The Determinants of Economic Efficiency in English and Welsh Universities

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Abstract

With imperfect markets for the services of the higher education sector, it is important to assess the effectiveness of institutions. Previous studies have analysed the costs of universities but only one, to our knowledge, their efficiency. In this paper, we examine the costs and efficiency of institutions of higher education as suppliers of teaching and research using the method of stochastic frontier analysis. This paper is unique in that it investigates the impact of staff and student characteristics on efficiency. We find that there is inefficiency in higher education. This result is robust to the inclusion of a qualitative measure of output into the cost function. There is also evidence of convergence in the inefficiency of institutions, implying that the less efficient institutions are 'catching up' with those nearer to the cost frontier. Our analysis suggests that the anticipation of the introduction of tuition fees may have led to a shake-up in the less efficient universities. However, the results suggest that this effect was short-lived and offset by the more efficient universities relaxing somewhat.

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> 'Universities are major users of the nation's resources. Inefficiency in the university sector represents a real welfare loss as surely as does the misallocation of resources elsewhere in the economy. In this sense, at least, higher education is no different from any other industry.'
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> Verry and Layard (1976), p.1.

1 Introduction

There have been many investigations of university costs and their implications for the scale and scope of the provision of the various aspects of higher education institutions (e.g., Cohn, Rhine and Santos, 1989; DeGroot, McMahon and Volkwein, 1991; Glass, McKillop and Hyndman, 1995; Hashimoto and Cohn, 1997; Nelson and Hevert, 1992; Johnes, 1997; Izadi and Johnes, 1997; Koshal and Koshal, 1999; and Koshal, Koshal and Gupta 2000). All of these studies save one, however, assume economic efficiency, i.e. that the university produces *on* the minimum-cost frontier. This study is unique in that it employs a method that allows us to not only account for inefficiency in university provision, but also investigate the influences on inefficiency.

There are many problems associated with the analysis of higher education institutions (HEIs) as producers. Rating their output is difficult without reference to a set of policy preferences. Is the primary purpose of the higher education sector merely to produce as many graduates as possible, or is it to safeguard the value of certification for the select few that undertake it? HEIs and society as a whole may have a number of objectives regarding the quality and quantity of both teaching and research. This problem has become more acute because of the blurring of the lines between the old polytechnics, with their emphasis on teaching and the vocational aspects in particular, and the 'old' universities with their accent on the more generalist and academic aspects. Tied up with this policy question is the analytical problem of how best to consider such institutions. The output of a HEI is generally considered to be the teaching and research it undertakes. However, the majority of the empirical work in this area before the 1980s ignored the research aspect of HEIs' activities. The view of a university as a producer in recent years has been overhauled in light of the pioneering work of Baumol, Panzar and Willig (1982) in industrial economics. HEIs are now considered as producers of multiple outputs.

In this study we employ the method of stochastic frontier analysis to estimate the cost relationship in higher education allowing for multiple outputs to be produced by HEIs and for inefficiency in production. This study is unique in that it employs a method that allows us to not only account for inefficiency in university provision, but also investigate the influences on inefficiency.

2 The University as Producer

Few would disagree with the assertion of Hare and Wyatt (1992) that 'The principal output of the higher education system is knowledge ... produced by ... research and teaching' (p. 48). However, it is difficult to be more specific when defining the precise *raison d'être* of a 'typical' higher education institution, or indeed whether such a typical institution exists. The higher education sector is now made up of new and old universities that were once polytechnics and universities with different functions, but are now legally identical entities. Any model of university production must be able to account for the fact that universities attach different levels of importance to the various aspects of higher education.

Early empirical work in this area concentrated on the cost per student of HEIs and the nature the economies of scale that might exist[1]. However, an important factor to consider when investigating the performance of HEIs is their 'multi-dimensional nature'[2]. Over the last decade or so, work has recognised the multi-product nature of HEIs by including a measure of research output (typically research funding attracted) and graduate instruction (e.g. Cohn, Rhine and Santos, 1989; Glass, McKillop and Hyndman, 1995: Hashimoto and Cohn, 1997; Koshal and Koshal, 1999). Other studies have tried to account for the fact that the production of science and arts graduates both have very different cost implications. This is done by including a dummy variable for lab-based subjects (Nelson and Hevert, 1992) or including numbers of both separately (Johnes, 1997; Izadi and Johnes, 1997). All of the studies so far mentioned have followed the path of estimating a cost function, although the functional forms adopted have differed. Cohn Rhine and Santos (1989) and Koshal and Koshal (1999) employed a flexible fixed cost quadratic cost function, DeGroot, McMahon and Volkwein (1991) and Nelson and Hevert (1992) a translog and Johnes (1997) and Izadi and Johnes (1997) a constant elasticity of substitution cost function. However, with the exception of Izadi and Johnes (1997), all of these studies have assumed there to be technical and allocative efficiency[3]. This is rather a strong assumption if, as Bowen (1991) postulated, universities merely spend what they get with no emphasis on cost minimisation, as they do not have to maximise profits or surplus. Moreover, in the absence of qualitative measures of inputs and outputs, such work is likely to give a seriously misleading picture of the effectiveness of the HE sector.

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[1] For a review of this literature from a US perspective see Brinkman and Leslie (1986).

[2] Cohn, Rhine and Santos (1989); p. 284.

[3] See Section 3 below for a definition of technical and allocative efficiency.

Another factor of which none of the previous studies mentioned above has taken into account is the *quality* of HEIs' output. Whilst it is difficult, if not impossible, to account fully for any such variation, one can account for differences in degree classification. In the presence of external examiners, visits by assessors such as the quality assurance agency (QAA) and the pressure of the maintenance of reputation, we believe that the proportion of firsts and upper seconds represents a relatively consistent measure of degree quality, and certainly the best that is readily available.

Previous studies have rarely taken into account the quality of the students enrolling at the HEI. An exception to this is Koshal and Koshal (1999) who included the average Student Aptitude Test scores of students. For the UK, work such as Bee and Dolton (1985), Dolton (1986) and Johnes and Taylor (1987) have found a strong positive relationship between degree results and A-level scores. Therefore, a failure to account for input quality would provide an imprecise measure of university teaching output. The value of higher education to both the student and society as a whole is the 'value added' by the university (Johnes, 1992; Cave and Weale, 1992). In this study we use the average A-Level/Highers score of students on entering the university as a measure of the quality of students as an input.

3 Stochastic Frontier Analysis

Stochastic frontier models date back to Aigner, Lovell and Schmidt (1977) and Meesen and van den Broek (1977), who independently proposed a stochastic frontier production function with a two-part 'composed' error term. In the production context, where its use is most common[4], this error is composed of a standard random error term, representing measurement error and other random factors, and a one-sided random variable representing what Farrell (1957) called 'technical inefficiency', i.e. the distance of the observation from the production frontier. This notion of technical efficiency reflects the ability of a firm, country or university to obtain maximal output from a given set of inputs. It is measured by the output of the firm relative to that which it could attain if it were 100 % efficient, i.e. if it lay on the frontier itself, and is therefore bound between zero and one. When one combines this with allocative efficiency, the ability of the firm etc to use the inputs in optimal proportions, given their respective prices, one has a measure of total *economic efficiency*.

