

# Does the Choice of University Matter? A Study of the Differences across UK Universities in Life Sciences Students' Degree Performance\*

Massimiliano Bratti<sup>†</sup>

*Department of Economics, University of Warwick*

February 21, 2001

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\*I am deeply indebted to Robin Naylor and Jeremy Smith for helpful comments and data provision. A number of people gave an important contribution in generating the dataset: in particular, Abigail McKnight at LSE, John McClure and Peggy Paul at UCAS, John McNeill in MIS at Warwick, and staff at DfEE, HEFCE, HESA and the Schools Register. I acknowledge both the USR, as the original depositor, and the UK Data Archive for the use of the data-set SN:3456 Universities' Statistical Record. I would also like to thank Riccardo Lucchetti, Luca Mancini, Stefano Staffolani and Stefano Santacroce for useful suggestions. The usual disclaimers apply.

<sup>†</sup>Address for correspondence: Department of economics, University of Warwick, CV4 7AL Coventry, UK. Telephone: +44 (0)24 76523035, fax: +44 (0)24 76523032, email: Massimiliano.Bratti@warwick.ac.uk

**Abstract**

This paper investigates differences across UK universities in 1993 life sciences students' degree performance using individual-level data from the Universities' Statistical Record (USR). Differences across universities are analysed by specifying and estimating a subject-specific educational production function. Even after including a wide range of controls for the quality of students, significant differences emerge across universities in students' degree performance. We apply a two-stage estimation procedure and find evidence that a large part of 'university effects' cannot be explained by the kind of institutional inputs commonly used in the literature on school quality. Finally, we compare the unadjusted ranking of universities based on the proportion of 'good' (first and upper second class honours) degrees awarded with that based on the estimated probability of a 'good' degree obtained from the microeconomic model and find significant differences between the two indicators of universities' performance.

*JEL classification numbers:* I21 J24.

*Keywords:* educational economics, input-output analysis, ordered probit, performance indicators, value-added.

## 1 Introduction

The rapid increase in the number of higher education (HE) institutions in the UK, their significant dependence on public funding and the consequent need to allocate scarce public resources efficiently, has led to public concern regarding the ‘accountability’ of such institutions and to the development of performance indicators (PIs) for higher education institutions.

The aims of building PIs in higher education include both the ‘accountability’ of the UK university system and the development of legitimate ‘league tables’ or rankings of universities against various criteria. Despite the existence of several institutions collecting data on the UK university system<sup>1</sup>, a new organisation, the Performance Indicators Steering Group (PISG) was established in 1997 with the primary aim of constructing PIs<sup>2</sup>. The PISG in its first report set the criteria for the construction of PIs, which emphasised the policy and managerial requirements of government and funding councils. PIs were also meant to fulfill the needs of prospective students and their advisers. In fact, it is likely that given the rising proportion of funding derived from students’ fees, consumer demand will have a greater role in the allocation of resources across universities, and prospective students and their advisers will require greater information to compare the performance of different institutions.

Jarrat (1985:53) divided PIs into *internal performance indicators* including access, progression and degree outcomes of students, *external performance indicators* including employability of graduates and the research record and *operational performance indicators* which relate to the activities of individual departments. PIs were similarly classified by the PISG (HEFCE 1999:6) that elaborated PIs related to: participation of under-represented groups, student progression, learning outcomes (including non-completion), efficiency of learning and teaching, student employment, research output, HE links with industry.

The performance indicators developed by the PISG build on the set of PIs suggested in the influential book of Johnes & Taylor (1990). The common feature of both the Johnes & Taylor’s and the PISG’s PIs is the attention placed

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<sup>1</sup>Among the others the Higher Education Management Statistics Group (HEMS), publishing statistics at both the sector and the institution level and the Higher Education Statistics Agency (HESA) collecting and publishing data on students, staff composition and expenditures for the UK university system.

<sup>2</sup>The first report of the PISG (HEFCE 1999:7) stated: ‘The working group took note of its task to find measures of performance rather than descriptive statistics’.

on the quality of the student intake (i.e. ‘the need to compare like-with-like’) neglected by simple ‘league tables’ reporting performance-related descriptive statistics without taking account of contextual differences across institutions. Another common characteristic is the use of data aggregated across institutions.

The comparison of aggregate data by institution taking account of the average quality of students enrolled represents substantial progress with respect to published ‘league tables’ based on raw (unadjusted) data. However, simply considering the average characteristics of the students enrolled at a specific university can obscure the effect of differences in the distribution of student quality and suffer from *aggregation bias*, compared to analyses which exploit individual student-level data.

Being aware of the potential bias introduced by aggregation, some researchers exploited individual-level data from the Universities’ Statistical Record, to address specific issues concerning the UK university system. McNabb, Pal & Sloane (1998) studied gender differences in degree performance of 1992 university leavers from English and Welsh universities. Smith and Naylor (2000) analysed the degree performance of the 1993 cohort of university leavers focusing on gender differences and differences by type of secondary school attended. Smith, McKnight & Naylor (2000) built PIs related to students’ employability for UK universities using individual-level 1993 USR data. Finally, Smith and Naylor (2001) investigated student drop-out decisions and developed a related PI from USR data. Drawing upon this body of research we exploit individual-level data from the USR in order to address a particular issue relating to Higher Education PIs: we investigate differences across ‘old’ UK universities<sup>3</sup> in 1993 life sciences students’ degree performance. We will motivate the particular choice of this cohort of students and of the subject in section 3. Two major differences with respect to the two previous studies of degree performance cited above are:

1. The adoption of a subject-specific approach and the use of new controls for previous educational qualifications that are likely to mitigate the problem of the non-random selection of students across universities;
2. The use of university dummies (and a two-stage estimation procedure) rather than university inputs in the degree performance equation that,

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<sup>3</sup>The universities established prior to the abolition of the binary divide (between universities and polytechnics) in 1992.

as we will see, helps to obtain consistent estimates of the covariates of interest.

The study of the differences across universities in students' degree performance is an interesting issue for several reasons. Differences in degree performance across universities that remain after controlling for individual characteristics of students can be considered as a measure of the 'value-added' produced by universities and of the effectiveness of the teaching process. If, however, differences across universities in students' degree performance are completely partialled out once one takes account of the quality of students, one can conclude that universities with better results in terms of degree classes awarded are simply selecting better prospective students, and that differences in the quantity and quality of university resources are not important for students' learning outcomes. This evidently has strong consequences in terms of public policy. For example, if funds are allowed on the basis of the proportion of 'good'<sup>4</sup> degrees awarded it would happen that the most selective or 'elitest' universities would receive more funds simply because they select better prospective students even if they do not produce any value-added. Only appropriate statistical modeling can explore this question properly. The analysis of degree performance is important not only to government and funding bodies to have an idea of the 'value-added' produced by universities, but also to prospective students: not least given the substantial economic return to a 'good' degree performance. Dolton & Makepeace (1990) observe that starting salaries are higher for graduates with a 'good' degree result and Smith *et al.* (2000) find that a 'good' degree performance substantially reduces the probability of unemployment and inactivity. Last, but not least, universities themselves are interested in the factors determining a 'good' degree performance for several reasons: for example, for student admission policy or to improve the effectiveness of teaching<sup>5</sup>.

The structure of the paper is as follows. In the next section we introduce an 'economic' model of degree performance, which represents a useful framework for the specification of an educational production function and for the interpretation

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<sup>4</sup>In analogy with the previous literature, in this paper with a 'good' degree we mean a first class or an upper second class honours degree.

<sup>5</sup>The PISG (HEFCE 1999) stated: 'The immediate priority is to publish institutional-level indicators for teaching and research' (p.11) and 'Institutions need to be able to identify entrants with the potential to benefit from higher education, and then to provide the support necessary to maximise their chances of success' (p.16).

of empirical results. In section 3, we specify the educational production function. In section 4, we describe data and variables used in the analysis and discuss the problem of the non-random selection of students across universities. Section 5 reports the results of inter-university comparisons obtained when applying different performance indicators. Section 6 concludes.

## 2 An ‘economic model’ of degree performance

Research on educational outcomes can be distinguished into two main bodies. The first treats schooling as something that is done to students, as in the economic literature based on the educational production function, i.e. the input-output techniques reviewed by Monk (1990). The second focuses on student learning, as in the psychological literature, and typically avoids generalisations across students. In their book, Johnes & Taylor (1990) adopt the first approach, where students are the ‘raw material’ that universities transform into the final output. A legitimate comparison between universities should compare the ‘like-with-like’ and therefore needs to take account of the quality of the ‘raw material’ used (students). This is probably a very extreme representation of the educational process since students are given a completely passive role. We will see in what follows that a more complete economic model of the demand for higher education can offer better insights not only for the empirical specification of educational production functions but also for the interpretation of empirical results<sup>6</sup>.

