, for simple planning, forecasting and resource allocation.

(ii) Comparative inter-institutional or international studies.

(iii) Approximate resource needs for new institutions and growth needs for existing ones.

(iv) Specific individual studies e.g. comparative approximate costs per student in broad subject areas.

The complete model commences at the departmental and proceeds to the overall university. At the forme level, each department is classified into the 10 broad subject classification areas of Chapter 4, table 2. Input data on the number of first degree and "all higher" degree students in a department (associated with the 15-university questionnaire) enables the evaluation of staff weekly teaching hours and academic, support and total departmental staff. This can then be translated into annual recurrent expenditure.

After the determination of these resources peculiar to a department, overall university relationships are developed. Academic staff for the university is the sum of departmental needs. Administrative, library and "other" staff (e.g. technicians etc.) totals are related directly to academic staff. The functions linking annual remuneration recurrent expenditures on these items to numbers required are outlined. To this is added recurrent non-staff expenditure, to give total annual recurrent expenditure for the university. On the assumptions utilized here, this equals the sum of departmental recurrent expenditures and centralized service expenditure (library, administration etc.).

Net university floor area is the sum of area requirements for teaching rooms, laboratories, staff offices, both academic and administrative, library and "other". Each of these is related in turn to academic staff, determined previously. By contrast, gross building area is related directly to academic staff in a proportionate way, and will always be greater than net floor area described above. Gross building area, together with car parking and recreation facilities yields total usable site. With the introduction of site density and "environmental limiting" factors, this is translated into total university site.

The total capital of a university is the monetary value assigned to its stock of buildings and other equipment. A simple costing procedure is outlined. Annual average capital expenditure presumes a growth situation, based on growing student population, and its evaluation in relation to academic staff can prove a useful guide for estimating expansion costs.

In order to demonstrate the usefulness of the procedure as a complete entity, two possible sets of parameter values, based on the 15-university and 80-university samples respectively, together with a complete example, are presented in parts 4 and 5. However the model can provide information on specific items of university requirements relatively directly without necessitating a full evaluation of relevant parameters. Hence academic staff for a department, for example, could be investigated using only the relevant sections.

At many points in the methodology, alternative evaluations of parameters are detailed. This is done to obtain the most accurate assessment of parameters relating the variables. In general the simplest means is presented first, followed by the more complicated.

2. Determination of Departmental Requirements

Each department is classified by broad subject field i, as shown in table 2 of Chapter 4. Student population is subdivided into first degree and "all higher" degree levels, as in the university questionnaire. This contrasts with the three divisions of fundamental, advanced and higher students utilized in the more conceptual departmental model of Chapter 3 (section 2.1.1.).

Using input data on student numbers, staff weekly teaching hours, and hence academic staff numbers, are determined. Flowing from this point are relationships for "other" departmental staff (technicians, administrative, etc.).

Let F_{T_i} = total departmental students

F_{U_i} = total departmental students - all first degrees

F_{O_i} = total departmental students - all "higher" degrees,

where i denotes the ith broad subject group (i = 1, 2 ..... 10).

Let $F_{T_i} = (F_U + F_G)_i$

and total student population across all departments, F_{T_i} is:

$$F_T = \Sigma^i F_{T_i} = \Sigma^i (F_U + F_G)_i$$

Total undergraduate student population, all departments,

$$F_i = \Sigma^i F_{U_i}$$

Total "higher" degree students in all departments,

$$F_6 = \Sigma^i F_{6_i}$$

Definitions. These relationships derived from the 15-university sample. Values for the ratios are given in table 4 of Chapter 4, together with the data analysis.

Let A be the ratio of departmental academic staff (D_A) to total departmental staff (D_T)

$$A = \frac{D_A}{D_T}$$

Let B be departmental weekly total staff teaching hours (T_T per academic staff member (D_A).

$$B = T_T/D_A$$

C is the proportion of total departmental staff weekly teaching hours devoted to undergraduate teaching (T_U)

$$C = \frac{T_U}{T_T}$$

D is the general departmental student academic staff ratio

$$D = \frac{F_T}{D_A}$$

E is the proportion of the total student population which is undertaking the first degree

$$E = \frac{F_U}{F_T}$$

<u>Staff weekly teaching hours</u> total is the sum of those hours spent in first degree teaching and those spent in "all higher" degree teaching. If the staff weekly teaching hours are expressed in terms of the above ratios, averaged values can be substituted into the expression to give a broad guide to anticipated staff teaching hours.

Staff hours weekly devoted to undergraduate teachings

$$T_{U_i} = \left[\frac{C.B}{E.D}\right]_i \cdot F_{U_i} \quad \text{(1a)}$$

Staff hours weekly devoted to higher degree teaching

$$T_{O_i} = \left[T_{T_i} - T_{U_i}\right] F_{G_i} = \left[\frac{B.(1-C)}{D.(1-E)}\right]_i \cdot F_{G_i} \quad \text{(1b)}$$

Therefore total weekly staff teaching hours is

$$T_{T_i} = \left[\frac{C.B}{E.D} \cdot F_U + \frac{B(1-C)}{D(1-E)} \cdot F_G\right]_i \quad \text{(1c)}$$

and $T_T = \Sigma^{i}\ T_{T_i}$

2.1. <u>Departmental Staff Requirements</u>

A <u>department's academic staff complement</u> is simply the total teaching hours per week given by academic staff divided by their average weekly teaching load.

Let D_{A_i} = departmental academic staff

Then $D_{A_i} = \dfrac{T_T}{B}$

$$= \left[\frac{C}{E.D} \cdot F_U + \frac{(1-C)}{D(1-E)} \cdot F_G\right]_i \quad \text{(2)}$$

and $D_A = \Sigma^i D_{A_i}$

where D_A is the total academic staff attached to all departments in a university, academic staff is in direct proportion to total departmental staff such that:

$$\left[\frac{D_A}{D_T}\right]_i = A_i$$

$$\text{or } D_{T_i} = \left[\frac{D_A}{A}\right]_i \quad \ldots\ldots (3)$$

and $D_T = \Sigma^i D_{T_i}$

"<u>Other" departmental staff</u> is the difference between total departmental staff and academic staff

If D_{O_i} = "other" departmental staff

$$D_{O_i} = D_{T_i} - D_{A_i} \quad \ldots\ldots (4)$$

$$D_O = \Sigma^i D_{O_i} = D_T - D_A$$

Given that values of A, B, C, D and E are available by subject and by region, as an example, table 1 of section 4, the departmental staff requirements are now defined.

2.2. <u>Annual Departmental Recurrent Expenditure</u>

This is in effect the assigning of an annual monetary value to staff resources and other items.

Let V_{T_i} = total departmental annual recurrent expenditure

D_T = total departmental staff

F = average annual recurrent expenditure per staff member.

i.e. $F = \frac{V_T}{D_T}$

(for the derivation of the value of F, see 2.1.2. and 2.1.3. of Chapter 4).

Therefore total departmental annual recurrent expenditure is the product of the average expenditure per staff member and the departmental staff complement.

$$V_{T_i} = \left[F . D_T\right]_i$$

from (3), $= \frac{F}{A} \cdot D_{A_i}$ .... (5)

$$V_T = \Sigma^i V_{T_i}$$

Analysis of survey data provides average values for F and A by region and subject area (see sections 2.1.2. and 2.1.3. of Chapter 4). Hence V_{T_i} is directly calculable from academic staff.

Departmental recurrent expenditure can be subdivided into that devoted to remuneration of academic and support staff and that devoted to other items.

Total departmental staff annual remuneration is the product of the average remuneration per staff member and the total number of staff.

Let V_{N_i} = departmental total staff remuneration per annum

= average annual remuneration per staff member.

i.e. $\sigma = \frac{V_N}{V_T}$

Then

$$V_{N_i} = \left[\sigma \cdot V_T\right]_i$$

from (5), $= \left[\frac{F.\sigma}{A} \cdot D_A\right]_i$ .... (6)

and $V_N = \Sigma^i V_{N_i}$

This total remuneration expenditure per annum is made up of that devoted to academic staff and that devoted to other support staff.

Let V_A = total departmental academic staff annual remuneration

H = average annual remuneration per academic staff

i.e. $H = \frac{V_A}{D_A}$

Then

$$V_{A_i} = \left[H \cdot D_A\right]_i \quad \text{.. (7)}$$

$$V_A = \Sigma^i V_{A_i}$$

i.e. departmental academic staff annual remuneration is the product of the average annual remuneration per academic and the member of academic staff.

Remuneration of "other" departmental support staff is treated as the difference between total staff remuneration and academic staff remuneration per annum.

Let V_O = total departmental "other" staff annual remuneration

Then $V_{O_i} = V_{N_i} - V_{A_i}$

$$= \left[\left(\frac{F.G}{A} - H\right) . D_A\right]_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

and $V_O = V_N - V_A = \Sigma^i V_{O_i}$

Departmental recurrent expenditure excluding remuneration is the difference between total annual recurrent expenditure and that devoted to staff remuneration.

Let V_R = total departmental annual recurrent expenditure excluding remuneration

$V_{R_i} = V_{T_i} - V_{N_i}$

$$= \left[\frac{F}{A} (1 - 6) . D_A\right]_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

Hence from the values available for the parameters A - H, it is possible to evaluate departmental staff requirements and annual recurrent expenditures. It will be noted that the values of expenditure parameters F, 6, and H are "cost standardized" for comparative purposes. The exchange rates and cost indices are set out in table 46 of chapter 4.

3. Overall University Resource Requirements

In general the resources utilized by all sectors of the university are treated at this university level. Hence library services, for example, are not treated as the responsibility of any one department, but as the responsibility of the entire university institution. However there must be a linking together of those resources found necessary at the departmental level and those necessary for the institution as a whole. This requires certain assumptions to be made. In this instance the simplest are selected.

1. All academic staff are assumed to be attached to a department. That is, total university academic staff (S_T) equals the sum of academic staff in all departments (D_A). Alternatively, all institutes etc., are treated as departments for the purpose of academic staff calculation.

2. All students, both first and higher degree are assumed to be attached to a department. Total university student enrolment (P_T) equals the sum of student numbers in all departments (F_T). In addition, total first degree student enrolment at the university equals the sum for all departments (F_U). Similarly for higher degree students.

3. Let s_U be the overall student/staff ratio ($^{P_T}/_{S_T}$). The two notations,

departmental and university, have been kept distinct as other assumptions are clearly possible, and may be necessary, for example, where independant institutes contribute importantly to teaching or student supervision. The total university notation will be employed for the remainder of the model.

3.1. University Staff

The previous section 2.1. provides the means of estimating university academic staff. It remains to evaluate central staff requirements for administration, library, technical and others. Each of these types of staff can be estimated in several ways. These alternative methods are described here as, according to the specific context, one may permit a simpler evaluation of parameters than another.

Administrative staff can be expressed as a function of total university staff, which in turn is a function of academic staff numbers.

Let N_D = total university administrative staff

N_T = total university staff

S_T = total university academic staff

Then $N_D = m_{TA} \cdot N_T$

but from section 2.2.2. of Chapter 4,

$$N_T = \frac{ST}{m_{TT}}$$

Therefore $N_D = \frac{m_{TA}}{m_{TT}} \cdot S_T$ .... (10a)

Alternatively, as shown in section 2.2.2. of Chapter 4, table 34, administrative staff can be expressed directly as a function of academic staff.

$N_D = m_D \cdot S_T$ .... (10b)

Comparison of the equations shows $m_D = \frac{m_{TA}}{m_{TT}}$.

Values of the coefficients $\frac{m_{TA}}{m_{TT}}$ and m_D, reached via the alternative routes, can be compared, and close agreement indicates that a reasonable approximation has been reached. In this case the values are similar, as can be shown in table 3 of section 4 below.

A third approximation for the parameter relating university administrative and academic staff is the mean of m_D and $\frac{m_{TA}}{m_{TT}}$

Hence $N_D = k_D \cdot S_T$ .... (10c) where $k_D = \frac{1}{2}\left[\frac{m_{TA}}{m_{TT}} + m_D\right]$

Library staff can be expressed as a function of student enrolment, and hence academic staff, or as a function of total university staff, in turn translated into terms of academic staff.

Let N_h = total university library staff

N_T = total university staff

P_T = total university student population

$N_L = \frac{P_T}{m_p}$ (see table 34, section 2.2.2. of Chapter 4).

but $P_T = s_u \cdot S_T$ where s_u is the student: staff ratio

therefore $N_h = \frac{s_u \cdot S_T}{m_p}$ .... (11a)

Alternatively:

$N_h = m_{TL} \cdot N_T$ (see table 34, section 2.2.2. of Chapter 4).

but $N_T = \frac{S_T}{m_{TT}}$

therefore $N_h = \frac{m_{Th}}{m_{TT}} \cdot S_T$ .... (11b)

Hence there are again two alternative values, $\frac{s_u}{m_p}$ and $\frac{m_{TL}}{m_{TT}}$ linking library and and academic staff.

The third approximation would again be the mean of these two alternatives.

Hence $N_L = k_L \cdot S_T$ .... (11c)

where $k_h = \frac{1}{2}\left[\frac{m_{TL}}{m_{TT}} + \frac{s_u}{m_p}\right]$

Technical and other staff can be expressed directly as a function of academic staff, or can be treated as a residual - the difference between total university staff and the sum of academic, administration and library elements. The values of constants below are shown from the 15-university sample, is table 34, Chapter 4.

Let N_O = total university technical and other staff

Then $N_O = \frac{m_{TO}}{m_{TT}} \cdot S_T$ .... (12a)

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Alternatively:

$$N_O = N_T - S_T - N_D - N_L$$

but N_T, N_A, N_h are all functions of S_T, as shown above. Using the equations (10c), (11c),

$$N_O = \frac{S_T}{m_{TT}} - S_T - k_D \cdot S_T - k_L - S_T$$

$$= \left[\frac{1}{m_{TT}} - 1 - k_D - k_h\right] \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots \quad (12b)$$

Alternatively (10a), (11a), or (10b) and (11b) substitutions could be used for N_D, N_L.

The third, mean, value for the parameter linking technical and academic staff is:

$$N_O = k_O \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots \quad (12c)$$

where $k_O = \frac{1}{2}\left[\left(\frac{1 + m_{TO}}{m_{TT}}\right) - 1 - k_D - k_L\right]$

Total university staff can be expressed directly as a function of total academic staff, as utilized above.

$$N_T = \frac{S_T}{m_{TT}} \quad \ldots\ldots\ldots\ldots\ldots \quad (13a)$$

or, alternatively, as the sum of the staff elements detailed above.

$$N_T = k_T \cdot S_T = N_D + N_L + N_O + S_T \quad \ldots\ldots\ldots\ldots\ldots \quad (13b)$$

where $k_T = (1 + k_D + k_h + k_o)$

The distribution of academic to total staff for the 15-university sample is shown in table 34 below.

3.2. University Annual Recurrent Expenditure

In addition to remuneration recurrent expenditure on academic staff, analysed at the departmental level in section 2.2., university recurrent expenditure includes remuneration of library, administrative and other staff, plus non-staff items. In this section a monetary value is assigned to these resources consumed. The exchange rates and cost indices used to enable regional comparisons are set out in section 2.4.3. of Chapter 4.

Academic University Staff Annual Remuneration is the sum of the departmental remuneration of academics, under the assumptions chosen above.

Let R_A = total university academic staff annual remuneration (£.s.e.).

Then $R_A = V_A$

Alternatively university academic staff can be treated as a total, and assigned a monetary "value".

Let r_A = relative weighting of academic remuneration between regions

e = currency exchange rate (U.K. = 1)

t = combined currency - cost index conversion factor (U.K. £2700 = 1).

$$R_A = r_A \cdot 2700. \; e. \; t. \; S_T \qquad (14)$$

Note that t, the cost conversion factor, is based on a detailed review average salaries of the various university groups and cost data generally, as set out in section 2.4.3. of Chapter 4.

Administrative staff annual remuneration (R_D) is the product of the average remuneration per administrative staff member and total administrative staff numbers.

$R_D = r_D \cdot 2700. \; e. \; t. \; N_D.$ (for derivation of values see section 2.2.1. of Chapter 4).

but from (10c), $N_D = k_D \cdot S_T$

therefore $R_D = r_D \cdot 2700. \; e. \; t. \; k_D \cdot S_T$ .... (15)

or $R_D = k_{RD} \cdot S_T$ where $k_{RD} = r_D \, 2700. \; e. \; t. \; k_D$.

Alternatively the simpler parameter $\frac{m_{TD}}{m_{TT}}$ as in equation (10a) can replace k_D.

Library staff remuneration per annum (R_L) is treated in a similar manner. It is initially expressed as the product of annual average library staff remuneration and the number of library staff.

$R_L = r_h \cdot 2700. \; e. \; t. \; N_h$ (section 2.2.1. of Chapter 4).

from equation (11c), $N_L = k_L \cdot S_T$

therefore $R_L = r_h \cdot 2700. \; e. \; t. \; k_h \cdot S_T$ .... (16)

or $R_L = k_{Rh} \cdot S_T$, where $k_{Rh} = r_h \, 2700. \; e. \; t. \; k_L$.

Alternatively the simpler value $\frac{m_{TL}}{m_{TT}}$, from equation (11b) can be used instead of k_h.

Technical and other staff annual remuneration (R_O) is described similarly, derived from section 2.2.1. of Chapter 4.

$R_O = r_O \cdot 2700. \; e. \; t. \; k_O \cdot S_T$ .... (17)

or $R_O = k_{RO} \cdot S_T$

where $k_{RO} = r_O \cdot 2700. e. t. k_O$.

Where desired the simpler value of $\frac{m_{TO}}{m_{TT}}$ can be substituted for k_O.

Total annual remuneration of university staff (R_S) can be expressed as the sum of the differentiated staff remuneration detailed above, or as a function of academic staff.

$$R_S = R_A + R_D + R_L + R_O$$

If it is desirable to utilize the departmental calculations of staff remuneration, summed for all departments in the university, the proportion of university and other staff remuneration which is allocated to departments must be known. This proportion is expressed as the ratio of number of "other" staff attached to departments to the total university administrative and other staff.

i.e. $$\frac{V_O}{(R_D + R_O)} = \frac{D_O}{(N_D + N_O)}$$

hence $$R_D + R_O = \frac{V_O (N_D + N_O)}{D_O}$$

and $R_A = V_A$

therefore $$R_S = V_A + \frac{V_O (N_D + N_O)}{D_O} + R_L \quad \text{.......................} \quad (18a)$$

$$= V_A + V_O + (R_D + R_O) \left[1 - \frac{D_O}{N_D + N_O} \right] + R_L \quad \text{......} \quad (18b)$$

or, alternatively, R_D, R_O, R_L can be expressed in terms of academic staff such that:

$$R_S = V_A + V_O + S_T \cdot (W_1 - \frac{D_O}{S_T} \cdot W_2) \quad \text{........................} \quad (19)$$

where $W_1 = (k_{RD} + k_{RO} + k_{RL})$, $W_2 = \left[\frac{k_{RD} + k_{RO}}{k_D + k_O} \right]$

or, alternatively, total university staff annual remuneration can be related directly to total academic staff, as detailed in section 2.2.1. of Chapter 4.

$$R_S = r_T \cdot 2700. e. t. N_T$$

but $N_t = k_T \cdot S_r$

therefore $$R_S = k_{RS} \cdot S_T \quad \text{..................................} \quad (20)$$

where $k_{RS} = r_t \cdot 2700 \cdot e \cdot t \cdot k_T$.

The last method derives from total academic staff directly, though incorporating cost indices. Where only an approximate calculate of total recurrent expenditure is required, and not the component elements, it is a simpler first measure.

A simplified method for estimation of total university staff annual remuneration and its components, is to utilize the simpler parameters equations (10a), (11b) and (12a), suggested as alternatives above. Hence

$$R_S = 2700 \cdot e \cdot t \cdot \left(r_A + r_D \cdot \frac{m_{TD}}{m_{TT}} + r_L \cdot \frac{m_{TL}}{m_{TT}} + r_O \frac{m_{TO}}{m_{TT}}\right) \cdot S_T$$

Recurrent Expenditure Excluding Remuneration

Annual recurrent expenditure of a university also includes non-staff items. This in turn can be broken down into administrative, library and "other" categories. Initially the total is derived, then the components.

Total non-remuneration recurrent expenditure can be expressed in a number of ways, either directly related to total university staff, or as the difference between total recurrent expenditure and that devoted to staff remuneration.

Let R_E = total recurrent annual expenditure of a university, excluding staff remuneration.

$$R_E = R_T - R_S$$

but, expenditure on staff remuneration is some constant proportion (P_m) of total recurrent expenditure, from analysis of section 2.4.1. of Chapter 4, and equation (20).

$$\frac{R_S}{R_T} = P_m \quad \text{or} \quad R_T = \frac{R_S}{P_m} = \frac{k_{RS} \cdot S_T}{P_m} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(21a)}$$

$$\text{therefore } R_E = \frac{R_S}{P_M} - R_S$$

$$= k_{RS} \cdot \left(\frac{1}{P_m} - 1\right) \cdot S_T$$

but R_T was also estimated from the 15-university data as follows:

$$R_T = 3000 \cdot N_T$$

$$= 3000 \cdot k_T \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(21b)}$$

As the most reliable value for R_T, the mean of these two expressions is taken:

$$R_T = \tfrac{1}{2}\left[\frac{k_{RS}}{P_m} + 3000\, k_T\right] \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(21c)}$$

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However total non-remuneration recurrent expenditure can also be written from column 2 of table 39, Chapter 4, as:

$$R_E = x_0 \cdot \frac{e}{t} \cdot N_T$$

$$= x_0 \cdot \frac{e}{t} \cdot k_T \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (22a)$$

incorporating cost indices for comparative purposes,

$$\text{or } R_E = n_{RT} \cdot N_T$$

$$= n_{RT} \cdot k_T \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (22b)$$

Taking the mean of the parameters linking recurrent non-remuneration expenditure per annum (R_E) and total academic staff (S_T).

$$\text{Let } R_E = k_E \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (22c)$$

and k_E is the mean:

$$k_E = 1/6 \left[k_T \ (3000 + 2n_{RT}) + 2x_0 \text{ e. t.} \ - k_{RS} \ (2 - \frac{1}{P_m}) \right]$$

$$\text{and } k_{RS} = r_T \cdot 2700 \text{. e. t. } k_T$$

$$\text{or } k_{RS} = 1350 \text{ e. t. } (r_T \, k_T + r_0 \, k_0 + r_A + r_D \cdot k_D + r_L \cdot k_L).$$

This total non-remuneration recurrent expenditure per annum is distributed between administrative library, and "other" functions as follows:

Let R_{ED} = total university annual recurrent expenditure excluding remuneration devoted to administration £.s.e. (per annum).

R_{EL} = total university annual recurrent expenditure excluding remuneration devoted to library £.s.e. (per annum).

R_{EO} = total university annual recurrent expenditure excluding remuneration devoted to all other facilities £.s.e. (per annum).

Administration: $R_{ED} = P_{OD} \cdot R_E$

$$= P_{OD} \, . \, k_E \, . \, S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (23)$$

Library: $R_{Eh} = P_{Oh} \cdot R_E$

$$= P_{Oh} \cdot k_E \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (24)$$

All "other" $R_{EO} = P_{OO} \, . \, R_E$

$$= P_{OO} \cdot k_E \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (25$$

where $R_{ED} + R_{EL} + R_{ED} = R_E$

i.e. $P_{OD} + P_{OL} + P_{OO} = 1$.

The distribution of recurrent expenditure (excluding remuneration) between these items, in the 15-university survey, is set out in columns 3-5 of table 15.

Total annual university recurrent expenditure is the sum of the remuneration and non-remuneration components.

$$R_T \cdot R_S + R_E \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (26)$$

Note: In all cases above simplified values, based on those of (10a), (11b) and (12a), consistently applied throughout the parameter calculations, can replace the non-simplified values used above. In the following sections, only non-simplified values are used. This involves substituting the simplified forms for k_D, k_T, etc., as appropriate.

3.3. Net University Floor Area

The following two sections develop a methodology for calculating university space requirements. In this section, university net building area is built up from the requirements for separate categories of space, defined by their function. Hence the areas necessary for teaching rooms, laboratories, academic and administrative staff offices, library and "other" activities are defined independently. The sum of these, net university building floor area, is then immediately calculable. The relevant data analysis from the 15-university survey is found in section 2.3.2. of Chapter 14, with summary table 38.

To avoid excessive repetition, only non-simplified values are given in the area sections following. However it is possible to substitute the simpler ratios indicated above at the relevant points.

Teaching rooms requirements are directly proportional to total student population.

If A_A = total net university teaching rooms (m^2)

P_T = total university student population

S_T = total university academic staff.

then $A_A = u_{FA} \cdot P_T$

but $P_T \cdot s_u \cdot S_T$

where s_u is the overall student/staff ratio.

$$\text{then } A_A = u_{FA} \cdot s_u \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (27)$$

Laboratory areas

If A_B = total net university laboratory area (m^2)

$$A_B = u_{FB} \cdot P_T$$

$$= u_{FB} \cdot s_u \cdot S_T \quad \ldots\ldots\ldots\ldots (28)$$

Academic staff offices are directly proportional to academic staff members.

If A_S = net university academic staff office area (m^2)

$$A_S = u_{FS} \cdot S_T \quad \ldots\ldots\ldots\ldots (29)$$

Administrative staff offices are directly proportional to the number of administrative staff.

If A_D = total net university administrative staff office area (m^2)

N_D = total university administrative staff.

$$A_D = u_{FD} \cdot N_D$$

from (10c), $N_D = k_D \cdot S_T$.

therefore $A_D = u_{FD} \cdot k_D \cdot S_T$ .... (30)

All "other" space including library is a function of total university staff (N_r).

Let A_O = total net university all other floor area (m^2)

$$A_O = u_{FO} \cdot N_T$$

from (13b) $= u_{FO} \cdot k_T \cdot S_T$ .... (31)

The library area component of this is a function of total student population.

Let A_L = total net university library floor area (m^2)

$$A_L = u_{FL} \cdot P_T$$

$$= u_{FL} \cdot s_u \cdot S_T \quad \ldots\ldots\ldots\ldots (32)$$

Total net university floor area is the sum of these components

Let A_T = total net university floor area (all kinds) (m^2)

$$A_T = A_A + A_B + A_S + A_D + A_O$$

which can be expressed as

$$A_T = k_{AT} \cdot S_T \quad \ldots\ldots\ldots\ldots (33)$$

where $k_{AT} = \left[s_u\ (u_{FA} + u_{FB}) + u_{FD} \cdot k_O + u_{FO} \cdot k_T + u_{FS} \right]$

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using equations (27) to (32).

3.4. Gross University Site Area

The method is developed by first evaluating gross "used" university land area. This is the sum of gross university building area, determined independently of net building floor space, car park and recreational facilities.

In order to assess the total site of the university from this, it is necessary to incorporate some evaluation of building density and environmental desirability.

The building density factor utilized here is the ratio of net university building floor area to total gross university building land area. "Environmental desirability" is the ratio of total gross university land area to total gross "used" university land area.

The matching of the "desirable" building and recreation areas to any actually available or potential site is demonstrated.

The parameter values based on the international survey can only give a general guide to land requirements. Values arising from a specific context can be substituted for those utilized here. This applies particularly to the area of land occupied by buildings, where different styles of building lead to a very wide range of values for the building density factor.

Gross university building land area can be assessed directly from academic staff numbers or total university staff, or related to total gross university "used" land area.

Let B_B = total gross university building land area (all kinds) (m^2)

B_U = total gross university "used" land area (m^2)

B_T = total gross university land area (all kinds) (m^2)

Then $B_B = u_{BS} \cdot S_T$ .... (34a)

or $B_B = u_{BT} \cdot N_T$

$= u_{BT} \cdot k_T \cdot S_T$ .... (34b)

or $B_B = b_{BU} \cdot B_U$

but, $B_U = b_U \cdot B_r$, and $B_T = u_{TP} \cdot P_T$

therefore $B_B = (b_{BU} \cdot b_U \cdot u_{TP} \cdot s_u)\, S_T$ .... (34c)

Let $B_B = k_B \cdot S_T$ .... (34d)

where $k_B = 1/3 \left[u_{BS} + u_{BT} \cdot k_T + b_{BU} \cdot b_U \cdot u_{TP} \cdot s_u\right]$

i.e. k_B is the mean value of the parameters linking B_B and S_T in (34a), (34b) and (34c).

Total gross university car parking land area (m^2) can be expressed in terms of total staff and students, or of gross "used" land.

Let B_P = total gross university car parking land area.

$$B_P = u_{PA}\ (P_T + N_T)$$

$$= u_{PA} \cdot (s_u + k_r)\ S_T \quad \ldots\ldots\ldots\ldots \quad (35a)$$

<u>or</u> $B_P = b_{PU} \cdot B_U$

$$= b_{PU} \cdot b_U \cdot u_{TP} \cdot s_u \cdot S_T \quad \ldots\ldots\ldots\ldots \quad (35b)$$

<u>or</u> let $B_P = k_P \cdot S_T$ .... (35c)

where $k_P = \frac{1}{2}\left[s_u\ (u_{PA} + b_{PU} \cdot b_U \cdot u_{TP}) + u_{PA} \cdot k_T\ .\right]$

i.e. k_P is the mean value of the parameters linking B_P and S_T in equations (35a) and (35b).

The number of car-parking spaces (Z) equals the total gross car parking area (B_P) divided by the effective land area per car-parking space (a_P).

$$Z = \frac{k_P}{a_P} \cdot S_T \quad \ldots\ldots\ldots\ldots \quad (36)$$

<u>Total gross university recreational facility area</u> can be related to the total student population or gross "used" land area.

Let B_R = total gross university recreational facility area (m^2)

$$B_R = u_{RP} \cdot P_T$$

$$= u_{RP} \cdot s_u \cdot S_T \quad \ldots\ldots\ldots\ldots \quad (37a)$$

<u>or</u> $B_R = b_{RU} \cdot B_U$

$$= b_{RU} \cdot b_U \cdot u_{TP} \cdot s_u \cdot S_T \quad \ldots\ldots\ldots\ldots \quad (37b)$$

Let $B_R = k_{BR} \cdot S_T$ .... (37c)

where $k_{BR} = \frac{s_u}{2}\left[u_{RP} + b_{BU} \cdot b_U \cdot u_{TP}\right]$

i.e. k_{BR} is the mean value of the parameters linking B_R and S_T in equations (37a) and (37b).

<u>Total gross university "used" land area</u> (m^2) is the sum of gross land areas for university buildings, car parks, and recreational facilities.

$$B_U = B_B + B_P + B_R \quad \ldots\ldots\ldots\ldots \quad (38)$$

The total gross university land area can be related to academic staff or to gross "used" university land area (B_U).

$$B_T = u_{TP} \cdot s_u \cdot s_T \quad \ldots\ldots \quad (39)$$

A better value, based on a broad site-density factor is:

$$\left[B_T\right]_s = \left[u_{TP}\right]_s \cdot s_u \cdot s_T \quad \ldots\ldots \quad (39a)$$

where $\left[u_{TP}\right]_s$ $=$ 55 for a high density situation
$=$ 2,0 for a low density situation

The alternative, incorporates a simple evaluation of "environmental desirability".

Let B_{TD} = desirable "environmental limiting" value of B_T, gross university land area.

then $B_{TD} = 2.5\ B_U$ .... (40)

Building density criterion: building density can be considered separately from the aggregated total site determinations. A building density factor is:

$$d_b = \frac{A_T}{B_B} \quad \ldots\ldots \quad (41)$$

which can be calculated directly from equations (33) and (34c) for each university.

The total sample appears to fall into three separate density groupings so that for an approximation it can be deduced that:

$d_B \doteq 0.526$ for a low average building density

$\doteq 1.664$ for a meduim average building density

$\doteq 2.749$ for a high average building density

and these values can be used to indicate the order of building density for any corresponding values of building floor area (A_T) and land area (B_B).

Desirable recreational land area. As a "second order" factor in environmental desirability it would be advantageous to satisfy a recreational land area criterion of the following order of magnitude (derived from column 4 of table 37).

from (37a), $B_R = u_{RP} \cdot s_u \cdot S_T$

such that u_{RP} approaches 12,

or $B_{RD} = 12 \cdot s_u \cdot S_T$ .... (42)

where B_{RD} is the desirable environmental limiting value of recreation land area, B_R.