Using duality in production, one can consider cost efficiency[5]. This is particularly useful in the context of higher education institutions as it allows for the unit of observation to produce more than one product (Baumol, Panzar and Willig, 1982). A typical stochastic cost frontier would be

$$C_i = c(\boldsymbol{X}_i, \boldsymbol{\beta}) + \eta_i + \varepsilon_i \qquad (1)$$

where costs for firm i, C_i, depend upon a vector of variables, $\boldsymbol{X}$, and parameters, $\boldsymbol{\beta}$, a non-negative random variable, η, and a random error term, ε. It is this η term that represents inefficiency. Note that the inefficiency effect is *added* in the cost frontier, rather than subtracted, as is the case for the SFA *production* frontier. This is because the cost function represents minimum cost, whereas the production function represents maximum output. Also unlike the production frontier SFA approach, this inefficiency represents total economic inefficiency, i.e. technical inefficiency (not getting enough output from the inputs) plus allocative inefficiency (not using the inputs or producing

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[4] See Lovell and Schmidt (1993) and Coelli, Rao and Battese (1999) for examples.

[5] E.g. Kumbhakar, Gosh and McGulkin (1991) and Reifschneider and Stevenson (1991)

the outputs in the correct proportions)[6]. Such a cost frontier is estimated for the UK HE sector by Izadi and Johnes (1997), who assume that $c(\bullet)$ takes a constant elasticity of substitution (CES) form.

The question that immediately arises from a casual inspection of (1) is 'what determines η?' Technical and allocative inefficiency can be caused by all sorts of productive and organisational inefficiency, from ineffective management to problems with inputs. Are certain types of HEIs more likely to be inefficient than others are? Does it depend upon the personal characteristics of the staff employed by an institution? or does a student body with particular characteristics make the efficient provision of HE more difficult? In the production context, work such as Pitt and Lee (1981) and Kalirajan (1981) investigated the determinants of technical efficiency of firms by performing a second stage regression of the predicted ηs on firm specific factors. However, as Kumbhakar, Gosh and McGulkin (1991) and Reifschneider and Stevenson (1991) have noted, there is a significant problem with this approach. In the first stage, the η terms are assumed to be independently and *identically* distributed, but in the second stage they are assumed to be a function of these firm-specific factors, implying that they are not identically distributed, unless all the coefficients of the factors are simultaneously equal to zero[7]. Kumbhakar, Gosh and McGulkin (1991), Reifschneider and Stevenson (1991) and Huang and Liu (1994) presented models to overcome this problem by estimating the both the frontier and efficiency terms in one stage. These models were extended by Battese and Coelli (1995) to allow for panel data estimation. It is the Battese and Coelli (1995) method that we employ in this study.

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[6] In the production function model, one requires relative input prices to determine whether production is optimal

[7] For more on this subject see Coelli, Rao and Battese (1999), chapter 8.

4 Empirical Model

In order to investigate empirically cost inefficiency in UK HEIs, we employ a multi-dimensional cost function model. The general form of the cost function is

$$C_{it} = f[\boldsymbol{Q}_{it}, \boldsymbol{W}_{it}, \boldsymbol{Z}_{it}, \eta_{it}] \quad (2)$$

where C_{it} is the total cost of university *i* at time *t*, $\boldsymbol{Q}$ is a vector of output quantities (undergraduate teaching in the arts and in the sciences, postgraduate teaching and research), $\boldsymbol{W}$ a vector of input prices[8], $\boldsymbol{Z}$ are other factors that influence costs directly and η_{it} represents inefficiency, which we discuss in greater detail below.

The outputs considered in this study are the numbers of arts and science undergraduates (AUG and SUG, respectively) [9], the number of post-graduate students (PG) and the total research funding attracted (RES). The use of what is apparently an input to measure an output may at first appear strange. Johnes (1997) argues that 'research grants are in general awarded to meritorious groups of researchers on the basis of the quality and quantity of their previous work (and … the weights assigned to quantity and quality in this measure are precisely those assigned by the 'market' for research)' (p. 728). Moreover, Koshal and Koshal (1999) argue that there is be a high correlation between research output and grant support.' They find a correlation of 0.7 between this and faculty publications (based on data compiled from the National Academy of Sciences), for the institutions in the US where the latter data is available.

[8] Although we only have one input price in this case, average staff costs.

[9] The science subjects are defined as those falling into the following categories: clinical medicine an dentistry, veterinary science, anatomy and physiology, nursing and paramedical studies, health and community studies, psychology and behavioural sciences, pharmacy, pharmacology, biosciences, chemistry, physics, agriculture and forestry, earth, marine and environmental sciences, general sciences, general engineering, chemical engineering, mineral, metallurgy and materials engineering, civil engineering, electrical, electronic and computer engineering, mechanical, aero- and production engineering, other technologies, architecture, built environment and planning, mathematics, information technology and systems sciences, sports science, and computer software engineering.

There is a correlation of 0.65 between the research funding a university attracts and the average score across all departments in the 1996 Research Assessment Exercise. The RAE is entirely retrospective and, moreover, also does not vary over the time-scale of this study. The research finding attracted is likely to be more representative of *current* research output as it is paying for current research. It does in part depend upon the outcome of the RAE, but also depends on more recent output[10]. It also reflects research outside of traditional publications and so reflects universities' more general research role.

We also consider the effect of the quality of student intake, as measured by the average A-Level/Highers score. The effect of the average A-Level/Highers score of a university's intake on its cost could be either positive or negative. Students with high A-levels may be cheaper to teach because of their higher ability (although this could go the other way because of their more voracious intellectual appetite). On the other hand, it may cost universities money to attract brighter students. Operating in this way, the average A-level score is acting as an indicator of factor price. Koshal and Koshal (1999) found a positive correlation between costs and SAT scores at private universities in the US, although they found no significant effect in public institutions. This is consistent with the view that only the private universities have the financial means with which to bid for the higher quality students[11].

The main difference between our model and the majority of the literature is the inclusion of the efficiency effect η_{it}. The only other model to include an effect of this

[10] E.g. the success of attracting this year's grants will depend upon the success of work done under last year's ones.

[11] The only potentially similar split that the UK has is between the 'old' and 'new' (i.e. former polytechnic) universities. However, we found no evidence that costs or efficiency are significantly different between these two types of institution, or that they were differently trended. In what follows, therefore, they are considered as a whole.

nature is, to our knowledge, Izadi and Johnes (1997). Izadi and Johnes (1997) look only at one time period and, moreover, do not attempt to investigate the determinants of this inefficiency. They find that inefficiency exists, but discus only the implications for economies of scale in any depth.