We consider here a simple model of demand for education. We assume that the individual decides whether to enroll at university and how to allocate her time between alternative activities and that she has a life-time utility function given by:

$$U = \sum_{t=1}^T \beta^t u_t(s_t, h_t, c_t) \quad (1)$$

where  $\beta = \frac{1}{1+r}$  is the discount factor, with  $r > 0$ .  $u_t$  are period felicity func-

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<sup>6</sup>Monk (1990) for example observes that several home and background variables have been included among the inputs into educational production functions without a strong theoretical rationale for their importance (p. 324). The idea of considering the educational production function as a part of a broader utility maximisation problem is also present in McGuckin & Winker (1979).

tions,  $s_t$  leisure time,  $h_t$  is the time devoted to study (i.e. study effort) and  $c_t$  consumption. At this level of the analysis we assume that there exists only one type of tertiary education. The utility function accounts also for the consumption motive of education: individuals may study not only because education produces an economic return but also because they like studying and the consequent cultural enrichment.

Individuals are subject to constraints in each period. They have time constraints:

$$m = s_t + h_t + l_t \quad t = 1, \dots, T \quad (2)$$

where  $m$  is the time available each period and  $l_t$  the time spent working; and budget constraints:

$$c_t = A + wP_{t-1}l_t \quad t = 1, \dots, T \quad (3)$$

where we have adopted the hypothesis of ‘perfectly imperfect capital markets’ (PICM), i.e. individuals must balance their budget each period.  $A$  is the amount of exogenous income (due for example to family transfers) and is equal in every period by assumption.  $wP_{t-1}$  is the salary depending on the economic return to educational performance ( $w$ ) and the educational performance in the previous period ( $P_{t-1}$ ). Past educational performance raises the opportunity cost of studying for current students because the market value of the time spent studying is higher, but at the same time it is an input into the current educational performance function<sup>7</sup>:

$$P_t = f(h_t, I_t, P_{t-1}, a) + \epsilon_t \quad (4)$$

where  $P_t$  is the educational performance at time  $t$ ,  $I_t$  are institutional inputs reflecting the ‘quality’ of the educational institution and  $a$  the innate ability or intelligence of the student, which we assume does not vary over time. This formulation relates to the ‘value-added’ approach<sup>8</sup> where the researcher is interested in the contribution of the factors on the RHS of equation (4) controlling for past educational achievement<sup>9</sup> (i.e. in students’ progress). We assume that

<sup>7</sup>We use the expressions ‘educational production function’ and ‘educational performance function’ exchangeably.

<sup>8</sup>See for example Bowles (1971) and Hanushek (1979).

<sup>9</sup>For an application of the ‘value-added’ approach to the study of students’ performance at secondary school see O’Donoghue, Thomas, Goldstein & Knight (1996).

performance is assessed at the end of each period and that it is uncertain. Uncertainty enters the problem through an additive stochastic term  $\epsilon_t$ .

The problem of the individual is to maximise the expected value of (1) with respect to the choice variables  $s_t$ ,  $l_t$ ,  $h_t$  and  $c_t$  subject to the time and budget constraints. Assuming well behaved functional forms, a demand for education (or study effort) can be obtained as a function of the exogenous variables:

$$h_t = g(A, r, e, w, I_t, P_{t-1}, a) \quad (5)$$

where  $e$  denotes the ‘taste for education’ and represents the parameters of the utility function driving the consumer demand for education. Of course, past educational performance depends on past inputs into the educational performance function. Substituting the demand for effort into the educational performance function we have:

$$P_t = f(g(A, r, e, w, I_t, P_{t-1}, a), I_t, P_{t-1}, a) + \epsilon_t. \quad (6)$$

When we move from the theoretical model to the empirical specification we seldom have information on the effort input ( $h_t$ ). Therefore we are not able to estimate a ‘structural production function’, i.e. equation (4) representing a technical relationship between inputs and outputs into education. We can only estimate the ‘reduced form’ (6) where the technical coefficients of the production function  $f$  are mixed with those of the ‘demand for study effort’, i.e. function  $g$ . This means that among the inputs we do not observe the input of effort but we can estimate nevertheless the effect of the ‘first determinants’ of the demand for study effort, assuming that we can observe all the exogenous variables of the model. A complete model of educational investment helps also to interpret the effects of some factors that are often found significant in estimates of educational performance functions, such as social class or gender, whose main role may be to differentiate the input of effort (i.e. to affect  $h_t$  as a result of differences in tastes, exogenous income or in the economic return to university education) and that have often been interpreted instead as technical coefficients for factors which directly affect performance<sup>10</sup> (i.e. factors not entering (4) through  $h_t$ ). Another advantage of this approach is to underline the central role of the student in the educational process, which has been largely advocated in the literature<sup>11</sup>.

<sup>10</sup>For example biological differences have been advocated to explain gender differences in school performance.

<sup>11</sup>Monk (1990:315) observes that ‘student time and effort are central ingredients in education

The empirical strategy we follow seeks to include among the covariates into the educational performance function variables reflecting heterogeneity in exogenous income, ‘taste for education’, past educational performance, innate ability, institutional effects and the return to educational performance. An implication of the reduced form approach is that since each variable can influence the educational performance through several channels we are not able to disentangle the separate effects. For example if the social class is a proxy for exogenous income  $A$ , and therefore for the tightness of the budget constraint, but it also influences the economic return to educational performance (e.g. through ‘social networks’ university students from higher social classes have access to better jobs), we are only able to estimate the overall effect and not the two separate effects.

### 3 The econometric model

In the theoretical analysis of section 2 we can abandon the hypothesis of homogeneity of education and assume that individuals can choose the subject ( $i$ ) of study and the institution ( $j$ ) where to enroll. In this case the educational performance function is:

$$P_t^{ij} = f^{ij}(g(A, r, e, w, I_t^{ij}, P_{t-1}, a), I_t^{ij}, P_{t-1}, a) + \epsilon_t. \quad (7)$$

The degree performance function becomes subject and institutional specific. Now the subject and the educational institution (i.e.  $I_t^{ij}$ ) are choice variables for the individual. We consider a restrictive version of equation (7), by assuming linearity of  $f^{ij}$  and that the impact of the institution is independent of the characteristics of the student<sup>12</sup>, i.e. there is a subject institutional-specific effect which adds to the effects of the other variables and which can be considered as production, Levin (1993) focuses on the role of students as workers doing the production and not as the raw material processed by educational institutions. Shanahan, Findlay, Cowie, Round, McIver & Barrett (1997) underline the need for a better link between the teaching and the learning side of the educational process, the first stressed by the input-output literature, the second by the psychological literature.

<sup>12</sup>In a linear specification this is equivalent to assuming that institutions are not differentially effective on students with different characteristics.

the ‘value-added’ of the  $i$  institution in the  $j$  subject:

$$P_t^{ij} = \beta_0 + \beta_1 A + \beta_2 r + \beta_3 e + \beta_4 w + \sum_z \beta_{5z} P_{t-1}^{zk} + \beta_6 a + \beta_7 I^{ij} + \epsilon_t. \quad (8)$$

Where  $z$  are the subjects studied at the secondary school and  $k$  the secondary school attended. This is the formulation derived from the theoretical analysis. Unfortunately, we do not have data on all the variables appearing on the RHS of equation (8) and some of them have to be proxied.

Although the PISG (HEFCE, 1999:16) in its report does not recommend subject splits of PIs ‘to keep the number of indicators small enough to be digested’, both intuition and the empirical evidence suggest the presence of differences across subjects in the impact of the covariates included on the RHS of (8) on degree performance. It is natural to think that the impact of a specific type of previous education on degree performance may vary across subjects, e.g. the effect of an A-level<sup>13</sup> in mathematics is probably different if a student engages in the study of mathematics rather than in the study of literature at university, or the university effect can be different across subjects, given that the quality of departments may vary within the same university.<sup>14</sup> Also the empirical evidence drawn from previous work support the presence of differences across subjects. Early work by Nevin (1972) showed that the proportion of ‘good’ degrees awarded varies by subject within the same university. Chapman (1996), for example, find that the impact of previous entry qualifications is very different across subjects and that the proportion of variability in good degrees explained by entry qualifications ranges from 5.3% for politics to 23.5% for mathematics. Clarke (1988), studying gender differences in degree performance, find that the relative under-achievement of females at first class degrees and the general worse performance of males both are less evident at the subject specific than at the

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<sup>13</sup>Compulsory education in Britain ends at age 16. Students wishing to enroll at university must complete two further years of studies and take the General Certificate of Education ‘Advanced’ Level (G.C.E. A-level). Success at two or more A-levels generally qualifies them for university entry. The equivalent examinations for Scotland and Northern Ireland are Scottish and Irish Higher respectively (see Pissarides, 1982).