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Practical Application

It is highly probable that calculated land values from the model will not satisfy equation (33), or alternatively, that the land available is limited/and does not allow for total site to total "used" land area ratio of 2.5 (40).

In these cases, total site B_{TD}, is fixed by circumstances external to the model. Given this total site, it is possible to proceed as follows:

Calculate the required net building floor space (A_T) from equation (33).

Set an "environmentally desirable" criterion for the total site relative to total usable land. It is suggested here that this should be of the order of 2.5. (equation (40)).

Calculate the total usable university land area (B_U) from equation (40).

Then: $B_B = B_U - B_R - B_P$ from (38). Gross university building area is hence determined.

Calculate building density from equation (41) $d_B = \dfrac{A_T}{B_B}$

Compare this value of d_B to the set of values of building density - low, medium, and high - derived from the international averages, to indicate the order of building density necessary for this site. If this is acceptable then the "environmental" equation (40) will be satisfied. If the density is unacceptable then it will be necessary to modify the car parking area, B_P, and/or recreation area B_R e.g. by the use of multi-storey car parks and high density recreational areas such as "dry-play" surfaces.

As a "second order" environmental desirability it would also be advantageous to satisfy the recreational land area criterion.

$$B_{RD} = 12 \cdot s_u \cdot S_T \qquad (42)$$

It is emphasized that the above method only gives an "order of magnitude" solution but it can be useful as an indication of desirable area distribution.

3.5. Total Capital Value and Annual Capital Expenditure

This is treated first as accumulated past capital expenditure, the existing value of capital stock, and second as a per annum expenditure in a growth situation. The latter treatment includes an attempt to distinguish within annual capital expenditure, that attributable to growth, and that which would be necessary even in a steady state - called the average annual basic or "true" capital expenditure.

Each of these types of capital expenditure are subdivided into building and non-building items. The growth situation presumes that the university institution already exists i.e. there is no analysis of expenditure requirement for a totally new university.

Data analysis based on the international sample of 15-universities is detailed in section 2.4.2. of Chapter 4, together with a more thorough appraisal of "true" or basic capital expenditure.

Total Capital Value

For all the following it is assumed that student population, P_T, is known.

Building

This entails assigning a monetary value to building requirements determined in sections 3.3. and 3.4.

From equation (33), net university building floor area (A_T) was related to total academic staff complement.

$$A_T = k_{AT} \cdot S_T$$

$$\text{where } k_{AT} = \left[s_u \; (u_{FB} + u_{FA}) + u_{FD} \cdot k_A + u_{FO} \cdot k_T + u_{FS}\right].$$

If k = construction cost per unit building net floor area (all kinds) in £.s.e. per m^2,

then the monetary value of the building capital (C_B) is:

$$C_B = k \cdot k_{AT} \cdot S_T \quad \ldots\ldots \quad (43)$$

All "Other" Capital Items

All other capital items are proportionately related to the capital value of buildings such that:

$$C_O = k_{CO} \cdot C_B$$

where C_O = the value of all "other" capital items

k_{CO} = the ratio of the value of all "other" capital items to value of buildings $\left(\frac{C_O}{C_B}\right)$

$$\text{from (43), } C_O = k_{CO} \cdot k \cdot k_{AT} \cdot S_T \quad \ldots\ldots \quad (44)$$

<u>Total capital value of university</u> is the sum of the capital values of buildings and all other items.

$$C_T = C_B + C_O$$

$$= (1 + k_{CO}) \cdot k \cdot k_{AT} \cdot S_T \quad \ldots\ldots \quad (45)$$

where C_T = the university total capital in £.s.e.

Annual Average Capital Expenditure

Within the total annual average capital expenditure, it is possible to distinguish between that associated with growth of the institutions, predominating expenditure on building accommodation, other capital expenditure related to growth and lastly a non-building "basic" capital expenditure which would be necessary even in a static situation. A method for the isolation of these elements is presented below.

Building

It is assumed that there is an annual growth in student population of $\frac{\Delta P_T}{P_T} = g$, and that this value is known.

C_{Bg} = annual average total university growth capital expenditure on building (£.s.e.)

$$C_{Bg} = g.\ k.\ A_T$$

and from (33), $= g.\ k.\ k_{AT}\ .\ S_T$ .... (46)

All Other Capital Expenditure

Using the growth factor g it is possible to reduce capital costs other than building to a "basic" or "true" expenditure necessary in a steady state. This latter hypothesis is based on the assumption that the growth element in other than building capital can be removed by using a simple growth factor correction as follows:

"Basic" average annual capital expenditure $C_b = C_0(1-g)$ .... (47)

where C_0 = total average "other than building" annual capital expenditure.

If C_{0g} = average annual total university capital expenditure, other than building, associated with growth.

then $C_{0g} = \frac{C_b}{1 - g}$ .... (48)

However basic annual average capital expenditure (unrelated to growth), C_b, is also related to academic staff numbers.

$$C_b = k_D\ .\ S_T$$

therefore $C_{0g} = \frac{k_b\ .\ S_T}{(1 - g)}$ .... (49)

Total Annual Average Capital Expenditure

If C_{Tg} = total annual average capital expenditure

then $C_{Tg} = C_{Bg} + C_{0g}$

$$= g.\ k.\ k_{AT}\ .\ S_T + \frac{k_b\ .\ S_T}{(1 - g)}$$

$$= \left[g.\ k.\ k_{AT} + \frac{k_b}{(1 - g)} \right] .\ S_T \quad \text{.................... (50)}$$

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4. Parameter Values deduced from the International Data

This section sets out the departmental and overall university constants, provided from the international 15-university sample and 80-university survey. Hence it provides two possible sets of values of the constants in the simple overall model, which can be utilized to determine various resource requirements. The two sets of values are not directly comparable as the larger number of observations in the 80-university survey enabled a classification into 5 geographical regions, contrasted to the 3 of the sample. However in many specific instances, the alternative values display a good degree of similarity.

The analysed results of the two surveys are presented separately. Tables 1, 2 and 3 refer to the sample of 15, whilst tables 4, 5, and 6 refer to the full 80-university survey. Tables 1 and 4 detail the departmental constants which could be utilized for the evaluation of section 2 of this chapter. The methods by which the raw data was analysed to arrive at these values is developed in Chapter 4, sections 2.1.2, and 2.1.3. Tables 2 and 5 detail the overall university model primary constants, which can be used for the determination of the relationships of section 3. Tables 4 and 6 provide the "secondary" constants from which the former primary constants were derived. They have been incorporated at the appropriate points within section 3 of the model.

It is emphasized that these two sets of internationally derived data provide only two possible sets of constants with which to evaluate the model. Alternative sets, based on specific local or national conditions, could equally as well be applied.

Chapter 4, particularly section 2, provide more detailed analysis and interpretation of the survey data, relevant to the overall simple model.

Section 5 of this chapter utilizes the values of constants provided in tables 1-3 (the 15-university sample results) to provide an example application of the methodology.

Table 1. Values of Departmental Parameters - 15-University Sample

Classification	Geog. Group Region	A Acad/ Total Staff (D_A/D_T)	B Teach Hrs. Acad Staff (T_T/D_A)	C 1st/Total Teach Hrs. (T_U/T_T)	D Stud/ Acad. Staff (F_T/D_A)	E 1st/Total Students (F_U/F_T)	F Recurrent / Tot. Staff (V_T/D_T)	G Tot. St. Remun. / Recurr. (V_N/V_T)	H Acad. Remun. / Acad. Staff (V_A/D_A)
1 Pure Sc.	UK (3)	.521	9.34	.609	7.83	.811	3314	.808	2819
	NA (2)	.771	8.30	.635	4.75	.549	3573	.831	3504
	EUR(8)	.529	8.10	.661	11.92	.843	2051	.801	2214
	Av	.607	8.58	.635	8.17	.734	2979	.813	2846
2 Archi-tect.	UK (0)	-	-	-	-	-	-	-	-
	NA (1)	.791	0.53	.393	6.36	.424	3687	.818	3277
	EUR(2)	.802	12.20	1.000	7.37	1.000	2604	.821	2358
	Av	.797	6.37	.697	6.87	.712	3146	.820	2818
3. Tech.	UK (2)	.519	11.34	.619	10.69	.829	2484	.811	2904
	NA (2)	.549	1.97	.295	7.48	.419	2790	.909	2960
	EUR(3)	.579	12.70	.889	10.55	.984	2831	.709	2500
	Av	.549	8.67	.601	9.57	.744	2702	.810	2788
4 Med.Sc	UK (1)	.500	4.13	.611	3.66	.734	2487	.778	2868
	NA (1)	.780	0.63	.700	13.47	.942	3732	.850	3781
	EUR(5)	.589	1.96	.376	15.74	.208	1898	.824	1963
	Av	.620	2.24	.562	10.96	.628	2706	.817	2871
5 Agric.	UK (0)	-	-	-	-	-	-	-	-
	NA (1)	.625	0.57	.319	11.37	.721	3006	.932	3726
	EUR(0)	-	-	-	-	-	-	-	-
	Av	.625	0.57	.319	11.37	.721	3006	.932	3726

3.

Table 1 (Continued).

Classification	Geog. Group	A	B	C	D	E	F	G	H
6 Hum.	UK (2)	.833	11.00	.916	10.00	.938	2371	.958	2563
	NA (3)	.837	10.08	.724	10.71	.354	3397	.912	3433
	EUR(6)	.784	9.67	.682	11.09	.582	2186	.879	2429
	Av	.817	10.25	.774	10.60	.625	2651	.916	2808
7 Fine Arts	UK (0)	-	-	-	-	-	-	-	-
	NA (2)	.609	18.65	.828	5.64	.742	2740	.855	3583
	EUR(1)	.718	6.98	.696	15.21	.739	2551	.874	2607
	Av	.664	12.82	.762	10.43	.741	2646	.865	2595
8 Educ.	UK (2)	.696	11.19	0.000	5.81	.000	3043	.643	2500
	NA (2)	.780	20.31	0.425	23.26	.736	3515	.830	3026
	EUR(3)	.738	8.24	.617	12.38	.643	2180	.827	1956
	Av	.738	13.25	.347	13.82	.460	2913	.767	2494
9 Law	UK (0)	-	-	-	-	-	-	-	-
	NA (1)	.512	6.36	1.000	18.59	1.000	3326	.944	4545
	EUR(6)	.739	11.88	.516	20.93	.667	2633	.895	2771
	Av	.626	9.12	.758	19.76	.834	2980	.920	3658
10 Soc. Sc.	UK (3)	.740	10.49	.737	9.12	.723	2595	.881	2725
	NA (3)	.804	9.06	.610	11.95	.754	3824	.829	2890
	EUR(8)	.720	7.11	.659	16.90	.784	2747	.780	2458
	Av	.755	8.89	.669	12.66	.754	3055	.830	2691
OVERALL AV	UK	.634	9.58	.582	7.85	.673	2716	.813	2730
	NA	.706	8.75	.593	11.59	.664	3359	.873	3473
	EUR	.689	8.76	.677	13.57	.717	2409	.823	2362
Aggregated Av.		.676	9.03	.617	11.00	.685	2828	.836	2855

The figures in brackets by UK, NA, etc. is the sample number of classifications available.

Table 2. Overall University (Primary Constants) - 15-University Sample

Equation No.	Primary Constant	Region U.K.	N.A.	EUR.	AVERAGE
10c	k_D	0.579	1.670	0.284	0.493
11c	k_L	$0.068+0.0070.s_u$	$0.060+0.0095.s_u$	$0.058+0.0033.s_u$	$0.055+0.0044.s_u$
12c	k_O	$1.028-0.0035.s_u$	$1.275-0.0047.s_u$	$0.550-0.0016.s_u$	$0.628-0.0022.s_u$
13b	k_T	$2.675+0.0035.s_u$	$4.005+0.0047.s_u$	$1.894+0.0016.s_u$	$2.176+0.0022.s_u$
15	k_{RD}	813 e.t.	5322 e.t.	375 e.t.	826 e.t.
16	k_{RL}	$(92+9.5.s_u)$e.t.	$(140+22.4.s_u)$e.t.	$(81+4.6.s_u)$e.t.	$(84+6.8.s_u)$e.t.
17	k_{RO}	$(991-3.4.s_u)$e.t.	$(3700-9.2.s_u)$e.t.	$(923-1.8.s_u)$e.t.	$(1037-2.4.s_u)$e.t.
19	W_1	$(1896+6.1.s_u)$e.t.	$(9162+13.2.s_u)$e.t.	$(1379+2.8.s_u)$e.t.	$(1947+4.4.s_u)$e.t.
19	W_2	$\left[\frac{(1804-3.4.s_u)\text{e.t.}}{1.607-0.0035.s_u}\right]$	$\left[\frac{(9022-9.2.s_u)\text{e.t.}}{2.945-0.0047.s_u}\right]$	$\left[\frac{(1298-1.8.s_u)\text{e.t.}}{0.834-0.0016.s_u}\right]$	$\left[\frac{(1863-2.4.s_u)\text{e.t.}}{1.121-0.0022.s_u}\right]$
22c	k_E	$(2528+3.3.s_u)$ + $(919+1.2.s_u)$ e.t.	$(3548+4.2.s_u)$ + $(1865+2.3.s_u)$ e.t.	$(1605+1.4.s_u)$ + $(538+0.5.s_u)$ e.t.	$(1917+1.9.s_u)$ + $(711+0.8.s_u)$ e.t.
23	P_{OD}	0.057	0.142	0.105	0.115
24	P_{OL}	0.080	0.063	0.036	0.049
25	P_{OO}	0.863	0.795	0.859	0.836
28	u_{FB}	5 For a reasonable balance of disciplines			
	u_{FB}	3 For an arts/humanities bias			
	u_{FB}	7 For a science/technology bias			

Table 2 (Continued).

Equation No.	Primary Constant	Region U.K.	N.A.	EUR.	AVERAGE
27	u_{FA}	1.4	2.0	2.9	2.3
29	u_{FS}	18.4	18.1	22.1	20.2
30	u_{FD}	16.7	10.1	34.6	26.6
31	u_{FO}	31.9	43.1	49.7	43.0
32	u_{FL}	1.5	1.7	0.8	1.2
33	k_{AT}	$115.0+(u_{FB}+1.51).s_u$	$209.5+(u_{FB}+2.20).s_u$	$124.0+(u_{FB}+2.89).s_u$	$126.7+(u_{FB}+2.39).s_u$
34d	k_B*	$396 + 0.25.s_u$	$121 + 0.07.s_u$	$157 + 0.07.s_u$	$195 + 0.09.s_u$
35c	k_P*	$8.80 + 3.30.s_u$	$36.93 + 9.26.s_u$	$5.21 + 2.75.s_u$	$9.51 + 4.38.s_u$
36	a_P	12	15	12	13
37c	k_{BR}*	$25.4 \cdot s_u$	$19.8 \cdot s_u$	$3.3 \cdot s_u$	$13.2 \cdot s_u$
39	u_{TP}	256	4196	80	876
39a	$[u_{TP}]s$	55 For a high density site situation			
39a	$[u_{TP}]s$	250 For a low density site situation			
41	d_B	0.526 signifies low building density			
	d_B	1.664 signifies medium building density			
	d_B	2.749 signifies high building density			
44	k_{CO}	0.471	0.266	0.612	0.471
49	k_b	836	340	630	634
		A value of k_b = 480 is an approximate alternative overall value			

* These constants have been modified from the original equations by ignoring an excessively high parameter value from one university (in a very small sample) which was biassing the numerical values.

Table 3. Overall University "Secondary" Constants - 15-University Sample.
(Used for evaluating primary constants)

Equat. No.	Secondary Constant	Region U.K.	N.A.	EUR.	AVERAGE
10c	m_{TA}	0.21	0.40	0.15	0.20
10c	m_{TT}	0.37	0.25	0.52	0.46
10c	m_D	0.59	1.74	0.28	0.55
11c	m_{TL}	0.05	0.03	0.06	0.05
11c	m_P	71.3	52.8	151.0	115.4
12c	m_{TO}	0.37	0.32	0.27	0.29
15	r_D	0.52	1.18	0.49	0.62
16	r_L	0.50	0.87	0.52	0.57
17	r_T	0.65	1.21	0.84	0.87
17	r_O	0.37	0.90	0.53	0.56
17	r_A	1.050	1.230	1.030	1.140
22c	n_{RT}	1335	1158	1042	1143
22c	x_O	1325	1960	1359	1457
22c	p_M	0.60	0.61	0.65	0.63
34d	u_{BS}	420	121	159	208
34d	u_{BT}	139	30	82	83
34d	b_{BU}	0.49	0.39	0.67	0.56
34d	b_U	0.251	0.437	0.394	0.369
35c	u_{PA}	3.29	9.22	2.75	4.37
37c	u_{RP}	25.4	19.8	3.3	13.2
44	c_O	0.32	0.21	0.38	0.32
44	c_B	0.68	0.79	0.62	0.68

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Table 4. Departmental Constants; Classified by Region and Subject Area

80-University Survey

Subject Classification	Region	A Academic/ Total Staff (D_A/D_T)	B Teaching Hrs/ Academic Staff (T_T/D_A)	C 1st Degree/ Total Teaching Hours (T_U/T_T)	D Student/ Acad. Staff (F_T/D_A)	E 1st Degree/ Total Students (F_U/F_T)	F Recurrent Expenditure/ Total Staff (V_T/D_T)	G Total Staff Remun./ Recurr. Expend. (V_N/V_T)	H Acad. Remuner. /Acad. Staff (V_A/D_A)
1. Pure Science	N.A. 1	0.700	8.45	0.597	5.37	0.448	2750	4.00	2969
	U.K. 2	0.550	9.98	0.709	7.87	0.891	2373	2.03	2803
	SCANDINAVIA 3	0.527	5.23	0.598	5.08	0.674	2200	3.10	2686
	"EEC" 4	0.594	-	-	-	-	2185	2.38	2112
	OTHER EUR. 5	0.760	7.71	0.916	10.99	0.967	1714	1.81	2014
	AVERAGE	0.610	8.08	0.684	7.14	0.783	2340	2.77	2667
2. Architecture	1	0.713	8.56	0.935	7.84	0.580	2771	4.00	2695
	2	0.577	22.00	0.927	11.13	0.976	2617	2.11	3130
	3	0.655	-	-	9.09	1.000	2550	3.45	2256
	4	0.826	12.84	-	4.86	-	2297	2.73	2248
	5	0.724	10.66	-	8.88	0.845	1898	1.50	1902
	AVERAGE	0.694	13.51	0.931	8.52	0.830	2493	3.03	2371
3. Technology	1	0.640	16.22	0.682	8.16	1.013	2861	3.86	2802
	2	0.542	6.98	0.830	9.70	0.877	2425	2.10	2887
	3	0.474	-	0.093	6.41	0.848	1786	3.22	2614
	4	0.634	9.96	-	6.16	-	2301	2.56	2443
	5	0.538	11.78	0.968	10.87	0.941	1864	1.41	1609
	AVERAGE	0.563	9.56	0.784	8.19	0.911	2332	2.58	2591
4. Medical Sciences	1	0.678	4.29	1.000	10.10	0.981	2836	3.62	2791
	2	0.488	6.77	0.857	4.58	0.813	2431	1.95	2931
	3	0.540	19.00	-	5.82	0.578	2253	3.18	2703
	4	0.493	-	-	4.42	5.464	1141	2.61	2312
	5	0.774	7.43	0.654	7.92	0.785	1621	1.54	2188
	AVERAGE	0.607	8.14	0.762	6.53	0.950	2187	2.89	2519
5. Agriculture	1	0.607	15.89	0.504	11.07	0.774	2629	4.29	3154
	2	-	-	-	-	-	-	-	-
	3	0.382	-	-	5.76	0.981	2369	2.72	3016
	4	-	-	-	-	-	-	-	-
	5	0.519	9.44	0.834	14.05	0.935	1803	1.48	1852
	AVERAGE	0.521	11.59	0.587	11.60	0.847	2192	2.66	2477
6. Humanities	1	0.815	11.19	0.604	2.49	0.759	2454	4.40	3004
	2	0.740	10.00	0.838	9.26	0.886	2151	2.33	2531
	3	0.802	6.04	0.716	9.50	0.685	3061	3.27	3026
	4	0.824	-	-	20.26	0.878	2236	2.76	2273
	5	0.806	6.78	0.961	12.67	0.978	2192	1.64	2057
	AVERAGE	0.798	8.53	0.762	11.35	0.807	2597	3.11	2699
7. Fine Arts	1	0.795	18.71	0.824	8.16	0.835	2141	4.32	3232
	2	0.867	-	-	6.31	0.878	2407	2.29	2546
	3	-	-	-	-	0.739	-	-	-
	4	-	-	-	-	-	-	-	-
	5	1.000	9.50	1.000	14.50	1.000	-	-	2108
	AVERAGE	0.829	17.40	0.849	9.66	0.863	2208	3.81	3006
8. Education	1	0.716	11.50	0.667	20.49	0.853	2870	4.02	2785
	2	0.650	9.75	0.846	10.64	0.098	2236	2.30	2700
	3	0.728	-	0.500	15.85	0.882	3139	3.23	3476
	4	-	-	-	-	-	-	-	-
	5	0.800	6.25	0.400	7.08	-	-	-	2677
	AVERAGE	0.710	10.10	0.624	15.75	0.782	2770	3.33	2917
9. Law	1	0.420	5.88	1.000	15.77	0.679	3284	3.60	3981
	2	-	-	-	-	-	-	-	-
	3	0.799	9.79	0.766	17.72	0.657	2666	3.42	2968
	4	0.755	-	-	38.54	-	2479	2.90	2514
	5	0.756	6.23	1.000	82.09	1.000	1851	1.55	1886
	AVERAGE	0.720	7.48	0.867	31.29	0.684	2669	3.11	2882
10. Social Sciences	1	0.702	10.73	0.625	17.65	0.743	2870	4.11	3177
	2	0.796	9.40	0.860	9.12	0.813	2427	2.28	2633
	3	0.776	5.80	0.519	17.68	0.812	2562	3.24	2675
	4	0.904	-	-	17.18	0.668	2571	2.89	2640
	5	0.816	7.70	0.882	14.53	1.049	1855	1.25	1985
	AVERAGE	0.769	8.93	0.695	15.23	0.840	2593	3.16	2722
OVERALL AVERAGE		0.674	9.16	0.728	11.41	0.828	2438	2.91	2669

Table 5. Overall University - Primary Constants

80-University Survey

Equat. No.	Primary Constant	Region: 1. North America	2. United Kingdom	3. Scandinavia	4. Predominantly EEC	5. "Other" European	AVERAGE
10c	k_D	1.001	0.518	0.459	0.278	0.213	0.477
11c	k_L	$0.138 + 0.006.s_u$	$0.051 + 0.005.s_u$	$0.47 + 0.003.s_u$	$0.053 + 0.004.s_u$	$0.023 + 0.001.s_u$	$0.056 + 0.004.s_u$
12c	k_R	$0.821 - 0.003.s_u$	$1.054 - 0.003.s_u$	$0.649 - 0.002.s_u$	$0.450 - 0.002.s_u$	$0.390 - 0.0004.s_u$	$0.659 - 0.002.s_u$
13b	k_T	$2.960 + 0.003.s_u$	$2.622 + 0.003.s_u$	$2.154 + 0.002.s_u$	$1.782 + 0.002.s_u$	$1.626 + 0.0004.s_u$	$2.192 + 0.002.s_u$
15	k_{RD}	1195 e.t.	641 e.t.	513 e.t.	328 e.t.	232 e.t.	552 e.t.
16	k_{RL}	$(168 + 7.0.s_u)$e.t.	$(62 + 6.4.s_u)$e.t.	$(52 + 3.6.s_u)$e.t.	$(72 + 5.1.s_u)$e.t.	$(20 + 0.7.s_u)$e.t.	$(66 + 4.2.s_u)$e.t.
17	k_{RO}	$(1168 - 2.6.s_u)$e.t.	$(1033 - 2.3.s_u)$e.t.	$(850 - 1.2.s_u)$e.t.	$(652 - 1.9.s_u)$e.t.	$(381 - 0.3.s_u)$e.t.	$(820 - 1.5.s_u)$e.t.
19	W_1	$(2531 + 4.4.s_u)$e.t.	$(1736 + 4.2.s_u)$e.t.	$(1414 + 2.4.s_u)$e.t.	$(1051 + 3.3.s_u)$e.t.	$(632 + 0.5.s_u)$e.t.	$(1437 + 2.7.s_u)$e.t.
19	W_2	$(2363 - 2.6.s_u)$e.t.	$(1674 - 2.3.s_u)$e.t.	$(1362 - 1.2.s_u)$e.t.	$(979 - 1.9.s_u)$e.t.	$(613 - 0.3.s_u)$e.t.	$(1372 - 1.5.s_u)$e.t.
22c	k_E	$1.822 - 0.0029.s_u$ $(9184 + 9.0.s_u)$ + $(6213 + 6.1.s_u)$e.t.	$3.571 - 0.0026.s_u$ $(3737 + 3.7.s_u)$ + $(765 + 0.8.s_u)$e.t.	$3.108 - 0.0016.s_u$ $(3139 + 2.4.s_u)$ + $(934 + 0.7.s_u)$e.t.	$0.729 - 0.0019.s_u$ $(2861 + 3.0.s_u)$ + $(792 + 0.9.s_u)$e.t.	$0.603 - 0.0004.s_u$ $(2332 + 0.6.s_u)$ + $(478 + 0.1.s_u)$e.t.	$1.136 - 0.0018.s_u$ $(3832 + 3.2.s_u)$ + $(1500 + 1.4.s_u)$e.t.
23	P_{OD}	0.215	0.062	0.108	0.075	0.107	0.109
24	P_{OL}	0.072	0.058	0.077	0.078	0.076	0.073
25	P_{OO}	0.816	0.881	0.849	0.872	0.865	0.852
28	u_{FB}	4.06	5.77	5.85	8.56	8.83	6.34
27	u_{FA}	1.51	1.79	3.37	2.70	3.65	2.73
29	u_{FS}	13.93	14.46	17.29	20.38	14.32	16.15
30	u_{FD}	12.63	15.50	25.90	15.21	55.28	26.59
31	u_{FO}	41.76	25.15	26.61	40.46	193.51	67.80
32	u_{FL}	2.20	1.74	12.85	1.17	0.54	5.91
33	k_{AT}	$150.2+(u_{FB}+1.63).s_u$	$88.4+(u_{FB}+1.85).s_u$	$86.5+(u_{FB}+3.41).s_u$	$96.7+(u_{FB}+2.78).s_u$	$340.8+(u_{FB}+3.73).s_u$	$133.1+(u_{FB}+2.95).s_u$
34d	k_B^*	$310 + 85.37.s_u$	$262 + 15.36.s_u$	$165 + 48.65.s_u$	$72 + 11.64.s_u$	$946 + 20.62.s_u$	$298 + 40.30.s_u$
35c	k_P^*	$13.09 + 78.98.s_u$	$10.26 + 8.32.s_u$	$2.89 + 16.44.s_u$	$0.28 + 6.39.s_u$	$8.99 + 9.68.s_u$	$5.68 + 21.10.s_u$
37c	k_{BR}^*	$159.8.s_u$	$44.1.s_u$	$78.0.s_u$	$19.0.s_u$	$48.9.s_u$	$72.4.s_u$
39	u_{TP}	1852	192	485	118	197	572
39a	$[u_{TP}]_s$ $[u_{TP}]_s$						
41	d_B $\left\{ \begin{array}{l} k_{CO} \\ k_B \end{array} \right.$	1.178	0.908	1.057	1.905	1.323	1.198

Table 6. Overall University Secondary Constants - 80-University Survey

(Used to evaluate primary constants).

Equat. No.	Secondary Constant	Region: 1. North America	2. United Kingdom	3. Scandinavia	4. Predominantly EEC	5. "Others" European	AVERAGE
10c	m_{TD}	0.31	0.19	0.19	0.15	0.13	0.19
10c	m_{TT}	0.33	0.38	0.46	0.55	0.61	0.47
10c	m_D	1.06	0.53	0.50	0.28	0.22	0.51
11c	m_{TL}	0.09	0.04	0.04	0.06	0.03	0.05
11c	m_P	86.60	95.39	154.67	132.27	591.89	194.61
12c	m_{TO}	0.26	0.39	0.30	0.24	0.23	0.29
15	r_D	0.43	0.45	0.40	0.42	0.39	0.41
16	r_L	0.44	0.44	0.40	0.49	0.31	0.41
17	r_T	0.64	0.62	0.65	0.72	0.50	0.63
17	r_O	0.41	0.36	0.39	0.45	0.34	0.39
17	r_A	0.91	1.00	0.83	0.86	0.58	0.84
22c	n_{RT}	7808	2776	2871	3318	2802	3594
22c	x_O	6409	1157	1795	1756	969	2248
22c	P_M	0.54	0.60	0.70	0.64	0.53	0.63
34d	u_{BS}	411	415	267	114	1612	578
34d	u_{BT}	176	141	105	58	753	253
34d	b_{BU}	0.41	0.40	0.65	0.29	0.73	0.56
34d	b_U	0.34	0.60	0.47	1.00	0.43	0.48
35c	u_{PA}	8.85	7.83	2.68	0.31	11.05	6.41
37c	u_{RP}	64.1	42.5	10.3	3.2	36.3	32.3
44	C_O						
44	C_B						

5. Example Application of the Methodology

In this section an example application of the methodology is presented, based on parameter values obtained in the 15-university sample, and set out in tables 1, 2 and 3 of section 4 above. This university is compared with the "overall average" university. Alternative parameter values, for example for the 80-university survey, could be substituted at the relevant points in the methodology to obtain an alternative set of approximations.

University X - Input Data.

Table 7. Departmental Student Data - Example

Classification No.	Subject Area	Students 1st Degree F_{Ui}	Students Higher Degree F_{Gi}	Total (F_{Ti}) = ($F_{Ui} + F_{Gi}$)
1	Pure Sciences	1311	850	2161
4	Medical Sciences	113	77	190
6	Humanities	1647	893	2540
8	Education	206	43	249
9	Law	1274	959	2233
10	Social Sciences	510	177	687
TOTALS	Σ	5061	2999	8060

Origin of X: It is assumed that University X is from Holland in the European grouping. Hence:

$e = 8.69$ $\quad t = 0.0967$ $\quad k = 57.6$ $\quad$ £.s.e.

Growth: Assumed to be at the rate of $g = 15\%$ per annum

Data at subject level

Using Table 7 and the constants from section 4, table 1, the following basic calculations can be made:

Table 8. Departmental Calculations - "University X" "Average University"

Equation =		1a	1b	1c	2	3	5	6	7
Classif. No. (i)	Univ.	Staff Teaching hours - 1st degree T_{Ui}	Staff Teaching hours - all higher degrees T_{Gi}	Total Staff weekly teaching hours T_{Ti}	Departmental Academic Staff D_{Ai}	Departmental Total Staff D_{Ti}	Recurrent Expenditure per annum V_{Ti}	Recurrent Staff Remun. per annum V_{Ni}	Recurrent Academic Staff Remun. per annum V_{Ai}
							£.s.e. x 10 - 3		
1	X	697	1247	1944	240.0	453.7	931	746	538
	Av.	1192	1225	2417	281.7	464.1	1383	1124	802
4	X	25	8	33	19.0	32.3	61	50	37
	Av.	23	19	42	18.8	30.3	82	67	54
6	X	1683	592	2275	235.3	300.1	656	577	572
	Av.	1973	751	2724	265.8	325.3	862	790	746
8	X	132	31	163	19.8	26.8	58	48	39
	Av.	149	50	199	15.0	20.3	59	45	37
9	X	559	791	1350	113.6	153.7	405	362	315
	Av.	534	666	1200	131.5	210.1	626	576	481
10	X	181	118	299	42.1	58.5	161	126	103
	Av.	318	167	485	54.6	72.3	221	183	147
Σ	X	3277	2787	6064	669.8	1025.1	2272	1909	1604
	Av.	4189	2878	7067	767.4	1122.4	3233	2785	2267

Example Results: Overall University Level:

Table 9 presents the values determined for University X, from the model. They are organized in the same format as the model itself. Only non-simplified values are used. Alternative simplified values can be substituted.