Our empirical model is a translog cost function of the form

$$\ln C_{it} = \alpha_0 + \sum_{j=1}^{4} \beta_j \ln Q_j + \sum_{j=1}^{4}\sum_{k=1}^{4} \beta_{jk} \left(\ln Q_j \cdot \ln Q_k\right) + \gamma_0 \ln W_{it} + \sum_{j=1}^{4} \gamma_j \ln W_{it} \ln Q_j + \sum_{l=1}^{L} \gamma_l \ln Z_{it} + \eta_{it} + \varepsilon_{it} \quad (3)$$

where Q_j is the output of the j-th product (see below for a more precise description of the four outputs). We only have one cost – that of staff – available to us. Therefore, W_{it}, represents average staff costs (total staff costs divided by staff FTE[12]) deflated using the sector average in 1995/6. We describe the other direct influences on cost and the determinants of the efficiency effects η_{it} below. The ε_{it} terms are random errors, assumed to be i.i.d. and have $N\left(0, \sigma_\varepsilon^2\right)$-distribution, independent of the η_{it} terms.

Because (3) is not defined for zero outputs, many studies have used flexible fixed cost quadratic form for (2) (e.g. Cohn, Rhine and Santos, 1989; Hashimoto and Cohn, 1997; and Koshal and Koshal, 1999). This is because multiple output concepts such as average incremental costs require the calculation of costs when one of the outputs is set to zero (Baumol, Panzar and Willig, 1982). Since the subject of this study is of the determinants of inefficiency (as defined as HEIs producing away from the cost frontier) rather than issues such as economies of scale and scope, we do not face this problem

[12] See below for a more thorough description of this and the other variables.

and can use the translog specification[13]. The translog function has the advantage over the other forms discussed in section 2 that it incorporates constant returns to scale and approximates more sophisticated functional forms, such as the CES.

Following Battese and Coelli (1995), the inefficiency effect is obtained by a truncation of the $N(\eta_{it}, \sigma^2)$-distribution, where

$$\eta_{it} = \delta \boldsymbol{E}_{it} \tag{4}$$

where $\boldsymbol{E}_{it}$ is a (M×1) vector of observable explanatory variables representing the characteristics of the student and staff bodies (discussed below), and δ is a (1×M) vector of unknown scalar parameters to be estimated (which includes an intercept parameter).

The staff characteristics considered are the proportion of staff that are aged over fifty years of age, the proportion of staff who are female, the proportion of staff who belong to non-white ethnic groups, the proportion of the teaching staff who are professors[14] or senior lecturers[15] and the proportion of staff who are research active[16]. The proportions are based on staff full time equivalents (FTE) rather than absolute numbers. Student characteristics beyond A-level points include the proportion of mature students (i.e. those over twenty five years of age on starting their course), the proportion of students who are female, the proportion of students from non-white ethnic groups, the proportion of students from lower social classes (i.e. SOC major groups 8 and 9, and

[13] NB. None of the universities in our sample produce zero of any of the outputs.

[14] As suggested by Earl (2001), who divides staff grades into five groupings: 'professors'; 'senior lecturers and researchers'; 'lecturers'; 'researchers'; and 'other grades'. The professor group includes: 'heads of departments (PCEF scale)'; 'professors (UAP minimum)'; 'research grade IV (UAP scale)'; 'clinical professors'; 'professors/heads of department (CSCFC scale)'; and 'professors in locally determined scales'.

[15] Again, defined according to the typology of Earl (2001) and including: 'principal lecturer (PCEF scale)'; 'senior lecturer (UAP scale)'; 'research grade III (UAP scale)'; 'Clinical senior lecturer', 'senior lecturer (CSCFC scale)'; and 'senior/principal lecturers in locally determined scales'.

[16] Defined as being active in the last Research Assessment Exercise.

those with unemployed parents/guardians[17]), the proportion of students from EU countries outside of the UK and the proportion of non-EU students. The effect of these variables may work in a number of ways. They could measure the determinants of efficiency in the sense that certain types of staff are more efficient than others. These variables could also be considered as background or environmental variables in that the university has little control over them (at least over the short run) and are what is considered in the efficiency literature as 'non-discretionary'[18]. Even if the university *could* control the amount of particular types of student i.e. the number of students it attracts from ethnic minorities or other groups such as mature students, there is a question mark over whether they *should* do so. Such selection choices are often implicit rather than explicit, being the indirect result of other criteria, such as entry requirements.

The log-likelihood function for this model is presented in Battese and Coelli (1993), as are the first partial derivatives of the log-likelihood function with respect to the different parameters of the model[19].

The maximum likelihood estimators for the parameters in the model were obtained using the FRONTIER computer program (Coelli, 1996).

One of the parameters estimated is

$$\gamma = \frac{\sigma^2}{\sigma_\varepsilon^2} \tag{6}$$

This γ-parameter lies between zero and one

[17] See footnote † to Table 1.

[18] C.f. Worthington (1999), Stevens and Vecchi (2001).

[19] This parameterisation originates in Battese and Corra (1977).

The generalised likelihood-ratio test for the null hypothesis that the γ parameter and the δ parameters are jointly equal to zero is calculated by using the values of the log-likelihood function for estimating the full frontier model and that obtained by using OLS regression to estimate the parameters of the cost function only. This statistic has a mixed chi-square distribution, as indeed will any generalised likelihood-ratio statistic associated with the null hypothesis involving the γ parameter [20].

The value of the γ parameter provides a useful test of the relative size of the inefficiency effects. If $\gamma = 0$, this would indicate that deviations from the frontier are due entirely to noise and that previous studies that use a standard (i.e. non-stochastic frontier) econometric methodology are entirely correct in their implicit assumption of technical and allocative efficiency. If $\gamma = 0$, however, this would indicate that all deviations are due entirely to economic inefficiency and hence the stochastic frontier model is not significantly different from the deterministic frontier model with no random error.

The terms included in the vector $\boldsymbol{E}_{it}$ in this study include the arts/science mix of the university (the proportion of students studying arts-based subjects), a time trend, and a set of staff and student characteristics. These are outlined in more detail below. Here we note that it is only the staff details, the arts/science mix and the proportion of students attaining first and upper second class degrees that have a time dimension. The other student details represent values from the cohorts in the 1997/8 student-body.

[20] See Coelli and Battese (1996).

5 Data

The data for the analysis come, directly and indirectly, from data collected by the Higher Education Statistics Agency (HESA) on behalf of the UK funding councils. The HESA data come from the Finance Record (1995/6 to 1998/9), the Individualised Staff Record (1995/6 to 1998/9) and the Individualised Student Record (1997/8). We also use annual data on entry requirements (Average A-Level/Highers points) and the percentage of students who achieve firsts and upper seconds published by the *Times Higher Education Supplement*. We confine our analysis to institutions of higher education in England and Wales, to avoid any problems caused by the differences in the system in Scotland. It is also argued that the universities in Northern Ireland also should be considered as separate entities from those on the mainland. This choice and various others of data availability give us a balanced panel of eighty institutions over four years. Definitions of the variables and descriptive statistics are presented in Table 1.