<sup>14</sup>Furthermore, departments rather than universities are often directly responsible for the admission policy. Since different departments within the same university may apply different admission criteria, we explain in the following section how the adoption of a subject-specific approach is likely to alleviate the problem of the non-random assignment of students to universities.

aggregate level. Smith and Naylor (2000) find that the effect of having attended an independent school on degree performance varies across subjects. For these reasons we decide to focus our attention on a specific subject. Our choice falls on life sciences. It is one of the most popular subjects of study at university in the UK and has a rather well-balanced gender composition. Furthermore, it is a subject field which has been at the centre of much recent public policy discussion. This has focused on the question of the quality of undergraduate life sciences students proceeding to post-graduate study. Clearly the determinants of degree performance are relevant to this. We use the 1993 cohort of university leavers, the same cohort used in Smith *et al.* (2000)<sup>15</sup>.

## 4 Data and variables

Data for the analysis come from the Universities' Statistical Record (USR). The USR was the institution in charge of the collection of the statistical returns from all university institutions in Great Britain which formerly received Exchequer grants from the University Funding Council (UFC), together with corresponding institutions for the Queen's University of Belfast and the University of Ulster. The USR has stored data from the academic year 1972/1973 until 1993/1994 when it was replaced by the Higher Education Statistics Agency (HESA). The USR data are rich in information concerning the academic life and prior educational qualifications of students and includes the entire cohorts of students leaving university each year.

In this paper, we consider students enrolled in life sciences (LS) courses. This means that the analysis is to be considered as conditional on the individual having chosen to enroll in a LS course. We do not address the issue of selection of individuals across subjects. If we adopt an optimising framework the fact that the individual has enrolled in a LS course means that this is the course which maximises her utility taking account of several individual, family, social and local factors<sup>16</sup>.

Another complication with respect to the simple theoretical model of section 3 arises from the fact that the individual has only a limited control on the

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<sup>15</sup>And the last cohort available from the USR.

<sup>16</sup>For an econometric model of college major choice see for example Berger (1988) and Montmarquette, Cannings & Mahseredjian (1997).

choice of university ( $I_t^{ij}$  in the model). In fact, prospective UK tertiary students generally apply to more than one university. In the case that they receive more than one acceptance they decide which university to enroll at. Admission is determined by universities on the basis of several criteria, such as prior educational qualifications, letter of references from previous educational institutions attended, personal interviews, etc. ‘Top ranked’ universities apply more selective criteria of admission and generally have a better quality of student intake. This means, for example, that students with different prior qualifications are not randomly sorted across universities. Since the main focus of the paper is on the assessment of the importance of institutional effects for students’ degree performance, we have a primary concern on the consistency of the estimates of university effects. Unfortunately, since the assignment of students to universities is non-random, the estimates of the university effects are inconsistent if we fail to take account of the selection mechanism. The selection mechanism consists of three stages. At the first stage the individual chooses the universities she wishes to apply to. This first stage of the selection can be ignored at the moment, since the same factors affecting it enter the selection mechanism later. At the second stage universities make their admission choice. This is generally based on prior educational qualifications of students. Other observable characteristics may affect the decision, such as the type of secondary school attended (state school, independent school, etc.) or social class<sup>17</sup>. We can control for these characteristics by including the related covariates in the RHS of the performance equation. The decision of the admission officers may also be affected by other students’ attributes, such as a subjective assessment of motivation, or the performance at interview, which are unobservable to the econometrician. However, common sense suggests that these characteristics, since they are unobservable or based on subjective evaluations, should be of minor importance for the decision and be only marginally relevant<sup>18</sup> (for example between students with the same observed characteristics).

Once the student is offered a place she decides the which institution to enroll at. At this stage the same factors affecting the first stage re-enter the selection

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<sup>17</sup>These factors are found significant by Collier & Mayer (1986) in their estimation of an ‘admission function’ for students applying at Oxford University.

<sup>18</sup>E.g. the student with poor secondary school qualifications but highly motivated would have the burden of justifying his/her past low performance and of persuading admission officers of his/her high learning potential.

mechanism. We may think that the decision is based on some observable factors such as prior educational qualifications, e.g. the individual enrolls in the most selective institution among those where she has been accepted (i.e. that with the highest entry qualifications), or distance from home (i.e. residence), but also on some unobserved factors, such as the preference of the individual for the city where the university is located or the idiosyncratic preference for a certain university. As observed by Barnow, Cain & Goldberger (1981) unbiasedness, in the estimation of institutional effects in this specific case, is attainable only when the variables driving the selection rule are known, quantified and included in the regression equation. The richness of the USR allows the analyst to include almost all the observable variables which are likely to determine the assignment rule. There are only few variables left, mainly truly unobservable variables that we can reasonably think to have only a minor role in determining the assignment rule<sup>19</sup>, to be sufficiently well proxied by the observed variables affecting selection<sup>20</sup> or not to affect degree performance.

Among the individual information available about students leaving universities there is the class of degree awarded. In the UK the degree classification relies on the aggregate percentage of educational credits accumulated during the academic life, even if academic results in the final year of study are generally more heavily weighted. In general the intervals adopted for degree classification are for the highest degree classes: First Class Honours (70% or above), Upper Second Class Honours (60%-69%); Lower Second Class (50%-59%); Third Class Honours (40%-49%).

We aggregate the degree classes in five groups, listed from the lowest to the highest class<sup>21</sup>:

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<sup>19</sup>In this regard the ‘admission function’ for the Oxford University applicants estimated by Collier & Mayer (1986) including observable variables such as A-levels total score, marks in some specific A-level examinations, type of school and social class, performs quite well in terms of fit.

<sup>20</sup>It is the assumption adopted by the *proxying and matching method*, see Blundell, Dearden, Goodman & Reed (1997). A similar approach is followed by Monk (2000) in his analysis of the return to college characteristics. A model of selection on observable and unobservable variables is considered by Dale & Krueger (1999) who estimate the return to attending a more selective college. They use information on the set of colleges at which students were accepted and rejected to remove the effect of unobserved characteristics. Unfortunately at present similar information are not readily available for UK university applicants.

<sup>21</sup>The main aggregation applies to degree classes lower than the Second class. This is mainly because there are marked differences across institutions in the tendency to award

1. fail: failure in the final year of study or drop out for academic reasons;
2. other degree: includes pass degrees, aegrotat degrees, unclassified honours degrees, Fourth class honours degrees, Third class honours degrees and other degree qualifications;
3. Lower Second class honours degree and Undivided Second class honours degrees;
4. Upper Second class honours degree;
5. First class honours degree

Let us assume that educational credits ( $P^*$ ) are obtained according to the following equation:

$$P_s^* = \alpha I_j + \beta X_s + \epsilon_s \quad (9)$$

where the  $I_j$  are university effects,  $X_s$  students' characteristics and  $s$  is the subscript for students. We do not observe the amount of educational credits obtained but only the final degree classification, which is a discrete variable. A possible way to account for the ordered qualitative nature of the outcome variable is to model the degree performance equation as an ordered probit<sup>22</sup>.

The variables included in the analysis can be distinguished into *personal characteristics, family and social background, prior educational qualifications, university effects*.

*Personal characteristics*

Gender and marital status: are included since males and females may have a different taste for specific subjects or different rates of return to various types of education and have therefore different levels of study effort. Married students may have a tighter time constraint and the effect may be different for males and females due to the existence of a *society gender role model* (single female students are the reference group).

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specific classes of degree lower than a Second class honours degree. These classes of degree are awarded anyway to only the 4.73% of 1993 life sciences university leavers. As observed by McNabb *et al.* (1998) two shortcomings of this measure are the comparability of degree results across universities, potentially ensured by the system of external examiners which has, however, been questioned in recent years (see Silver, Stennett & Williams, 1995), and the fact that degree classes are broadly defined.