Table 9. Overall "University X" Requirements

Equat. No.	Item	Units	"University X"	Average University
Data	Dept. students - total $F_r = P_T$		8060	8060
Data	Dept. undergrad. students $F_U = P_U$		5061	5061
Data	Dept. postgrad. students $F_G = P_G$		2999	2999
1	Staff weekly teaching hrs. T_T		6064	7067
2	Dept. Academic Staff $D_A = S_T$		669.8	767.4
3	Total dept. staff D_T		1025.1	1122.4
4	Dept. "other" staff D_O		355.3	355.0
5	Dept. recurrent expend. p.a. V_T	£.s.e.(p.a.)	2,272,000	3,233,000
6	Dept. staff remun. p.a. V_N	£.s.e.(p.a.)	1,909,000	2,785,000
7	Dept. acad. staff remun. p.a. V_A	£.s.e.(p.a.)	1,604,000	2,267,000
8	Dept. recurrent expend. excl. remun. V_R	£.s.e.(p.a.)	363,000	448,000
9	Dept. "other" staff remun. p.a. V_O	£.s.e.(p.a.)	305,000	518,000
-	Student staff ratio $s_u = P_r / S_T$		12.03	10.50
10c	Univers. admin. staff N_D		190.2	378.3
11c	Univers. library staff N_L		65.6	77.5
12c	Univers. technician and "other" staff N_O		355.7	464.3
13b	Total univ. staff N_T		1,281.3	1,687.5
15	Univ. admin. staff remun. p.a. R_D	£.s.e.(p.a.)	211,000	499,000
16	Univ. library staff remun. p.a. R_L	£.s.e.(p.a.)	77,000	94,000
17	Univ. "other" staff remun. p.a. R_O	£.s.e.(p.a.)	532,000	642,000
-	Univ acad. staff remun. p.a. $R_A = V_A$	£.s.e.(p.a.)	1,604,000	2,267,000
18b	Total univ. remun. p.a. R_S	£.s.e.(p.a.)	2,245,000	3,539,000
19	Total univ. remun. p.a. R_S	£.s.e.(p.a.)	2,237,000	3,521,000
22c	Univ. recurrent expend. excl. remun. R_E	£.s.e.(p.a.)	1,393,000	1,921,000

Table 9 (Continued).

Equat. No.	Item		Units	"University X"	Average University
23	Univ. recurrent expend. excl. remun. (admin.)	R_{ED}	£.s.e.(p.a.)	146,000	221,000
24	Univ. recurrent expend. excl. remun.-library	R_{EL}	£.s.e.(p.a.)	50,000	94,000
25	Univ. recurrent expend. excl. remun.-"other"	R_{EO}	£.s.e.(p.a.)	1,197,000	1,606,000
26	Univ. total recurrent expend. p.a.	R_T	£.s.e.(p.a.)	3,638,000	5,460,000
27	Net univ. floor area - teaching	A_A	m^2	23,400	18,500
28	Net univ. floor area - labs.	A_B	m^2	32,200	(*) 32,200
29	Net univ. floor area - acad. offices	A_S	m^2	13,400	15,400
30	Net univ. floor area - admin. offices	A_D	m^2	6,600	10,100
31	Net univ. floor area - "other"	A_O	m^2	63,700	72,500
32	Net univ. floor area - library	A_L	m^2	6,500	9,700
33	Net univ. floor area	A_r	m^2	139,300	148,700
34d	Gross univ. building area	B_B	m^2	105,700	105,300
35c	Gross univ. car park area	B_P	m^2	25,600(d)	42,600(d)
36	Approx. no. of car spaces	Z	spaces	2,137	4,259
37	Gross univ. recreation area	B_R	m^2	26,600	106,400
40	"Desirable" value of B_R	B_{RD}	m^2	96,700(c)	89,300(c)
38	Gross univ. "used" land area	B_U	m^2	157,900	299,300
39	Gross univ. land area	B_T	m^2	644,600	7,058,500
39a	$[B_T]_s$ high		m^2	443,200(a)	443,200(a)
39a	$[B_T]_s$ low		m^2	2,014,400	2,014,400
41	Building density factor $d_B = A_T/B_B$			1.318 (meduim density)	0.989 (meduim/low density)
38	Gross univ. land area	B_U	m^2	228,000	282,000 (using 40 instead of 37c in 38)
40	"Desirable" value of B_T	B_{TD}	m^2	394,800	748,300

(*) An interpolated value u_{FA} = 4.0 is used here.

Table 9 (Continued).

Equat. No.	Item		Units	"University X"	Average University
				or 570,000(b)	or 705,000(b)
				Note that (a) does not satisfy (b)	
40	Gross univ. land area	B_U	m^2	177,200	177,200
				(Using values (a))	
38	Gross univ. building area	B_B	m^2	54,900	45,300
				(Using values (c) and (d))	
41	Building density factor	d_B		2.537	3.283
				(High building density. Investigate alternative parking and/or recreation areas).	
43	Capital value of total univ. building	C_B	£.s.e.(total)	7,984,000	9,191,000
44	Capital value of total univ. other than building	C_O	£.s.e.(total)	4,886,000	4,329,000
45	Total univ. capital	C_T	£.s.e.(total)	12,870,000	13,520,000
46	Univ. growth capital on building	C_{Bg}	£.s.e.(p.a.)	1,204,000	1,378,000
49	Univ. growth capital on other than building	C_{Og}	£.s.e.(p.a.)	378,000	433,000
50	Av. univ. growth capital-total	C_{Tg}	£.s.e.(p.a.)	1,582,000	1,811,000
49	Av. "basic" capital expend.	C_b	£.s.e.(p.a.)	322,000	368,000

Table 10. A Selected Summary of Results (Costs in Currency of "University X").

University "X" and Average University

Item	Units	"University X"	Average University
Pure Science Subject Area			
Total students		2161	2161
Total academic staff		240.0	281.7
Total staff		453.7	464.1
Total annual staff remuneration	Guild.p.a.	7869000	12364000
Total annual recurrent expenditure	Guild.p.a.	9589000	15213000
Humanities Subject Area			
Total students		2540	2540
Total academic staff		235.3	265.8
Total staff		300.1	325.3
Total annual staff remuneration	Guild.p.a.	5943000	8690000
Total annual recurrent expenditure	Guild.p.a.	6757000	9482000
Total University			
Total students		8060	8060
Total academic staff		669.8	767.4
Total staff (all kinds)		1281.3	1687.5
Total admin. staff annual remuneration	Guild.p.a.	2173000	5489000
Library recurrent less remuneration expenditure	Guild.p.a.	515000	1034000
Total staff annual remuneration	Guild.p.a.	23124000	38929000
Total recurrent annual expenditure	Guild.p.a.	37471000	60060000
Total laboratory net floor area	m^2	32200	32200
Total building net floor area	m^2	139300	148700
University members per car park space		4.37	2.29
Total used land area	m^2	157900	299300
Total site land area	m^2	443200	443200
Desirable site land area	m^2	570000	705000
Average annual growth buildings capital	Guild.p.a.	12401000	15158000
Total average annual capital	Guild.p.a.	16295000	19921000

CHAPTER 3. A CONCEPTUAL METHODOLOGY FOR THE DETERMINATION OF DEPARTMENTAL REQUIREMENTS.

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1. Introduction

The methodology developed here has as its goal the determination of academic, technical support and administrative staff at the departmental level of university type institutions. The approach is a combined conceptual/data analysis one and would provide reliable intra-university data although it can be used in aggregated form for institutional requirements (see reference 5).

The method has been developed to be as flexible as possible so that it can be applied internationally. Thus a basic concept of programmes of study at defined levels of study has been introduced, from which springs specific equations for departmental academic staff for particular geographical regions. It is thought that this basic concept is applicable to other forms of organization than the common faculty-department-arrangement. Such application is left to the reader.

The basic concepts for academic staff analysis are described. These are then developed for departments in general terms from which practical evaluations are facilitated using data based parameters which vary by subject classification and by geographical region. A comprehensive example is given to illustrate the application of the complete method.

The determination of supporting staff (technicians, assistants, etc.) and administrative staff depends upon a reasonably accurate estimate of academic staff distribution. The former is also found to depend significantly on effective "laboratory" area and hence an analysis of this is also developed in terms of academic staff.

The whole approach is kept as simple as possible as the objective is to provide methodology and useful data to enable individual universities to develop their own specific equations and methods. Decisions on method and data constraints should spring from bodies which include academic staff, students and administrators. However it should be added that the appendices of this chapter, and Chapter 4, contain a considerable quantity of general information, which can be of use in solving specific academic planning problems.

2. Academic Staff Estimation by Department

2.1. Basic Methodology

The functions of academic staff can be broadly described as follows:

(a) Teaching Function: First degree or diploma, higher degree or diploma, short specialized programmes, research supervision and industrial visiting to students (where "sandwich" or co-operative programmes are involved).

(b) Personal research and "consultancy function".

(c) Other Functions: Administration, committees (university, professional and national), student counselling.

The assessment of academic staff requirements presented here takes into account only the teaching function. It has been reasonably well established within an international framework that average staff/student contact teaching loads are of the order of 9-10 hours/week (with a factor of about 2.5 for conversion to actual worked hours - allowing for preparation, marking, etc.) and that personal research and consultancy occupies 25-30% of a normal working week. This accounts for about 36 working hours per week with say, at least four hours per week for the other functions. Thus on this basis it is assumed justifiable to concentrate on the teaching function to define the staff requirement for a university or department - the remaining time being available for research and other functions. This definition must, of course, be based on the average staff member and does not imply that every staff member proportions his time in a uniform way. Having established a staff requirement based on the overall teaching function commitments in a reasonably equitable way it is a matter of detailed management within the university and its organizational structure to determine the individual functions of its academic staff.

Thus the method of staff estimation is based on the teaching function which is, in any case, the basic "raison d'être" of a university.

2.1.1. The Generalized Programme of Study Concept

Departmental teaching responsibilities can be analysed via the utilization of a generalized programme of study concept. A programme of study is defined as those requirements which must be satisfied for the satisfactory completion of the student's period in the university. It frequently is terminated by the award of a degree or diploma. Thus the concept embraces all the teaching functions of the department - undergraduate courses, student research work, short courses, industrial training etc.

Each programme will generally include lecturing, seminar, and/or project/thesis commitments. Each programme is further classified by the levels of study incorporated. A study of various systems of university education across nations suggests that academic work can be defined at three levels of study:

Level 1:	Fundamental.	Early first degree/diploma study
Level 2:	Advanced.	Intermediate between first degree/diploma and higher degree/diploma study.
Level 3:	Higher.	Higher degree/diploma study.

Two particularly difficult problems regarding the choice of approach were encountered. The first concerned the decision as to whether the basic approach should derive from subject elements or from complete programmes of study. The second, connected, problem was that of making adequate allowance for service teaching between departments. The generalized programme of study was finally selected as all students must eventually satisfy a particular programme to qualify for a specific degree or diploma.

Departmental servicing contributions are incorporated through the use of distribution factors which are developed in some detail (as it is often here in practical application that the greatest emotion is generated inter-departmentally).

Hence a general equation is derived for the departmental teaching function, in terms of different levels of study - fundamental, advanced, and higher. From this simplified expressions for particular types of study programmes, e.g. short courses, are easily evolved. The various types of study programmes are detailed individually.

At this stage it is not possible to simplify the equations further because of differing programme structures and approaches at the international level. It is, however, possible to provide considerable data reduced parametric information for specific geographical regions and subject classifications and these can be used in the generalized equations which can then be conditioned to the particular university teaching function. In order to illustrate the late application of the method, therefore, the equations are developed for typical university in the United Kingdom and worked examples are given for a typical technology department in which academic staff estimations are made for first and higher degree programmes, (including a detailed estimate of servicing distribution factors), short courses, research supervision and industrial visiting.

Principal Notation.

l_1, l_2, l_3	- average student lecture hours/week at study levels 1, 2, 3.
s_1, s_2, s_3	- average student seminar hours/week at study levels 1, 2, 3. Seminar hours are all hours spent in the classroom, excluding lectures.
g_1, g_2, g_3	- average student seminar group size at study levels 1, 2, 3. This is the average size of all teaching groups, excluding lectures.
p_1, p_2, p_3	- total student numbers in a programme at study levels 1, 2, 3.
w_1, w_2, w_3	- total number of weeks tuition at study levels 1, 2, 3.
y_1, y_2, y_3	- number of years in a programme at study levels 1, 2, 3.
k_1, k_2, k_3	- weighting factor on staff loading relative to the fundamental level (1) at study levels 1, 2, 3.
p_{p_2}, p_{p_3}	- total student numbers on project/theses at study levels 2, 3.
b_2, b_3	- average weekly staff hours per student of project supervision at study levels 2, 3.
b_R	- average weekly staff hours per student of thesis supervision
h_1	- average lecturing staff hours/week at fundamental level of study (1).
h_s	- average seminar staff hours/week at fundamental level of study (1).
w	- number of weeks in university academic year
S_y	- academic staff requirements for a generalized programme of study.
S_D	- total departmental academic staff contribution to a programme of study.
D_A	- total departmental academic staff requirement
S_S	- departmental academic staff requirement for short courses
S_R	- departmental academic staff requirement for research student supervision

S_I - departmental academic staff requirement for industrial visiting of students on "sandwich" courses.

A_b - departmental support area requirements (m^2)

D_S - total departmental support staff (excluding administrative)

D_D - total departmental administrative staff.

2.1.2. Academic Staff Contribution to a Programme of Study

Consider a programme of study at the advanced level (level 2). It enrols p_2 students, and each student has a weekly load of l_2 lectures and s_2 seminars, in average seminar groups of size g_2. The duration of this level is y_2 university academic years each of w weeks. The students receive a total of w_2 weeks tuition over the complete period. The staff weekly loading is h_{1/k_2} and h_{s/k_2} hours for lecturing and seminars respectively, where k_2 is a weighting factor reflecting the level of study relative to the fundamental level p_{p_r} students undertake a project thesis involving b_2 hours per week of academic staff supervision.

This is represented algebraically as:

$$\text{Staff required for lecturing} = k_2 \cdot \frac{w_2}{w} \cdot \frac{l_2}{h_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\text{Staff required for seminars} = k_2 \cdot \frac{w_2}{w} \cdot \frac{s_2}{g_2 h_s} \cdot \frac{p_2}{y_2} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\text{Staff required for project/thesis} = \frac{k_2 \cdot p_{p_2} \cdot b_2}{h_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Thus the academic staff requirement for a completely generalized programme of study is given by:

$$S_y = k_1 \cdot \frac{w_1}{w}\left[\frac{l_1}{h_1} + \frac{s_1}{g_1 h_s} \cdot \frac{p_1}{y_1}\right] + k_2 \cdot \frac{w_2}{w}\left[\frac{l_2}{h_1} + \frac{s_2}{g_2 h_s} \cdot \frac{p_2}{y_2}\right]$$

$$+ k_3 \cdot \frac{w_3}{w}\left[\frac{l_3}{h_1} + \frac{s_3}{g_3 h_s} \cdot \frac{p_3}{y_3}\right] + \frac{k_2\, p_{p_2}\, b_2}{h_s} + \frac{k_3\, p_{p_3}\, b_3}{h_s} \quad \ldots\ldots\ldots\ldots \quad (4)$$

This is the basic equation from which departmental and hence university staff requirements are derived. It will be noted that equation (4) is largely conditioned by the parameters l_{1/h_1} $\frac{s_1}{g_1 h_s}$, etc., and b (as in reference 2) and the values of these parameters are examined in section 2.2. for various broad subject areas and geographical regions.

Thus for a particular programme structure the basic academic staff equation can be derived from (4). Examples of this are as follows:

1st Degree in the U.K.

Normally this would embrace 2 years at fundamental level and 1 year at advanced (i.e. a total of 3 years).

Typical values would be:

$w_1/w = 2 \quad y_1 = 2 \quad w_2/w = 1 \quad y_2 = 1$

(All third higher level would be zero).

Thus:

$$S_y = k_1\left[\frac{2l_1}{h_1} + \frac{s_1}{g_1 h_s} \cdot p_1\right] + k_2\left[\frac{l_2}{h_1} + \frac{s_2}{g_2 h_s} \cdot p_r\right] + \frac{k_2\, p_{p_2} \cdot b_2}{h_s}$$

Higher (masters) degree in the U.K. by course:

$\frac{w_3}{w} = \frac{2}{3} \quad y_3 = 1 \quad p_{p_3} = p_3$ (all others zero).

$$S_y = \frac{2}{3} k_3\left[\frac{l_3}{h_1} + \frac{s_3}{g_3\, h_s} \cdot p_3\right] + \frac{k_3\, p_{p_3} \cdot b_3}{h_s}$$

1st Diploma in a European University

Normally this would embrace 3 years at fundamental level and 2 years at advanced (i.e. a total of 5 years).

Typical values would be:

$w_{1/w} = 3 \quad y_1 = 3 \quad w_{2/w} = 2 \quad y_2 = 2$ (see third level zero)

$$S_y = k_1\left[\frac{3l_1}{h_1} + \frac{s_1}{g_1 h_s} \cdot p_1\right] + k_2\left[\frac{2l_2}{h_1} + \frac{s_2}{g_2 h_s} \cdot p_2\right] + \frac{k_2\, p_{p_2} \cdot b_2}{h_s}$$

Other variations are apparent but the above examples serve to indicate the flexibility of the generalized programme of study concept.

2.1.3. Incorporation of Inter-Departmental Service Teaching

In general any programme of study will be serviced by a number of departments although it will almost certainly be attached to a particular department for organizational purposes and will be in the general subject area of that department.

Thus each department servicing a programme of study requires a proportionate allocation of staff. This is achieved here by developing departmental academic staff distribution factors for the generalized programme of study.

Staff are to be allocated to departments according to their contribution to a particular programme. In order to assess this contribution, complete programmes must be broken down, at each level, into subject elements. For each subject element the following must be taken into account:

(i) The lecturing load and duration of the subject.

(ii) The seminar load and duration of the subject.

(iii) The degree of common lecturing between different programmes of study.

(iv) Allowance for elective subjects within or across programmes of study.

(v) The repetition of the lecturing content of subject elements for the specific course of study only (due to lecture groups being too large to utilize available accommodation or other reasons).

The subject element distribution factors represent lectures (seminars) given in one subject, as a contribution to the total given in the programme.

Consider the nth subject element at level of study and let:

w_{n1} = number of weeks of duration of the subject element

l_{n1} = number of lecture hours per week

s_{n1} = number of seminar hours per week

x_{n1} = number of repetitions of lecture content

c_{n1} = number of different programmes of study to which lecture content of the subject element is jointly delivered.

Hence the subject element distribution factors are:

Lectures: $$\beta_{n1} = \frac{x_{n1}}{c_{n1}} \cdot \frac{w_{n1} \cdot l_{n1}}{\Sigma w_{n1} \cdot l_{n1}} \qquad (5)$$

Seminars: $$\gamma_{n1} = \frac{w_{n1} \cdot s_{n1}}{\Sigma w_{n1} \cdot s_{n1}} \qquad (6)$$

Similarly for study levels 2 and 3:

$$\beta_{n2} = \left[\frac{x}{c} \cdot \frac{w.l}{\Sigma w.l}\right]_{n2} \qquad \beta_{n3} = \left[\frac{x}{c} \cdot \frac{w.l}{\Sigma w.l}\right]_{n3}$$

$$\gamma_{n2} = \left[\frac{w.s}{\Sigma w.s}\right]_{n2} \qquad \gamma_{n3} = \left[\frac{w.s}{\Sigma w.s}\right]_{n3}$$

where all elective subject elements in a programme are included in the summation.

To evaluate the total contribution of a specific department, it is necessary to sum the distribution factors for all the subjects given by this department over the entire programme.

If j_1 subject elements at level 1 in the programme of study are contributed by one department then the departmental distribution factor is:

Lectures: $\beta_1 = \Sigma^{j_1} \beta_{n1}$ .... (7)

Seminars: $\gamma_1 = \Sigma^{j_1} \ _{n1}$ .... (8)

Similarly for levels of study 2 and 3:

$$\beta_2 = \Sigma^{j_2} \beta_{n2} \qquad \beta_3 = \Sigma^{j_3} \beta_{n3}$$

$$\gamma_2 = \Sigma^{j_2} \gamma_{n2} \qquad \gamma_3 = \Sigma^{j_3} \gamma_{n3}$$

Then the total departmental academic staff contribution to a programme of study is:

$$S_D = k_1 \cdot \frac{w_1}{w}\left[\beta_1 \frac{l_1}{h_1} + \gamma_1 \cdot \frac{s_1}{g_1 \cdot h_s} \cdot \frac{p_1}{y_1}\right] + k_2 \cdot \frac{w_2}{w}\left[\beta_2 \cdot \frac{l_2}{h_1} + \gamma_2 \cdot \frac{s_2}{g_2 \cdot h_s} \cdot \frac{p_2}{y_2}\right]$$

$$+ k_3 \cdot \frac{w_3}{w}\left[\beta_3 \cdot \frac{l_3}{h_1} + \gamma_3 \frac{s_3}{g_3 \cdot h_s} \cdot \frac{p_3}{y_3}\right] + \frac{k_2\, p_{P_2} \cdot b_2}{h_s} + \frac{k_3 \,.\, p_{P_3} \cdot b_3}{h_s} \; \ldots\ldots\ldots \; (9)$$

NOTE: p_{P_2} and p_{P_3} might need to be modified is projects/theses are shared across departments. In general they will be supervised by the department organizing the particular programme of study.

It will be observed from (4) and (9) that for a complete programme of study:

$$\Sigma\gamma = \Sigma\ \gamma_2 = \Sigma\ \gamma_3 = 1$$

that is, in the case of seminars, the sum of staff allocated in this manner between contributing departments, equals the total required for the programme. This is as logically expected.

However $\Sigma\beta_1$, $\Sigma\beta_2$ and $\Sigma\beta_3$ will only equal unity if there is no repetition of lectures within a programme (the influence of x) or no common lecturing across programmes (the influence of c). These latter will respectively increase or decrease the value of Σ from unity if they occur.

These equations are perhaps more easily understood by reference to the following table 11 which illustrates a method of calculation of the distribution factors for the fundamental level of a programme of study (tables 4 and 5 of section 2.3. also present a practical calculation with typical values).

The importance of allowing for servicing is demonstrated in section 4.3. of Chapter 4 which indicates average inter-faculty servicing up to 30% and over 50% where faculties are largely professional (e.g. agriculture and forestry).

Table 11. Programme of Study Distribution Factors

Level		Fundamental								
Dept.	Subject Element n	Lecture Repetition x	Common Lectures c	Duration weeks w	Lecture hours/ week l	Seminar hours/ week s	w.l	w.s	β	γ
z.1	1	..	..	..	..	..	..	..	..	..
	2	..	..	..	..	..	..	..	..	..
	n	x_{nl}	c_{nl}	w_{nl}	l_{nl}	s_{nl}	$[w.l]_{nl}$	$[w.s]_{nl}$	β_n	γ_n
	j	..	..	..	..	..	..	..	..	..
$\beta_n = \left[\frac{x_{nl}}{c_{nl}} \cdot \frac{w_{nl} \cdot l_{nl}}{\Sigma\, w.l}\right]$ $\gamma_n = \left[\frac{w_{nl} \cdot s_{nl}}{\Sigma\, w.s}\right]$							Σ for Dept z.1		$\beta_{1z.1}$	$\gamma_{1z.1}$
z.2	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..
							Σ for Dept z.2		$\beta_{1z.2}$	$\gamma_{1z.2}$
Etc. for all departments involved										
Σ for all departments, of programme at fundamental level							Σ w.l	Σ w.s	$\Sigma\,\beta$	$\Sigma\,\gamma = 1.000$

2.1.4. Total Departmental Academic Staff Requirement and its Composition

The basic methodology for departmental staff determination via the generalized programme of study concept has been elucidated in sections 2.1.1. and 2.1.2. From this general equation (9), simplified expressions for different teaching programmes which may not incorporate all types of teaching, can be directly deduced.

(i) Short Courses.

Short courses are defined as specialized programmes of study of a concentrated form which are generally of durations varying from a few days to several weeks. Section 4.3. of Chapter 4 gives some averaged data on such courses for various geographical regions. It will be noted that such courses average 9 working days duration, 50 students per course and a frequency of some 40 courses per year. In total they can account for up to about 10% of an academic staff requirement.

Such courses are generally of post-first degree/diploma level but could obviously be at any of the levels of study defined in section 2.1.1. Their academic staff requirement can be determined from the generalized equation (9) as follows:

Let S_s be departmental academic staff requirements for short courses.

$$S_s = f.\ k_s \cdot \frac{w_s}{w}\left[\beta_s \cdot \frac{l}{h_l} + \gamma_s \cdot \frac{s.\ p_s}{g_s \cdot h_s}\right] \qquad \ldots\ldots\ldots\ldots\ldots (10)$$

where f = a concentration factor (a good value is 2.0).

w_s = total weeks of short courses/yr. at the appropriate level of study.

p_s = average number of students per short course at the appropriate level of study

β_s, γ_s = the distribution factors for the department

and $k_s = k_{s1}, k_{s2}, k_{s3}$.

$l = l_1, l_2, l_3$

$s/_{gs} = {}^{s}1/g_{s1}\ ,\ {}^{s}2/g_{s2}\ ,\ {}^{s}3/g_{s3}$, according to the appropriate level of study.

NOTE: Each short course could be treated exactly as a programme activity, utilizing equation (9), with the inclusion of the concentration factor f. However they usually relate to one level of study (and this is invariably level 3) and therefore the simpler form of equation (10) has been used.

(ii) Full-time Student Research Supervision

This can be treated exactly as the projects/theses except that they will be exclusively in the higher level of study catagory (level 3) and will require a greater degree of academic staff supervision.

Thus for a total of p_R full-time research students per year requiring b_R hours/week of staff supervision, the total academic staff requirement,

$$S_R = \frac{k_3 \cdot p_R \cdot b_R}{h_S} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

(iii) Industrial visiting:

This is only applicable where sandwich or co-operative programmes are involved. In such courses the academic staff requirement for visiting students in industrial and other establishments where the student is undergoing a programme of study combining academic and professional industrial training, must be incorporated. Section 4.3. of Chapter 4 provides some data on such programmes. It will be observed that their occurance is relatively rare but that where formal programmes are provided (and this is particularly relevant in the U.K.) they require an average of 45 hours/year of academic staff time. Such commitments can amount to 0.03-0.1 staff per sandwich student and a 20% increase in staff for a fully integrated programme.

A simple first approximation of academic staff requirements for this activity is presented here. This is similar to that for project/theses and research supervision. The full implications of such forms of study will only be revealed by a comprehensive analysis.

If p_I = Total number of students in industry etc. per year.

q = Effective number of academic staff hours/year per industrial visit per student.

r = number of industrial visits per student per year.

Then academic staff requirement is:

$$S_I = \frac{p_I \cdot q.r.}{w.h} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

where $q = 12$ as an average value derived from section 4.3 of Chapter 4, and based on 4 industrial visits per complete year.

NOTE: For a highly developed sandwich programme the following staff functions are involved:

(a) Counselling students on industry.

(b) Placing students in an appropriate industry.

(c) Actual visiting of students in industry.

(d) Assessment of student performance in industry.

(e) Administration.

The value of $q = 12$ can be taken to encompass all of the academic staff function in the above (in the absence of more accurate information). It does not, of course, include administrative support.

There have now been developed expressions for all departmental teaching activity. The total departmental staff requirement is the sum of the requirements for different programmes - degree courses, short courses, research student supervision and industrial visiting.

Thus the total departmental academic staff requirement can be expressed in the following generalized form:

$$D_A = \Sigma S_D + \Sigma S_S + S_R + S_I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

or using (9), (10), (11), (12) then:

$$\begin{aligned}
D_A = \Sigma \Bigg\{ & k_1 \cdot \frac{w_1}{w} \left[\beta_1 \cdot \frac{l_1}{h_1} + \gamma_1 \cdot \frac{s_1}{g_1\, h_s} \cdot \frac{p_1}{y_1}\right] + k_2 \cdot \frac{w_2}{w_3} \left[\beta_2 \cdot \frac{l_2}{h_1} + \gamma_2 \cdot \frac{s_2}{g_2\, h_s}\right] \\
& \cdot \frac{p_2}{y_2} + k_3 \cdot \frac{w_s}{w} \left[\beta_3 \cdot \frac{l_3}{h_1} + \gamma_3 \cdot \frac{s_3}{g_3\, h_s} \cdot \frac{p_3}{y_3}\right] + k_2 \cdot \frac{p_{p_2} \cdot b_2}{h_s} \\
& + k_3 \cdot \frac{p_{p_3} \cdot b_3}{h_s} \Bigg\} + \Sigma . k_s \cdot \frac{w_s}{w} \left[\beta_s \cdot \frac{l}{h_1} + \gamma_s \cdot \frac{s}{g_s\, h_s} \cdot p_s\right] + k_3 \cdot \frac{p_R . b_R}{h_s} \\
& + \frac{p_I \cdot q \cdot r.}{w.h_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (14)
\end{aligned}$$

It will be observed that although the concepts leading to the development of equation (14) are relatively simple the resulting equation is relatively complex. When to this is added the further data analysis of section 4.3. of Chapter 4, which indicates an average of 6-7 faculties per institution (each faculty of which may contain 3-10 departments), the overall magnitude of the university academic staff estimation problem immediately becomes apparent. This emphasizes the need for simplicity not only in terms of the reduction of the analysis but also in terms of gaining acceptance from the academic staffs themselves.

Fortunately it is possible to reduce equation (14) in two ways:

(a) From the use of certain generalized data (or conceptualized) values for some of the coefficients.

(b) From application to a particular teaching function university structure and using further data values appropriate to subject classification and geographical region. The way in which this can be done is illustrated in later sections.

The Composition of Departmental Academic Staff

The full-time equivalent departmental academic staff have now been determined. However this is only one side of the equation since full-time equivalent academic staff comprise, in general, a combination of "established" full-time staff together with part-time contributions from persons external to the university, university assistants and students. This may be normally sufficient to compute costs but it is important to determine the established full-time complement for academic staff distribution. Here are developed generalized expressions for determining this composition of staff.

Part-time Equivalent Staff

It will be observed from section 4.3. below that part-time equivalent is normally a small part of the total full-time equivalent academic staff. Nevertheless it is important to assess this approximately especially at departmental level since it will influence the full-time academic staff establishment (i.e. established university appointments).

Thus it can be assumed that:

$$D_A = S_E + S_N + S_O \quad \text{(15a)}$$

where S_E = the permanent established full-time academic staff

S_N = the F.T.E. academic staff from student support teaching

S_O = the F.T.E. academic staff from external support teaching

Values of S_N and S_O can be determined approximately as follows:

$$S_N = \frac{l_N}{w.h_s} \quad \text{(15b)}$$

since most student teaching will be of the seminar type

$$\text{and } S_O = \frac{2\, l_O}{w(h_l + h_s)} \quad \text{(15c)}$$

where l_N and l_O are the total part-time teaching hours per annum from student support teachers and external teachers respectively.

Clearly the above equations could be applied in a more detailed way for various study levels, for seminars and lectures, etc, using the same methodology being developed for the total academic staff assessment. This will not usually be required but the application of the method will be self evident and hence will not be taken further here.

However it will be clear from the above that once the F.T.E. staff has been determined the established and part-time contributions can then be evaluated to any required level of refinement.

2.2. Initial Simplification of the Equations and Parametric Data

Initial Simplification of the equations

This refers to mathematical simplification of the equations, together with the substitution of values that apply generally across the subject classifications and geographical regions.

It is assumed that advanced level of study (level 2) parameters are an arithmetic mean of the fundamental (level 1) and higher (level 3) study level parameter values. A limited data testing analysis suggests that this is a reasonable assumption. For some parameters this can be built into the data reduction. This is achieved as follows:

(i) Insertion of values for k. These are, effectively, factors for academic staff teaching loads at the various levels of study. Thus since h_1 and h_s are referred to at the fundamental level, $k = 1$ generally. Also a limited amount of data testing suggested a value of $k_3 = 1.5$ (with $k_1 = 1$). This value leads to an overall student weighting of higher to first degree/diploma work of between 2.0 and 2.5, which is approximately the value quoted nationally and internationally. Appendix A1 gives an analysis which supports this conclusion.