Table 1 Definitions of variables and descriptive statistics

NB descriptive statistics in table refers to original data (i.e. not logs)

		Mean	Std. Dev	Minimum	Maximum
TEXP	Total Expenditure (£m)	99.37	61.99	9.45	355.35
SUG	Science Undergraduates (000s)	5.50	2.57	0.07	13.73
AUG	Arts Undergraduates (000s)	6.32	2.67	0.49	16.75
PG	Post-graduates (000s)	22.89	12.42	1.34	59.52
RES	Research Income (£m)	15.99	24.52	0.10	126.19
SUGAUG	*SUG*×*AUG*	37.80	28.19	0.10	153.96
SUGPGG	*SUG*×*PG*	142.10	128.62	0.12	687.51
SUGRES	*SUG*×*RES*	112.54	209.09	0.01	1161.8
AUGPG	*AUG*×*PG*	152.94	121.85	2.24	581.8
AUGRES	*AUG*×*RES*	97.54	177.33	0.29	1221.9
PGRES	*PG*×*RES*	588.72	1181	0.22	7510
W	Average staff costs/1995/6 sector average	27.25	4.48	15.32	41.52
WSUG	*W*×*SUG*	149.60	76.07	2.16	389.50
WAUG	*W*×*AUG*	173.55	81.25	8.95	504.77
WPG	*W*×*PG*	17447	18643	52.28	120821
WRES	*W*×*RES*	387.59	567.29	2.87	4305
ALEV	Average A-Level score	17.55	5.03	8.20	29.70
FIRST	Proportion 1st and 2:1s	0.54	0.10	0.28	0.87
FIRSTSUG	*FIRST*×*SUG*	2.958	1.579	0.028	8.65
FIRSTAUG	*FIRST*×*AUG*	20.14	15.86	0.042	78.77
FIRSTPG	*FIRST*×*PG*	57.50	73.20	0.009	345.96
FIRSTRES	*FIRST*×*RES*	1995.8	5272.6	0.002	31393
FIRSTW	*FIRST*×*W*	14.49	2.86	6.78	23.07
STA51	Proportion of staff aged > 50	0.23	0.04	0.13	0.37
STAF	Prop^n of female staff	0.31	0.07	0.14	0.48
STANW	Prop^n of non-white staff	0.08	0.04	0.01	0.32
STAPR	Prop^n of professors	0.08	0.06	0.00	0.22
STASL	Prop^n of senior lecturers	0.19	0.08	0.00	0.74
STARA	Prop^n of RAE active staff	0.44	0.19	0.00	1.00
STU25	Prop^n of students aged ≥ 25*	0.10	0.03	0.05	0.18
STUF	Prop^n of female students*	0.51	0.06	0.29	0.65
STUNW	Prop^n of non-white students*	0.18	0.13	0.02	0.54
STUC8	Prop^n of students from lower classes†*	0.14	0.11	0.00	0.92
EUSTU	Prop^n of students from other EU*	0.06	0.03	0.02	0.19
FORSTU	Prop^n of non-EU students*	0.09	0.06	0.02	0.41
ARTSTU	Prop^n of arts students	0.48	0.03	0.40	0.58

* These come from the Student Record 1997/8, and, therefore, do not have a time dimension.

† Defined as having their prime parent/guardian who is employed in Standard Occupational Classification major groups 8 (plant and machine operatives) and 9 (other occupations), or is unemployed

6 Results

The results of the maximum likelihood estimation of the stochastic frontier quadratic cost function for the academic-years 1995/6 to 1998/9 are presented in Table 2 and Table 3. We consider three specifications. In model 1 we consider the simplest case, which includes a variable for student quality only (*ALEV*), as do Koshal and Koshal (1999). Model 2 is a more sophisticated version of model 1 that accounts for the interactions between student quality and the other variables in a manner more in keeping with the general translog cost function approach. Model 3 also includes our undergraduate teaching output quality measure (*FIRST*).

The implications of our cost function for economies of scale and scope in university production are not the main thrust of this study and so we do not, therefore, consider them in any depth. Briefly, the results presented in Table 2 correspond to those of work such as deGroot, McMahon and Volkwein (1991) or Nelson and Hevert (1992), with the exception of the time trend, which shows a very slight increase in inefficiency *ceteris paribus*. Our first model is a similar those used in the previous work, discussed above. Like Koshal and Koshal (1999) we find a positive (although not very significant) effect of student quality on costs. This may reflect the higher cost of attracting the better-qualified students. It may however be the product of misspecification, as we discuss below. The results with regard the interaction between the two broad roles of a higher education institution, teaching and research, are mixed. The coefficients on the interaction terms between science undergraduates and research (*SUGRES*) and arts undergraduates and research (*AUGRES*) imply diseconomies of scope between undergraduate teaching and undertaking research, suggesting benefits from separating these. Conversely, the positive sign on the interaction term between post-graduate teaching and research, implying the opposite. This result is not surprising since graduate instruction is much more closely related to research and one can see the potential for economies of scope from the viewpoint of academic staff more clearly. Moreover, many students reading for taught post-graduate courses are preparing for research and those reading for degrees by research are actually undertaking research themselves. Certainly, Cohn, Rhine and Santos (1989) also find a statistically significant negative relationship between undergraduate enrolment and research in public universities and a positive relationship between postgraduate enrolment and research in both public and private US universities. The results of Koshal and Koshal (1999), also in the US, concur less well. They find a significant positive interaction between undergraduate teaching and research in private universities but no interaction between either type of teaching and research in public universities.