<sup>22</sup>For some technical notes see Maddala (1983:46-49).

Age group dummies: are included to proxy for different levels of maturity of students. Maturity may affect the input of effort and the degree performance. In general it is observed that performance increases with age (see for example Hoskins, Newstead & Dennis 1997 and McNabb *et al.* 1998). We consider four age groups: <24 (base group), 24-27, 28-33,  $\geq 34$ .

*Academic variables*

Transferred students. We include a dummy for the individuals who transferred to another university during the course to control for the effect of changing the learning environment (non-transferred students are the reference group);

‘Home’ students. We include a dummy for students who remained at the parental address for the full duration of the course. Different speculations are possible for the sign of the effect of this variable: students at home may be engaged in extra-curricular activities (mainly domestic duties) and perform relatively worse than ‘non-home’ students. But the same argument may be used to justify an eventual lower performance of students living in university residences, who may have a more intense ‘social life’ (‘non-home’ students are the reference group).

University dummies are included to pick up the additive university effect described in section 3 (university 11 is the reference group).

Prior educational qualifications. We include a wide range of controls for prior educational qualifications most of which have been omitted in previous studies:

(i) *aslscore*: the individual student’s score in the best three A-levels or AS-levels obtained (out of 30)<sup>23</sup>. It is a measure of secondary school examination results that we interpret as an ability indicator. In fact, since the individual has a time constraint in the allocation of study effort across different subjects and that she may have a different taste for the study of different subjects, if she obtains good results in a high number of subjects studied she can reasonably be considered as relatively more able. The score is computed as follows: A=10 points, B=8 points, C=6 points, D=4 points, E=2 points for A-levels, A=5 points, B=4 points, C=3 points, D=2 points, E=1 point for AS-level<sup>24</sup>;

(ii) *hlscore*: score in the best five Scottish Highers obtained (out of 15). It

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<sup>23</sup>This variable and the scoring system reported below is that commonly applied by the Universities and Colleges Admission Service (UCAS) for the UK.

<sup>24</sup>‘Advanced Supplementary’ level examinations, often taken by students from abroad as a way to meet entry requirements.

is a control for the ability of the student. It is computed as follows: A=3 points, B=2 points, C=1 point;

(iii) *hlescori*: score in the best five Irish Highers obtained (out of 15). It is a control for ability. It is computed as *hlescore*;

(iv) *abiol\**: dummies for the score obtained in the A-level in biology. There are five possible outcomes: A, B, C, D, E. It is included as a measure of aptitude (the quality of the matching with the subject) and of starting knowledge relevant to the study of LS. Students who took and obtained good marks in the A-level or Higher in biology are likely to have a special aptitude towards the study of life sciences and surely some previous knowledge of specific subjects, which may be a prerequisite to further study (see for example Altony 1993);

(v) *alchem\**: dummies for the score obtained in the A-level in chemistry. There are five possible outcomes: A, B, C, D, E;

(vi) *alphys\**: dummies for the score obtained in the A-level in physics. There are five possible outcomes: A, B, C, D, E;

(vii) *almath\**: dummies for the score obtained in the A-level in mathematics. There are five possible outcomes: A, B, C, D, E;

(viii) *hbiol\**: dummies for the score obtained in the Scottish or Irish Higher in biology. There are three possible outcomes: A, B, C;

(ix) *hchem\**: dummies for the score obtained in the Scottish or Irish Higher in chemistry. There are three possible outcomes: A, B, C;

(x) *hphys\**: dummies for the score obtained in the Scottish or Irish Higher in physics. There are three possible outcomes: A, B, C;

(xi) *hmath\**: dummies for the score obtained in the Scottish or Irish Higher in mathematics. There are three possible outcomes: A, B, C.

Past performance in specific subjects can be important for many reasons. Firstly, to assess the relevance of the knowledge of specific subjects to the study of life sciences. Secondly, because the score in subjects like mathematics or physics may be interpreted as a measure of quantitative ability<sup>25</sup>. Finally, admission officers may consider not only the total A-levels or Highers score, but also the type and quality of prior educational qualifications. In this case including the above covariates will help to alleviate the problem of non-random selection of students into different universities and to have consistent estimates

<sup>25</sup>Smith & Naylor (2000) for example find that students who previously studied mathematics, chemistry and physics have a better degree performance.

of university effects.

(xii) other entry qualifications dummies are included to assess if students with non traditional prior qualifications have a disadvantage with respect to entrants with A-levels or Highers. Hoskins *et al.* (1997) and McNabb *et al.* (1998) found for example that mature students with non-traditional qualifications perform relatively well in higher education. They are useful also to alleviate the non-random assignment of non traditional students across universities (implicitly students with A-level qualifications but who did not take any of the subjects biology, chemistry, mathematics and physics are the base group).

(xiii) type and quality of secondary school attended. Department for Education and Employment (DfEE) data on secondary schools were matched with the USR data (see Smith and Naylor 2000). We include these variables mainly as controls for the admission policies adopted by different universities which may prefer students coming from schools with different levels of selectivity or ‘quality’ (comprehensive admission state sector Local Authority school is the reference group).

*Family and social background*

**Social Class.** The USR data set has information on parental occupation, which is mapped into a social class variable. There are nine possible social classes (dummies): professional, intermediate, skilled non manual, skilled manual, partly skilled, unskilled, armed forces, inadequately described, non-workers. There are different rationales for the inclusion of the social class variable. Social class may be a primary determinant of the student effort proxying the tightness of the budget constraint, but also the expected return to education (social networking). It is also a control for the non-random assignment of students with different social backgrounds to universities (intermediate social class is the base group).

**Prior residence.** We include some dummies for the region of prior residence of students (at the county level for UK students, students from abroad are aggregated into a single class). Several reasons can be provided for the inclusion of this variable. If the labour market is not a nation-wide but a mainly local labour market individuals may have different levels of study effort according to the expected local economic return to educational performance (depending on the interaction between supply and demand of specific kinds of human capital). Moreover, it may pick up the effect of the catchment area of the university and

alleviate therefore the selection problem<sup>26</sup> (Warwickshire is the control group).

## 5 Inter-university comparisons

Before describing the results of the analysis it is useful to describe the data.

From the original sample of 1993 life sciences university leavers, we exclude students not aiming at a (first) degree level qualification and students who left university for non-academic reasons. In this selected sample of 8229 students we consider only full-time students enrolled in a 3-year or longer undergraduate life sciences course<sup>27</sup>. The final sample includes 7997 individuals.

Table 1 reports the percentage of students by degree class for the ‘old’ universities. Universities are anonymised following the recommendation of the PISG (HEFCE 1999). The average across all universities in the proportion of Firsts awarded is 8.62 per cent, but there is substantial variation across universities with university 11 awarding a remarkable 38.27 per cent of Firsts and university 45 not awarding Firsts. The same variation is present in the proportion of ‘good’ degrees awarded where the average gap from the best performing university (11) is 33 percentage points. The standard deviation in the proportion of ‘good’ degrees awarded is about 11.

These differences in degree results can be interpreted as a measure of the effectiveness of the teaching process (i.e. ‘value added’) only if students are randomly assigned to universities. Unfortunately, table 2, reporting the distribution of students per institution by social class and average A-level score per A-level entrant, shows that this is hardly the case. As to the two universities mentioned above, university 11 turns out to have the highest percentage of students coming from the professional social class across all universities, 38.3 per cent, and the highest average A-level score per A-level entrant (29 points),

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<sup>26</sup>Collier & Mayer (1986), for example, found that the area of the country from which the applicants come matters in determining the likelihood of being accepted at Oxford University.

<sup>27</sup>For part-time students the effect of the covariates included on the RHS of the educational production function, especially of those determining study effort, is likely to be different from that of full-time students, since they have a tighter time constraint, generally working full-time. For these individuals, 178, study can not be considered as the main activity. Moreover also the PIs developed by the PISG, which may provide in future a term of comparison, focus on full-time undergraduate students. As a consequence of this choice we have to drop one university which remains with only one student, which does not allow the computation of the university effect.

whereas for university 45 the corresponding figures are 11.15 per cent and 19 points respectively, with a remarkable 23.1 per cent of students coming from the ‘non-worker’ social class.