Thus $k_1 = 1.0 \qquad k_2 = 1.25 \qquad k_3 = 1.50$

(ii) Insertion of values for b. These relate to academic staff supervision of project/theses and student research. A brief analysis of typical values is given in section 3, Chapter 4, where it is suggested that values of b are relatively uniform across subject classifications and geographical regions although medicine appears to be between two and three times greater than for all other subjects. Appropriate values for b are:

$b_2 = 0.5 \qquad b_3 = 0.75 \qquad b_R = 1.20$

(iii) The assumption that advanced level parameters are an arithmetic mean of the fundamental and higher level parameters is applied to the parameters $\frac{1}{h_1}$ and $\frac{s}{g.h_s}$

Let $l_3 = u.l_1 \qquad \frac{s_3}{g_3} = v.\frac{s_1}{g_1}$

Then $l_2 = \left(\frac{1+u}{2}\right).l_1 \qquad \frac{s_2}{g_2} = \left(\frac{1+v}{2}\right)\frac{s_1}{g_1}$ .... (16)

Use of all of the above simplifications in the basic programme of study equation (4) leads to:

$$S_y = \frac{l_1}{h_1} \cdot \left[\frac{w_1}{w} + 0.625\,(1+u)\frac{w_2}{w} + 1.5u \cdot \frac{w_3}{w}\right] + \frac{s_1}{g_1\,h_s}\left[\frac{w_1}{w}\cdot\frac{p_1}{y_1} + 0.625\,\frac{w_2}{w}\cdot\frac{p_2}{y_2}(1+v) + 1.5\,\frac{w_3}{w}\cdot\frac{p_3}{y_3}\cdot v\right]$$

$$+ \frac{1}{h_s}\left[0.625\,p_{p_2} + 1.125\,p_{p_3}\right] \quad \text{.......................... (16)}$$

This is now in a form which provides considerable simplification when applied to a specific programme of study structure. This is illustrated by applying it to the same examples as in section 2.1.2. as follows:

First Degree in the U.K.

This incorporates 2 years at the fundamental level and 1 year at advanced level.

Typical values are:

$$\frac{w_1}{w} = 2 \qquad y_1 = 2 \qquad \frac{w_2}{w} = 1 \qquad y_2 = 1.$$

together with the above parameter values, this yields:

$$S_{b_y} = \frac{l_1}{h_1}\left[2.625 + 0.625\ u\right] + \frac{s_1}{g_1 \cdot h_s}\left[p_1 + 0.625\ p_2\ (1 + v)\right] + 0.625\ \frac{p_{p_2}}{h_s}$$

Higher (Masters) Degree in the U.K., by Course

$$\frac{w_3}{w} = \frac{2}{3}, \quad y_3 = 1, \quad p_{p_3} = p_3 \quad \text{(all others zero).}$$

$$S_{b_y} = \frac{l_1}{h_1} \cdot u + \frac{s_1}{g \cdot h_s} \cdot v \cdot p_3 + \frac{1.125\ p_3}{h_s}$$

First Diploma in a European University

This normally embraces 3 years at fundamental level and 2 years at advanced.

Typical values would be:

$$\frac{w_1}{w} = 3 \qquad y_1 = 3 \qquad \frac{w_2}{w} = 2 \qquad y_2 = 2 \quad \text{(all higher level zero).}$$

$$S_{b_y} = \frac{l_1}{h_1}\left[4 + u\right] + \frac{s_1}{g_1 \cdot h_s}\left[p_1 + 0.625\ p_2\ (i + v)\right] + 0.625\ \frac{p_{p_2}}{h_s}$$

The evaluation of the specific instances sited above depends on a knowledge of the parameters l/h_1, $s/g.h_s$, u, v, and h_s for any given student enrolment in a programme of study. These parameters will in general vary with subject area and geographical region.

It will be obvious from the above that a similar simplification procedure can be adopted for the departmental contributions expressed by equation (14). However to avoid confusion from repetition of generalized equations attention will now be directed to the application of the methodology to a particular geographical region. Before this, it is necessary to present the results of a data analysis for the values of the controlling parameters in the equations and this follows in the next section.

Parametric Data

The data collected from reference 1 has been reduced to provide values of l/h_1, $s/g.h_s$, h_s, u and v in terms of broad subject classification and geographical region.

Some details of this are given in section 3. of Chapter 4 and the results are presented here in a form for immediate application to the derived equations. Basically they present standard values of the parameters for six broad subject classifications together with geographical region weighting factors for four regions. The data is presented in tables 12 and 13 below.

Table 12. Parametric Data for Subject Classification

Subject classification	$^{l}l/h_{l}$	$^{s}l/g_{l} \cdot h_{s}$	u	v	h_{s}*
Pure Science	1.18	0.0525	0.636	2.100	
Technology/Applied Science	1.44	0.0513	0.778	1.780	
Medical Science	1.78	0.0602	0.669	1.292	
Humanities and Art	1.13	0.0281	0.752	1.887	
Education	0.96	0.0283	0.760	1.629	
Social Science/Law	1.56	0.0250	0.744	1.652	
All Subjects	1.32	0.0423	0.747	1.491	11.58

* Only the overall value is quoted here as this is recommended for use with the project/thesis/research supervision terms of the equations.

Table 13. Geographical Region Weighting Factors

Region / Factor Applied To →	$^{l}l/h_{l}$	$^{s}l/g_{l} \cdot h_{s}$	u	v	h_{s}
North America	0.84	0.86	0.82	1.14	1.08
United Kingdom	0.69	1.40	1.19	1.21	1.00
Europe: EEC and Scandinavia	0.91	0.79	1.15	0.99	0.98
Europe: Others	1.79	1.26	0.99	0.80	0.77

Example of use: The value of v in Humanities for Europe (others) is 1.887 0.80 = 1.51.

This table may be used to select appropriate data for substitution in the academic staff equations. It is particularly useful for comparative purposes. The similarity of some of the parameters suggests that further simplications might be made with a small loss in accuracy (e.g. grouping Science and Technology on the one hand and Humanities, Education and Social Science on the other). This however has not been tested.

2.3. Application of the Methodology to a Typical U.K. University

General

The previous sections provide the methodology and data to enable specific universities to develop specific and considerably simplified equations for academic staff estimation. The procedure involves the use of the basic programme of study equation to develop equations for most types of particular programmes describing the full departmental teaching function. It is then necessary to substitute appropriate parametric data into these equations and to determine appropriate departmental subject element distribution factors for each type of programme in order to allow for inter-departmental service teaching. This then permits calculation of the total departmental staff requirement for a given student complement.

The method is illustrated here for a typical U.K. university and an associated technological department. Reduced examples illustrate the process in all of its essential elements.

Simplified equations for a general U.K. university department

Following the method of section 2.1.3.:

(i) First Degree Programmes

Using equation (9) simplified above:

$$D_{A_{12}} = \frac{l_1}{h_1}\left[2\beta_1 + 0.625\ \beta_2\ (1 + u)\right] + \frac{s_1}{g_1 \cdot h_s}\left[\gamma_1 \cdot p_1 + 0.625\ \gamma_2\ (1 + v)\ p_2\right]$$

$$+ \frac{0.625 \cdot p_{p_2}}{h_s}$$

(ii) Masters (higher) degree programmes

With previous simplification and equation (9),

$$D_{A_3} = \beta_3 \cdot \frac{l_1}{h_1} \cdot u + \gamma_3 \cdot \frac{s_1}{g_1 \cdot h_s} \cdot v \cdot p_3 + 1.125\ \frac{p_{p_3}}{h_s}$$

(iii) Short courses

It is assumed that all short courses are of graduate level (i.e. higher level of study 3) and that a concentration factor (k_s) of 2.0 is appropriate.

Then using equations (10) and (9) and w = 30:

$$S_S = k_S\left[\beta_S \cdot \frac{l_1}{h_1} \cdot \quad + \gamma_S \cdot \frac{s_1}{g_S \cdot h_S} \cdot \quad \cdot p_S\right]$$

(iv) Research Supervision

Using (12):

$$S_R = 1.8 - \frac{p_R}{h_s}$$

(v) Industrial Visiting

Using (13) and $w = 30$

$$S_I = \frac{0.4\, r \,.\, p_I}{h_s}$$

The summation of the requirements for these functions of the departmental academic staff yeilds the academic staff complement required by the department.

Algebraically:

$$D_A = \Sigma \frac{l_1}{h_1}\left[2\beta_1 + 0.625\ \beta_2\ (1 + u)\right] + \frac{s_1}{g_1 \,.\, h_s}\left[\gamma_1\, p_1 + 0.625\ \gamma_2\ (1 + v)\ p_2\right]$$

$$+ 0.625 \,.\, \frac{p_{P_2}}{h_s}$$

First degree programmes

$$+ \Sigma \left[\beta_3\, \frac{l_1}{h_1} \,.\, u + \gamma_3 \,.\, \frac{s_1}{g_1 \,.\, h_s}\, v.p_3 + 1.125\, \frac{p_{P_3}}{h_s}\right]$$

Masters degree programmes

$$+ w_s \left[\beta_S \,.\, \frac{l_1}{h_1} \,.\, u + \gamma_S \,.\, \frac{s_1}{g_s \,.\, h_s}\ v \,.\, p_s\right] + 1.8\, \frac{p_R}{h_s} + \frac{0.4\, r.p_I}{h_s}$$

Short courses | Research supervision | Industrial supervision

Application to a Specific Technology Department

Using tables 12 and 13 from section 2.2. the following data is appropriate to a technology department in a U.K. university

$$\frac{l_1}{h_1} = 1.44 \,.\, 0.69 = 0.994$$

$$\frac{s_1}{g_1 \,.\, h_s} = 0.0513 \,.\, 1.4 = 0.0719$$

$$u = 0.778 \,.\, 1.19 = 0.927$$

$$v = 1.780 \,.\, 1.21 = 2.17$$

$h_s = 11.58 \cdot 1.00 = 11.58$

and subsitituting these values in the general equation for academic staff yields:

$$D_A = \Sigma \underbrace{\left[1.998\ \beta_1 + 1.194\ \beta_2 + 0.0719 \cdot \gamma_1 \cdot p_1 + 0.1423\ \gamma_2\ p_2 + 0.0542\ p_{p_2}\right]}_{\text{First degree programmes}}$$

$$+ \Sigma \underbrace{\left[0.921\ \beta_3 + 0.156\ \gamma_3 \cdot p_3 + 0.0974\ p_{p_3}\right]}_{\text{Masters degree programmes}}$$

$$+ \underbrace{w_S \left[0.0921 \cdot \beta_S + 0.0156\ \gamma_S \cdot p_S\right]}_{\text{Short courses}} + \underbrace{0.1555\ p_R}_{\text{Research supervision}} + \underbrace{0.0336\ r \cdot p_I}_{\text{Industrial supervision}}$$

Thus with student numbers defined and the distribution factors B and Y determined by the methods of section 2.1.3., the full-time equivalent academic staff requirement for this specific technology department can be estimated.

Example calculation for the U.K. technology department

It will be assumed that the U.K. technology department has the following teaching functions (which are deliberately simplified).

(a) The departments own first degree programme (sandwich type).

(b) Servicing to one other departments' first degree programme.

(c) The departments' own masters degree programme.

(d) A series of short courses run wholly by the department.

(e) Higher degree research students.

(f) Industrial visiting for the departments' own first degree programme.

Then the calculation of the total academic staff requirement proceeds as follows:

Own First Degree Programme.

The following initial data is assumed:

Fundamental level: p_1 = 93 students total

(50 first year and 43 second year).

Advanced level: p_2 = 42 students total.

(42 final year).

p_{P2} = 38 students

(whose projects are supervised by departmental staff).

Then it is first necessary to calculate the distribution factors for the complete programme of study according to the methods outlined in section 2.1.3. This is effected in the following tables 14 and 15 for the fundamental and advanced levels respectively.

Before proceeding to the calculations it is useful to comment on the results of tables 14 and 15. These are:

(i) The overall value of β for the fundamental part of the programme (table 14) is considerably less than unity because common lecturing provides a greater weighting than the repetition of lectures (see columns "x" and "c").

Conversely for the advanced part the value of β is greater than unity.

(ii) The overall value of γ is unity for both parts of the programme (as it should be).

(iii) The department's own contribution, shown in the subject distribution factors β_1 and γ_1, is relatively small at the fundamental level, and considerably greater at the advanced level.

(iv) The summations for β and γ, excluding β_1 and γ_1, represent the distribution factor crediting to departments servicing the programme. Hence of the total staff required for the programme at fundamental level, the mathematics department is credited with 6.58/.6339 per cent of them for lectures, and 13-52% for classes.

(v) It will be noted that no allowance is made for project/thesis work as this is accounted for separately.

(vi) All elective subjects are included - this is especially significant in the advanced part of the programme.

Thus the department's own academic staff requirements to provide its undergraduate degree course, can be calculated via tables 14 and 15, from equation 9.

$\beta_1 = 0.3684 \qquad \beta_2 = 0.8334$

$\gamma_1 = 0.5045 \qquad \gamma_2 = 0.7916$

$p_1 = 93 \qquad p_2 = 42 \qquad p_{P_2} = 38$

For first degree programme:

$$D_{A_{UG}} = \Sigma \left[1.988 \cdot \beta_1 + 1.194\, \beta_2 + 0.0719\, \gamma_1\, p_1 + 0.1423\, \gamma_2\, p_2 + 0.0542\, p_{P_2} \right]$$

$$= 1.988 \cdot 0.3684 + 1.194 \cdot 0.8334 + 0.0719 \cdot 0.5045 \cdot 93 + 0.1423 \cdot 0.7916 \cdot 42 + 0.0542 \cdot 38$$

$$= 11.891$$

i.e. 11.891 full-time equivalent academic staff are required by the technology department to teach its own undergraduate programme in aeronautical engineering.

Table 14. Programme Distribution Factors: Example.

Programme		Aeronautical Engineering								
Department		Transport			Level Fundamental					
Depart.	Subject Element	Lecture Repetition x_i	Common Lectures c_i	Duration of Tuition (weeks) w_i	Lecture hours per week l_i	Seminar hours per week s_i	w_l	w_s	β	γ
Trans.	Materials	1	3	20	1.5	1.0	30	20	.0117	.0360
"	Machines	1	2	30	1.5	1.0	45	30	.0263	.0541
"	Thermodyns	1	2	30	1.5	1.0	45	30	.0263	.0541
"	Mech. Fluids	1	3	30	1.5	1.0	45	30	.0175	.0541
"	Structures	1	2	30	3.0	2.0	90	60	.0526	.1080
"	Control	1	2	20	2.0	1.0	40	20	.0234	.0360
"	Aerodynamics	1	1	30	2.0	1.5	60	45	.0702	.0811
"	Propulsion	2	1	30	2.0	1.5	60	45	.1404	.0811
Trans.								Σ	β_1 = .3684	γ_1 = .5045
Maths	Maths I	1	4	30	3.5	1.5	105	45	.0307	.0811
"	Maths II	1	3	30	3.0	1.0	90	30	.0351	.0541
Maths								Σ	= .0658	γ_2 = .1352
Elect.	Electrics	1	2	20	2.0	1.0	40	20	.0234	.0360
"	Electronics	1	2	10	2.0	1.0	20	10	.0117	.0180
"	Control	2	3	10	2.0	1.0	20	10	.0156	.0180
Elect.								Σ	= .0507	γ_3 = .0720
Mech.	Eng. Design	2	1	30	1.0	2.0	30	60	.0702	.1080
Mech.								Σ	= .0702	γ_4 = .1080
Soc. Sc.	Humanities	1	2	30	1.0	1.0	30	30	.0175	.0541
"	Economics	1	2	30	1.0	1.0	30	30	.0175	.0541
Soc. Sc.								Σ	= .0350	γ_5 = .1082
Manag.	Materials	1	2	10	1.5	1.0	15	10	.0088	.0180
"	Ind. Manag.	1	2	30	1.0	1.0	30	30	.0175	.0541
"	Bus. Studies	1	2	30	1.0	-	30	-	.0175	-
Manag.								Σ	.0438	γ_6 = .0721
						Σ	855	555	.6339	1.0000

NOTE: $\beta = \frac{x}{c} \cdot \frac{w_l}{\Sigma w_l} = \frac{x}{c} \cdot \frac{w_l}{855}$ $\qquad \gamma = \frac{w_s}{\Sigma w_s} = \frac{w_s}{555}$

Table 15. Programme Distribution Factors

Programme		Aeronautical Engineering								
Department		Transport			Level		Advanced			
Depart.	Subject Element	Lecture Repetition x_i	Common Lecture c_i	Duration weeks w_i	Lecture hrs./week l_i	Seminar hrs./week s_i	wl	ws	β	γ
Trans.	Aerodynamics	1	1	30	2	1	60	30	.1429	.1250
"	Structures	1	2	30	2	1	60	30	.0714	.1250
"	Propulsion	2	1	30	2	1	60	30	.2858	.1250
"	Stability	1	2	30	2	1	60	30	.0714	.1250
"	Design	1	1	30	2	1	60	30	.1429	.1250
"	Design Topics	1	2	20		1	20	20	.0238	.0833
"	Synthesis	1	1	20	2	1	40	20	.0952	.0833
								Σ	β_2 = .8334	γ_2 = .7916
Ergon.	Design Topics	1	2	10		1	10	10	.0119	.0417
								Σ	.0119	.0417
Maths.	Maths. III	2		10	2	1	20	10	.0952	.0417
								Σ	.0952	.0417
Soc. Sc.	Econ. and Soc.	1		30	1	1	30	30	.0714	.1250
								Σ	.0714	.1250
						Σ	420	240	1.019	1.000

NOTE: $\beta = \frac{x}{c} \cdot \frac{wl}{\Sigma wl} = \frac{x}{c} \cdot \frac{wl}{420}$ $\gamma = \frac{ws}{\Sigma ws} = \frac{ws}{240}$

Servicing to other departments' programme.

Here it will be assumed that servicing is to the advanced level of another technological programme and for which:

$\beta_2 = 0.105 \qquad \gamma_2 = 0.087 \qquad p_2 = 60 \qquad p_{P_2} = 4$

(also: $\beta_1 = \gamma_1 = 0$)

The general simplified equation is again utilized:

$$D_{A_{12}} = 1.194 \,.\, 0.105 + 0.1423 \,.\, 0.087 \,.\, 60 + 0.0542 \,.\, 4$$

$$= 1.085$$

i.e. 1.085 F.T.E. academic staff are required by this technology department to service the outside technological programme.

Own masters degree programme

To avoid unnesessary complication full distribution factor tables similar to tables 14 and 15 will not be reproduced here. Thus it will be assumed that:

$\beta_3 = 0.700 \qquad \gamma_3 = 0.750 \qquad p_3 = 20 \qquad p_{P_3} = 15$

Master's degree requirements for academic staff are:

$$D_{A_3} = \Sigma \left[0.921 \,.\, \beta_3 + 0.156\, \gamma_3 \,.\, p_3 + 0.0974\, p_{P_3} \right]$$

$$= 0.921 \,.\, 0.700 + 0.156 \,.\, 0.750 \,.\, 20 + 0.0974 \,.\, 15$$

$$= 4.446$$

The master's degree programme in technology necessitates the technology department having 4.446 full-time equivalent academic staff.

Short course programmes

Here it is assumed that 12 weeks (total) of short courses are given entirely by the departmental staff with an average of 18 students per course i.e.

$w_S = 12 \qquad \beta_S = \gamma_S = 1 \qquad P_S = 18.$

The relevant calculation is:

$$S_S = w_S \left[0.0921 \,.\, \beta_S + 0.0156\, \gamma_S \,.\, P_S \right]$$

$$= 12 \left[0.0921 + 0.0156 \,.\, 18 \right]$$

$$= 4.475$$

The transport department's short courses require 4.475 full-time equivalent academic staff to teach them alone.

Research supervision

It is assumed that there are 15 full-time research students requiring supervision: i.e. $p_R = 15$.

The relevant calculation from equation (37) is:

$$s_R = 0.1555\ p_R$$

$$= 0.1555\ .\ 15$$

$$= 2.333$$

Research student supervision requires 2.333 full-time equivalent academic staff within the technology department.

Industrial visiting etc.

Since the first degree programme is of the sandwich type it is assumed that all students are in industry for 1 year between the fundamental and advanced level studies. It is also assumed that each student is visited twice during this annual period i.e.:

$p_I = 43 \qquad r = 2$

The relevant calculation is:

$$s_I = 0.0336 : r.\ p_I$$

$$= 0.0336.\ 2.\ 43$$

$$= 2.890$$

The total academic staff requirement, in full-time equivalents, for this technology department is summarized in the following table 16:

Table 16. Total F.T.E. Academic Staff Requirement

- Transport Department: Example.

Item	Own 1st Degree Prog.	Servicing other 1st Degree Prog.	Own Masters Degree Prog.	Short Courses	Research Super-vision	Indust. Visiting Etc.	Total
Academic Staff Requir. I.	11.891	1.085	4.446	4.475	2.333	2.890	27.120
% of Total	43.8	4.0	16.4	16.5	8.6	10.7	100.0

3. Estimation of Departmental Technical Support Staff

The estimation of departmental supporting staff is important in that it contributes significantly to the total recurrent costs of a department particularly in the science and technology areas where considerable laboratory and other support space is involved. However it is equally important to academic staff if they are to perform their duties effectively and efficiently. The latter applies whether the supporting staff is large or small in relation to the total academic staff.

For example the arts, social sciences and humanities require adequate support even though this will not be on the scale of that required for, say, engineering.

This section, therefore, presents a simplified method of estimating such supporting staff for departments. This staff refers not only to technician staff usually associated with science and technology but also to assisting staff for any academic purpose (but excluding administrative staff).

The method supposes that supporting staff is a function of departmental support area and of the total departmental academic staff support area in this context includes working space of all kinds, necessary to the adequate functioning of the department. A large portion of this may be laboratories. However arts, social science, etc. departments also need such space although it will be small generally compared with laboratory-based science and technology. The data analysis (reference 4) shows this to be so.

The method proceeds initially to test the basic suppositions in terms of support area using the full data from reference 1 and then proceeds to develop an expression for support area in terms of academic staff. The final result therefore is presented as a function of academic staff which can be calculated from section 2 and of data derived constants.

The data suggests that departmental supporting staff is much less sensitive to geographical regional variations than to broad subject classification so that the data constants are presented in terms of variation of the latter only.

It will be observed that a by-product of the method is an analysis which facilitates the calculation of departmental support area in terms of departmental academic staff.

3.1. Basic Methodology

A preliminary study of the full data of reference 1 suggested that the departmental supporting staff was largely dependent on departmental support area and total academic staff. It further suggested that the data could be grouped into the following broad subject classifications:

Group 1	Pure Science
Group 2	Applied Science and Technology
Group 3*	Arts/Social Science/Law/Mathematics/Education
Group 4	Medical Sciences

* That mathematics is included in Group 3 and that geographical regional variations were relatively small.

Appendix A2 of this chapter tests these observations. The results show a reasonably good linearity between support area and supporting staff for each group. The proportionality is less good between total academic staff and supporting staff. This was subsequently shown to be the minor influence and averaged constant proportionalities were assumed for each group.

Thus $\frac{A_b}{N_T} = d_3$, from the graphs of Appendix A2 .... (17)

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where A_b = departmental support area (m^2)

N_T = total departmental support staff (excluding administrative)

also $\frac{N_T}{S_T} = d_4$ .... (18)

where S_T = total departmental academic staff.

Thus if: $N_T = d_1 \cdot A_b + d_2 \cdot S_T$ .... (19)

then Appendix A2 derives values of d_1 and d_2 from d_3 and d_4 (using group 3 data as a base as follows:

$N_T = d_1 A_b + 0.07 S_T$ .... (20)

Table 17 presents the values of d_1, d_2, d_3 and d_4.

Table 17. Values of Proportions d_1, d_2, d_3, d_4.

Subject Classifications	d_1	d_2	d_3	d_4
Group 1. Pure Science	0.00855	-	105	0.68
Group 2. Applied Science and Technology	0.00647	-	139	0.69
Group 3. Arts/Social Science/Law/Maths/Education	0.00444	-	77	0.106
Group 4. Medical Sciences	0.00892	-	99	0.60
Average		0.07		

Thus for a given "support" area and academic staff, the departmental supporting staff can be calculated for any subject classification group.

However departmental "support" area is itself related to academic staff. If this relationship can be specified, supporting technical staff can be calculated directly from academic staff.

The estimation of departmental "support" ("laboratory") area.

The method for the determination of departmental support area distribution factors in terms of academic staff, drawn from reference 2, is as follows:

Let: S_H = total departmental academic staff required for higher degree/diploma research and other higher level of study work. (This can be determined from section 2).

a_F = support area per first degree/diploma student (m^2)

ω = ratio of higher degree/diploma support area per student to a_F

θ = factor to allow for different types of support work.

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s_u = overall university student/staff ratio (calculated using section 2 of this chapter by departmental aggregation).

Then the "effective" number of staff in a department is:

For first degree/diploma $= s_u (D_A - S_H)$

For higher degree/diploma $= s_u \cdot S_H$

Hence $A_b = \Theta \left[s_u (D_A - S_H) a_F + s_u \cdot D_A \cdot \omega \cdot a_F \right]$

$$\text{or } A_b = s_u \Theta a_F (D_A - S_H) + \omega . S_H \quad \text{.....................} \quad (21)$$

Values a_F and w are data derived in Appendix A2 and equation (21) can be rewritten as:

$$A_b = s_u \Gamma \; 6.1 \; (D_A - S_H) + \omega S_H \quad \text{.....................} \quad (22)$$

where $\Gamma = \Theta \lambda_2$, and is the "effective" value of Θ, which varies according to subject area of the department, conditioned by the group factor λ_2.

3.2. Departmental Support Staff Estimation.

If we substitute equation (22), expressing total support area in terms of academic staff, into equation (20).

$$D_S = d_1 \; s_u \Gamma \cdot 6.1 \left[(D_A - S_H) + \omega S_H \right] + 0.07 \; D_A$$

Thus s_u, D_A and S_H can be determined from section 2 and the values of d_1 and w are given in tables 7 and 8 respectively. It remains to determine suitable values of . Appendix A2 gives a method for determining this from the data of reference 1. However the results are somewhat varied for individual departments due, probably, to the unreliability of the data at this level of disaggregation. Nevertheless they are of the right order of magnitude and some values compare well with those used in a U.K. university (see Appendix A2).

In the absence of more reliable data the following broad subject classification values for Γ may be used as a guide (table 18):

Table 18. Data-Derived Values of ω and Γ .

Subject Group	Subject	ω	Γ
Group 1	Pure Sciences	2.26	0.72
Group 2	Technology	2.18	1.04
	Architecture		0.30
	Agriculture		0.95
Group 3	Fine Arts	2.80	0.05
	Social Science		0.15
	Law		0.01
	Humanities		0.03
	Education		0.14
Group 4	Medical Sciences	2.26	1.20

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It should perhaps be added that very little published information exists for the determination of "support" area coefficients for specific subjects as typified by Γ and that this is a field requiring research.

3.3. Example Applied to the Typical Technology Department in the U.K.

Based on the previous example of the technology department in the United Kingdom, detailed in section 2.3:

Total departmental academic staff $D_A = 27.12$

Total departmental academic staff required for all higher level work:

$$S_H = 4.446 + 4.475 + 2.333 = 11.254$$

From table 17:

$$d_1 = 0.00647 \text{ for group 2.}$$

From table 8:

$$\omega = 2.18 \text{ for group 2.}$$

$$\Gamma = 1.04 \text{ for technology.}$$

Since the calculation in section 2.3. did not proceed to the aggregate university situation it is necessary to assume a typical value for the overall staff/student ratio (s_u). Thus for a typical U.K. university:

$$s_u = 9.5$$

Then from equation (22):

$$\text{"support" area } A_b = 9.5 \cdot 1.04 \cdot 6 \cdot 1 \left[(27.12 - 11.25) + 2.18 \cdot 11.25\right]$$
$$= 2435 \text{ m}^2$$

and from (20):

$$D_S = 0.00647 \cdot 2435 + 0.07 \cdot 27.12 = \underline{17.65}$$

"Support" area (including laboratories) for this department is 2435 m^2, and 17.65 full-time equivalent technical support staff are required.

4. Estimation of Departmental Administrative Staff

4.1. Basic Methodology

Since the method of calculation of departmental academic staff (section 2) and of supporting staff, other than administrative staff, (section 3) effectively defines the academic function and type of the department it is logical to postulate that the number of departmental administrative staff is a function of the total departmental academic and supporting staff. Furthermore it is a reasonable assumption that administrative servicing would relate to the degree of responsibility of such other staff. These are the bases of the simple analysis that follows.

Let S_T = total full-time academic staff in a department

D_D = total full-time administrative staff in a department

D_S = total full-time supporting staff (technicians, assistants, demonstrators, etc.) in a department but excluding administrative staff.

Assuming that academic staff can be classified into three broad gradings;

1. Professoral: x_1 = factor of academic staff (D_A) at grade 1.

2. Senior: x_2 = factor of academic staff (D_A) at grade 2.

3. Junior: x_3 = factor of academic staff (D_A) at grade 3.

where $x_1 + x_2 + x_3 = 1$

Then the proportionate administrative staff support can be expressed as:

$_1$ administrative staff per grade 1 academic staff

$_2$ administrative staff per grade 2 academic staff

$_3$ administrative staff per grade 3 academic staff

$_T$ administrative staff per supporting staff (D_S)

and will be ordered in decreasing values of

Thus the total departmental administrative staff required is:

$$D_D = ({}_1 \cdot x_1 + {}_2 \cdot x_2 + {}_3 \cdot x_3) D_A + \quad + D_S \qquad (23a)$$

This can be written as:

$$D_D = \eta \cdot D_A + {}_T \cdot D_S \qquad (23b)$$

$$\text{or } \frac{D_D}{D_A} = \eta + {}_T \cdot \frac{D_S}{D_A} \qquad (23c)$$

where $\eta = {}_1 \cdot x_1 + {}_2 \cdot x_2 + {}_3 \cdot x_3$.

These data cover 323 individual items and the values of table 9 are plotted in graph 1. This plot shows that there is little evidence of subject dependency except that the humanities/arts/social science type subjects bunch towards the D_D/D_A ordinate since the supporting staff is small in these areas. It also shows a good degree of linearity and hence justifies the assumptions of equation (23).