Table 2 Results, Cost Function

	Model 1		*Model 2*		*Model 3*	
Constant	2.960	(14.305)	0.860	(0.394)	11.291	(3.305)
SUGN	0.081	(1.405)	1.092	(3.029)	1.109	(2.246)
AUGN	-0.113	(1.315)	-1.352	(3.182)	-1.911	(3.627)
PGN	0.649	(6.481)	-0.128	(0.235)	1.177	(1.773)
RESG	0.038	(0.938)	-0.306	(1.099)	-0.068	(0.207)
$SUGN^2$	0.047	(2.379)	-0.007	(0.295)	-0.028	(1.156)
$AUGN^2$	0.053	(2.710)	0.063	(3.123)	0.059	(2.872)
PGN^2	0.224	(4.280)	0.218	(3.901)	0.208	(3.841)
$RESG^2$	0.079	(9.213)	0.064	(4.973)	0.065	(5.248)
SUGAUG	0.070	(1.728)	0.149	(3.175)	0.153	(3.296)
SUGPGG	-0.171	(4.281)	-0.121	(2.192)	-0.083	(1.545)
SUGRES	0.024	(1.411)	0.089	(3.361)	0.098	(3.735)
AUGPG	-0.141	(2.509)	-0.145	(2.591)	-0.152	(2.783)
AUGRES	0.029	(1.246)	-0.045	(1.390)	-0.028	(0.914)
PGRES	-0.161	(4.259)	-0.206	(5.096)	-0.224	(6.094)
W	-0.120	(0.754)	1.005	(1.133)	0.241	(0.215)
W^2	-0.048	(0.340)	-0.071	(0.517)	-0.133	(1.007)
WSUG	0.013	(0.151)	0.000	(0.003)	-0.040	(0.460)
WAUG	0.155	(2.492)	0.132	(2.283)	0.146	(2.561)
WPG	-0.422	(3.582)	-0.401	(3.474)	-0.428	(3.814)
WRES	0.129	(2.899)	0.200	(2.936)	0.190	(3.041)
ALEV	0.094	(1.534)	2.236	(1.495)	-4.243	(2.004)
$ALEV^2$			-0.490	(1.857)	0.475	(1.391)
ALEVSU			-0.401	(3.136)	-0.437	(2.912)
ALEVAU			0.422	(2.944)	0.532	(3.391)
ALEVPG			0.286	(1.574)	-0.010	(0.051)
ALEVRES			0.161	(1.548)	0.110	(1.012)
ALEVW			-0.431	(1.332)	-0.211	(0.608)
ALEVFIR					-1.938	(3.663)
FIRST					5.097	(2.889)
FIR^2					-0.079	(0.250)
FIRSU					-0.147	(0.981)
FIRAU					-0.321	(2.246)
FIRPG					0.710	(3.377)
FIRRES					0.175	(1.616)
FIRW					-0.319	(0.857)
time trend	0.010	(1.462)	0.014	(1.957)	0.013	(2.226)
Log likelihood function	353.56		367.18		384.37	
LR test of the one-sided error	139.49		154.25		179.41	

Turning to the efficiency effects presented in Table 3, which are the main focus of this study, most of the (δ) terms are statistically significant in all of the models. Those of models 1 and 2 are generally of similar size and significance. The efficiency scores themselves are presented in the appendix to this paper (Table 7 to Table 9). Summary statistics and correlations are presented in Table 4, below. The efficiency score shows an institution's costs relative to the frontier, i.e. a score of one indicates that it is fully efficient and scores above one indicate actual costs are a multiple of efficient costs.

Table 3 Results, Inefficiency Effects

	Model 1		*Model 2*		*Model 3*	
Constant	-1.208	(0.548)	-1.391	(0.659)	-1.047	(0.496)
STA51	1.097	(2.479)	1.239	(2.903)	1.165	(4.177)
STAF	1.131	(3.802)	1.187	(4.172)	0.128	(0.470)
STANW	0.399	(1.492)	0.202	(0.779)	-0.703	(1.968)
STAPR	-0.784	(2.006)	-0.787	(2.209)	-0.672	(2.379)
STASL	-0.724	(2.509)	-0.733	(2.543)	-0.132	(1.468)
STARA	-1.431	(5.575)	-1.546	(6.356)	-0.289	(3.972)
FIRST	-0.134	(1.915)	-0.177	(2.568)	0.978	(2.478)
STU25	-1.722	(3.402)	-1.797	(3.630)	-1.698	(3.498)
STUF	0.330	(1.097)	0.570	(1.979)	0.520	(1.655)
STUNW	-0.064	(0.486)	0.043	(0.328)	-0.007	(0.054)
STUC8	-0.597	(3.108)	-0.552	(3.107)	-0.633	(3.401)
EUSTU	-0.870	(1.303)	-0.956	(1.389)	-1.153	(1.660)
FORSTU	0.217	(0.592)	-0.001	(0.002)	-0.047	(0.133)
ARTSTU	7.027	(0.771)	7.187	(0.822)	5.311	(0.614)
$ARTSTU^2$	-6.823	(0.718)	-6.964	(0.765)	-5.174	(0.575)
time trend	-0.036	(3.125)	-0.038	(3.336)	-0.040	(3.598)
σ^2	0.009	(8.139)	0.008	(8.944)	0.008	(8.849)
γ	0.636	(6.093)	0.663	(7.766)	0.812	(12.768)

As have noted above, the γ-parameter gives an impression of the influence of the efficiency terms as the γ value shows the contribution of the η efficiency term to the whole of the dichotomous error term ($\varepsilon + \eta$). The estimate of γ for model 1 is 0.636. That is, η contributes 63.6% of the total variance of the error term. The estimates of γ for models 2 and 3 are 0.663 and 0.812, respectively. The generalised likelihood ratio test of $\gamma = 0$ indicates that this effect is significantly different from zero. Therefore, the 'average response' cost function is not an adequate representation of the data. This result mirrors Izadi and Johnes' (1997) findings using the simple stochastic frontier model and suggests that previous estimates of economies of scale and scope may be biased.

The time trend has a significant negative coefficient in all specifications, implying that universities have shifted down toward the cost frontier and have, therefore, become more efficient over the period. Looking at models 1 and 2 together, the proportion of staff who are over fifty, non-white, or female have a negative effect on efficiency, *ceteris paribus*, whereas the proportion who are of professorial or senior lecturer grade or who are research active has a positive one. (NB a positive coefficient represents a positive effect on *inefficiency*, i.e. causes the university to be further above the minimum cost frontier). The fact that staff who are of a higher ability (i.e. those that reach the grade of professor or senior lecturer) are more efficient should not be a great surprise. Note that this is above and beyond the direct cost they incur in terms of higher wages, which operates through the cost function itself. Given that wage profiles of staff are determined by grade and age, the negative coefficients on the proportions of professors and senior lecturers and the positive one on staff over 51 could be related. Since promotions in grade are likely to be related to both innate ability and experience, those members of staff who are over 51 but are not senior lecturers or professors may well be less efficient than those who are. The negative effect of female and non-white academic staff on efficiency is more difficult to explain, although the latter effect becomes even less significant in model 2 (and becomes negative in model 3). The higher inefficiency of staff with a large number of female staff could be a human capital effect caused by absence from the labour market due to career breaks for example. However, studies have consistently found that women earn less than men for a given set of characteristics and so one might expect the effect to work in the opposite direction, since women's wages reflect their productivity less than that of men.

Table 4 Descriptive statistics and correlations of estimated efficiency scores

	1995/6	**1996/7**	**1997/8**	**1998/9**	**Average**
Model 1					
Mean	1.268	1.262	1.213	1.195	1.235
Median	1.212	1.221	1.179	1.133	1.190
Std. Dev	0.227	0.227	0.188	0.180	0.199
Min	1.010	1.009	1.012	1.012	1.011
Max	1.880	1.710	1.631	1.608	1.631
Model 2					
Mean	1.279	1.272	1.217	1.198	1.242
Median	1.231	1.239	1.204	1.129	1.214
Std. Dev	0.236	0.236	0.194	0.184	0.206
Min	1.007	1.008	1.011	1.011	1.010
Max	1.867	1.743	1.669	1.658	1.646
Model 3					
Mean	1.287	1.292	1.245	1.221	1.261
Median	1.259	1.26	1.187	1.185	1.282
Std. Dev	0.252	0.26	0.222	0.201	0.224
Min	1.007	1.008	1.014	1.012	1.012
Max	1.95	2.011	1.744	1.714	1.751

Correlations †	**1995/6**	**1996/7**	**1997/8**	**1998/9**	**Overall**
Correlation between Model 1 & 2	0.995	0.994	0.993	0.995	0.995
Correlation between Model 2 & 3	0.986	0.977	0.977	0.971	0.986
Correlation between Model 1 & 3	0.981	0.972	0.968	0.964	0.980

† All correlations significant at the 1 level.