If we want to compare ‘like-with-like’ we need to take account of differences in students’ characteristics across universities. This is done by estimating an ordered probit including university dummies, picking up effects operating at the institutional level (which by assumption are common to all students enrolled at a specific university), and the range of controls listed in the previous section. The list of the estimated university effects along with their t-values are reported in table 3. The model correctly predicts the degree class of about 49% of students. Several university effects turn out to be significant at the 10% level (34 on 51 included and 29 at the 5% level), showing the existence of genuine differences between universities in the proportion of the different degree classes awarded which can not be accounted for by differences in the student intake. The coefficients of the ordered probit are difficult to interpret: a positive sign of the university effect means that students enrolled at that university are more likely to obtain a First and less likely to fail with respect to the reference institution (the reverse for a negative sign) while nothing can be said for intermediate degree classes.

Since the main focus of the paper is on the investigation of the differences in students’ degree performance between higher education institutions, we omit here a complete description of the effects of all the covariates included<sup>28</sup>. Significant regressors and the sign of the estimated effects are similar to those found in previous studies<sup>29</sup>. However, it may be important to underline that the type and the quality of previous A-level (Higher) qualifications, which have been often omitted in previous studies, are highly significant in the explanation of degree performance. In particular we find that an ‘A’ or a ‘B’ in the A-level in biology significantly raises the academic performance of life sciences students, the premia in the probability of a ‘good’ with respect to the reference individual are about 0.094 and 0.05 respectively. As already said this variable is a measure of the goodness of the match between a student and a subject and of her prior knowledge of the subject. Students who took an A-level in

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<sup>28</sup>These are available on request from the author. A likelihood ratio test for the full model against the model including the intercept only gives a value of 1910.04 distributed as a  $\chi^2(175)$ . The pseudo  $R^2$  is 9.12%.

<sup>29</sup>For example gender and social class are two important predictor of degree performance.

biology with poor results may not have a special aptitude towards the study of life sciences. Only an ‘A’ in the A-level in chemistry raises the performance (+0.067 in the probability of a ‘good’ degree) while an ‘E’ in the same subject reduces the performance (-0.067) with respect to students with an A-level different from biology, chemistry, physics and mathematics (the reference group). Finally an ‘A’ or a ‘B’ in mathematics and an ‘A’ in physics seems to raise the performance in life sciences courses (with probability premia of 0.093, 0.036, 0.075 points respectively). These measures can be considered as measures of quantitative ability. The effect of an ‘A’ in a previous A-level taken in the set of disciplines considered on the degree performance in life sciences can be ordered from the biggest to the lowest: biology, mathematics, physics, chemistry. Similar effects are found only for ‘A’ and ‘B’ marks for the Higher in chemistry (with probability premia of 0.084 and 0.039 respectively with respect to the Higher entrant with average Higher score). The high significant impact of the type and the score obtained in specific A-levels or Highers suggests that educational performance functions omitting quality of previous educational outcomes split by subject are likely to be misspecified.

In order to compare the performance of universities across the full spectrum of degree classes we compute the predicted probabilities of the different degree classes for the reference individual. This procedure partials out the effect of the particular composition of the student intake and provides the *expected proportion of different degree classes that would be awarded if the student intake is homogeneous across universities and equal to the reference group*<sup>30</sup>. The results are shown in table 4. The distance between universities strongly reduces: for universities with significant effects<sup>31</sup> (i.e. statistically significant differences from the base category university 11) the maximum gap from the best performing university (in terms of the proportion of ‘good degrees’ awarded, i.e. again the reference category university 11) falls from about 58 percentage points to 24 percentage points while the minimum gap falls from 15 percentage points to -7.4

<sup>30</sup>I.e. a single female student less than 24 years old of the intermediate social class, coming from Warwickshire, who did not live at parental home and did not transfer for the full duration of the course, attended a LEA comprehensive admission school, with A-levels but not in biology, chemistry, mathematics or physics.

<sup>31</sup>We compare only universities for which the university effect is significant at least at the 10% level. The other universities do not show statistically significant differences from university 11.

points. Therefore the use of ‘raw league tables’ based on descriptive statistics is likely to overestimate the distance existing between universities and in some cases to change also the relative position of some institutions.

The marginal effects of universities on students’ degree performance computed by using the characteristics of the reference individual can be considered as a measure of ‘theoretical value-added’ (v.a. 1), the ‘value-added’ that would be produced if all universities have the same student intake. It is, therefore, an abstract measure of ‘value-added’, since it is unlikely that we observe the same student intake in different universities (due to the characteristics of the selection process) and it is sensitive to the attributes of the reference individual<sup>32</sup>. The same is true if the marginal effects are computed at the mean of the sample<sup>33</sup>. For this reason it may be interesting to consider another measure of ‘value-added’ which accounts for the specific composition of the student intake by university. For each university we compute the difference between the average expected probability of a ‘good’ degree calculated for its specific student intake and that obtained with the same student intake enrolled at the reference university. This measure, unlike the previous one, takes into account differences in the student intake across universities also for the calculation of marginal effects which are computed with the specific student intake of the university of interest. It can be considered as a measure of differential ‘real value-added’ (v.a. 2) with respect to the reference university. The results are reported in table 4.

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<sup>32</sup>The marginal effect for a dummy variable, e.g. the university effect  $I_j$ , in the ordered probit model  $P_s^* = \alpha I_j + \beta' X_s + \epsilon_s$ , where  $P_s^*$  is the latent variable, is:

$$\frac{\partial Prob[P_s = i]}{\partial I_j} = [\phi(-\alpha - \beta' X_s) - \phi(\mu_k - \alpha - \beta' X_s)] - [\phi(-\beta' X_s) - \phi(\mu_k - \beta' X_s)]$$

where  $s$  and  $j$  are the usual subscripts for students and institutions respectively,  $P_s$  is the ordered qualitative variable (in our case degree class),  $\phi(\cdot)$  is the standard normal density function,  $X_s$  is the vector of student characteristics and  $\beta$  the relative vector of coefficients,  $\alpha$  is the estimated university effect,  $i$  the outcome of interest and  $\mu_k$  the appropriate estimated cut-point. It is evident that because of the shape of the normal distribution the marginal effect is sensitive to the particular point of the distribution in which it is computed (i.e. to  $\beta' X_s$ ).

<sup>33</sup>In this regard we would like to observe that since the characteristics of the reference individual are all aggregated in the intercept, the simple computation of the marginal effects of university dummies at the mean for all variables, among which the other dummies included, does not give the marginal effect at the mean characteristics of the sample. To compute this measure it is necessary to recover from the intercept the effect of the single characteristics of the reference group (see Suits, 1994).

Similarly to Smith *et al.* (2000) the marginal effect of the university dummies can be used to rank departments. Figure 1 shows a cross-plot between the unadjusted ranking, i.e. the ranking based on the proportion of ‘good’ degrees awarded, and the adjusted ranking obtained using the ‘theoretical value-added’, i.e. v.a. 1. There is a substantial amount of dispersion across the 45-degree line. The most evident cases are university 31 that falls from the third to the 33rd position and university 40 rising from the 28th to the third position (see table 4). Our results confirm that of Smith *et al.* (2000): ‘naive’ university league tables may be misleading not only when they are used as PIs of graduate employability but also when they are employed for inter-university comparisons of students’ academic performance. Similar results are obtained comparing the unadjusted ranking with the ranking derived from the second measure of ‘value added’ introduced, i.e. v.a. 2 (see figure 2). Figure 3 shows that despite the high correlation between the two adjusted measures of ‘value-added’ there exist some big movers from the 45-degree line suggesting that the ranking of some departments may be sensitive to the particular definition of ‘value-added’ used.

Following the literature on school quality<sup>34</sup> it may be interesting to assess whether differences across universities can be explained by the type of institutional characteristics which are commonly used in the empirical work on school quality. This can be done by regressing the university effects estimated at the first stage on university-level covariates, i.e. by estimating the following regression which represents the second stage of our analysis:

$$I_j = \gamma Z_j + u_j \quad (10)$$

where the  $I_j$  are university effects and  $Z_j$  are observable university characteristics. We consider departmental measures of student-staff academic related ratio, the salary per academic related member of staff, as a measure of ‘quality’ of the staff<sup>35</sup>, size of the department (total number of the academic related staff) and the result of the 1992 Research Assessment Exercise, as a measure of research quality which can have some feedbacks<sup>36</sup> into teaching. We consider several categories of expenditure per student<sup>37</sup>, this time at the university

<sup>34</sup>See for example Betts (1996) and Dearden, Ferri & Meghir (1997).

<sup>35</sup>On the grounds that market wages reflect quality (even if it is not clear in what measure this is the case, see for example Hanushek, Kain & Rivkin 1999).