A good expression from the straight line of graph 1 is:

$$D_D = 0.178\, D_A + 0.085\, D_S \qquad (24)$$

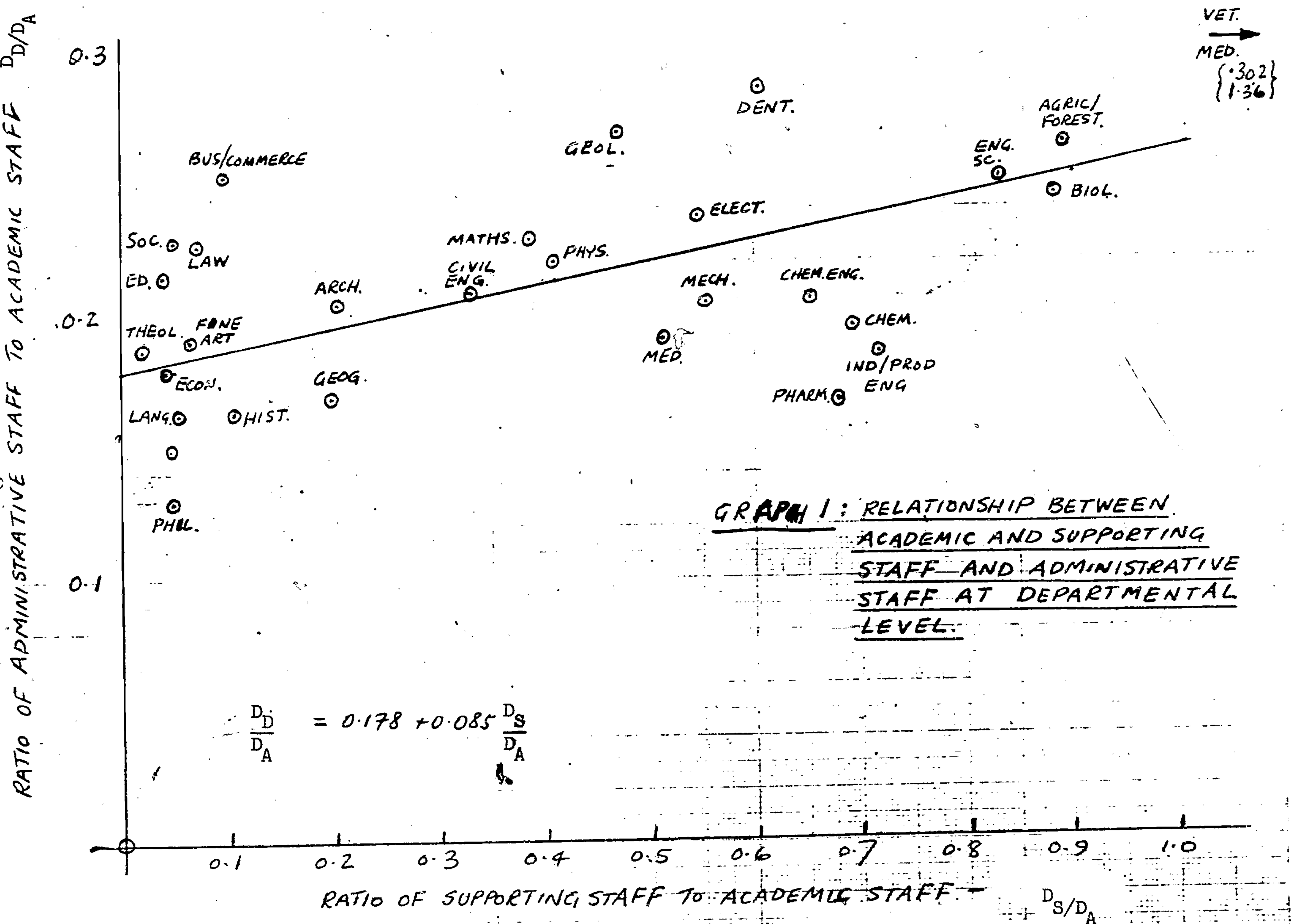
Equation (23) can be tested using computerized departmental data from reference 1 and the results are summarized in table 19:

Table 19. Proportions of Administrative and Technical Staff to Academic Staff by Department

Department*	D_D/D_A	D_S/D_A	Department*	D_D/D_A	D_S/D_A
Pure Sciences			Agriculture		
04. Biology	0.245	0.885	41/43. Agric. and Forestry	0.264	0.895
06. Chemistry	0.195	0.694	44. Vet. Medicine	0.302	1.360
08. Geology	0.269	0.472	Humanities		
10. Maths	0.229	0.387	52. History	0.162	0.105
13. Physics	0.220	0.410	53. Languages	0.162	0.052
Architecture			56. Philosophy	0.129	0.046
19. Architecture	0.204	0.204	58. Theology	0.186	0.020
Technology			Fine Arts		
20. Eng. Science	0.252	0.824	61/64. All kinds	0.190	0.061
21. Const. and Civil Eng.	0.208	0.332	Education		
25. Ind. and Prod. Eng.	0.185	0.717	65. Education	0.214	0.037
26. Elect. Eng.	0.237	0.546	Law		
27. Mechanical Eng.	0.204	0.554	10. Law	0.226	0.071
28. Chem. Eng.	0.205	0.653	Social Sciences		
Medical Sciences			71. Business & Committee	0.253	0.098
31. Dentistry	0.286	0.606	72. Economics	0.179	0.040
32. Medicine	0.190	0.513	73. Geography	0.168	0.198
34. Pharmacy	0.167	0.679	78. Sociology	0.228	0.039
			Overall Average	0.213	0.411

* The number reference refers to the computer coding.

FIGURE 1


GRAPH 1: RELATIONSHIP BETWEEN ACADEMIC AND SUPPORTING STAFF AND ADMINISTRATIVE STAFF AT DEPARTMENTAL LEVEL.
RATIO OF ADMINISTRATIVE STAFF TO ACADEMIC STAFF D_D/D_A
RATIO OF SUPPORTING STAFF TO ACADEMIC STAFF D_S/D_A
0·3
0·2
0·1
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
$\frac{D_D}{D_A} = 0{\cdot}178 + 0{\cdot}085\,\frac{D_S}{D_A}$
VET.
MED.
{·302 1·36}
DENT.
GEOL.
BUS/COMMERCE
AGRIC/FOREST.
ENG. SC.
BIOL.
ELECT.
SOC.
LAW
MATHS.
PHYS.
ED.
CIVIL ENG.
ARCH.
MECH.
CHEM.ENG.
THEOL.
FINE ART
CHEM.
MED.
IND/PROD ENG
ECON.
GEOG.
PHARM.
LANG.
HIST.
PHIL.

which indicates a bias towards academic staff for administrative support, as would be anticipated. Administrative staff numbers are now rapidly determinable from academic and technical support staff.

It should be noted that once equation (23) has been evaluated departmentally it can be summed to give the total university departmental administrative staff and this together with the information of section 4.3. of Chapter 4 can then provide an approximate assessment of additional central administration staff required. (It is about 40-50% of the university total).

4.2. Application of the Method to the U.K. Universities

Although it is possible to apply the simplified equations directly, to provide a more accurate figure for administrative staff of particular departments, it is necessary to investigate the relationships between administrative staff and various grades of academic staff applicable to those departments. Once determined, such values can be used in equation (23) for any given composition of academic staff (any values of x_1, x_2 and x_3).

For the U.K. the following approximate values of x are generally admitted by the University Grants Committee.

$$\left.\begin{array}{l} \text{Professors: } x_1 = 0.125 \\ \text{Readers, Senior Lecturers: } x_2 = 0.225 \\ \text{Lecturers: } x_3 = 0.650 \end{array}\right\}$$

(Research fellows funded by the university would normally be included in an appropriate catagory).

As an initial assumption for the values of , let

$$x_1 : x_2, : x_3 = \frac{1}{1} : \frac{1}{2} : \frac{1}{3}$$

(which may be regarded as a "responsibility" equation.

Then: $$\frac{x_1}{x_1 + x_2 + x_3} = \frac{1}{\left(\frac{1}{1} + \frac{1}{2} + \frac{1}{3}\right.} \quad \text{etc.}$$

but $x_1 + x_2 + x_3 = 1.$

Let $1 = x_1 \quad {}_1 = \left(\frac{1}{1} + \frac{1}{2} + \frac{1}{3}\right) = x_2 \quad {}_2 = x_3 \quad 3$.......... (57)

Thus $1 = \eta/3$

using the values from the initial simplification, then:

$1 = 0.0593$ and $= 0.085$

${}_1 = 0.0475$, ${}_2 = 0.264$, ${}_3 = 0.092$

These represent 2.11 Grade 1 academic staff to 1 administrative staff

3.79 Grade 2 academic staff to 1 administrative staff

10.90 Grade 3 academic staff to 1 administrative staff

11.80 support staff to 1 administrative staff, and provide reasonable guide values. Thus, using these, equation (23) becomes:

$$D_D = (0.475\, x_1 + 0.264\, x_2 + 0.092\, x_3)\, D_A + 0.085\, D_S$$

for any academic and supporting staff composition.

Example calculation applied to a typical U.K. technology department

From UGC data: $x_1 = 0.125$, $x_2 = 0.225$, $x_3 = 0.650$

From table 6 of section 2.3: $S = 27.12$

From section 3.3: $D_S' = 17.65$

Thus $D_D = (0.475 \cdot 0.125 + 0.264 \cdot 0.225 + 0.092 \cdot 0.650)\, 27.12 + 0.085 \cdot 17.65$

or $= 6.33$

i.e. the technology department described above requires 6.33 full-time departmental administrative staff.

Appendix A1

Weighting of Fundamental to Advanced Levels of Students in Relation to the Value of k_3.

A short analysis relating to U.K. universities was undertaken to investigate the suitability of a value of $k_3 = 1.5$ in the academic staff equation of section 2.2.

Using the geographical region weighting factors of table 13 section 2.2. for U.K. universities and the simplified first and higher degree equations of the same section, with:

$$P_{P_2} = P_2 \qquad P_{P_3} = P_3 \qquad \text{and}$$

$$P_1 = 1.14\, P_2 + 1.03\, P_2 = 2.17\, P_2$$

(i.e. 14% and 3% wastage in the 1st and second years respectively).

Then:

$$S_{y12} = \frac{l_1}{h_1}(1.81 + 0.513\, u) + P_2\, \frac{s_1}{g_1 \cdot h_s}(3.91 + 1.06\, v) + 0.0542$$

$$= G_o + H_o \cdot P_2 \quad \ldots\ldots \quad \text{A1.1}$$

where $G_o = \dfrac{l_1}{h_1}(1.81 + 0.513\, u)$

$$H_o = \frac{s_1}{g_1 \cdot h_s} (3.91 + 1.06\ v) + 0.0542$$

and $$S_{y3} = 0.82 \cdot \frac{l_1}{h_1} \cdot u + P_3 \left(1.70 \cdot \frac{s_1}{g_1 \cdot h_s} \cdot v + 0.0974\right)$$

$$= g_o + h_o \cdot P_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{A1.2}$$

where $$g_o = 0.82\ \frac{l_1}{h_1} - u$$

$$h_o = 1.70 \cdot \frac{s_1}{g_1 \cdot h_s} v + 0.0974$$

These represent academic staff requirements for complete programmes of study at first and higher degree level respectively and include the value of $k_3 = 1.5$.

Thus: Equation A1.1 relates to $3.17 \cdot P_2$ students

Equation A1.2 relates to P_3 students

Then the first degree student: staff ratio, using equation A1.1 is:

$$s_{u12} = \frac{3.17\ P_2}{G_o + H_o \cdot P_2} = \frac{3.17}{\left(\frac{G_o}{P_2} + H_o\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{A1.3}$$

and the higher degree ratio using equation A1.2 is:

$$s_{u3} = \frac{P_3}{g_o + h_o\ P_3} = \frac{1}{\left(\frac{g_o}{P_3} + h_o\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{A1.4}$$

Now if δ = the higher/first degree student weighting factor, then for equivalence:

$\delta = \frac{s_{u12}}{s_{u3}}$ and using equations A1.3 and A1.4,

$$\delta = 3.17 \left[\frac{\frac{g_o}{P_3} + h_o}{\frac{G_o}{P_2} + H_o}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{A1.5}$$

This can be investigated for a range of values but provided P_2 and P_3 are not very small the variation in   is not very great. Thus it will be investigated for the following assumptions: –

For average annual intakes of

$P_2 = 50 \qquad P_3 = 20$

then $$\delta = 3.17 \left[\frac{0.05\, g_o + h_o}{0.02\, G_o + H_o}\right] \qquad \text{A1.6}$$

and when P_2 and P_3 are very large (i.e. $\frac{g_o}{P_3}$ and $\frac{G_o}{P_2}$ are small compared with h_o and H_o respectively) then:

$$\delta^1 = 3.17\, \frac{h_o}{H_o} \qquad \text{A1.7}$$

Thus using equations A1.1, A1.2, A1.6, and A1.7 together with the parametric data from table 12 of section 2.2. the following values of δ are obtained:

Table 20. Weighting of Fundamental/Advanced Level Students

Subject / Classification	G_o	H_o	g_o	h_o	δ	δ^1
Pure Science	2.53	0.376	0.615	0.285	2.34	2.40
Technology	3.18	0.351	0.920	0.252	2.28	2.28
Med. Science	3.83	0.372	0.977	0.230	1.97	1.96
Hum./Arts	2.49	0.220	0.696	0.187	2.49	2.69
Education	2.12	0.214	0.598	0.176	2.55	2.60
Soc. Sc./Law	3.42	0.196	0.951	0.168	2.57	2.72
All	2.89	0.287	0.808	0.205	2.28	2.27

It will be observed that the values of δ are reasonably consistent and give values between 2.0 and 2.7 with an overall of 2.28. These are in good agreement with the order of values usually quoted for higher/first degree student weightings and hence are some justification for the staff teaching load factor assumption of $k_3 = 1.5$.

Appendix A2

Analysis of Relationships between Departmental Academic Staff, Support Area, and Supporting Staff.

A2.1. Relationship of total academic staff to supporting staff

From the data source of reference 1, for faculty and departmental level, the following proportionality values were obtained for four broad subject groups.

Table 21. Ratio: Supporting Staff/Academic Staff $\frac{D_S}{D_A} = d_4$

Group 1 Science	Group 2 Technology	Group 3 Arts/Social Sciences	Group 4 Medical Sciences
0.97	0.33	0.135	0.75
0.73	0.78	0.103	0.52
0.50	0.56	0.055	0.83
0.42	0.71	0.059	0.70
0.75	0.56	0.122	0.77
0.34	0.66	0.136	0.31
0.41	1.16	0.042	1.00
0.42	0.48	0.093	0.36
0.65	0.37	0.250	0.48
1.19	0.79	0.290	0.42
1.28	1.48	0.046	0.45
0.52	0.68	0.166	
	1.06	0.030	
	0.43	0.016	
	0.72	0.040	
	0.66		
	0.28		
Average 0.68	Average 0.69	Average 0.106	Average 0.60

A2.2. Relationship of Departmental Support Area to Support Staff

Values of support area A_b are plotted against support staff N_T for four broad subject groupings in graphs 2-5. These indicate good linearity especially at the lower end of the range, which is the most usual circumstance. Since the values plotted represent over 70 items of data from about 12 different countries it will be apparent that geographical regional variation is not a very significant factor. Thus from the slopes of the graphs:

$$\frac{A_b}{D_S} = d_3 = 105 \text{ for group 1}$$

$$= 139 \text{ for group 2}$$

$$= 77 \text{ for group 3}$$

$$= 99 \text{ for group 4}$$ .... (table 17)

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A2.3. Relationship between Academic Staff, Laboratory Area and Supporting Staff.

From equation (40) of section 3.2:

$$D_S = d_1 \cdot A_b + d_2 \cdot D_A \quad \text{.............................} \quad (19)$$

also: $\dfrac{A_b}{D_S} = d_3 \qquad \dfrac{D_S}{D_A} = d_4$

Thus for (19) to be satisfied:

$$d_1 = \frac{1}{d_3} - \frac{d_2}{d_3} \cdot d_4 \quad \text{.................................} \quad A2.1$$

Hence if d_2 can be determined then d_1 can be calculated. A survey of the data from reference 1 provided a quantity of information on supporting staff and academic staff where the support area was zero (or very small). Since the d_2 term will be small in equation (19) where support area is the dominating factor, this specific data was used in aggregated form to determine d_2 (i.e. it being assumed that geographical regional variation could be neglected).

Aggregated value of $\dfrac{D_S}{D_A}$ $(A_b = 0) = 2.823$

Total number of observations = 40

Average value of $\dfrac{D_S}{D_A} = d_2 = \dfrac{2.823}{40} = 0.07$

Thus equation A2.1 becomes:

$$d_1 = \frac{1}{d_3} - \frac{0.07}{d_3 . d_4} \quad \text{.....................................} \quad A2.2$$

and using the group values of d_3 and d_4 above then:

d_1 = 0.00855 for Group 1

= 0.00647 for Group 2

= 0.00444 for Group 3

= 0.00892 for Group 4

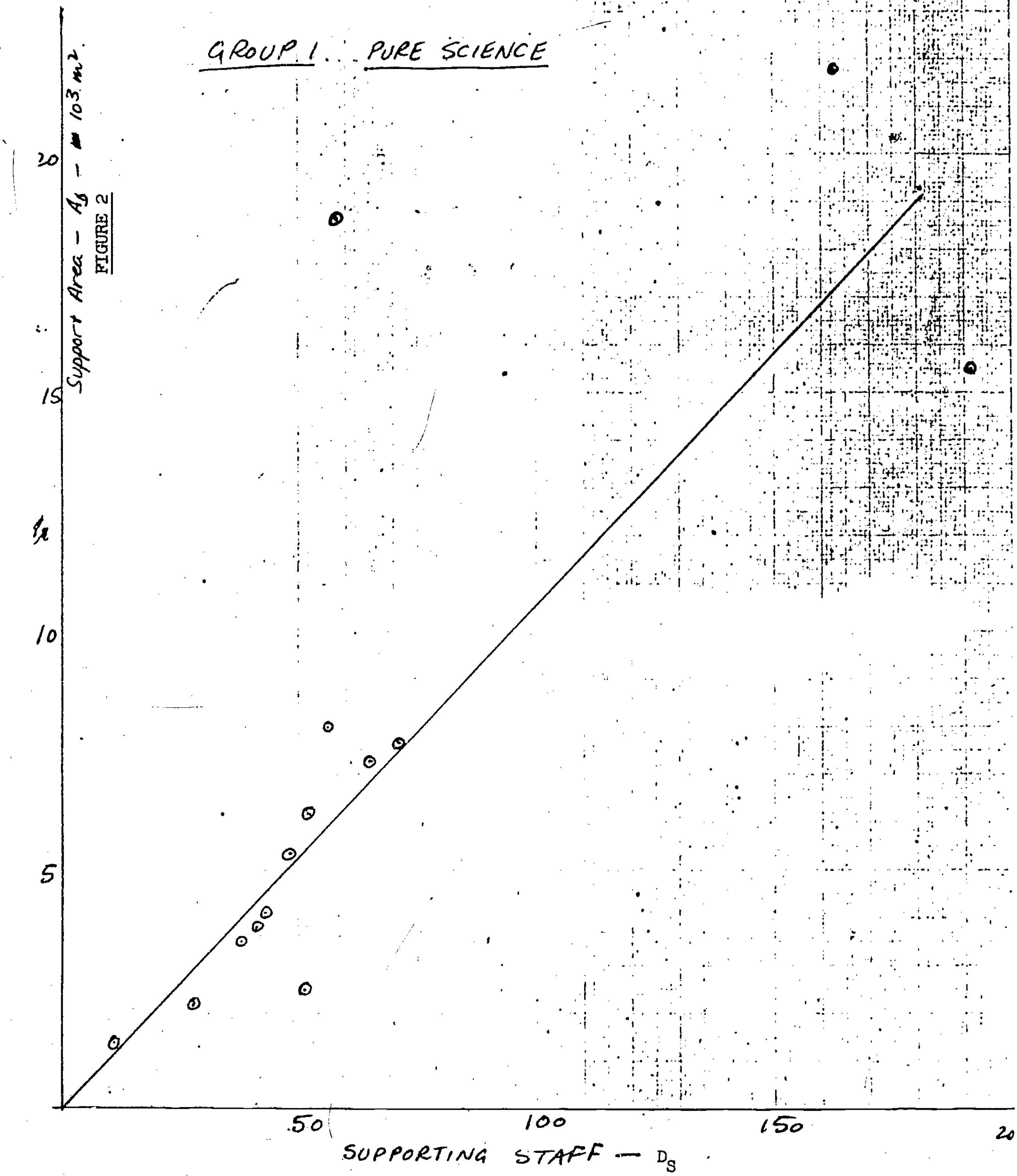
where: $D_S = d_1 A_b + 0.07 D_A$ .... (19)

A2.4. Values of Support Area per Student

This data is derived from reference 1 in terms of support area per first degree/diploma student a_F and the ratio of higher degree/diploma support area to this a_F, (ω).

GRAPH A2

FIGURE 2



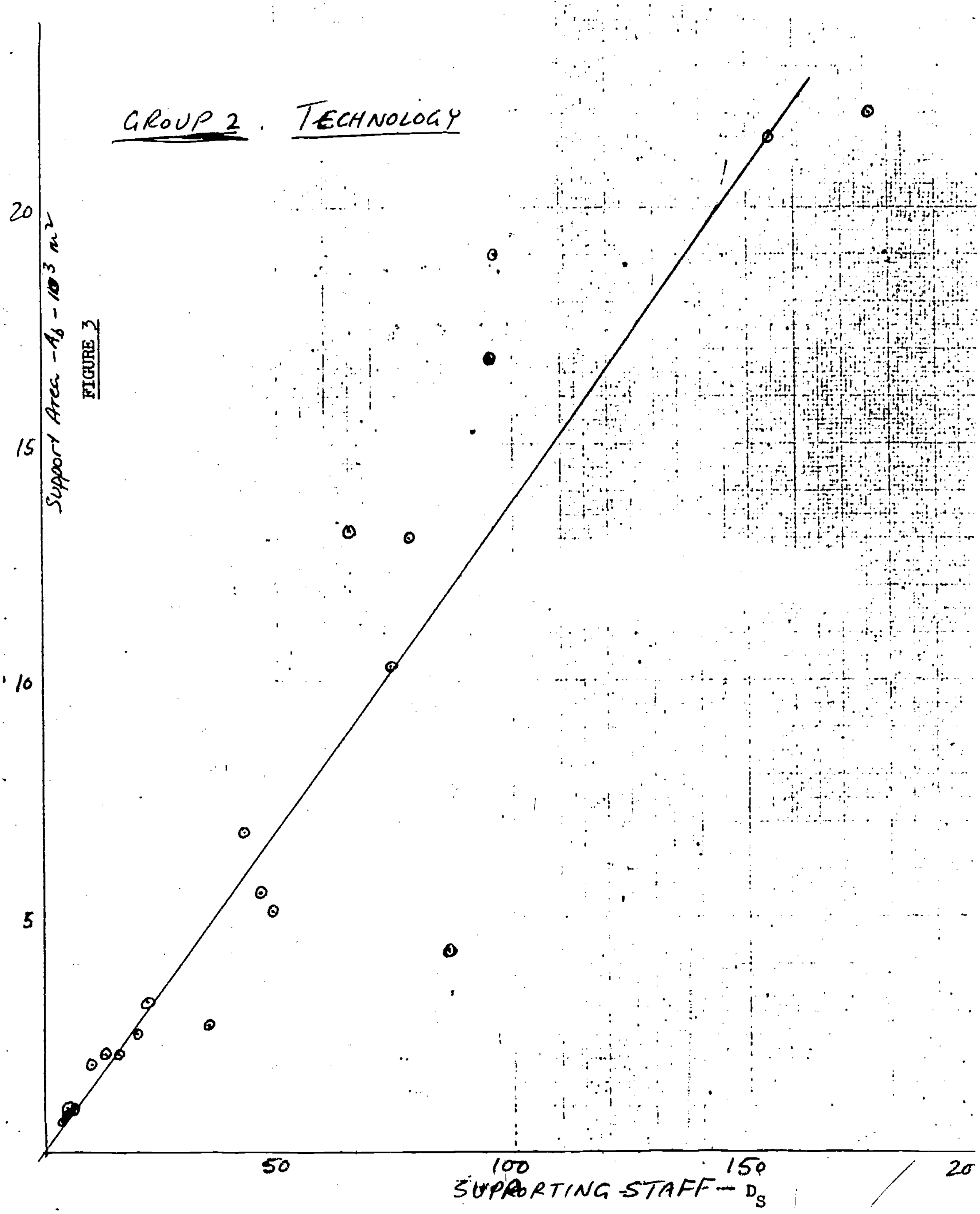
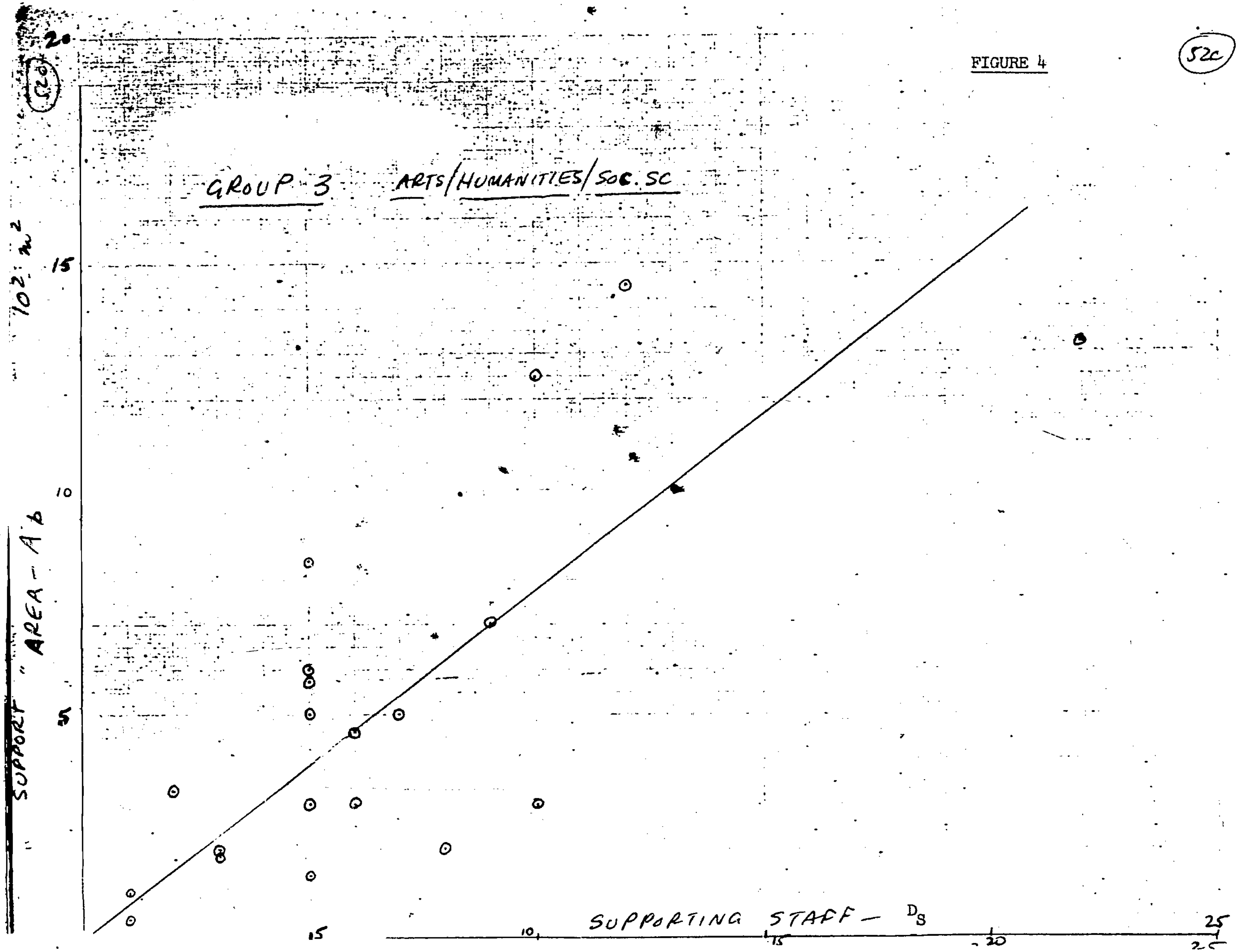
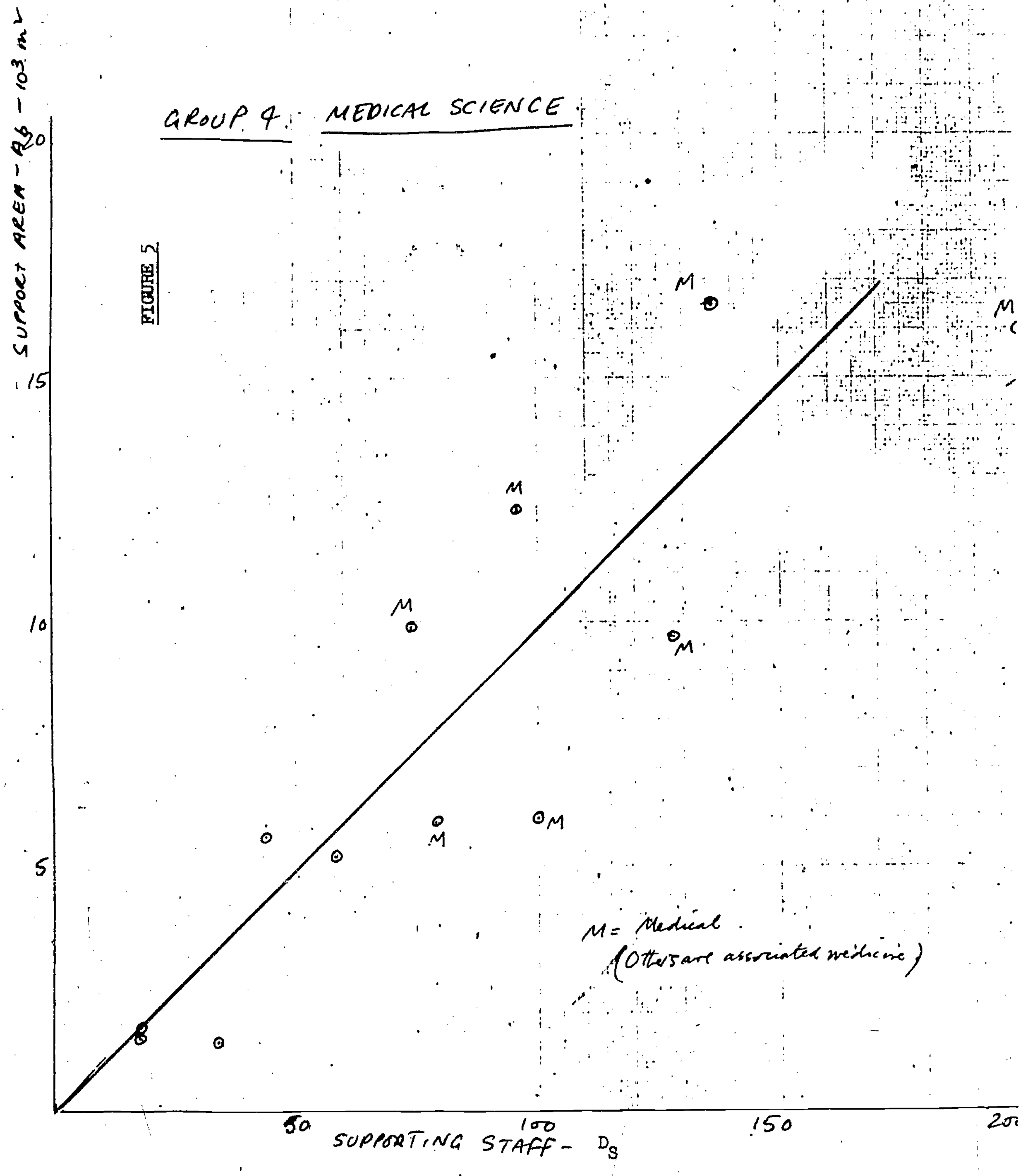

GROUP 2. TECHNOLOGY
FIGURE 3
Support Area - A_b - 10^3 m^2
20
15
10
5
50
100
150
20
SUPPORTING STAFF — D_S

FIGURE 4

(52c)



GROUP 3 ARTS/HUMANITIES/SOC. SC
SUPPORT " AREA - A_b
$10^2 \cdot m^2$
SUPPORTING STAFF — D_S
20
15
10
5
5
10
15
20
25


GROUP 4. MEDICAL SCIENCE
FIGURE 5
SUPPORT AREA - A_S - $10^3 m^2$
SUPPORTING STAFF - D_S
M = Medical
(Others are associated medicine)
5
10
15
20
50
100
150
200
M

The values are presented in the following tables, catagorized by the four subject groupings used above.

Table 22. Values of Support Area per Student

Group 1 Science		Group 2 Technology		Group 3 Arts/Social Science		Group 4 Medical Sciences	
a_F m^2	ω	a_F m^2	ω	a_F m^2	ω	a_F m^2	ω
4.5	2.08	4.5	2.08	4.5	2.08	4.5	2.08
4.5	2.08	4.5	2.08	2.3	1.00	9.0	1.89
4.6	2.40	4.5	2.08	6.0	5.84	15.0	1.24
3.4	2.71	5.1	2.18	6.0	5.84	10.0	2.50
3.7	2.00	4.5	2.08	4.0	1.50	8.0	3.13
8.0	2.50	6.5	2.15	4.0	1.50	20.0	1.00
4.6	1.84	4.5	2.08	8.0	1.88	3.0	1.10
4.2	2.40	8.0	2.50	4.0	1.50	6.0	2.50
4.4	2.34	8.3	1.87	5.0	3.00	5.0	4.00
5.9	2.24	4.0	4.25	7.0	3.86	5.0	3.20
		6.6	2.04			5.0	2.26
		10.0	3.20				
		12.0	1.67				
		3.0	2.18				
Averages		Averages		Averages		Averages	
4.8	2.26	6.1	2.18	5.1	2.80	8.2	2.26
Averages for all groups: $a_{av} = 6.1\ m^2$ $\omega = 2.36$							

If: $a_F = \lambda_2 \cdot a_{F_{av}} = \lambda_2 \cdot 6.1$ A2.3

Then: λ_2 = 0.79 for Group 1

= 1.00 for Group 2

= 0.84 for Group 3

= 1.34 for Group 4

A2.5. Method of Determining "Support" Area type Factor or .