The proportion of students who are mature or from the lower social classes[21] is positively correlated with efficiency whereas HEIs with large numbers of arts students are generally more efficient. Model 2 indicates that institutions with larger proportions of female students also tend to be more efficient. However this effect is not significant in model 1.

The proportion of students achieving first and upper second class degrees is positively correlated with efficiency. However, it could be argued that the proportion of students achieving first and upper second should be considered an output in and of itself. That is, that the decision to go for quality rather than just quantity has more complex ramifications than merely the effect on efficiency. Therefore, in our third specification we include quadratic and interaction terms for the proportion of students achieving firsts. With these terms included, we can account for the cost implications of the decision between quantity and quality of teaching.

The results of this estimation are shown in the last columns of Table 2 and Table 3. Again, there is a slight upward trend in costs and efficiency over the period. Looking at the results for the cost function in Table 2, as one would expect, it costs money to produce better quality degrees *ceteris paribus*. There is no evidence of a trade off between quality and quantity in science subjects, although there do appear to be economies of scope in the arts. There does appear to be a negative interaction between the quality of undergraduate teaching and research, a trade-off that academics who have had students knocking on their door outside office hours can understand. There is a significant interaction between the quality of the undergraduate teaching and the costs of post-graduate teaching and supervision.

[21] See fn. † to Table 1 above for a definition of the *STUC8* variable.

The effect of this change in specification on the significance and sign of the efficiency terms is relatively minor. The exception to this is, as one might expect, the effect of the proportion of students achieving firsts and upper seconds. This remains significant, but changes sign from negative to positive. That is, universities that produce a large number of high-achieving students tend to be less efficient, when one accounts for the direct effect of teaching quality on costs. The γ-parameter for model 3 increases from around 0.6 to 0.812, indicating that an even greater proportion of the error variance is accounted for by $\eta(\boldsymbol{E})$.

It is interesting to note the correlation across years. The Pearson correlation statistics presented in Table 5 show that scores are highly correlated over the years and the Spearman rank correlations suggest that there is little movement in rankings between years.

Table 5 Correlations

	Pearson				*Spearman (Rank)*			
Model 1	1995/6	1996/7	1997/8	1998/9	1995/6	1996/7	1997/8	1998/9
1995/6	1	0.944	0.910	0.881	1	0.951	0.924	0.902
1996/7		1	0.944	0.915		1	0.948	0.924
1997/8			1	0.944			1	0.953
1998/9				1				1
Model 2	1995/6	1996/7	1997/8	1998/9	1995/6	1996/7	1997/8	1998/9
1995/6	1	0.945	0.907	0.880	1	0.957	0.917	0.889
1996/7		1	0.946	0.918		1	0.922	0.983
1997/8			1	0.941			1	0.971
1998/9				1				1
Model 3	1995/6	1996/7	1997/8	1998/9	1995/6	1996/7	1997/8	1998/9
1995/6	1	0.905	0.845	0.831	1	0.938	0.880	0.851
1996/7		1	0.932	0.889		1	0.949	0.882
1997/8			1	0.922			1	0.907
1998/9				1				1

†All correlations significant at the 1% level.

Another question of interest is whether there has been any convergence in the efficiency of HEIs. Studies of economic growth that compare the per capita income levels of different countries distinguish two types of growth: β convergence and σ convergence[22]. The former case refers to a tendency for low income countries (inefficient HEIs in our case) to grow (decrease their costs) faster than more efficient ones. This is often referred to as 'regression toward the mean'. The second type of convergence, σ convergence, refers to a tendency for dispersion of inefficiency scores to decline over time. β convergence tends to generate σ convergence, but this process can be offset by new disturbances that tend to increase dispersion. We apply the same approach to our HEI inefficiency measures, looking to see first whether there is regression to the mean and secondly whether inefficiency scores have become less dispersed over time.

In Table 6 we present the results of regressing the change in inefficiency scores, $(\eta_{it} - \eta_{i,t-1})/\eta_{i,t-1}$, on the institution's initial score (i.e. for 1995/6) and a constant. For all three models, we find that the change in inefficiency does indeed depend negatively on initial inefficiency. That is, the greater the inefficiency in a HEI in 1995/6, the more inefficiency is expected to fall. The process is slow, with only 6% of the gap between the actual values and the mean being closed on average in any year. However, closer examination of Table 6 shows that this average reflects a fairly large adjustment in 1997/8 and little movement in other years, indeed the third model implies a small *increase* in the year after. 1997/8 was the last academic year before tuition fees were introduced and university provision may have been effected by the anticipation of a one-off surge of students deciding against deferring their studies (the so-called 'gap

[22] See for example, Barro and Sala-i-Martin (1995).

year') to avoid paying fees. The belief on which this anticipation is based – one that was certainly prevalent at the time – is not consistent with the data however. The increase in overall student numbers in England and Wales was relatively unaffected by the introduction of fees. Student numbers increased by about 2.6% between 1996/7 and 1997/8 and more than 3% between 1997/8 and 1998/9. One could argue that this increase in student numbers was largely unforeseen by the education authorities since there was no rise in the numbers of student places funded or staff numbers[23]. However, it is perhaps better to see this in the broader context of the government's attempts to keep public spending down.

Table 6 β Convergence Regression Results

	Constant	$\eta_{95/6}$	R^2
Model 1			
1996/7	0.038	-0.033	0.019
1997/8	0.114**	-0.116**	0.259
1998/9	0.031	-0.035	0.030
Average	0.061*	-0.062*	0.291
Model 2			
1996/7	0.039	-0.034	0.020
1997/8	0.118*	-0.121**	0.029
1998/9	0.033*	-0.036**	0.033
Average	0.063**	-0.064**	0.205
Model 3			
1996/7	0.067	-0.047	0.021
1997/8	0.112**	-0.111**	0.200
1998/9	0.043	0.045*	0.033
Average	0.074**	-0.068**	0.265

** Significant at the 1% level
* Significant at the 5% level

[23] The 'Maximum Aggregate Student Numbers' set by the government were the same for 1997/8 as for 1996/7 at 740,000 (HEFCE, 1997). Total staff numbers in English and Welsh HEIs remained stable, being 96,753 in 1996/7 and 96,241 in 1997/8.