<sup>36</sup>It is not clear whether positive or negative. Staff highly committed to research may devote less time to undergraduate tuition or research excellence may improve teaching effectiveness.

<sup>37</sup>We follow the suggestion of Murnane, Willet, Kemple & Olsen (1991:7) as the

level<sup>38</sup>: equipment, amenities, residences, computers, books, periodicals, other. A proxy for the ‘peer effect’, the average A-level score per A-level entrant, is included on the grounds that the performance may be increased by peer competition<sup>39</sup>. OLS can not be used because the coefficients estimated at the first stage are observed with different sampling errors, introducing heteroscedasticity in the error term. We use the estimator suggested by Hanushek (1974). Regression results are shown in table 5<sup>40</sup>. Despite the proportion in the variation explained by the attributes considered is not negligible (38.5%) only expenditure on residences is significant (and has a negative sign). Some of the variables have a counterintuitive sign. Both outcomes may be produced by the presence of multicollinearity in the data, especially for the different kinds of expenditure at the university level. A computation of the ‘condition number’ proposed by Belsey, Kuh & Welsch<sup>41</sup> (1980) gives a very high value of 1,788 suggesting that multicollinearity may be a serious problem of the data. However, it is clear that an high proportion of the difference across universities is not accounted for by common measures of quality of education<sup>42</sup>. These differences, reflecting unobserved university attributes, are likely to enter the error term in specifications of the degree performance equation including university-level inputs (instead of university dummies). In this case the error term in equation (9) becomes  $e_s = \epsilon_s + u_j$ , i.e. the errors of all students enrolled at the same university contain a common component  $u_j$ . Then, because of the non-random assignment of students with different observed characteristics to universities the error term in the degree performance equation is likely to be correlated with students’ characteristics producing inconsistent estimates of their effect. However, as observed by Bee & Dolton (1985) whether these ‘unexplained differences’ are genuine measures of ‘value-added’ or simply arise through arbitrary and inconsistent perceptions is still an open question. Even though from the point of view

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inclusion of total expenditures is a ‘sterile’ approach which gives no indication on the components to be increased to enhance students’ performance.

<sup>38</sup>Since the detail by department is not available.

<sup>39</sup>See Robertson & Symons (1996).

<sup>40</sup>Two universities are excluded from this second stage of the analysis since data at the departmental level are not available.

<sup>41</sup>The ratio between the highest and the lowest eigenvalue of the scaled data matrix, see also Greene (1997:422). Belsey *et al.* (1980) suggest that when the value exceeds 20 multicollinearity may cause estimation problems.

<sup>42</sup>Our findings are similar to those of Bee & Dolton (1985) who analysed differences in degree class and pass rates across universities using aggregate data.

of the students seeking a ‘good’ degree result finding the ‘true’ source of the differences across higher education institutions in degree classification is only of minor importance, it becomes essential to government and funding bodies when these differences are used to build performance indicators and to ‘rank’ institutions.

## 6 Concluding remarks

In this paper we use individual level university data and microeconomic techniques to develop university performance indicators relating to students’ learning outcomes. The analysis is applied to a specific subject: life sciences. The main findings of the paper are:

1. The type and the score in specific A-levels (Highers) turn out to be highly significant in the explanation of students’ degree performance. Previous studies that have omitted these covariates are likely to be misspecified;
2. The ranking of universities obtained using simple ‘league tables’ based on raw descriptive statistics is substantially different from that obtained using microeconomic techniques which account for the quality of the student intake;
3. In some cases even using microeconomic techniques the ranking of departments is sensitive to the particular definition of ‘value-added’ adopted, showing that a clear definition of this concept should be a priority of the body of research on university performance indicators;
4. University effects, i.e. the measure of ‘value-added’ estimated, are only partially explained by measures of educational quality commonly used in the empirical work. About 60% of the variance remains unexplained. Since students are not randomly assigned to universities, this implies that specifications of educational production functions directly including university-related attributes are likely to produce inconsistent estimates of the effects of students’ characteristics.

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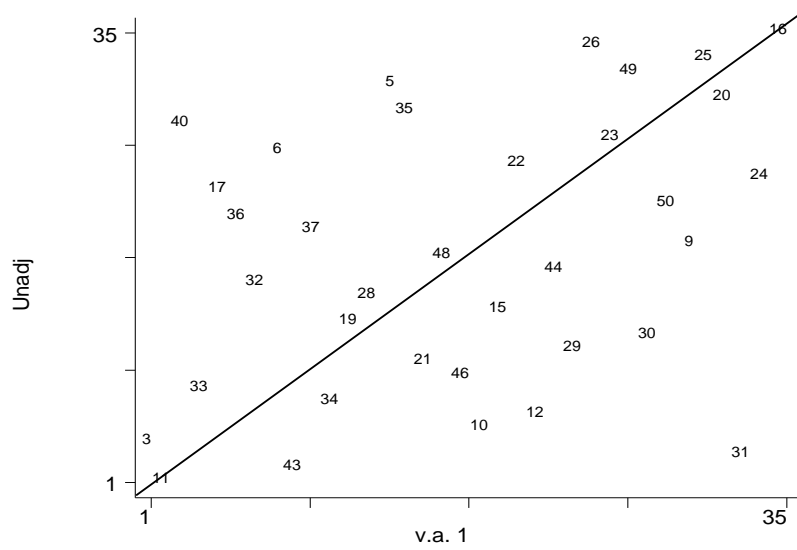
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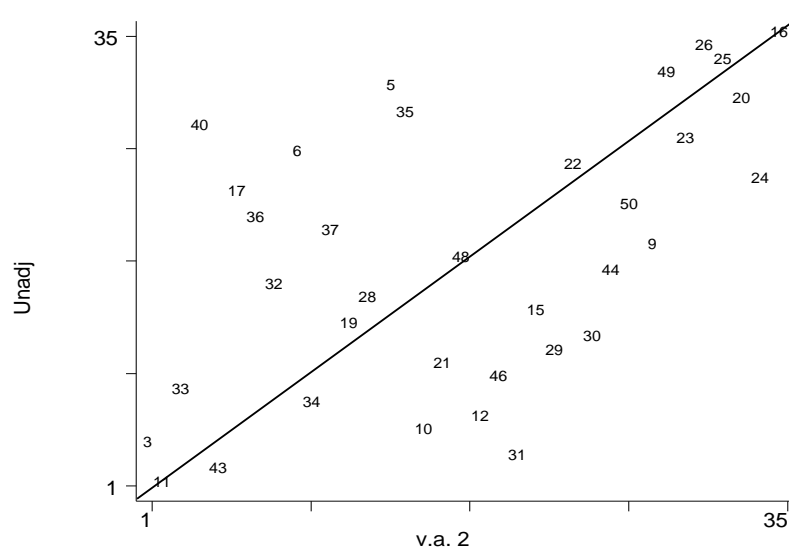
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Figure 1: Cross-plot between the ‘unadjusted’ ranking and the ranking based on v.a. 1



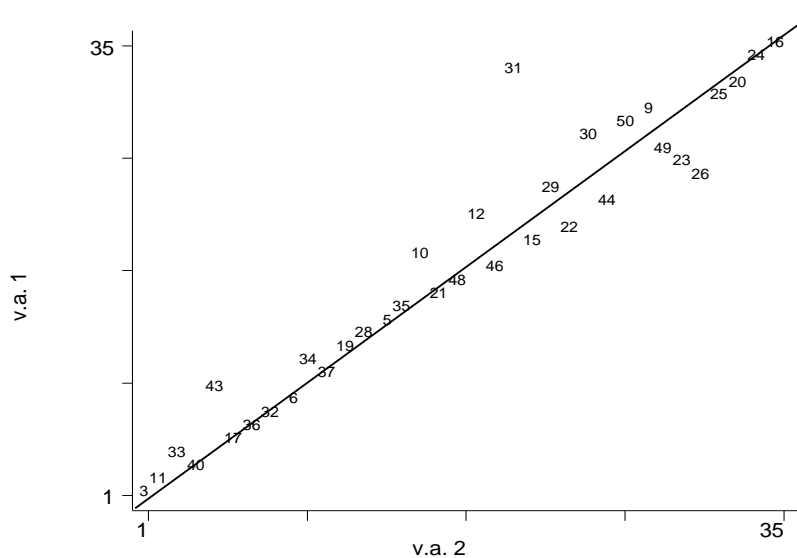
Notes. The figure shows the cross-plot between the ranking of life sciences departments obtained from the proportion of ‘good’ (first and upper second class honours) degrees awarded (unadj) and that obtained from the expected probability of a ‘good’ degree (for the reference individual) obtained from the ordered probit model, i.e. v.a. 1.