This method has been derived from section 3 analysis but using data available from reference 1. This is approximate only and the analysis of section 3 would be better tested with new data in a specific study for the determination of θ or Γ.

If T_F = Total average scheduled staff hours given for first degrees/diplomas (lecture plus seminar)

T_H = Total average scheduled staff hours given for higher degrees/diplomas (lecture plus seminar plus research supervision).

Then using notation of section 2 and section 3.3.:

$$\frac{S_H}{(S_T - S_H)} = \frac{k_3 \cdot T_H}{h_s} \cdot \frac{h_s}{T_F} = k_3 \cdot \frac{T_H}{T_F} = \epsilon \quad \text{(say)} \quad \ldots\ldots\ldots\ldots\ldots \text{A2.4}$$

Then: $$S_H = \frac{\epsilon}{(1 + \epsilon)} \cdot S_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{A2.5}$$

Using this in the equation of section 3.2. then:

$$\Gamma = \theta \cdot \lambda_2 = \frac{(N_T/S_T - 0.007)}{\left[d_1 \cdot \alpha \left\{\frac{2.36\,\epsilon + 1}{\epsilon + 1}\right\}\right]} \quad \ldots\ldots\ldots\ldots \text{A2.6}$$

Since all of the values in this expression are given at departmental level (except α which is for the university as a whole) then Γ can be determined.

A first evaluation of this is given in the following table for 10 broad subject classifications and for individual subject departments.

Table 23. Values of Γ by 10 Subject Fields.

Subject Field	Γ
Pure Sciences	0.91
Architecture	0.33
Technology	1.04
Medical Sciences	0.90
Agriculture	0.95
Humanities	0.03
Fine Arts	0.06
Education	0.17
Law	0.01
Social Sciences	0.15

These values are clearly of the right order but there are a number of obviously wrong values. This is due to data inconsistencies and a further analysis may yield better values.

For comparison the following values of Γ used by a particular U.K. university are given with appropriate similar subject values quoted from the above analysis.

Table 24. Comparison of Derived Values of Γ.

Subject Area	Γ (U.K.)	Γ (Analysis)
Aeronautical Eng.	1.07	
Chem. Eng.	1.00	1.18
Chemistry	0.67	1.08
Civil Eng.	1.07	0.40
Elect. Eng.	0.93	0.84
Ergonomics	0.87	
Industrial Eng.	0.53	
Mathematics	0.20	
Mech. Eng.	1.00	0.86
Physics	0.80	0.79
Library Studies	0.13	0.17
Design (Eng.)	0.47	

It will be seen that in general the comparison is quite good and for this reason it is suggested that in the absence of more accurate data the values from the analysis can be used as a guide.

CHAPTER 4. COMPARATIVE DATA ANALYSIS

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Appendix A3. Aggregated Departmental Data for all Sample Universities

1. Introduction

The general purpose of the international comparisons of this chapter is to present the trends derived from the 15-university sample and 80-university international survey data. These provide a basis for the formulations of the overall university data-based, and the more conceptualized departmental methodologies of Chapters 2 and 3 respectively. At the same time some data interpretations not of immediate application to the models, but pertinent to the general study of university management, are included.

The objectives of the data analysis may be set out as:

(i) to provide a "first look" at comparisons between universities and geographical regions at the overall university and departmental (subject classification) levels. This is especially true of section 2 below.

(ii) to identify important parameters and variables with a major influence on resource requirements.

(iii) to provide background and data analysis for the simple more-conceptual model developed in Chapter 3.

Most of these objectives bear directly on the development of the overall simplified university model (Chapter 2) and the more conceptualized departmental model (Chapter 3). Where relevant reference is made to the specific sections of these models.

This chapter is divided into three major sections. The first, section 2, deals mainly with the derived values of parameters for the overall model of Chapter 2. This is based largely on the 15-university selected sample. Simultaneously certain comparisons and interpretations of data, not immediately applicable to the overall model, but of general interest, are incorporated.

Section 3.2. concentrates on the 80-university survey. It does not repeat the data constants set out in section 4 of Chapter 2, but provides further information, particularly related to departmental staffing, not available elsewhere.

In section 3.3., the evaluation of specific parameters of the departmental model of Chapter 3 is detailed.

2. A Brief 15-University Sample Approximate Data Comparison

As detailed in the introduction to this chapter, this sample analysis was carried out with a view to identifying important parameters, to provide background information, and to develop a simple methodology for data reduction for a more comprehensive analysis.

The analysis is divided into two parts:

(i) data arising from the departmental level,

(ii) data concerned with the university as a whole. These correspond with sections 2 and 3 respectively of the model developed in Chapter 2. Where the data analysis provides insights for the model or values for parameters, the appropriate section of the model is noted.

The small survey data is grouped into three geographical regions: North America (N.A.), United Kingdom (U.K.) and Europe (EUR). Even with this very broad classification, the samples are small, and the raw data contains a number of obvious inconsistencies.

As far as possible the data has been revised, where available evidence permits, and various ratio parameters and percentages are frequently used to avoid scale effects and variable cost indices across countries. In addition, in order to provide an approximate basis for comparison (especially on growth and cost) a simple cost index rating (Part II, section 2.4.3.) was developed from the overall university data and applied where appropriate. Where this has been employed the data is referred to as "standardized".

It is emphasized that the information contained in this note should be treated with considerable caution and not used for qualitative studies. The enlarged 80-university survey, some data from which is presented in Chapter 2, section 4, and in section 3 of the present chapter, is potentially useful for such studies. Nevertheless the information contained here can be of considerable usefulness in providing initial approximate forecasts since data of the type and scope presented is not readily available elsewhere.

Part I. 2.1. Departmental Subject Data (see section 2 of Chapter 2)

2.1.1. General

A considerable volume of raw data, related to staff and student numbers, staff teaching hours and recurrent expenditures was gained from the survey. In order to present a reasonable overall picture it was decided to concentrate on nine selected items of data and analyse eight parameter ratios determined from this selected data. The data and parameters concerned are summarized in Table 25 in the notation used throughout the overall model of Chapter 2, and the following work. All departments were also classified into subject areas as listed in Table 26.

2.1.2. Initial Survey by Subject Classification

The values of A, B, C, etc. were calculated for each university and averaged for each subject classification (i.e. aggregate averages at university level). This provided an opportunity of testing the reliability of the raw data at departmental level in relation to the overall university and to modify or omit obvious errors. The overall data of Table 27 was thus compiled. At this stage regional variation was introduced and the raw data converted to a better degree of consistency based on all the information available.

2.1.3. Subject Classification with Geographical Grouping

The full results of the above procedure are given in Appendix 1, for the basic data (i), (ii) (iii) etc. by subject classification and university, the actual values being the sum of all departments in a specific catagory and university. Into this data tables 28, 29 and 30 have been compiled. Table 28 is repeated in table 1 of section 4, Chapter 2, substitution of parameter values in the model.

Because of the small sample, some groupings cannot be regarded as representative. The most reliable data is in Social Sciences, Education, Humanities, Technology and Pure Sciences for regional and general comparison. For individual geographical groupings Law (in Europe), Fine Arts (in North America) and Medical Sciences (in Europe) are the most significant although the samples are small and Medical is largely confined to dentistry, pharmacy etc., rather than medicine as such.

The following observations are based on the information contained in tables 27, and 28 - 30.

Table 25. Selected Data for Single Departments in Specific Universities, and Corresponding Parameters Analysed.

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Total Staff (All Kinds)	Academic Staff	Total Teaching Hours	First Degree Teaching Hours	Total Students	First Degree Students	Recurrent Expend. Total Standard £ Equiv.	Total Staff Remuneration Standard £ Equiv.	Total Academic Staff Remuneration Standard £ Equiv.
D_T	D_A	T_T	T_U	F_T	F_U	V_T	V_N	V_A

ANALYSIS RATIO PARAMETERS

A	B	C	D	E	F	G	H
Acad.Staff / Tot.Staff	Total / Acad.Staff (Teach. Hours)	First Deg. / Total (Teach. Hours)	Students / Acad.Staff	First Deg. / Total (Students)	Tot.Recurr. / Tot. Staff Standard £ Equiv./Staff	Tot.Remun. / Tot.Recurr. Standard £ Equiv./Staff	Acad.Rem. / Acad.Staff Standard £ Equiv./Staff
D_A/D_T	T_T/D_A	T_U/T_T	F_T/D_A	F_U/F_T	V_T/D_T	V_N/V_T	V_A/D_A

Table 26. Subject Field Department Classification

Classification 1
PURE SCIENCES

Astronomy
Bacteriology
Biochemistry
Biology
Botany
Chemistry
Entomology
Geology
Geophysics
Mathematics
Meteorology
Mineralogy
Physics
Zoology

Classification 2
ARCHITECTURE

Classification 3
TECHNOLOGY

Applied Sciences
Construction &
Civil Engineering
Geodesy
Metallurgy
Mining
Surveying
Technology
Textile Engineering
Electrical Engineering
Mechanical Engineering
Chemical Engineering

Classification 4
MEDICAL SCIENCES

Anatomy
Dentistry
Medicine
Midwifery
Nursing
Optometry
Osteopathy
Pharmacy
Physiotherapy
Public Health
Surgery

Classification 5
AGRICULTURE

Agricultural biological Sciences
Agricultural economics
Agricultural physical Sciences
Animal husbandry
Crop husbandry
Dairy farming
Fisheries
Food Technology
Forestry
Horticulture
Veterinary medicine

Classification 6
HUMANITIES

Archeology
History
Languages
Library Science
Literature
Philosophy
Psychology
Theology

Classification 7
FINE ARTS

Drawing
Music
Painting
Sculpture
Speech and dramatic art

Classification 8
EDUCATION

Education
Pedagogy
Physical Education

Classification 9
LAW

Classification 10
SOCIAL SCIENCES

Banking
Commerce
Diplomacy
Economics
Ethnology
Geography
Home Economics
International Relations
Journalism
Political Science
Public Administration
Social Welfare
Sociology
Statistics

Pure Sciences: Supporting staffs are relatively large for all regions with N.A. somewhat less so. In general they are about 40% of the total departmental staff. The teaching hours/staff are reasonably uniform at about 8.6 and some 75% are first degree students (with N.A. appreciably lower). The student/staff ratio is fairly variable (high in Europe and low in N.A.). The remuneration to recurrent expenditure ratio is reasonably uniform across the regions at about 80%. The cost per staff figures suggest that N.A. is somewhat high (probably due to high post-graduate loading) and Europe somewhat low (probably due to somewhat lower salaries of auxiliary staff).

Architecture: A poor sample. Support staff about half that for pure science (i.e. some 20%) but apart from this falls into a similar classification to Technology and Pure Sciences.

Technology: Not a very large sample. Requires the most support staff of any classification at about 45%. In other respects it is similar to pure science with slightly higher staff loadings and student/staff ratios.

Medical Sciences: A poor sample and mainly relative to supporting subjects to medicine rather than medicine itself. General trends suggest high supporting staffs (similar to Pure Sciences) low teaching loadings for academic staff (2 - 4 hours/week) and relatively modest costs (but clearly does not include hospitals) although N.A. is markedly above U.K. and Europe in this respect. The proportion of post graduate work is high - about 45% to 50% - and this is particularly so in Europe. The high student/staff ratios suggest considerable teaching support from outside sources.

Agriculture: Only one sample from the N.A. region. The figures suggest that it might be classified under Technology but the matter needs further investigation.

Humanities: Is fairly consistent across the three regions. About 20% support staff and some 10 hours/week academic staff teaching load with similar student/staff ratios. The higher degree proportion is reasonably large being between 30% - 40%. Recurrent expenditure other than salaries is small at about 8% of the total recurrent expenditure.

Fine Arts: Again a small sample. Generally requires a fairly large supporting staff (about 35%) but with high academic teaching loads of some 13 hours/week. Higher degree population is similar to Pure Science and recurrent expenditure other than salaries is small (about 14%), but larger than for Humanities.

Education: The support staff across regions is fairly uniform at about 25% - 30%. Staff loading varies very widely as does student/staff ratio and the proportion of higher degree work. This latter is probably the key to the variations (as costs also vary considerably).

Law: Information here is predominantly European although the single N.A. example follows similar trends. Apart from higher support staff the results are somewhat similar to those for Humanities. The higher student/staff ratios probably reflect a high degree of outside academic support plus appreciable servicing from other classifications. In general academic staff remuneration is high.

Social Sciences: Although not numerically the largest group this classification provided the best overall sample. There is a high degree of uniformity across regions with support staff at about 20% - 25% of total staff, academic staff loading at about 9 hours/week and some 25% higher degree proportion.

Table 27. Selected Overall University Ratios Classified by Subject Area.

Subject Classification	A Acad. / Total Staff	B Total Teach. Hours / Acad. Staff	C 1st Degree / Total Teach Hours	D Students / Acad. Staff	E 1st Degree / Total Students	F Recurrent / Total Staff	G Remun. / Recurr.	H Remun. / Staff Acad.
1. P. Sciences	.583	8.16	.683	12.80	.779	2613	.802	2450
2. Architect.	.792	11.86	.766	7.58	.808	2178	.931	2712
3. Technology	.547	10.56	.543	9.22	.759	2783	.800	2910
4. Med. Sciences	.544	4.39	.367	13.10	.616	2701	.825	2521
5. Agricult.	.625	0.57	.319	11.37	.721	3006	.932	3726
6. Humanities	.813	9.57	.686	8.38	.728	2666	.913	2703
7. Fine Arts	.794	18.43	.830	3.91	.651	2907	.899	3304
8. Education	.739	10.93	.377	12.60	.377	2866	.788	2656
9. Law	.713	10.01	.681	23.38	.816	2870	.890	3171
10. Social Sciences	.752	8.62	.654	19.18	.794	3046	.822	2874
Average	.690	9.31	.591	12.15	.705	2764	.860	2903

TABLE 28

SELECTED DEPARTMENTAL RATIOS BY SUBJECT & GEOGRAPHICAL REGION

CLASSI-FICATION	GEOG. GROUP REGION	A ACAD/ TOTAL STAFF	B TEACH HRS. ACAD. STAFF	C 1ST/TOTAL TEACH HRS.	D STUD/ ACAD. STAFF	E 1ST/TOTAL STUDENTS	F RECURRENT / TOT. STAFF	G TOT. ST. REMUN. / RECURR	H ACAD. REMUN. / ACAD. STAFF.
1 Pure Sc.	UK (3)	.521	9.34	.609	7.83	.811	3314	.808	2819
	NA (2)	.771	8.30	.635	4.75	.549	3573	.831	3504
	EUR (8)	.529	8.10	.661	11.92	.843	2051	.801	2214
	Av	.607	8.58	.635	8.17	.734	2979	.813	2846
2 Archi-tect.	UK (0)	–	–	–	–	–	–	–	–
	NA (1)	.791	0.53	.393	6.36	.424	3687	.818	3277
	EUR (2)	.802	12.20	1.000	7.37	1.000	2604	.821	2358
	Av	.797	6.37	.697	6.87	.712	3146	.820	2818
3 Tech.	UK (2)	.519	11.34	.619	10.69	.829	2484	.811	2904
	NA (2)	.549	1.97	.295	7.48	.419	2790	.909	2960
	EUR (3)	.579	12.70	.889	10.55	.984	2831	.709	2500
	Av	.549	8.67	.601	9.57	.744	2702	.810	2788
4 Med.Sc	UK (1)	.500	4.13	.611	3.66	.734	2487	.778	2868
	NA (1)	.780	0.63	.700	13.47	.942	3732	.850	3781
	EUR (5)	.589	1.96	.376	15.74	.208	1898	.824	1963
	Av	.620	2.24	.562	10.96	.628	2706	.817	2871
5 Agric.	UK (0)	–	–	–	–	–	–	–	–
	NA (1)	.625	0.57	.319	11.37	.721	3006	.932	3726
	EUR (0)	–	–	–	–	–	–	–	–
	Av	.625	0.57	.319	11.37	.721	3006	.932	3726

TABLE 28 CONTINUED.

CLASS.	GEOG. GROUP	A	B	C	D	E	F	G	H
6 Hum.	UK (2)	.833	11.00	.916	10.00	.938	2371	.958	2563
	NA (3)	.837	10.08	.724	10.71	.354	3397	.912	3433
	EUR (6)	.784	9.67	.682	11.09	.582	2186	.879	2429
	Av	.817	10.25	.774	10.60	.625	2651	.916	2808
7 Fine Arts	UK (0)	-	-	-	-	-	-	-	-
	NA (2)	.609	18.65	.828	5.64	.742	2740	.855	3583
	EUR (1)	.718	6.98	.696	15.21	.739	2551	.874	2607
	Av	.664	12.82	.762	10.43	.741	2646	.865	2595
8 Educ.	UK (2)	.696	11.19	0.000	5.81	.000	3043	.643	2500
	NA (2)	.780	20.31	0.425	23.26	.736	3515	.830	3026
	EUR (3)	.738	8.24	.617	12.38	.643	2180	.827	1956
	Av	.738	13.25	.347	13.82	.460	2913	.767	2494
9 Law	UK (0)	-	-	-	-	-	-	-	-
	NA (1)	.512	6.36	1.000	18.59	1.000	3326	.944	4545
	EUR (6)	.739	11.88	.516	20.93	.667	2633	.895	2771
	Av	.626	9.12	.758	19.76	.834	2980	.920	3658
10 Soc. Sc.	UK (3)	.740	10.49	.737	9.12	.723	2595	.881	2725
	NA (3)	.804	9.06	.610	11.95	.754	3824	.829	2890
	EUR (8)	.720	7.11	.659	16.90	.784	2747	.780	2458
	Av	.755	8.89	.669	12.66	.754	3055	.830	2691
OVERALL AV	UK	.634	9.58	.582	7.85	.673	2716	.813	2730
	NA	.706	8.75	.593	11.59	.664	3359	.873	3473
	EUR	.689	8.76	.677	13.57	.717	2409	.823	2362
Aggregated Av.		.676	9.03	.617	11.00	.685	2828	.836	2855

The figures in brackets by UK, NA, etc. is the sample number of classifications available.

TABLE 29

SELECTED DEPARTMENTAL RATIOS, AGGREGATED AVERAGES, BY SUBJECT.

SUBJECT CLASSIFICATION	A ACAD. / TOT.STAFF	B TOT.TEACH. HOURS / ACAD.STAFF	C 1ST DEG. / TOTAL TEACH. HOURS	D STUDENTS / ACAD. STAFF	E 1ST DEG. / TOTAL STUDENTS	F RECURR / TOTAL STAFF	G REMUN. / RECURR	H REMUN. / STAFF ACADEMIC
1 P.Sciences	.553	8.32	.648	10.26	.824	2414	.806	2493
2 Architect.	.798	7.58	.983	6.97	.792	3036	.820	2724
3 Technology	.556	8.00	.768	9.29	.765	2753	.811	2758
4 Med.Sc.	.591	2.07	.437	14.19	.288	2105	.820	2234
5 Agriculture	.625	.57	.319	11.37	.721	3006	.932	3726
6 Humanities	.803	9.93	.715	10.89	.536	2753	.897	2756
7 Fine Arts	.768	14.54	.806	9.01	.740	3198	.861	3239
8 Education	.768	17.94	.424	20.62	.716	3272	.819	2832
9 Law	.716	11.48	.536	20.76	.689	2704	.901	2901
10 Soc.Sc.	.747	8.20	.703	13.21	.764	3027	.822	2909
Av.	.693	8.86	.634	12.66	.684	2827	.849	2857
AGGREGATED AV. *	.643	8.89	.671	11.67	.703	2658	.831	2694

* Averaged by aggregating all departmental data for the individual classifications

SELECTED DEPARTMENTAL DATA - OVERALL AVERAGES (**Corresponding to table 5**)

TABLE 30

SUBJECT CLASSIFICATION	(i) TOTAL STAFF D_T	(ii) ACAD STAFF D_A	(iii) TOTAL TEACH. HOURS T_T	(iv) 1ST DEG. TEACH HOURS T_U	(v) TOTAL STUDENT F_T	(vi) 1ST DEG STUDENT F_U	(vii) TOTAL RECURRENT V_T	(viii) TOTAL STAFF REMUN. V_N	(ix) TOTAL ACAD. STAFF REMUN. V_A
1	331	183	1521	986	1875	1545	713000	643000	456000
2	56	45	339	333	311	247	170000	139000	122000
3	264	147	1175	902	1364	1044	727000	590000	405000
4	83	49	101	44	693	200	174000	143000	109000
5	48	30	17	5	341	246	144000	135000	112000
6	164	132	1311	938	1437	771	453000	406000	364000
7	69	53	771	621	478	354	221000	190000	172000
8	54	42	746	317	857	613	177000	145000	118000
9	60	43	495	265	896	617	163000	147000	125000
10	119	84	686	482	1104	843	339000	278000	243000
TOTALS	1248	808	7162	4893	9356	6480	3281000	2816000	2126000

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Recurrent expenditure other than remuneration is about 17% of the total. Student/staff ratio provides the greatest regional variation (being high in Europe and low in U.K.) and looking at these in conjunction with the academic loadings, suggests that the major difference may lie in the amount of individual work (private study) the student is expected to do and the importance attached to small group teaching.

Overall Observations: These provide overall comparisons between regions for the aggregated classifications and in general show remarkably similar results. The values, with variational percentages in brackets, are given below:

Support Staff: 32% $\begin{bmatrix} +5\% \\ -3\% \end{bmatrix}$ of total departmental staff.

Academic Loading: 9 hours/week $\begin{bmatrix} +6\% \\ -3\% \end{bmatrix}$

Higher Degree Work: 38% $\begin{bmatrix} +5\% \\ -4\% \end{bmatrix}$ of total

Student/Staff Ratio: 11.0 $\begin{bmatrix} +23\% \\ -28\% \end{bmatrix}$

Total Recurrent/Total Staff: £2830 (equivalent standardized) $\begin{bmatrix} +19\% \\ -15\% \end{bmatrix}$

"Other" Recurrent/Total Recurrent: 16% $\begin{bmatrix} +4\% \\ -2\% \end{bmatrix}$

Academic Salaries: £2860 (equivalent standardized) $\begin{bmatrix} +21\% \\ -17\% \end{bmatrix}$

Thus the major departures are in student/staff ratios where Europe is high and U.K. low and in recurrent costs per staff and academic salaries both of which mainly reflect large salary variations with N.A. high and Europe low.

Finally it should be observed here that data similar to that in tables 28 - 30 and Appendix A3 could be used to investigate at the disaggregated level some of the factors considered in Part II for the overall university.

2.1.4. An Approximate Cost Ranking of Subject Classifications

Although the "cost" of various subjects must be a matter for more detailed conceptual and data analyses based on the comprehensive questionnaire it is possible to use the results in the previous sections to give an approximate guide as to the cost rankings of the various subject classifications by regional groupings.

The method adopted here was to use merit ranking numbers for each of the parameters A, B, C, etc., in order of costliness and to sum these to provide overall rankings. Some considerable thought was given to the individual importance of each parameter and guide table 31 was then constructed. Factors are weighted equally for the ranking exercise.

Table 32 presents the results of table 28 on a geographical region basis for each subject classification (and incidentally, follows comparisons within regions). Summing the rankings for each parameter (together with those of table 29) gives the following overall rankings:

METHOD OF SUBJECT CLASSIFICATION COST RANKING

TABLE 31

PARAMETER	CONSTITUENTS OF PARAMETER	* COST ORDER	REMARKS
A	ACAD. STAFF / TOTAL STAFF	HIGH	Measure of supporting staff costs High value → low numbers → low cost.
B	TOTAL TEACH HOURS / ACAD. STAFF	HIGH	Measure of academic staff loading High value → less staff → lower cost.
C	FIRST DEG. / TOTAL (TEACHING HOURS)	HIGH	Measure of Higher degree loading High value → low higher degree load → lower cost.
D	STUDENTS / ACAD. STAFF	HIGH	Measure of academic staff numbers High value → fewer staff → lower cost.
E	FIRST DEG. / TOTAL (STUDENTS)	HIGH	Measure of higher degree student numbers High value → fewer higher degree students → lower cost.
F	TOT.RECURR / TOTAL STAFF	LOW	Low value → lower cost
G	TOT.REMUN. / TOT.RECURR	HIGH	Measure of "other" than remuneration relative costs High value → "other" costs low → lower costs.
H	TOT.REMUN / TOT.ACAD. STAFF (ACADEMIC)	LOW	Low value → lower cost.

* Denotes whether high or low value of the parameter contributes to least overall cost.

Ranking in order of increasing costs:

U.K.	N.A.	EUR.	ALL	
6	9	2	6	Humanities
3	8	= 6	9	Law
10	6	= 8	2	Architecture
8	7	9	1	Pure Science
1	10	1	7	Fine Arts
4	4	7	10	Social Sciences
	5	4	8	Education
	3	= 10	4	Medical Sciences
	1	= 3	3	Technology
	2		5	Agriculture

The numbers represent subject classification and can be identified from the right-hand column.

It is emphasized that the above is a very rough guide but does elicit some interesting factors. Of the principal subject classifications Humanities is relatively least costly with Education near to this but quite costly in the U.K. (probably associated with high post-graduate content). Pure Science is relatively costly in U.K. and N.A. but less so in Europe, Technology is less costly than Pure Science in the U.K. (a surprising and probably erroneous result) but is about as costly as Pure Science in N.A. and is the highest cost in Europe. Social Sciences are of average cost generally but high in Europe.

Of the remaining significant classifications Law is relatively of low cost, Fine Arts falls between the costs of Humanities and Social Sciences and Medicine, although not very representative, is generally costly.

Architecture and Agriculture are of little significance in these rankings because of the very small samples involved.

Part II. Overall University Data

2.2. Population

2.2.1. Salary Ratings for all Staff Catagories (relevant to section 3.2. of model of Chapter 2).

No cost index is incorporated in table 33. However the final column in each category is independent of this. There is an appreciable agreement in the average figures for the U.K. and Europe although the latter includes two largish variations (one is a specialized and somewhat costly institute and the other is an Eastern European university with a low cost index and these tend to balance one another). The North American (N.A.) values vary appreciably (a small sample anyway) but the averages are appreciably higher reflecting the higher cost index. Also apparent for N.A. is the narrower spread of salary range between all kinds of non-academic staff levels (this also applies to the East European university).

TABLE 32

Ratio parameters for subject classification by geographical Groupings

REGION	CLASSIFICATION (i)	(ℓ) RATIO PARAMETERS A	B	C	D	E	F	G	H
UK	1	.521	9.34	.609	7.83	.811	3314	.808	2819
	3	.519	11.34	.619	10.69	.829	2484	.811	2904
	4	.500	4.13	.611	3.66	.734	2487	.778	2868
	6	.833	11.00	.916	10.00	.938	2371	.958	2563
	8	.696	11.19	.000	5.81	.000	3043	.643	2500
	10	.740	10.49	.737	9.12	.723	2595	.881	2725
	Av	.634	9.58	.582	7.85	.673	2716	.813	2730
NA	1	.771	8.30	.635	4.75	.549	3573	.831	3504
	2	.791	0.53	.393	6.36	.424	3687	.818	3277
	3	.549	1.97	.295	7.48	.419	2790	.909	2960
	4	.780	0.63	.700	13.47	.942	3732	.850	3781
	5	.625	0.57	.319	11.37	.721	3006	.932	3726
	6	.835	10.08	.724	10.71	.354	3397	.912	3433
	7	.609	18.65	.828	5.64	.742	2740	.855	3583
	8	.780	20.31	.425	23.26	.736	3515	.830	3026
	9	.512	6.36	1.000	18.59	1.000	3326	.944	4545
	10	.804	9.06	.610	11.95	.754	3824	.829	2890
	Av	.706	8.75	.593	11.59	.664	3359	.873	3473
EUR	1	.529	8.10	.661	11.92	.843	2051	.801	2214
	2	.802	12.20	1.000	7.37	1.000	2604	.821	2358
	3	.579	12.70	.889	10.55	.984	2831	.709	2500
	4	.589	1.96	.376	15.74	.208	1898	.824	1963
	6	.784	9.67	.682	11.09	.582	2186	.879	2429
	7	.718	6.98	.695	15.21	.739	2551	.874	2607
	8	.738	8.24	.617	12.38	.643	2180	.827	1956
	9	.739	11.88	.516	20.93	.667	2633	.895	2771
	10	.720	7.11	.659	16.90	.784	2747	.780	2458
	Av	.689	8.76	.677	13.57	.717	2409	.823	2362

The following presents a brief summary of the main features of the table by category although it should be observed that the definition of staff levels vary considerably between, and even within, countries and a study in depth of this would produce more consistent data.

Academic Staff: Close agreement between U.K. and Europe with professorial salaries some 70% greater than overall academic average. The N.A. region professorial salaries are some 100% greater (and contrasts sharply with the narrower salary spread for other categories).

Administrative Staff: The average administrative salaries are about half the average academic salaries in U.K. and Europe although there is a greater spread in level in the U.K. The administrative salaries in N.A. are comparable with the academic salaries although slightly lower (about 5% - 10%).

Library Staff: Average library staff salaries are about the same as average administrative salaries in the U.K. and Europe but some 20% lower in N.A. However the library situation depends on the importance placed on library provision, consequent facilities, responsibilities and size, and these need to be studied in detail.

Technical and Other Staff: This shows the greatest variation between regions but is reasonably consistent within them. It is clearly a function of the type of university (technological, general, specialized, etc.) and must normally be viewed in relation to this function (this is apparent from the departmental analysis in Part I). There is also a need to distinguish between technical staff and others since their respective functions are quite different especially on the science, technology and medical sides (where specialized support staff tend to be a high proportion of total staff). The results shown, however, suggest that average salaries for technical and other staff in N.A. and Europe are about the same as those for the average library staff with the U.K. some 13% lower than this. In all cases the comparative top salary level is lower than for the other staff categories and there is less overall spread.

Total Employees: The average salary quoted is clearly some reflection of the cost index of the various countries and, in particular, of the specific institutions (the latter on the theory that 'costliness' is often reflected through salary levels). The ratings in the three regions vary fairly markedly - the average total employee salaries being about 60%, 100% and 80% of the average academic staff salaries in the U.K., N.A. and Europe respectively. This appears to stem largely from the relatively high proportion of Technical and other staff in the U.K., of administrative staff in N.A. and of academic staff in Europe (see distribution of staff).