There is also some evidence of σ convergence. As we can see from Table 4, there is a decline in the standard deviation of the inefficiency scores for the first two models model over the entire period and for the second model except for a small increase in academic year 1996/7. This supports the view that there has been convergence in the cost efficiency in English and Welsh HEIs. Moreover, any new disturbances to this process do not appear to have swamped the overall convergence. However, it should be borne in mind that these results are not very strong and only refer to a short time period.

One of the motivations of this study was to assess the effect of the introduction of tuition fees on university production. The results for β convergence might suggest that the anticipation of the introduction of tuition fees led to a 'shake-up' of the less efficient universities and prompting them to become more efficient. However, the σ convergence results suggest that fees did not have a large overall effect compared to other trends. The anticipatory improvement of the poor institutions also appears to have been offset by others slipping.

7 Conclusions

We have examined the costs of higher education and found that there is inefficiency in production. Moreover, the inefficiency in higher education institutions can be modelled as a function of their student and staff bodies. This result is robust to the inclusion of a qualitative measure of output into the cost function. Our results suggest that a significant portion of the error term in the cost function is explained by the inefficiency effect. Therefore, any study that seeks to assess the costs of production (i.e. issues such as economies of scale and scope) are liable to produce biased results.

Although costs have generally risen, output has more so and efficiency does appear to have increased over the period 1995/6 to 1998/9. We have observed a number of influences on efficiency. The proportions of staff who are non-white, of professorial or senior lecturer grade or are research active have a positive effect on efficiency, *ceteris paribus*, whereas the proportion that is over-fifty has a negative one. The proportion of students achieving first and upper second class degrees is negatively correlated with efficiency, once one accounts for its direct impact on costs, as is the proportion of students who are female. Conversely, HEIs with large numbers of students who are mature (over twenty-five years of age when starting their course) or from lower social classes are generally more efficient, as are those with larger proportions of female and non-white students.

Finally, the results for our analysis of convergence issues suggest that the anticipation of the introduction of tuition fees may have lead to a shake-up in the less efficient universities. However, the results suggest that this effect was short-lived and offset by the more efficient universities relaxing somewhat.

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9 Tables

Table 7 Inefficiency scores, Model 1

	1995/6	1996/7	1997/8	1998/9	Average
Anglia Polytechnic	1.516	1.710	1.474	1.540	1.560
Aston	1.251	1.169	1.151	1.046	1.154
Bath	1.023	1.020	1.020	1.019	1.020
Birmingham	1.043	1.036	1.032	1.019	1.033
Bournemouth	1.438	1.411	1.377	1.309	1.384
Bradford	1.069	1.071	1.073	1.053	1.067
Brighton	1.482	1.447	1.406	1.297	1.408
Bristol	1.040	1.028	1.023	1.016	1.027
Brunel	1.032	1.036	1.036	1.038	1.035
Cambridge	1.018	1.014	1.013	1.012	1.014
Central England	1.341	1.364	1.382	1.368	1.364
Central Lancashire	1.619	1.643	1.536	1.608	1.601
City	1.030	1.032	1.031	1.065	1.039
Coventry	1.559	1.616	1.465	1.371	1.503
De Montfort	1.626	1.452	1.388	1.293	1.440
Derby	1.458	1.462	1.396	1.462	1.445
Durham	1.091	1.050	1.033	1.048	1.055
East Anglia	1.041	1.085	1.025	1.017	1.042
East London	1.434	1.409	1.375	1.276	1.374
Essex	1.030	1.030	1.023	1.019	1.026
Exeter	1.218	1.264	1.235	1.140	1.214
Glamorgan	1.337	1.305	1.288	1.307	1.309
Goldsmiths	1.270	1.218	1.198	1.273	1.240
Greenwich	1.413	1.359	1.322	1.258	1.338
Hertfordshire	1.576	1.566	1.523	1.431	1.524
Huddersfield	1.465	1.502	1.344	1.377	1.422
Hull	1.185	1.231	1.291	1.259	1.242
Imperial	1.010	1.009	1.012	1.013	1.011
Keele	1.028	1.018	1.017	1.016	1.020
Kent	1.052	1.064	1.055	1.050	1.055
King's College	1.033	1.037	1.037	1.030	1.034
Kingston	1.608	1.621	1.631	1.493	1.588
Lancaster	1.249	1.069	1.042	1.040	1.100
Leeds	1.089	1.062	1.042	1.030	1.056
Leeds Metropolitan	1.880	1.628	1.505	1.511	1.631
Leicester	1.020	1.024	1.022	1.015	1.020
Lincolnshire and Humberside	1.566	1.568	1.353	1.284	1.443
Liverpool	1.068	1.047	1.038	1.033	1.046
Liverpool John Moores	1.612	1.668	1.562	1.447	1.572
London Guildhall	1.581	1.439	1.252	1.381	1.413
Loughborough	1.047	1.043	1.031	1.031	1.038
LSE	1.207	1.071	1.051	1.063	1.098
Luton	1.436	1.524	1.285	1.508	1.438
Manchester	1.202	1.094	1.104	1.039	1.110
Manchester Metropolitan	1.497	1.428	1.408	1.428	1.440

Table 7 Inefficiency scores, Model 1 (Continued)

	1995/6	1996/7	1997/8	1998/9	Average
Middlesex	1.463	1.525	1.566	1.428	1.495
Newcastle-upon-Tyne	1.061	1.041	1.026	1.021	1.038
Northumbria at Newcastle	1.616	1.648	1.568	1.427	1.565
Nottingham	1.064	1.062	1.035	1.027	1.047
Nottingham Trent	1.647	1.633	1.590	1.545	1.604
Oxford	1.019	1.018	1.015	1.014	1.016
Oxford Brookes	1.430	1.461	1.474	1.407	1.443
Plymouth	1.321	1.386	1.222	1.261	1.297
Portsmouth	1.461	1.372	1.276	1.205	1.329
QMW	1.049	1.053	1.034	1.058	1.049
Reading	1.052	1.045	1.044	1.045	1.047
Royal Holloway	1.185	1.194	1.187	1.192	1.190
Salford	1.156	1.407	1.359	1.292	1.304
Sheffield	1.020	1.026	1.025	1.015	1.021
Sheffield Hallam	1.427	1.321	1.315	1.276	1.335
South Bank	1.276	1.237	1.147	1.101	1.190
Southampton	1.024	1.024	1.023	1.018	1.022
Staffordshire	1.422	1.648	1.275	1.213	1.390
Sunderland	1.545	1.506	1.343	1.271	1.416
Surrey	1.038	1.058	1.040	1.035	1.043
Sussex	1.029	1.025	1.031	1.019	1.026
Teesside	1.465	1.469	1.367	1.357	1.414
Thames Valley	1.247	1.220	1.321	1.493	1.320
UCL	1.036	1.026	1.020	1.020	1.025
UMIST	1.038	1.020	1.019	1.023	1.025
UofW Aberystwyth	1.165	1.171	1.199	1.126	1.166
UofW Bangor	1.122	1.222	1.146	1.078	1.142
UofW Cardiff	1.083	1.084	1.041	1.034	1.061
UofW Lampeter	1.519	1.457	1.171	1.171	1.329
UofW Swansea	1.145	1.234	1.129	1.113	1.155
Warwick	1.036	1.065	1.063	1.061	1.056
West of England	1.433	1.352	1.322	1.227	1.333
Westminster	1.454	1.357	1.236	1.199	1.312
Wolverhampton	1.566	1.634	1.503	1.507	1.553
York	1.035	1.031	1.022	1.017	1.026
Mean	1.268	1.262	1.213	1.195	1.235
Median	1.212	1.221	1.179	1.133	1.190
Std. Dev	0.227	0.227	0.188	0.180	0.199
Min	1.010	1.009	1.012	1.012	1.011
Max	1.880	1.710	1.631	1.608	1.631