Figure 2: Cross-plot between the ‘unadjusted’ ranking and the ranking based on v.a. 2



Notes. The figure shows the cross-plot between the ranking of life sciences departments obtained from the proportion of ‘good’ (first and upper second class honours) degrees awarded (unadj) and that obtained for each university from the difference between the expected probability of a ‘good’ degree computed with its specific student intake and the same probability computed for the reference university with the same student intake, i.e. v.a. 2.

Figure 3: Cross-plot between the two adjusted rankings based on ‘valued-added’



Notes. The figure shows the cross-plot between the ranking of life sciences departments obtained from the expected probability of a ‘good’ degree (for the reference individual), i.e. v.a. 1, and that obtained for each university from the difference between the expected probability of a ‘good’ degree computed with its specific student intake and the same probability computed for the reference university with the same student intake, i.e. v.a. 2.

Table 1: Degree classes awarded as a percentage of total by university

university	fail	other	2.2+2	2.1	1	good (1+2.1)
1	13.92	6.70	14.95	52.58	11.86	64.43
2	9.14	5.91	17.74	56.99	10.22	67.20
3	2.90	2.07	26.97	58.92	9.13	68.05
4	13.33	1.67	14.17	60.00	10.83	70.83
5	16.10	13.56	28.81	37.29	4.24	41.53
6	20.53	16.32	17.37	39.47	6.32	45.79
7	20.18	9.65	22.81	38.60	8.77	47.37
8	24.00	2.00	20.00	44.00	10.00	54.00
9	13.39	6.30	27.56	42.91	9.84	52.76
10	5.43	1.63	25.00	57.07	10.87	67.93
11	0.00	0.00	11.73	50.00	38.27	88.27
12	4.08	1.02	31.63	56.12	7.14	63.27
13	5.91	2.46	32.02	47.78	11.82	59.61
14	11.25	1.25	18.75	53.75	15.00	68.75
15	12.80	2.40	29.60	46.40	8.80	55.20
16	27.12	10.17	32.20	23.73	6.78	30.51
17	8.88	4.14	36.09	45.56	5.33	50.89
18	16.00	6.00	26.00	40.00	12.00	52.00
19	9.14	4.99	29.64	50.97	5.26	56.23
20	9.20	10.43	38.04	38.65	3.68	42.33
21	12.73	3.03	24.85	53.94	5.45	59.39
22	12.03	5.50	34.02	42.96	5.50	48.45
23	22.22	3.70	28.70	40.74	4.63	45.37
24	19.14	3.70	26.54	42.59	8.02	50.62
25	17.61	9.15	34.51	31.69	7.04	38.73
26	20.09	8.41	34.58	28.97	7.94	36.92
27	2.04	5.44	20.41	61.90	10.20	72.11
28	14.77	6.25	23.86	47.73	7.39	55.11
29	10.37	3.32	27.39	48.96	9.96	58.92
30	12.70	1.64	27.05	50.41	8.20	58.61
31	3.57	2.60	22.73	58.77	12.34	71.10
32	14.14	5.24	26.70	49.74	4.19	53.93
33	9.55	3.82	24.84	52.87	8.92	61.78
34	8.57	5.71	23.81	52.38	9.52	61.90
35	8.75	2.50	45.00	35.00	8.75	43.75
36	8.44	6.67	32.89	42.67	9.33	52.00
37	18.56	6.19	22.68	45.36	7.22	52.58
38	13.48	3.90	35.46	41.49	5.67	47.16
39	8.33	2.31	26.85	58.33	4.17	62.50
40	2.99	7.19	45.51	36.53	7.78	44.31
41	11.22	3.74	16.82	56.07	12.15	68.22
42	8.70	2.17	23.91	52.17	13.04	65.22
43	10.67	0.00	16.00	61.33	12.00	73.33
44	24.00	2.67	20.00	49.33	4.00	53.33
45	11.54	0.00	23.08	65.38	0.00	65.38
46	17.78	0.00	22.22	55.56	4.44	60.00
47	13.51	2.70	35.14	39.19	9.46	48.65
48	0.87	6.96	39.13	47.83	5.22	53.04
49	6.25	12.50	41.67	33.33	6.25	39.58
50	7.84	3.27	37.25	43.14	8.50	51.63
51	10.14	2.30	28.57	53.00	5.99	58.99
52	21.47	0.56	25.42	44.07	8.47	52.54

Notes. 1: First class honours degree; 2.1: Upper Second class honours degree; 2.2+2: Lower Second class honours and Undivided Second class honours degrees; other: other degree classifications; fail: failure in the final year or drop-out for academic reasons. Universities are anonymised following the recommendation of the PISG (HEFCE 1999).

Table 2: Distribution of students by social class and average A-level score per A-level entrant

University	I	II	IIIN	IIIM	IV	V	A.F.	i.d.	N.W.	A-l. score
1	15.5	37.6	12.4	8.8	6.7	1.5	1.5	3.1	12.89	17
2	24.2	38.7	8.6	7.5	4.8	1.6	0.5	3.8	10.22	23
3	20.3	31.5	11.6	11.6	10.4	0.4	0.8	2.9	10.37	20
4	31.7	34.2	4.2	10.0	5.8	0.8	0.0	2.5	10.83	21
5	17.8	33.9	11.9	7.6	11.0	1.7	0.0	4.2	11.86	19
6	10.5	28.4	6.3	12.6	8.9	2.1	0.0	3.7	27.37	17
7	20.2	29.8	10.5	15.8	5.3	1.8	0.0	4.4	12.28	17
8	18.0	40.0	8.0	14.0	8.0	2.0	0.0	6.0	4.00	15
9	22.4	34.3	10.6	13.8	6.7	1.6	1.2	2.4	7.09	22
10	26.6	46.2	11.4	6.5	2.2	0.5	0.5	2.7	3.26	25
11	38.3	45.1	8.6	4.3	1.9	0.0	0.0	1.2	0.62	29
12	17.3	58.2	8.2	6.1	5.1	0.0	0.0	0.0	5.10	25
13	21.7	34.0	10.8	10.3	9.4	1.5	2.5	2.5	7.39	22
14	18.8	36.3	15.0	11.3	5.0	1.3	0.0	5.0	7.50	21
15	20.0	37.6	10.4	13.6	9.6	0.8	0.8	3.2	4.00	21
16	20.3	28.8	8.5	11.9	13.6	0.0	0.0	1.7	15.25	15
17	15.4	42.6	12.4	11.2	5.3	1.8	0.6	3.6	7.10	19
18	18.0	40.0	12.0	12.0	6.0	2.0	2.0	4.0	4.00	18
19	18.6	38.2	11.6	11.4	10.5	0.8	0.8	1.7	6.37	21
20	13.5	32.5	12.3	18.4	8.0	0.0	0.6	4.9	9.82	20
21	12.7	34.5	16.4	12.1	8.5	0.6	2.4	3.6	9.09	20
22	15.1	36.8	8.6	17.2	7.6	1.7	1.7	2.1	9.28	21
23	12.0	35.2	7.4	10.2	8.3	0.9	0.9	1.9	23.15	16
24	19.8	42.6	9.9	5.6	8.6	0.6	0.0	4.3	8.64	21
25	16.9	32.4	12.7	8.5	7.0	2.8	1.4	2.8	15.49	18
26	20.1	40.7	8.9	9.8	8.4	0.9	0.9	4.2	6.07	14
27	22.4	44.9	11.6	4.1	2.7	1.4	1.4	3.4	8.16	20
28	19.9	41.5	9.7	5.1	7.4	0.6	0.6	3.4	11.93	18
29	20.7	42.7	11.2	8.3	6.6	0.8	1.2	1.2	7.05	24
30	17.2	42.6	9.4	10.7	7.0	1.6	0.8	2.5	8.20	23
31	29.9	51.6	5.5	2.3	3.9	0.0	1.3	1.9	3.57	27
32	19.9	33.5	9.9	6.8	9.4	0.5	0.0	3.7	16.23	18
33	19.1	36.9	15.3	10.2	5.1	0.0	1.3	1.3	10.83	22
34	18.1	41.0	11.4	14.3	5.7	1.0	1.9	2.9	3.81	22
35	18.8	32.5	15.0	12.5	10.0	2.5	1.3	2.5	5.00	18
36	13.3	45.8	10.7	8.9	6.2	0.0	0.4	3.6	11.11	18
37	16.5	30.9	10.3	16.5	9.3	0.0	1.0	6.2	9.28	16
38	12.1	30.9	13.8	13.1	7.8	1.8	0.7	3.9	15.96	16
39	16.7	37.0	11.6	10.2	5.1	1.4	1.9	2.8	13.43	18
40	12.6	37.7	12.0	10.2	12.6	2.4	0.6	4.2	7.78	18
41	19.6	30.8	14.0	15.9	10.3	0.0	0.9	0.9	7.48	19
42	13.0	32.6	26.1	8.7	6.5	0.0	0.0	4.3	8.70	21
43	14.7	42.7	13.3	10.7	6.7	0.0	1.3	1.3	9.33	24
44	10.7	37.3	8.0	9.3	12.0	1.3	1.3	5.3	14.67	19
45	11.5	34.6	11.5	7.7	3.8	0.0	0.0	7.7	23.08	20
46	15.6	42.2	2.2	24.4	2.2	0.0	0.0	2.2	11.11	19
47	9.5	33.8	5.4	16.2	5.4	2.7	0.0	4.1	22.97	15
48	17.4	40.9	17.4	13.0	3.5	0.9	0.0	1.7	5.22	21
49	14.6	39.6	10.4	10.4	8.3	0.0	0.0	2.1	14.58	20
50	16.3	47.7	9.2	11.1	5.9	0.0	1.3	2.0	6.54	23
51	8.3	36.9	6.0	18.0	8.8	0.9	0.5	9.7	11.06	18
52	4.0	26.6	7.3	14.1	7.9	4.5	0.0	3.4	32.20	15