2.2.2. Some Staff Ratios and Staff Distribution (relevant for section 3.1. of model, Chapter 2).

From table 34, the following observations are pertinent:

Staff ratios: These refer to administrative and library only (academic is dealt with under student/staff ratio and "Technical and Others" combined has more significance at departmental level). The library student/staff ratio is some measure of the service provided since student population is the most significant specific group involved. The values vary widely between and within regions reflecting the varying degrees of importance with which library facilities are regarded. High values imply inadequate facilities and here Europe comes off worst (although probably exaggerated by two very high values) with a ratio of about 150. The U.K. is about half this and N.A. just over one third. However

SALARY RATINGS FOR ALL STAFF CATEGORIES

TABLE 33

REGION	UNIV	ACADEMIC *ALL (r_A)	ACADEMIC *PROF	ACADEMIC PROF/ALL	ADMINISTRATION *ALL (r_D)	ADMINISTRATION *MAX	ADMINISTRATION *MIN	ADMINISTRATION MAX/ALL	LIBRARY *ALL (r_L)	LIBRARY *MAX	LIBRARY *MIN	LIBRARY MAX/ALL	TECHNICIANS - OTHERS: *ALL (r_O)	TECHNICIANS - OTHERS: *MAX	TECHNICIANS - OTHERS: *MIN	TECHNICIANS - OTHERS: MAX/ALL	TOTAL EMPLOYEES AV SALARY £ EQUIV r_T	TOTAL EMPLOYEES RATING
U.K.	1	1.00	1.67	1.67	–	–	–	–	0.43	1.48	0.22	3.48	0.37	0.77	0.18	2.05	–	–
	2	1.03	1.76	1.70	0.51	2.11	0.36	4.15	0.49	1.52	0.24	3.07	0.37	0.64	0.26	1.76	1780	0.66
	3	1.13	1.89	1.67	0.52	1.85	0.32	3.57	0.57	0.99	0.30	1.75	0.38	0.90	0.19	2.36	1740	0.64
	Av	1.05	1.77	1.68	0.52	1.98	0.34	3.86	0.50	1.33	0.25	2.77	0.37	0.77	0.21	2.06	1760	0.65
N.A.	4	–	–	–	–	–	–	–	0.75	1.31	0.50	1.76	–	–	–	–	–	–
	5	2.34	3.17	1.36	1.35	2.35	0.40	1.74	0.99	3.24	0.51	3.29	0.62	1.33	0.41	2.16	3620	1.34
	6	1.11	2.94	2.65	1.01	2.09	0.62	2.05	–	–	–	–	1.18	1.59	0.78	1.35	2920	[illegible]
	Av	1.23	3.06	2.01	1.18	2.22	0.51	1.90	0.87	2.28	0.51	2.53	0.90	1.46	0.60	1.76	3270	1.21
EUR.	7	1.42	1.88	1.68	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	8	1.18	2.32	1.97	0.58	0.87	0.43	1.49	0.76	1.16	0.64	1.52	0.68	1.35	0.26	1.99	2490	0.92
	9	1.06	1.49	1.41	0.58	1.52	0.47	2.63	0.67	1.42	0.39	2.11	0.54	0.67	0.46	1.23	2200	0.81
	10	1.06	1.47	1.39	0.58	1.52	0.52	2.59	0.61	1.19	0.43	1.95	0.59	0.82	0.48	1.38	2500	[illegible]
	11	1.09	2.18	2.00	0.44	1.91	0.40	4.48	0.53	1.62	0.36	3.03	0.38	1.26	0.35	3.33	2010	0.74
	12	1.42	2.59	1.82	0.50	2.39	0.39	4.81	0.51	2.22	0.38	4.33	0.77	1.97	0.38	2.54	3130	1.16
	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	14	0.74	1.50	2.03	0.44	2.05	0.28	4.61	0.24	0.33	0.17	1.39	0.53	1.04	0.12	1.98	2370	0.88
	15	0.53	0.69	1.30	0.34	0.85	0.30	2.50	0.33	0.58	0.24	1.75	0.25	0.40	0.18	1.60	1110	0.41
	Av	1.03	1.77	1.70	0.49	1.59	0.40	3.30	0.52	1.22	0.37	2.30	0.53	1.07	0.32	2.01	2250	0.84
Overall Av		1.14	1.97	1.74	0.62	1.77	0.41	3.15	0.57	1.43	0.37	2.45	0.56	1.06	0.34	1.98	2340	0.87
Av of Av		1.10	2.20	1.80	0.73	1.93	0.42	3.02	0.63	1.61	0.38	2.53	0.60	1.10	0.38	1.94	2430	[illegible]

* A rating of 1.00 relates to £2700 p.a. equivalent. Rates of exchange used are 1968/69 values given in section 2.4.3.

a glance at the column does suggest that a ratio of about 75 is a reasonable currently acceptable level. The administrative staff/academic staff ratio is some measure of the administrative back-up support to academic staff and again is quite variable. The figures indicate that this back-up is least in Europe (about 25%) is very high in N.A. (about 170%) with U.K. falling in between (about 60%). This follows the same pattern as for salaries except that the differences are more marked on a personnel number basis.

Table 34. Ratios of Staff Numbers, by Type of Staff

Region	Univ.	Staff Ratios		Distribution of Staff % Numbers			
		Tot. Stud. / Lib. Staff (m_P)	Admin. / Acad. Staff (m_D)	Acad. (m_{TT})	Admin. (m_{TA})	Lib. (m_{TL})	Tech. and Other (m_{TO})
U.K.	1	44.4	0.28	43	14	8	35
	2	86.0	0.55	39	21	4	36
	3	83.5	0.95	30	28	4	38
	Av.	71.3	0.59	37	21	5	37
N.A.	4	29.8	-	-	-	-	-
	5	87.3	2.47	20	50	3	27
	6	41.3	1.00	31	31	2	36
	Av.	52.8	1.74	25	40	3	32
EUR	7	343.6	0.17	68	12	4	16
	8	109.2	0.21	50	10	7	33
	9	68.9	0.35	50	18	5	27
	10	61.2	0.31	50	16	6	28
	11	83.8	0.38	49	19	4	28
	12	98.8	0.49	53	26	15	6
	13	318.7	0.12	33	4	1	62
	14	140.9	0.23	69	16	3	12
	15	133.7	0.23	52	12	5	31
	Av.	151.0	0.28	52	15	6	27
Overall Av.		115.4	0.55	46	20	5	29
Av. of Avs.		91.7	0.87	38	25	5	32

Distribution of Staff: The last four columns of table 34 present this as percentages of the total for academic, administrative, library and "technicians and other" staffs. Library staff is about 5% generally and the lower figure for N.A. could well represent an economy of scale since the absolute staff numbers are relatively high. The Technician and Other Staff shows a relatively modest variation in terms of percentage of the total staff (37% in the U.K. to 27% in Europe) but expressed as a proportion of academic staff it represents about 1 per academic staff member, 1.25 per academic and 0.5 per academic for U.K., N.A. and Europe respectively. The greatest variations however occur between academic and administrative staff percentages. Combined they represent 60% - 65% of the total staff for all regions but individually they are 37%, 25% and 52% for academic staff and 21%, 40% and 15% for administrative staff respectively for U.K., N.A. and Europe. The major difference in staff distributions between regions seems to be the degree of administrative support.

2.2.3. Student Population and Weighting

Table 35 is deduced from the overall raw data which in some instances departs considerably from the incrementally summed departmental data and must therefore be viewed with some suspicion from the outset. However it can provide an approximate picture relevant to the basis of the general model, outlined in section 3, of Chapter 2.

Student/Staff and Student Level Ratios: The student/staff ratios (s_u) vary considerably across and within regions with the average values being about 9, 8.5 and 11 respectively for the U.K., N.A. and Europe. It is perhaps unfortunate that this ratio often assumes exaggerated importance as a measure of university efficiency whereas analysis shows it to be a complex function of many university data variables. However as a refinement, it is often associated with the level of higher degree to first degree work and for this reason the second column in table 11 presents this ratio. Before relating this to student/staff ratio it is worth noting that the overall figures give approximate higher/first degree ratios of about 22%, 55% and 48% respectively for the U.K., N.A. and Europe. The level of "effective post-graduate" work in Europe and N.A. is about twice that in the U.K. If it is assumed that higher degree work is more demanding (and also more costly) on staff time then a high level of higher degree work will imply a low student/staff ratio and vice-versa. In table 35 it will be seen that although in a number of cases this implication is substantiated there are also sufficient cases to the contrary to suggest the need for a much more elaborate analysis. Additionally in the case of Europe there is considerable doubt as to what constitutes first and higher degree levels, a ("first degree") diploma often taking several years more to complete in Europe than in the U.K. or N.A. All of this suggests that these two ratios taken on their own are not a very reliable guide to overall university comparison. Nevertheless it was considered worthwile to extend the analysis here to determine whether "weighted" student/staff ratios showed a better correlation and to gain some idea of the approximate relative weighting factors.

Student Weighting: A simple analysis yields the following relationship:

$$a_1 = -\alpha a_2 + \lambda w \quad \ldots\ldots\ldots\ldots \quad (1)$$

where a_1 = First degree student/staff ratio based on total staff

a_2 = Higher degree student/staff ratio based on total staff

α = Relative weighting of 1 higher degree to 1 first degree student.

λw = Weighted student/staff ratio based on total staff.

Values of a_1 and a_2 are given in table 35. Clearly if λ_w and α are constant within regions then plots of a_1 against a_2 will be linear and yield values for these constants. This was done and provided graphs containing considerable scatter although the trends suggested the negative slope of equation (1). Mean lines gave the very rough values for α and λ_w presented on table 11 for the various regions. Obviously the values for U.K. and N.A. can have no statistical significance because of the small number of samples. The weighting factors vary from about 1.6 to 4.3 for the regions but the overall value of approximately 2 is

TABLE 35

THE DISTRIBUTION OF STUDENTS TO ACADEMIC STAFF

REGION	UNIV	OVERALL STUDENT/STAFF RATIO ($s_u = \frac{P_T}{S_T}$)	HIGHER DEGREE to FIRST DEG. RATIO ($\frac{P_G}{P_U}$)	FIRST DEG. STUD/STAFF RATIO $a_1 (= \frac{P_U}{S_T})$	HIGH DEG. STUD/STAFF RATIO $a_2 (= \frac{P_G}{S_T})$	WEIGHTING FACTOR α	WEIGHTED STUD/STAFF RATIO. λ_w α = AV VALUE FOR REGION.
U.K.	1	8.52	0.170	7.27	1.25	(3.34)	11.4
	2	8.23	0.213	6.62	1.40	(3.34)	11.3
	3	10.30	0.267	8.13	2.19	(3.34)	15.4
	Av	9.02	0.217	7.34	1.61	3.34	12.7
N.A.	4	(9.77)	0.480	(6.60)	(3.17)	(4.32)	20.3
	5	12.70	0.216	10.50	2.27	(4.32)	20.3
	6	2.98	0.965	1.52	1.46	(4.32)	7.8
	Av	8.46	0.554	6.21	2.30	4.32	16.2
EUR.	7	19.20	0.004	19.17	0.08	(1.63)	19.3
	8	15.80	0.819	8.54	6.99	(1.63)	19.9
	9	7.23	0.364	5.28	1.92	(1.63)	8.4
	10	7.43	0.040	7.15	0.30	(1.63)	7.6
	11	6.86	0.651	4.14	2.70	(1.63)	8.5
	12	27.10	2.020	9.00	18.16	(1.63)	38.6
	13	8.45	0.115	7.57	0.88	(1.63)	9.0
	14	5.93	0.942	2.23	2.11	(1.63)	5.7
	15	12.40	(0.000)	(12.40)	(0.00)	(1.63)	12.4
	Av	11.16	0.441	8.38	3.68	1.63	14.4
Overall Av.		10.80	0.484	7.76	2.91	1.96	13.5

Figures in brackets are estimated values.

of the order expected. However the degree of scatter from these values is clearly demonstrated by the weighted student/staff ratios quoted in the last column of table 11 which are calculated for the regions from equation (1) using the average α value for each region. The conclusions of this section must be that such simplified analyses should be treated with considerable caution at the overall university level.

A similar approach at departmental level, as in section 2.1. of the general model, yields more useful results. However it might be more meaningful to use staff teaching hour data in association with the level of degree work, as in the more complex methodology of Chapter Three's departmental approach.

2.3. Area

2.3.1. Land and Gross Building Areas

Area Ratios

Land and building area values are only given in broad terms from the questionnaire data. In terms of total land area the results are likely to be influenced by location of the university (i.e. rural, urban etc.) and general land costs.

The observations on the land area results in table 36 can at most show a very rough guide as to what may be acceptable environmentally. The employment of the term 'used land' refers to that area occupied by buildings, car parks and recreational facilities (field) and therefore represents the minimum practical land areas. Thus the ratio of land used/total land area is some measure of the intensity of land use (somewhat similar to building density). As expected, there are no wide differences between regions and the overall figure in column 1 of table 36 suggests that some 2½ times the minimum practical area is about average to provide for general environment. Car parking is, of course, an increasingly complex problem for universities and has often been neglected in the past especially for students. The major problem is one of effective land utilization and general cost arising from the density of parking (i.e. multi-story, underground, open lateral). It is not surprising therefore that the ratio of car parking area to total land area varies considerably. It averages at about 5% but when, more meaningfully, related to used land (column 5), varies widely.

The distribution of building, recreational and car parking land is given as a percentage of 'used land' area in the last three columns of table 36. Here, despite the small samples, there are fairly marked regional trends. The marked importance the U.K. place on recreational facilities and the relative unimportance attached to car parking is clear. The latter is markedly high for N.A. which clearly reflects private vehicle ownership trends whilst Europe concentrates on its buildings to the detriment of its recreational facilities.

Unit Gross Areas. (For section 3.4. of the model of Chapter 2).

The main purpose of these figures, shown in table 37, is to provide the orders of unit area associated with the particular applications and, in the case of buildings, to explore briefly which university group might give most consistency either within or between regions.

Land Unit Areas: The total and 'used' land areas are associated with student population. The overall area/student is excessively influenced by a single N.A. university, but apart from this, the results appear to divide roughly into two groups associated with high and low density situations with orders of 55 and 250 m^2/

TABLE 36

BUILDING, RECREATION & CAR PARK AREAS AS % OF "USED" LAND

REGION	UNIV	USED LAND / TOT. LAND AREA RATIO (b_U)	CAR PARKING / TOT. LAND AREA %AGE RATIO	%AGE DISTRIBUTION OF USED LAND: BUILDING (b_{BU})	RECREATION (ALL) (b_{RU})	CAR PARKING (b_{PU})
U.K.	1	.158	0.75	38	57	5
	2	–	0.44	–	–	–
	3	.344	3.24	61	30	9
	Av	.251	1.48	49	44	7
N.A.	4	–	–	–	–	–
	5	.005	0.26	27	26	47
	6	.870	10.00	51	38	11
	Av	.437	5.13	39	32	29
EUR.	7	–	–	–	–	–
	8	.335	4.17	82	6	12
	9	–	–	–	–	–
	10	–	–	–	–	–
	11	.386	2.12	88	7	5
	12	.608	16.25	32	41	27
	13	–	–	–	–	–
	14	.246	3.75	65	20	15
	15	–	–	–	–	–
	Av	.394	6.57	67	18	15
Overall Av		.369	4.55	56	28	16

TABLE 37

UNIT GROSS AREAS RELATING TO LAND AND BUILDING

REGION	UNIV	TOTAL LAND AREA PER STUDENT (u_{TP}) m^2	"USED LAND" AREA PER STUDENT *($u_{TP} \cdot b_U$) m^2	CAR-PARK AREA PER TOT. STAFF AND STUDENTS m^2 (u_{PA})	RECREATION AREA PER STUDENT m^2 (u_{RP})	UNIT BUILDING AREAS m^2: PER ACAD STAFF (u_{BS})	UNIT BUILDING AREAS m^2: PER STUDENT ($b_{BU} \cdot b_U \cdot u_{TP}$)	UNIT BUILDING AREAS m^2: PER TOTAL STAFF (u_{BT})	UNIT BUILDING AREAS m^2: PER TOTAL STAFF AND STUDENTS
U.K.	1	424	66.8	2.63	38.2	217	25.5	93	21.1
	2	56	–	0.19	2.9	–	–	–	–
	3	289	99.4	7.05	35.1	622	60.2	185	45.5
	Av	256	83.1	3.29	25.4	420	42.9	139	33.3
N.A.	4	–	–	–	–	–	–	–	–
	5	8325	45.0	15.30	17.9	156	12.2	32	8.8
	6	66	57.1	3.14	21.7	86	28.9	27	13.9
	Av	4196	51.1	9.22	19.8	121	20.6	30	11.4
EUR.	7	–	–	–	–	–	–	–	–
	8	53	17.9	1.98	1.0	230	14.7	114	13.0
	9	54	–	–	–	–	–	–	–
	10	161	–	–	3.6	120	16.2	60	12.8
	11	112	43.1	1.82	2.8	259	37.7	127	29.2
	12	20	12.3	4.74	5.0	108	4.0	58	3.7
	13	–	–	–	–	–	–	–	–
	14	81	20.0	2.44	4.1	77	12.9	53	10.3
	15	–	–	–	–	–	–	–	–
	Av	80	23.3	2.75	3.3	159	17.1	82	13.8
OVERALL AV		876	43.0	4.37	13.2	2[illegible]8	23.6	83	17.6

* Used land area comprises the sum of building; recreational and car park areas.

student respectively. The 'used' land unit areas are relatively more consistent and suggest an overall figure of about 40 m^2/student (a little less than the N.A. figure) with the U.K. being about twice this and Europe about half. Car park unit areas are associated with the overall university population (staff and students) and again show wide variation with the same regional emphasis referred to above.

Table 38. Building Floor Area Ratios.

Region	Univ.	Tot. Build. Floor Area / Tot. Build. Land Area $d_B = \frac{A_T}{B_B}$	Tot. Build. Floor Area Per Univ. Member A_T/N_T+P_T m^2/pers.	Tot. Build. Floor Area Per Tot. Staff A_T/N_T m^2/pers.	"Other" Floor Area Per Tot. Staff Member $A_O/N_T = u_{FO}$ m^2/pers.
U.K.	1	0.842	16.84	78.15	47.16
	2	-	13.09	54.85	22.74
	3	0.252	11.48	46.77	25.71
	Av.	.547	13.80	59.92	31.87
N.A.	4	-	-	-	-
	5	1.785	15.77	56.50	42.48
	6	2.522	34.85	66.85	43.69
	Av.	2.154	23.36	61.68	43.09
EUR.	7	-	-	-	-
	8	1.500	19.59	171.11	113.47
	9	-	-	-	-
	10	1.550	19.76	93.10	46.18
	11	0.483	14.10	61.41	-
	12	1.821	6.76	104.69	27.17
	13	-	7.18	27.02	2.58
	14	2.976	30.72	117.13	59.09
	15	-	-	-	-
	Av.	1.666	16.35	95.74	49.70
Overall Av.		1.526	16.93	79.78	43.03

The overall value is about 4.4 m^2/member with N.A. over twice this figure. However the more important consideration is the degree of availability of car parking spaces. A measure of this can be determined from assumed values of 'effective' area per car parking place - this will usually vary from about 12 m^2/place in the U.K. and Europe to 15 m^2/place in N.A. and using these values imply about 1 place for 4 university members in the U.K. and Europe and 1 place for (less than) 2 members in N.A. Recreation unit areas are about 20-25 m^2/student in the U.K. and N.A. whereas they are only some 3 m^2/student in Europe which is almost certainly inadequate. Most of this refers to field area and there is much that can be done with the use of intensive "dri-play" areas and the like.

Building Unit Areas: The overall area of about 24 m^2/student compares quite favourably with the known average value of about 20 m^2/student for all universities in the U.K. However a mean deviation calculation suggests that for parametric variation purposes the best university group basis is either total or academic staff which perhaps more accurately describes the full functions of the buildings.

2.3.2. Net Floor Unit Areas (see related to section 3.3., Chapter 2).

The raw data for table 39 was sparse and any deductions must be extremely tentative. In general laboratory area per student shows little regional variation (with the exception of one N.A. university which is specialized and highly research oriented) and fairly uniform values with an average of about 5 m^2/student. Obviously the individual values will depend on the amount of science and technology work undertaken and a further analysis at faculty level should elicit more reliable information. All teaching room space per student again shows comparatively reasonable uniformity with Europe having rather more space than N.A. and U.K. (in that order). The average value is nearly 3 m^2/student. Library area per student is similar to teaching room space per student for the U.K. and N.A. (and is about 1.5 - 2.0 m^2/student) but is substantially less for Europe (about half). Academic staff office space is fairly uniform across regions and is some 20 m^2/academic staff on average. Administrative staff office space is rather less than academic staff space in U.K. and N.A. but appreciably more in Europe. Obviously this latter depends on the definition of office space (e.g. whether it includes machinery). The whole problem of office accomodation would benefit from a deeper analysis at faculty level since although it has relatively small effects on overall university costs it is a vital matter concerning staff morale.

Building Density: The values of building density are quoted in column 1 table 38. Since floor areas are net and land areas are gross it is possible to obtain a value of d_B less than unity (which would otherwise denote all ground-level buildings only). There is no particular reason why there should be regional differences and the samples are too small to provide these anyway. However the total sample appears to fall into three separate density groupings so that for an approximation it can be deduced that:

d_B = 0.526 for a low average building density

d_B = 1.664 for a medium average building density

d_B = 2.749 for a high average building density

and these values can be used to indicate the order of building density for any corresponding values of building floor area (A_B) and land area (B_B).

These values are those utilized in equation (41) of section 3.4. of the simplified overall model.

NET FLOOR UNIT AREAS

TABLE 39

REGION	UNIV.	LABORATORY AREA PER STUDENT m^2 (u_{FB})	ALL TEACHING ROOMS PER STUDENT m^2 (u_{FA})	LIBRARY AREA PER STUDENT (u_{FL}) m^2	ACAD. OFFICE AREA PER ACAD. STAFF m^2 (u_{FS})	ADMIN. OFFICE AREA PER ADMIN. STAFF m^2 (u_{FD})
U.K.	1	2.8	1.4	2.6	24.0	42.8
	2	6.2	1.7	0.6	14.2	5.8
	3	2.8	1.0	1.4	17.0	16.0
	Av	3.9	1.4	1.5	18.4	16.7
N.A.	4	-	-	-	-	-
	5	0.8	2.1	1.4	20.0	4.9
	6	12.6	1.9	2.0	16.1	16.1
	Av	6.7	2.0	1.7	18.1	10.1
EUR.	7	-	-	-	-	-
	8	5.1	0.8	0.8	9.3	75.2
	9	-	-	-	-	9.9
	10	4.9	2.5	0.9	30.1	8.1
	11	-	-	-	-	-
	12	-	2.6	1.6	50.4	36.7
	13	3.7	2.9	0.3	12.8	53.6
	14	2.9	5.9	0.6	7.7	23.8
	15	-	-	-	-	-
	Av.	4.2	2.9	0.8	22.1	34.6
Overall Av.		4.6	2.3	1.2	20.2	26.6

2.4. Finance

2.4.1. Recurrent Expenditure (Related to section 3.2. of the overall model).

Information on recurrent expenditure was relatively sparse especially in the distribution of recurrent expenditure excluding remuneration.

The ratio of total staff remuneration to total recurrent expenditure is remarkably consistent both within and across regions and is of the order of 60% - 65%. Since the difference between the two quantities represents the recurrent expenditure on non-salary items it is then evident that the expenditure excluding salaries is about one-third of the total annual recurrent expenditure (i.e. about half the total salary bill).

Within the category, recurrent expenditure excluding remuneration, the results are very poor.

On the administration and "other" percentages it would be unwise to draw even tentative conclusions other than between them they account for about 95% of the total. The library percentage is fairly consistent at 5% overall with the N.A. values showing a possible economy in scale.

2.4.2. Capital Expenditure (Relevant to section 3.5. of the model in Chapter 2).

Table 41 sets out the annual average capital expenditures of the 15-universities, classified by purpose of expenditure.

Distribution of Total Averaged Annual Capital Expenditure: Capital expenditure does not necessarily have any determinable relationship to recurrent expenditure. Furthermore capital expenditure can vary enormously from year to year according to growth, economic climate, research, etc. Thus any analysis in depth should be time-dependent. It also follows that to explore the effects of capital on recurrent cost then time dependent data on recurrent costs is also needed, but this is not available from the survey.

Building capital expenditure for all regions, is quite high, indicating a fairly high university growth rate during the period 1965-69. The average proportion for building of total capital expenditure is nearly 70%. Thus remaining capital for other purposes is about 30% overall but this almost certainly includes some capital resulting from the building programme. Thus a major problem arises in distinguishing capital expenditure for and arising from, buildings and necessary or "true" capital expenditure associated with the university in its steady state. This problem is clearly demonstrated in the figures for administration and library in table 42 which in the case of the former is almost certainly also influenced by the inclusion of maintenance, minor extensions and alterations, etc. It is therefore not possible to draw even rough meaningful conclusions from the Administration and Library capital data although it appears that the "true" capital costs are in the region of 4% or less of the total capital expenditure.

Relationship of Building Capital to University Growth: The following simple analysis is the basis of the growth factor utilized in section 3.5. of the simple model of Chapter 2.

Growth is usually presented as an annual percentage rate based on student number increase hence:

RECURRENT EXPENDITURE RATIOS AND DISTRIBUTION

TABLE 40

REG-ION	UNIV.	TOT. STAFF REMUNERATION TO TOTAL RECURRENT EXPENDIT. RATIO (r_T)	TOT. RECURRENT (EXCLUD. REMUNERATION) PER TOTAL STAFF MEMBER EQUIV. £ * (n_{RT})	%AGE RECURRENT EXPENDITURE (EXCLUDING REMUNERATION). ADMIN. (P_{OD})	LIBRARY (P_{OL})	OTHER (P_{OO})
U.K.	1	-	1645	5.1	8.9	86.0
	2	.58	1272	-	(4.1)	-
	3	.62	1058	6.3	7.1	86.6
	Av	.60	1325	5.7	8.0	86.3
N.A.	4	.53	-	-	(1.8)	-
	5	.70	1571	15.7	11.3	73.0
	6	.61	2348	12.7	1.3	86.0
	Av	.61	1960	14.2	6.3	79.5
EUR.	7	-	-	-	-	-
	8	-	-	-	-	-
	9	.64	1250	3.2	1.6	95.2
	10	.59	1754	17.8	5.5	76.7
	11	.55	1613	-	(2.5)	-
	12	.78	891	-	-	-
	13	-	-	-	-	-
	14	.46	2518	(20.2)	-	-
	15	.90	128	-	-	-
	Av	.65	1359	10.5	3.6	85.9
Overall Av		.63	1457	11.5	4.9	83.6 (APPROX)

* Converted using rates of exchange for 1968/69 values given in Section 2.4.2.

TABLE 41

AVERAGE ANNUAL UNIVERSITY CAPITAL EXPENDITURES *

UNIV.	CURRENCY	TOTAL UNIVERSITY AVERAGE PER YEAR (x 10^{-3})			OF TOT. UNIVERSITY AV/YEAR (x 10^{-3})	
		TOTAL (C_{rg})	BUILDINGS (C_{Bg})	OTHER (C_{OE})	ADMIN.	LIBRARY
1	£	956	784	172	45	109
2	£	637	405	232	66	10
3	£	1675	971	704	11	142
4	$ Can.	6890	6740	150	14	1800
5	$ U.S.	6280	4860	1420	150	2000
6	$ U.S.	12600	7720	4880	3740	-
7	F. FR.	-	-	-	-	-
8	B. FR.	258000	72000	186000	5680	1580
9	N. KR.	22800	15100	7700	72	50
10	N. KR.	20240	13160	7080	46	5
11	GUILD.	25500	17100	8400	2610	30
12	GUILD.	14160	13520	642	-	-
13	T.L.	-	29200	-	56400	-
14	$ U.S.	9200	4680	4520	2920	13
15	DINARS	630000	-	-	-	72300

* These are largely for the period 1965-69 inclusive.

Table 42. Ratio Distribution of Average Annual Capital Expenditures

Region	Univ.	Factor of Total Annual Average Capital Expenditure			
		Building	Other	Admin.	Library
U.K.	1 2 3	.82 .64 .58	.18 .36 .42	.047 .104 .007	.114 .016 .085
	Av.	.68	.32	.053	.072
N.A.	4 5 6	.98 .77 .61	.02 .23 .39	.002 .024 .297	.261 .318 -
	Av.	.79	.21	.108	.290
EUR.	7 8 9 10 11 12 13 14 15	- .28 .66 .65 .67 .95 - .51 -	- .72 .34 .35 .33 .05 - .49 -	- .022 .003 .002 .102 - - .317 -	- .006 .002 .000 .001 - - .001 .115
	Av.	.62	.38	.089	.021
Overall Av.		.68	.32	.084	.084

Percentage growth $g = \frac{s_u(S_2 - S_1)\,100}{s_u\,S_1} = 100\,\frac{(S_2 - S_1)}{S_1}$ .... (1)

where s_u = overall student/staff ratio for the university.

S_1 = number of staff at year 1

S_2 = number of staff at year 2

If the university is reasonably well established then:

Let total building capital value at year 1 = C_1

Capital value per staff member = $\frac{C_1}{S_1}$

Let C_{Bg} = annual building capital from year 1 to year 2 (i.e. the "building" growth capital)

Then $C_{Bg} = \frac{C_1}{S_1}\,.(S_2 - S_1)$ and using equation (1).

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$$C_{Bg} = \frac{C_1\ g}{100} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

However C_1 is not known from the data supplied but is a function of building area i.e.

$$C_1 = k.\ A_{T_1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where A_T = total building area of the university relative to S_T staff

k = cost per unit area (all building types).

Thus from equation (3) and (2):

$$C_{Bg} = \frac{k.\ A_T.\ g}{100} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

k will of course vary across countries according to a complex cost index but assuming this index is approximately proportional to the average salary of total staff in the various universities (and which also probably reflects their nature and individual cost indices), then k can be determined as follows:

Let: R_s = total university annual remuneration for all staff in the country's <u>own currency</u>.

N_T = total university staff associated with R_s

e = currency rate of exchange index

X = <u>suffix</u> relating to a specific country where r = 1.

Then: Average cost/staff $= \frac{1}{e} \cdot \frac{R_s}{N_T}$ in equivalent currency of country X.

and if the value for k for country X is known then:

$$k = \frac{R_s}{e\ N_T} \left[\frac{N_T.\ k}{R_s}\right]_X \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

which if $[\ \ ]_X$ is known for country X then k can be calculated for any university from data given.

Also from (4) and (5):

$$g = \frac{100\ C_{Bg}}{k.\ A_T} = \frac{100\ C_{Bg}}{A_{T1}}\ e\ \frac{N_T}{R_s} \left[\frac{R_s}{k.N_T}\right]_X \qquad \ldots\ldots\ldots\ldots \quad (6)$$

<u>NOTE</u>: A good value for k in the U.K. is £60 per m^2 based on U.G.C. estimates for <u>1967/68</u> (a mean of the 5 year period 1965-69) i.e.

$$g = \frac{100\ C}{A_T} \cdot e\ \frac{N_T}{R_s} \cdot \left[\frac{R_S}{60\ N_T}\right]_X \qquad \ldots\ldots\ldots\ldots \quad (7)$$

This method is obviously very approximate and highly simplified but it enables the available data to be used to estimate growth orders and comparative values across countries. It is proposed to extend this type of analysis in later work as it may provide a link between building and "true" capital and, possibly, with recurrent expenditure. The results of application of this analysis to the 15-universities is presented in table 43.

The values for growth (g) in table 43 are clearly of the right order (generally established universities avoid very high growth rates because of the discontinuity involved and most rates are in the range 0% - 20%).

The average rate of about 18% is relatively high but includes some young and rapidly developing universities. A more realistic figure for the well established universities would appear to be about 9% annual growth (i.e. a doubling of student population in about 9 years).

It should be noted that the analysis ignores lag effects and this suggests that any extended analysis along these lines (especially where recurrent expenditure capital related analysis is included) should be on a time-dependent basis.

Comparative Observations on Capital and Recurrent Expenditure: Using the above work on the growth of building capital (g), and standardized cost data, based on a cost index of a modified value of the building index k (see table 21), it is possible to reduce capital costs other than building to a 'basic' true cost. This is the element C_g introduced in equation (47) of section 3.5., Chapter 2.

It is assumed that the growth element in other than building capital can be removed by using a simple growth factor correction as follows:

$$\text{"Basic" average annual capital} = C_b = \cdot C_{og} \cdot (1 - g) \quad \dots (8)$$

where C_{og} = total "other than building" annual capital (average) expenditure.

The results of all these considerations together with raw data are given in table 44 below. Overall building to recurrent is about 30% for the five year period and "other" than building capital is about one-third of this. It is intended only as a lead to a wider study of the problem in depth.

The standardized expenditure values cannot be compared directly because of the varying size of the universities. However when plotted against student, academic staff and total staff numbers, these gave an approximation to linearity. There were no obvious indications of economics of scale. The total recurrent expenditure plot against total staff was a good linear fit (passing through the origin) and gave a slope value of approximately £3000 equivalent standardized with little regional variation. However since the cost index was based largely on total staff remuneration which is itself a large part of the total recurrent expenditure this result is not surprising. In all cases deviation was less with the total staff and academic staff plots than with the students (which is generally true of most of the data analysed in this note). Recurrent expenditures tended to be better with total staff plots and capital expenditures with academic staff. The "basic" or true capital average annual expenditure (i.e. with an approximate building element removed) clearly gave an improved linearity but still some isolated large scatter points. Apart from the smallness of the sample plot this latter could well be due to research finance complications relative to the staff numbers provided in the raw data. Thus in any study in depth on finance both building and research costs must be included in detail.