Notes. I: professional occupations; II: managerial and technical occupations; IIIN: skilled occupations - non manual; IIIM: skilled occupations - manual; IV: partly skilled; V: unskilled occupations; A.F.: armed forces; i.d.: inadequately described; N.W.: non-workers; A-l. score: average A-level score per A-level entrant.

Table 3: Universities' dummies

University	Coeff.	t-value
1	0.15	1.08
2	-0.14	-1.00
3	0.24	1.76
4	0.11	0.71
5	-0.33	-2.20
6	-0.29	-1.96
7	-0.20	-1.33
8	-0.03	-0.15
9	-0.48	-3.82
10	-0.42	-3.19
11	base	base
12	-0.42	-2.77
13	-0.21	-1.59
14	-0.08	-0.49
15	-0.42	-2.90
16	-0.64	-3.55
17	-0.27	-1.97
18	-0.30	-1.57
19	-0.33	-2.70
20	-0.51	-3.71
21	-0.37	-2.65
22	-0.42	-3.36
23	-0.46	-3.04
24	-0.64	-4.66
25	-0.51	-3.61
26	-0.46	-3.50
27	0.02	0.16
28	-0.33	-2.41
29	-0.45	-3.59
30	-0.47	-3.75
31	-0.55	-4.79
32	-0.28	-2.10
33	-0.24	-1.75
34	-0.33	-2.16
35	-0.35	-2.16
36	-0.28	-2.16
37	-0.31	-2.00
38	-0.19	-1.51
39	-0.07	-0.55
40	-0.23	-1.65
41	-0.04	-0.26
42	-0.20	-1.02
43	-0.30	-1.80
44	-0.44	-2.60
45	-0.23	-0.92
46	-0.38	-1.90
47	-0.02	-0.14
48	-0.37	-2.55
49	-0.47	-2.45
50	-0.48	-3.43
51	0.25	1.57
52	0.17	1.10

Notes. This table shows the estimated universities' dummies from the ordered probit model.

Table 4: Expected probabilities, ‘value-added’ and ranking of life sciences departments

University	Expected probability					Value Added		Ranking		
	fail	other	2.2+ 2	2.1	1	v.a. 1	v.a. 2	Unadj	v.a. 1	v.a. 2
3	1.84	1.54	16.06	61.22	19.34	80.56	8.33	4	1	1
5	6.55	4.01	28.25	53.74	7.45	61.19	-11.80	31	14	14
6	5.99	3.76	27.33	54.80	8.11	62.91	-10.16	26	8	9
9	8.68	4.87	31.09	49.80	5.56	55.37	-16.10	19	30	28
10	7.71	4.49	29.91	51.57	6.32	57.89	-12.34	5	19	16
11	3.26	2.40	21.17	59.81	13.36	73.17	0	1	2	2
12	7.78	4.52	30.00	51.44	6.26	57.70	-13.35	6	22	19
15	7.73	4.50	29.94	51.53	6.31	57.84	-14.46	14	20	22
16	11.43	5.83	33.62	45.11	4.01	49.12	-21.86	35	35	35
17	5.79	3.68	26.99	55.18	8.36	63.55	-9.67	23	5	6
19	6.48	3.98	28.14	53.88	7.53	61.41	-11.10	13	12	12
20	9.18	5.06	31.64	48.90	5.22	54.12	-18.33	30	32	33
21	6.96	4.18	28.88	52.96	7.02	59.98	-12.40	10	16	17
22	7.73	4.50	29.95	51.52	6.30	57.82	-14.74	25	21	24
23	8.40	4.76	30.77	50.31	5.77	56.08	-16.76	27	26	30
24	11.39	5.81	33.59	45.18	4.03	49.21	-21.65	24	34	34
25	9.11	5.03	31.56	49.03	5.27	54.30	-17.90	33	31	32
26	8.37	4.75	30.73	50.36	5.79	56.15	-16.87	34	25	31
28	6.48	3.98	28.15	53.86	7.52	61.39	-11.63	15	13	13
29	8.23	4.70	30.57	50.60	5.89	56.50	-14.48	11	24	23
30	8.50	4.80	30.88	50.13	5.70	55.82	-15.07	12	28	25
31	9.76	5.26	32.21	47.90	4.87	52.76	-14.43	3	33	21
32	5.91	3.73	27.19	54.96	8.21	63.17	-9.89	16	7	8
33	5.46	3.52	26.37	55.82	8.82	64.64	-7.83	8	4	3
34	6.47	3.97	28.12	53.90	7.54	61.44	-10.62	7	11	10
35	6.80	4.12	28.64	53.26	7.18	60.43	-12.14	29	15	15
36	5.90	3.72	27.18	54.97	8.22	63.20	-9.77	21	6	7
37	6.29	3.90	27.83	54.24	7.75	61.99	-11.08	20	10	11
40	5.29	3.44	26.05	56.14	9.08	65.22	-8.06	28	3	4
43	6.11	3.82	27.54	54.57	7.95	62.52	-8.48	2	9	5
44	7.98	4.60	30.27	51.06	6.09	57.15	-15.10	17	23	26
46	7.15	4.26	29.15	52.61	6.83	59.44	-13.47	9	18	20
48	7.08	4.23	29.05	52.74	6.90	59.64	-12.54	18	17	18
49	8.40	4.76	30.77	50.30	5.77	56.06	-16.22	32	27	29
50	8.56	4.82	30.95	50.02	5.65	55.67	-15.61	22	29	27

Notes. This table shows the estimated expected proportion of students obtaining various degree classes in different universities (when the student intake equals the reference individual) derived from the ordered probit model, measures of ‘value added’ introduced in section 5 and ranking of departments according to different criteria: the percentage of ‘good’ degrees awarded (unadj) and two different measures of ‘value-added’ (v.a. 1 and v.a., 2 see section 5).

Table 5: Explanation of universities' effects

Variable	Coeff.	t-value
const	0.59	1.14
salpro	0.00	0.07
staffls	0.00	1.12
ssrls	-0.01	-0.27
eqpro	-0.09	-0.66
amenpro	0.33	0.60
residpro	-0.20	-2.25
comppro	-0.56	-1.04
bookspro	-2.18	-1.26
perpro	-1.33	-0.85
othpro	0.28	0.71
rae92	-0.13	-1.19
peer	0.00	-0.19
R <sup>2</sup>	0.3849	

Notes. This table shows the estimated coefficients obtained from regressing the universities' dummies on measures of 'quality of education'. Explanatory variables included are: const (constant), salary per member of academic staff (salpro), number of academic staff (staffls), student-(academic) staff ratio (ssrls), average A-level score for A-level entrant (peer), all measured at the department level. Other variables measured at the university level are expenditure per student on equipment (eqpro), amenities (amenpro), residences (residpro), computers (comppro), books (bookspro), other (othpro). Finally we included the result of the 1992 Research Assessment Exercise (rae92).