TABLE 43

ANNUAL BUILDING CAPITAL GROWTH - APPROXIMATE AVERAGES

REGION	UNIV	* CURRENCY	BUILDING CAPITAL AVERAGE PER YEAR. (G_{Bg})(CURRENCY OF COUNTRY)	TOTAL FLOOR AREA OF BUILDING AT m^2 (A_T)	R_s/N_T AV. COST PER STAFF (CURRENCY OF COUNTRY) (R_S/N_T)	COST PER UNIT BUILDING AREA m^2 (k) (CURRENCY OF COUNTRY)	AVERAGE ANNUAL GROWTH (g%)
U.K.	1	£	784000	40946	1762	60	31.9
	2	£	405000	59125	1781	60.6	11.3
	3	£	971000	53362	1743	59.3	30.7
	Av						24.6
N.A.	4	$ Can	6740000	-	-	(240)	-
	5	$ US	4860000	391164	8695	296	4.2
	6	$ US	7720000	565246	7016	239	5.7
	Av						5.0
EUR.	7	F.FR	-	-	-	(950)	-
	8	B.FR	72000000	222289	299341	10193	3.2
	9	N.KR	15100000	-	37791	1287	-
	10	N.KR	13160000	89100	42908	1461	10.1
	11	GUILD	17100000	193237	17466	595	14.9
	12	GUILD	1352000	35698	27196	926	40.9
	13	T.L.	29200000	62360	-	(1440)	32.5
	14	$ US	4680000	188614	5130	175	14.2
	15	DIN.	-	-	33256	1132	-
	Av						19.3
Overall Av							18.1

NOTE: * The rate of exchange index for 1968/69 (U.K. = 1) is given in section 3.2.5 and the value of **k** in equivalent £ are given in table 21 of section 2.4.3.

COMPARATIVE CAPITAL AND RECURRENT EXPENDITURE DATA

TABLE 44

REGION	UNIV	AVERAGED ANNUAL CAPITAL RATIOS: BUILD.CAP / TOT.RECURR. (C_{Bg}/R_T)	'OTHER' CAPITAL / TOT.RECURR. (C_{Og}/R_T)	TOTAL CAPITAL / TOT.RECURR. (C_{Tg}/R_T)	* STANDARDIZED COMPARATIVE DATA: TOTAL ANNUAL RECURRENT EQUIV. £ x 10^{-3} (R_T)	RECURRENT LESS REMUNERATION. EQUIV. £ x 10^{-3} (R_E)	"OTHER" CAPITAL AV. ANNUAL EQUIV. £ x 10^{-3} (C_o)	"BASIC" CAPITAL AV. ANNUAL EQUIV. £ x 10^{-3} (C_b)
U.K.	1	–	–	–	–	862	172	117
	2	.123	.070	.193	3258	1357	230	204
	3	.304	.220	.524	3330	1257	734	509
	Av	.214	.145	.359				
N.A.	4	.345	.008	.353	4885	2246	39	–
	5	.056	.016	.072	19674	5940	324	310
	6	.080	.051	.131	25009	12329	1264	1192
	Av	.160	.025	.185				
EUR.	7	–	–	–	–	–	–	–
	8	–	–	–	–	–	1092	–
	9	.218	.111	.329	3428	1241	380	–
	10	.188	.101	.289	2870	1182	291	262
	11	.172	.085	.257	9578	4263	812	691
	12	1.134	.054	1.188	920	204	50	30
	13	–	–	–	–	–	–	–
	14	.347	.335	.682	3929	2127	1315	1128
	15	–	–	–	–	396	–	–
	Av	.412	.137	.549				
Overall Av		.297	.105	.402				

* Based on cost indices given in table 46.
Averaged annual capital values generally averaged over five years (1965/69)

STANDARDIZED COMPARATIVE
RECURRENT: CAPITAL EXPENDITURES PER STAFF MEMBER

TABLE 45

REGION	UNIV	*STANDARDIZED COMPARATIVE DATA: RECURR. LESS REMUN. EQUIV £ PER STAFF (R_E)		"OTHER" ANNUAL AV. CAPITAL EQUIV. £ PER STAFF (C_o)		"BASIC" CAPITAL AV. ANNUAL EQUIV. £ PER STAFF (C_b)	
		PER TOT. STAFF (R_E/N_T)	PER ACAD. STAFF (R_E/S_T)	PER TOT. STAFF (C_o/N_T)	PER ACAD. STAFF (C_o/S_T)	PER TOT. STAFF (C_b/N_T)	PER ACAD. STAFF (C_b/S_T)
U.K.	1	1645	3849	328	768	223	522
	2	1259	3249	213	550	189	488
	3	1102	3699	643	2160	446	1497
	Av	1335	3599	395	1159	286	836
N.A.	4	–	–	–	–	–	–
	5	858	4250	47	231	45	221
	6	1458	4746	149	486	141	459
	Av	1158	4498	98	359	93	340
EUR.	7	–	–	–	–	–	–
	8	–	–	–	–	–	–
	9	1059	2095	–	–	–	–
	10	1235	2474	304	609	274	548
	11	1355	2762	258	526	220	448
	12	598	1121	147	275	88	165
	13	–	–	–	–	–	–
	14	1761	2559	1089	1584	934	1359
	15	246	469	–	–	–	–
	Av	1042	1913	450	749	379	630
Overall Av		1143	2843	353	799	284	634

*Based on cost indices given in Section 2.4.3.
Annual capital values generally averaged over the five year period 1965-69.

CONVERSION EXCHANGE RATES and APPROXIMATE COST INDICES FOR INTERNATIONAL COMPARISONS

TABLE 46

REGION	UNIV	CURRENCY	1968/69 EXCHANGE RATE (e)	BUILDING COST VALUE (EQUIV. £ PER m^2)	GENERAL COST INDEX. (1968/69)	COST CONVERSION FACTOR FOR EQUIV. *£ (1968/69) "STANDARDIZED" (£)
U.K.	1	£	1	60.0	1.00	1.000
	2	£	1	60.6	1.01	0.990
	3	£	1	59.3	0.96	1.042
	Av.			60.0	0.99	
N.A.	4	$ Can.	2.6	92.3	1.54	0.250
	5	$ U.S.	2.4	123.0	1.83	0.228
	6	$ U.S.	2.4	99.6	1.61	0.259
	Av.			105.0	1.66	
EUR.	7	F. FR	11.85	80.2	1.34	0.0630
	8	B. FR	120	84.9	1.42	0.00587
	9	N. KR	17.14	75.1	1.18	0.0494
	10	N. KR	17.14	85.2	1.42	0.0411
	11	GUILD	8.69	68.5	1.19	0.0967
	12	GUILD	8.69	107.0	1.49	0.0772
	13	T.U.	21.6	66.7	1.11	0.0417
	14	$ U.S.	2.4	72.9	1.43	0.291
	15	DINARS	30.0	37.7	0.52	0.0641
	Av.			75.4	1.23	
Overall Av.				78.2	1.27	

* Multiplying the cost in the country's currency by this factor provides the "standardized" cost in equivalent £.

Despite the scatter on the "basic" capital plot a very approximate figure of £480 equivalent standardized per academic staff member was obtained.

The figures in table 45 demonstrate the variations due to building and, possibly, research referred to previously. In general recurrent expenditure less remuneration per total staff member is fairly constant across the regions being about £1140 per total staff overall. The greater consistency with total staff rather than academic staff is also apparent. The capital expenditure values demonstrate the greater consistency with academic staff but also emphasise the caution that should be exercised in their interpretation. A study of the "basic" capital cost columns shows that the value of £480 equivalent standardized per academic staff member would give a rough guide in the absence of better data.

2.4.3. Conversion Exchange Rates and Approximate Cost Indices.

The indices set out in table 46 have been used throughout the discussions of expenditure above, and at the appropriate points in the preparation of the parameter values of section 4 of Chapter 3.

Building costs have been based on an approximate cost index of equivalent £ per square meter, deduced from average total staff salaries for the various universities (which also reflect the individual nature and relative cost, within a region, of these universities).

The cost indices are based on a more detailed review of average salaries of the various university groups and cost data generally. Cost conversion factors combine these indices with the exchange rates for the country concerned to provide "standardized" data - referred to as £ equivalent "standardized" in the text, for comparative purposes.

It is emphasized that although exchange rates are official values the other indices are only approximate and should be used with caution.

3. Further Data Observations on a Larger International Survey.

Two sets ~~of~~ values of parameters, developed in the overall university model of Chapter 2, have been incorporated in section 4 of that chapter. The above observations based on the 15-university sample supplement the first set. In this part further observations on the larger 80-university survey, which may not have been required for immediate use in the model evaluation, are presented. The majority of these have particular relevance to the departmental academic, support, and administrative staff formulations in "both" the overall model and the departmental model (Chapter 3).

Part 3.3. of this section provides an evaluation of some additional parameters utilized in the more conceptual departmental model of Chapter 3.

In the 80-university survey the data reduction is divided into five geographical groupings comprised as follows:

Group A North America	Group B United Kingdom	Group C Scandinavia	Group D Predominantly EEC	Group E "Other" European
United States	England	Denmark	Germany	Spain
Canada	Wales	Norway	Austria	Greece
	Ireland	Sweden	Belgium	Portugal
		Finland	France	Turkey
		Iceland	Italy	Yugoslavia
			Netherlands	
			Luxembourg	
			Switzerland	

3.1. Overall University Data

The following observations are derived from table 47.

Table 47. Overall University Data

Item		Area Group A	Area Group B	Area Group C	Area Group D	Area Group E	All
Av. No. of Faculties		7.4	4.6	5.4	7.3	6.1	6.5
Av. No. of Spec. Insts. Centres		9.8	7.0	3.4	5.2	5.3	6.2
Inst. per Faculty (Av.)		1.32	1.52	0.63	0.71	0.87	0.92
Av. No. Short Cours. /year		63	46	44	15	46	44
Av. Length of Each Short Cours. (days)		9.1	6.6	6.2	9.9	7.9	7.9
Av. No. Students/ Short Course		76	25	45	42	43	48
Relative intensity of effort index (1)		16.0	25.7	17.5	5.5	41.1	23.6
% E.F.T. Staff used for Short Courses (Approx.)		4.2	11.0	5.4	1.1	8.9	6.1
% Students in Resid. (3)		27.3	36.8	14.1	18.2	21.9	24.2
% Students in Resid. (4)		24.3	36.8	2.0	13.4	21.9	18.5
% E.F.T. part-time of total acad. staff		8.5	1.7	8.5	22.1	21.8	13.0
% E.F.T. part-time of total acad. staff (4)		5.3	1.7	8.5	13.3	9.4	8.8
% Servicing from one faculty ~~to another~~ (Av.)		29	18	27	31	16	23
Servicing received by	Med. Sc.	App.Sc./Tech	Soc.Sc./Ed./Law	Pure Sc.	Educat.	Ag.&Forest.	Humanit.
Subj.Class.	Z1	22	23	17	48	56	15
% Students in Ind. (sandwich) (5)		2.1	1.7 | 26.0	0	9.0	7.3	5.5 | 26
Av. Hrs. visiting/ year/student		45 (all)					
% Central Adm. (by Staff)		54	56	44	34	39	44
Library: Total Volumes (Av.)		977000	166000	1088000	759000	310000	702000
Volumes/Acad.Staff		1154	535	1300	898	1576	1060
Total periodicals/ year		9976	2140	9752	7430	2180	6890
Periodicals/Acad. Staff		13.6	7.2	13.2	9.4	5.6	10.1

NOTES:

(1) This index represents the relative intensity of effort on short courses and is given by the average for all universities in each group of [(No. courses) X (Av. length) X (Av. students/course)] ÷ (No. Acad. Staff) = $(d/_s)$.

(2) An approximate estimate of the percentage of total staff resource taken up by short course activity and given by:

$$\% = 0.175 \cdot \frac{d}{s} \cdot \frac{(1+s)}{g}$$

where (1 + s) = student lecture and seminar hours/week loading (graduate)

g = graduate average group (tutorial) size

See also (1) above.

(3) Allowance is made in these figures for sandwich type students who are out in industry and hence would not require residence.

(4) A number of universities gave no return but suggested that the activity was nil. The second set of figures reflects this but it is probably pessimistic especially for part-time staff.

(5) The alternative (and greater) figures for B(i.e. the U.K.) are for formal sandwich courses reflecting approximately 1 year out of 4 in industry.

Faculties and Institutes: The trend is to a larger number of faculties in North America and Europe, with Scandinavia and the U.K. countries less. (Probably a reflection of larger student populations the former). The relative number of institutes to faculties is higher in N.A. and U.K. than elsewhere.

Short Courses: The greatest intensity of effort in short courses is in "other" European countries and U.K., with N.A. less so. EEC Europe and Scandinavia represents a relatively small effort. N.A. has large group sizes (about 75) whereas U.K. has small ones (about 25) with Europe generally in between (about 43). Average course length is between 1 and 2 weeks it being largest in N.A. (9 days), near this in Europe (8 days) and least in U.K. (6 days). An approximate estimate of the percentage of total staff required for short course activity varies up to about 10% with average about 6%. U.K. is highest at 11%. "Other" Europe at 9% and the remainder in the 1-5% region. This represents an average less than half the equivalent staffing detained from graduate student teaching. The above applies to those universities doing short course work.

Student Residence: In general % age residence varies on average up to 40% between regions. U.K. and N.A. (30% - 40%) have more university organized residential accomodation than Europe, with Scandinavia quite small. Overall the provision is about 20%.

Part-time Staff: This is difficult to assess since some universities clearly did not give the effective full-time equivalent staff value and others did not indicate at all. Most universities make use of part-time staff, with greatest reliance on them being in the EEC and "Other" European countries (10% - 20%), less in Scandinavia and North America (5% - 8%) and very little in the U.K. (2%). Individual variation of up to 40% occur, but overall F.T.E. part-time staff averages 10% of total academic staff.

Service-Teaching Between Faculties: Information was very poor on this and often misinterpreted. Practically no university had estimated staff loading from service teaching. Generally the information provided represented service received by students from staff of other faculties. The latter approximated 23% overall, but ignoring smaller values (which related to staff loading), all the group values lay between 22 and 29% with an average of 26%. Very scanty evidence suggested that staff loading for serving other faculties was about 6% - 10% of total academic staff duties. The indications from subject classification show 15% - 23% servicing received by the more formal and established faculties (Humanities, Pure Science, Medicine, etc.) whilst the value is about 50% for the more vocational disciplines (Education, Agriculture/Forestry).

Sandwich Courses: Only universities in the U.K. ran full formal sandwich programmes, in which the percentage of students in industry was 26% (i.e. one year in four). For other less formal programmes the group average was about 6% in industry, though rather greater in EEC Europe and "Other" Europe. Most of these programmes appear associated with Technology. Only five universities provided a value for average hours spent visiting students in industry, but these values did not vary excessively, and averaged 48 hours per year per student, based on 4 visits per year to each student. This represents, very roughly, about 0.1 staff per sandwich student on academic teaching hours scales, or about 0.03 staff per sandwich student based on a 35 hour working week. Thus full sandwich courses could imply up to 20% increase in staff.

Central Administration: This was based on staff numbers and defines the percentage of staff employed centrally, the remainder being distributed into faculties, departments etc. Central administrative staff averages 55% of total administrative support in N.A. and U.K. universities, and about 40% for European universities. The overall average of central/departmental or faculty administrative staff is 44%. There is considerable inter-regional variation. In terms of cost these proportions would be almost certainly higher as higher grades are often recruited centrally.

Library - Volumes and Periodicals: There is considerable variation in total volumes in libraries, from 166,000 in U.K. to 1,088,000 in Scandinavia. However values per academic staff member do not vary so widely. Overall the latter is 1000 volumes/academic staff which could be regarded as the minimum desirable. U.K. is about half this, although the sample is almost entirely "new" universities. "Other" European and Scandinavian are 50% and 30% more, respectively. N.A. and "EEC" countries approach the average. To some extent these results reflect the methods of teaching adopted. There is again considerable variation in the absolute totals of periodicals received annually, which vary from 2,000 in the U.K. and "Other" European universities to 10,000 for N.A. and Scandinavian. Again, the value of periodicals per academic staff member is more uniform, varying from 5.6 to 13.6, in similar rankings to the totals. Clearly language and cost are vital factors. A rough desirable overall value might be about 10 periodicals per staff member, i.e. about 100 volumes per periodical. Clearly a full analysis must include such factors as research, subject coverage and nature, special institutes, ability and dependence on different languages etc. It must also include time-dependence as volume capacity is clearly a function of time for collections to grow to large size.

3.2. Faculty Data

The following observations relate to table 48.

Student Teaching: Overall there is few first degree students providing teaching support and where it is undertaken, it is usually limited to under 2 hours/week. There is considerably more higher degree student (graduate) teaching, and the teaching referred to here does not include full-time paid assistants working for degrees. North America allows more hours per week at 8.8 than other group (but Canada generally limits this to well below 6). This compares with 4.5 hours per week in the U.K., and an overall average of 6.3 hours per week. N.A. and U.K. utilize graduates more for teaching support, particularly laboratory supervision, than Europe. Where such support is effected, the number of graduates students involved can be up to one-third of the total academic staff number. The percentage of equivalent full-time teaching staff derived from this information suggests that graduate student teaching is about 15% for N.A. and U.K. and half this for Europe.

Research Supervision: Only a limited number of results were available and the tabulated figures include both faculty and departmental values (the latter being derived for total data). The general range for almost all values was between 1.0 and 1.5 hours/week although medicine was quoted nearer to 4.0 and this biassed all other subject classifications. Thus a good overall value excluding medicine is about 1.2 hours/week. A number of the values also indicated project type supervision at first degree/diploma and higher levels (by programmes of study) and from these it is suggested that 0.5 and 0.75 hours/week would be reasonable approximations in the absence of more accurate data.

Table 48. Faculty Data - 80-University Survey

Item	Regional Group					All
	N.A. A	U.K. B	Scandinavia C	Predom. EEC D	"Other" Europe E	
Teach. Hrs./Week (Grads).	8.8	4.5	5.0	9.0	4.9	6.3
% Teach. Grads/Acad. Staff	0.435	0.616	0.128	0.132	0.486	0.347
%F.T.E. Grad. Teachers of Acad. Staff *	15.6	14.3	4.3	9.4	18.3	12.9
Research Supervision Hrs./ Week/Stud.	1.0	1.0	-	2.9	1.8	1.4
Research Supervision Hrs./ Week/Stud. (Exclud. Medicine)						1.21

* This is based on an effective staff loading of 13 hours/week for this type of work

3.3. Evaluation of Some Parameters for the Departmental Conceptual Model

Section 2.2. of Chapter 3, develops equation (16) for academic staff estimation in terms of the basic governing parameters. These parameters will in general vary with subject classification and geographical region. The data survey of reference 1 provides data at subject departmental level from which such parameters can be evaluated by aggregation. Since the data is computerized it was programmed to determine the results given below. In order to eliminate data inconsistencies as far as possible a careful survey of the raw data was also effected. A study of the detailed results suggested that the original 10 subject classifications chosen could be reduced to the following 6 classifications:

Classification No.	Broad Subject Area
1	Pure Science
2	Applied Science, Technology, Agriculture
3	Medical Sciences
4	Humanities and Arts
5	Education
6	Social Sciences and Law

(For individual subjects within this broad classification see Chapter 4, table 26).

The following values of l, s and g were then estimated for first degree/diploma and higher/degree diploma using some 190 sets of departmental data (but distributed principally in the areas of pure science, technology, humanities and social sciences).

Table 49. Values of Departmental Teaching Parameters, By Subject Area.

Subject Classif. No.	First			Higher		
	l_{12}	s_{12}	g_{12}	l_3	s_3	g_3
1.	9.8	9.3	1.70	6.2	9.2	8.0
2.	14.4	10.9	17.0	11.2	10.3	9.0
3.	14.4	10.4	17.0	9.7	10.5	13.3
4.	10.6	5.3	16.0	8.0	4.7	7.5
5.	11.2	4.9	13.0	7.8	4.6	7.5
6.	13.7	4.8	17.5	10.2	5.0	11.0
All	12.2	8.1	16.5	9.1	7.3	10.0

In order to calculate the required parameters it is necessary to have a knowledge of h_l and h_s and this is not provided directly from the data of reference 1. However it can be derived from the data analysis parameters derived in section 2 above, together with an assumption relating h_l and h_s. This method is outlined below: from section 2 (above):

The overall value of academic weekly loads for all level of teaching are given by B where:

$$B = \frac{\text{total staff teaching hours}}{\text{total academic staff}} = \frac{T_F + T_H}{D_A} \text{ for a département} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ 3.3.1.$$

where T_F = total average scheduled staff hours given for first degrees/diplomas (lecture + seminar).

T_H = total average scheduled staff hours given for higher degrees/diplomas (lecture + seminar + research supervision)

This notation is the same as used in Appendix A2.5 of Chapter 3.

The problem is to determine values of staff loading for first degree/diploma teaching only since these are the values (h_1 and h_s) used in the academic staff equations of section 2, Chapter 3.

Also from section 2 of this chapter:

$$C = \frac{T_F}{T_H + T_F} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.3.2.$$

Hence from 3.3.1. and 3.3.2.:

$$\frac{T_F}{D_A} = B.C. \qquad \frac{T_H}{D_A} = B(1-C) \quad \ldots\ldots\ldots\ldots\ldots\ldots \; 3.3.3.$$

Let h_o = average (tutorial and lecture) first degree/diploma academic staff loading (hours/week)

$$\text{Then } h_o = \frac{T_F + k_3 \cdot T_H}{D_A} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.3.4.$$

using section 2, Chapter 3.

and substituting equation 3.3.3.:

$$h_o = B[C - k_3(C - 1)]$$

using the value of $k_3 = 1.5$, from Appendix 1, Chapter 3,

$$h_o = B(1.5 - 0.5\,C) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.3.5.$$

Let $h_s = m \cdot h_1$

$$\text{Then } h_o = \frac{h_1 + h_s}{2} = \frac{(1 + m)}{2} \cdot h_1$$

$$\text{and } h_1 = \frac{2}{(1 + m)} \cdot h_o \qquad h_s = \frac{2m}{(1 + m)} \cdot h_o \quad \ldots\ldots\ldots\ldots \; 3.3.6.$$

Previous application in the U.K. used a value of $m = 1.5$ but this was generally considered too high by academic staff and a value of $m = 1.25$ was agreed. Substituting this latter value in equation 3.3.6. and using 3.3.5 gives:

$$h_1 = 0.890\,B\,(1.5 - 0.5C)$$

$$h_s = 1.25\,h_1 = 1.111\,B\,(1.5 - 0.5C) \quad \ldots\ldots\ldots\ldots\ldots\ldots \; 3.3.7.$$

Table 28 above provides computerised values of B and C for all university departments. The subject classification values for h_1 and h_s are presented in table 50.

Table 50. Values for Average Staff Teaching Loads per Week

Subject Classif. No.	B	C	h_o	h_1 Hrs./Week	h_s Hrs./Week
1	8.08	0.684	9.36	8.33	10.40
2	10.12	0.780	11.25	10.00	12.50
3	8.14	0.762	9.12	8.12	10.15
4	9.52	0.772	10.60	9.44	11.80
5	10.10	0.624	11.98	10.65	13.30
6	8.70	0.724	9.89	8.80	11.00
All	9.16	0.728	10.40	9.26	11.58

Thus using these values of h_1 and h_s together with the values of s, l and g above gives the subject classification parameters in the following table 51.

Table 51. Subject Classification Parameter Values

Subject Classif. No.	l_{12}/h_1	l_3/k_1	$s_{12}/g_1 \cdot h_s$	$s_3/g_3 \cdot h_5$	u	v	h_T
1	1.18	0.75	0.0525	0.1103	0.636	2.100	10.40
2	1.44	0.12	0.0513	0.0915	0.778	1.780	12.50
3	1.78	1.19	0.0602	0.0778	0.669	1.292	10.15
4	1.13	0.85	0.0281	0.0530	0.752	1.887	11.80
5	0.96	0.73	0.0283	0.0461	0.760	1.629	13.30
6	1.56	1.16	0.0250	0.0413	0.744	1.652	11.00
All	1.32	0.98	0.0423	0.0630	0.747	1.491	11.58

where: $u = l_3/l_1$ $\qquad v = \dfrac{s_3/g_3}{s_1/g_1}$

The above process can be repeated to investigate geographical regional variation. However as subject classification appeared to be more significant the exercise was limited to determining weighting factors for various geographical regions based on aggregated overall data. The resulting values are quoted directly in table 13 of Chapter 3.

TABLE 52

APPENDIX A_3

Aggregated departmental data by subject classification for all sample universities

CLASS	UNIV	(i) TOTAL STAFF (D_T)	(ii) ACAD. STAFF (D_A)	(iii) TOTAL TEACH HRS (T_T)	(iv) 1ST DEG TEACH HRS (T_U)	(v) TOTAL STUD. (F_T)	(vi) 1ST DEG STUDENT (F_U)	TOTAL (vii) RECURRENT EXPENDITURE (V_T)	(viii) TOTAL STAFF REM. (V_N)	(ix) AC. ST. REM. (V_A)
1	1	171	87	852	580	541	453	438000	290000	207000
	2	226	135	(1050)	804	960	799	556000	470000	379000
	3	304	143	1506	690	1356	1055	1329000	1117000	443000
	4	112	78	1071	528	910	718	363000	335000	290000
	5	333	265	1775	1280	718	274	(123000)	986000	912000
	7	201	133	1141	679	3469	2627	485000	353000	297000
	8	610	297	990	308	1028	610	(1250000)	(1009000)	(569000)
	9	370	213	(2190)	(1100)	2109	1198	880000	697000	504000
	10	245	160	1929	1929	3959	3959	508000	416000	322000
	11	881	410	(3750)	(1980)	2161	1311	1682000	1358000	963000
	13	298	135	438	387	2720	2668	(598000)	(526000)	367000
	14	199	132	512	440	2515	2475	(327000)	(262000)	181000
	15	349	188	2566	2114	1928	1928	736000	557000	490000
TOTAL		4299	2376	19770	12819	24374	20085	10379000	8367000	5924000
AV		331	183	1521	986	1875	1545	714000	644000	456000
2	6	(67)	53	(28)	(11)	337	143	(247000)	(202000)	174000
	10	62	52	679	679	277	277	128000	114000	103000
	15	39	29	309	309	320	320	(135000)	(102000)	(88000)
TOTAL		168	134	1016	999	934	740	510000	418000	365000
AV		56	45	339	333	311	247	170000	139000	122000

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Alternative Comparative Table (Continued)(1)

CLASS	UNIV	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
3	2	244	134	(1530)	993	1377	1170	604000	493000	384000
	3	78	33	364	180	408	310	196000	156000	101000
	4	19	12	146	64	157	114	59000	55000	45000
	6	(763)	417	(598)	(197)	(3052)	1231	2123000	1928000	1225000
	8	(29)	20	138	68	223	152	(75000)	(60000)	(47000)
	10	439	267	3553	3553	2494	2494	867000	730000	536000
	15	277	145	1797	1260	1839	1839	1167000	706000	497000
TOTAL		1849	1028	8226	6315	9550	7310	5091000	4128000	2835000
AV		264	147	1175	902	1364	1044	727000	590000	405000
4	2	76	38	(157)	96	139	102	189000	147000	109000
	5	41	32	20	14	431	406	153000	130000	121000
	7	274	176	19	0	2898	0	(515000)	425000	352000
	8	(21)	14	185	43	402	217	(42000)	(34000)	(23000)
	11	46	22	(110)	(39)	190	113	87000	74000	54000
	13	42	9	(35)	(20)	(396)	(210)	(92000)	(74000)	(24000)
	14	79	51	183	98	398	351	(141000)	(116000)	81000
TOTAL		579	342	709	310	4854	1399	1219000	1000000	764000
AV		83	49	101	44	693	200	174000	143000	109000

Alternative Comparative Table (Continued)(2)

CLASS.	UNIV	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
5	5	48	30	17	5.4	341	246	144000	135000	112000
6	1	98	84	1120	1025	883	820	235000	225000	213000
	2	34	26	134	124	217	212	78000	75000	69000
	4	157	125	1500	879	1321	1032	479000	467000	422000
	5	267	232	3000	2425	3280	499	946000	842000	806000
	6	123	100	48	31	295	202	433000	386000	341000
	7	214	196	1596	1046	(2805)	(205)	(509000)	(454000)	440000
	8	182	108	981	544	1009	664	(365000)	(333000)	(228000)
	9	177	140	1680	1390	1696	1485	443000	402000	360000
	11	322	271	2900	1770	2540	1647	799000	747000	708000
	14	58	45	277	208	326	277	109000	100000	56000
	15	176	125	1125	875	1438	1438	583000	432000	358000
TOT.		1808	1452	14421	10317	15810	8481	4978000	4463000	4001000
Av.		164	132	1311	938	1437	771	453000	406000	364000
7	4	15	12	221	221	172	172	44000	39000	36000
	5	114	91	1700	1370	409	259	419000	357000	333000
	8	(78)	(56)	391	272	852	630	(199000)	(174000)	(146000)
TOT.		207	159	2312	1863	1433	1061	662000	570000	515000
AV.		69	53	771	621	478	354	221000	190000	172000

Alternative Comparative Table (Continued) (3)

CLASS.	UNIV.	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
8	1	13	9	39	0	23	0	47000	23000	20000
	2	10	7	(140)	0	70	0	23000	22000	20000
	4	15	10	167	75	151	36	44000	41000	35000
	5	280	220	4504	1912	5200	3900	993000	820000	661000
	8	28	20	138	68	223	152	(68000)	(54000)	(42000)
	11	20	13	(158)	(131)	249	2066	38000	35000	27000
	14	13	12	75	30	85	0	27000	21000	19000
TOT.		379	291	5221	2215	6001	4294	1240000	1016000	824000
AV.		54	42	746	317	857	613	177000	145000	118000
9	5	43	22	140	140	409	409	143000	135000	100000
	7	45	29	152	140	830	800	(113000)	(85000)	(71000)
	8	(66)	42	185	47	1393	605	(155000)	(138000)	(104000)
	9	11	9	(113)	(113)	241	241	29000	28000	26000
	11	152	120	(1370)	(625)	2233	1274	379000	371000	343000
	12	55	48	1250	600	675	500	(163000)	(145000)	(135000)
	15	50	32	256	192	489	489	159000	126000	97000
TOT.		422	302	3466	1857	6270	4318	1141000	1028000	876000
AV.		60	43	495	265	896	617	163000	147000	125000

Alternative Comparative Table (Continued) (4)

CLASS.	UNIV	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
10	1	89	62	357	230	345	220	235000	162000	139000
	2	94	78	460	317	678	412	229000	219000	203000
	3	229	165	2384	1810	1759	1348	605000	561000	489000
	4	70	56	602	183	496	206	236000	229000	211000
	5	364	289	2886	1965	3835	3182	1360000	1092000	1003000
	6	64	48	74	26	365	153	274000	229000	199000
	7	38	28	203	173	598	598	103000	85000	77000
	8	119	79	755	296	2020	1286	285000	234000	177000
	9	31	27	284	214	226	208	94000	75000	70000
	11	73	57	522	338	687	510	171000	163000	149000
	12	190	134	552	487	(920)	(196)	514000	423000	345000
	13	76	61	287	112	(2230)	(2197)	206000	182000	166000
	14	71	50	251	196	432	394	126000	103000	64000
	15	58	36	504	396	(865)	(865)	303000	141000	112000
TOT		1566	1170	9597	6743	15456	11805	4741000	3898000	3404000
AV		119	84	686	482	1104	843	339000	278000	243000

Figures in brackets denote modified values of basic data to provide consistent figures.

References

1. CERI/OECD. University Information Survey 1968-69. CERI/IM/70.01. (O.E.C.D., Paris, January 1970.)

2. Legg, K.L.C., Note on an Approximate Analytical Approach to University Academic Planning. CERI/IM/69.06. Annex I. (O.E.C.D., Paris, 1969.)

3. Khan, A.G., and Fredrikson, B., A Preliminary Report on the CERI University Information Survey 1968-69. CERI/IM/70.28. (O.E.C.D., Paris, 1970.)

4. Legg, K.L.C., Brief Data Analysis on a 15-University International Sample. CERI/IM/71.27. (O.E.C.D., Paris, 1971.)

5. Legg, K.L.C., A Simple and Approximate International Data-Based University Overall Resource Model. CERI/IM/71.28. (O.E.C.D., Paris, 1971.)

6. Frederikson, B., University Information Survey 1968-69. Report on Data Collection and Processing. CERI/IM/71.21. (O.E.C.D., Paris, 1971.)