Table 8 Inefficiency Scores, Model 2

	1995/6	1996/7	1997/8	1998/9	Average
Anglia Polytechnic	1.527	1.743	1.486	1.542	1.575
Aston	1.335	1.260	1.285	1.102	1.245
Bath	1.021	1.019	1.019	1.020	1.020
Birmingham	1.044	1.033	1.028	1.016	1.030
Bournemouth	1.476	1.467	1.423	1.328	1.424
Bradford	1.057	1.070	1.062	1.050	1.060
Brighton	1.489	1.460	1.399	1.294	1.410
Bristol	1.045	1.031	1.025	1.015	1.029
Brunel	1.028	1.032	1.031	1.033	1.031
Cambridge	1.016	1.012	1.011	1.011	1.013
Central England	1.354	1.373	1.393	1.366	1.372
Central Lancashire	1.653	1.700	1.570	1.658	1.646
City	1.029	1.030	1.028	1.086	1.043
Coventry	1.563	1.617	1.462	1.358	1.500
De Montfort	1.711	1.499	1.432	1.320	1.491
Derby	1.463	1.465	1.406	1.472	1.451
Durham	1.106	1.067	1.038	1.049	1.065
East Anglia	1.043	1.068	1.023	1.015	1.037
East London	1.443	1.404	1.370	1.270	1.372
Essex	1.029	1.026	1.020	1.018	1.023
Exeter	1.233	1.269	1.241	1.134	1.220
Glamorgan	1.333	1.302	1.263	1.288	1.297
Goldsmiths	1.290	1.228	1.210	1.290	1.254
Greenwich	1.427	1.459	1.407	1.353	1.412
Hertfordshire	1.540	1.532	1.493	1.421	1.497
Huddersfield	1.489	1.513	1.343	1.375	1.430
Hull	1.208	1.239	1.308	1.271	1.256
Imperial	1.007	1.008	1.011	1.013	1.010
Keele	1.028	1.018	1.016	1.015	1.019
Kent	1.057	1.067	1.055	1.050	1.057
King's College	1.033	1.041	1.041	1.033	1.037
Kingston	1.628	1.643	1.669	1.512	1.613
Lancaster	1.276	1.074	1.042	1.039	1.108
Leeds	1.105	1.065	1.040	1.028	1.059
Leeds Metropolitan	1.867	1.688	1.514	1.512	1.645
Leicester	1.031	1.031	1.025	1.016	1.026
Lincolnshire and Humberside	1.589	1.576	1.344	1.280	1.447
Liverpool	1.071	1.047	1.037	1.030	1.046
Liverpool John Moores	1.627	1.682	1.583	1.450	1.585
London Guildhall	1.684	1.499	1.279	1.417	1.470
Loughborough	1.041	1.039	1.027	1.027	1.034
LSE	1.194	1.046	1.028	1.036	1.076
Luton	1.433	1.519	1.281	1.467	1.425
Manchester	1.229	1.096	1.109	1.034	1.117
Manchester Metropolitan	1.584	1.532	1.431	1.419	1.492

Table 8 Inefficiency Scores, Model 2 (Continued)

	1995/6	1996/7	1997/8	1998/9	Average
Middlesex	1.525	1.599	1.603	1.472	1.550
Newcastle-upon-Tyne	1.067	1.043	1.026	1.021	1.039
Northumbria at Newcastle	1.626	1.652	1.581	1.445	1.576
Nottingham	1.080	1.090	1.046	1.030	1.062
Nottingham Trent	1.687	1.640	1.584	1.521	1.608
Oxford	1.019	1.016	1.013	1.012	1.015
Oxford Brookes	1.410	1.450	1.458	1.393	1.428
Plymouth	1.323	1.386	1.223	1.258	1.298
Portsmouth	1.443	1.366	1.263	1.199	1.318
QMW	1.033	1.039	1.024	1.046	1.035
Reading	1.059	1.047	1.045	1.045	1.049
Royal Holloway	1.200	1.206	1.209	1.222	1.209
Salford	1.140	1.411	1.338	1.278	1.292
Sheffield	1.018	1.024	1.024	1.014	1.020
Sheffield Hallam	1.430	1.309	1.296	1.257	1.323
South Bank	1.279	1.245	1.164	1.098	1.196
Southampton	1.026	1.026	1.024	1.017	1.023
Staffordshire	1.454	1.645	1.285	1.212	1.399
Sunderland	1.537	1.494	1.325	1.264	1.405
Surrey	1.031	1.041	1.033	1.028	1.033
Sussex	1.030	1.025	1.029	1.017	1.025
Teesside	1.473	1.482	1.342	1.355	1.413
Thames Valley	1.299	1.240	1.330	1.526	1.349
UCL	1.045	1.027	1.020	1.019	1.028
UMIST	1.030	1.018	1.016	1.024	1.022
UofW Aberystwyth	1.190	1.178	1.199	1.124	1.173
UofW Bangor	1.087	1.207	1.130	1.059	1.121
UofW Cardiff	1.088	1.083	1.041	1.031	1.061
UofW Lampeter	1.493	1.419	1.156	1.150	1.305
UofW Swansea	1.159	1.255	1.132	1.115	1.165
Warwick	1.029	1.050	1.044	1.038	1.040
West of England	1.457	1.361	1.327	1.234	1.345
Westminster	1.522	1.397	1.246	1.229	1.348
Wolverhampton	1.594	1.648	1.496	1.498	1.559
York	1.034	1.029	1.020	1.016	1.025
Mean	1.279	1.272	1.217	1.198	1.242
Median	1.231	1.239	1.204	1.129	1.214
Std. Dev	0.236	0.236	0.194	0.184	0.206
Min	1.007	1.008	1.011	1.011	1.010
Max	1.867	1.743	1.669	1.658	1.646

Table 9 Inefficiency Scores, Model 3

	1995/6	1996/7	1997/8	1998/9	Average
Anglia Polytechnic	1.567	2.011	1.706	1.678	1.740
Aston	1.424	1.333	1.377	1.188	1.331
Bath	1.017	1.023	1.022	1.038	1.025
Birmingham	1.052	1.042	1.037	1.018	1.037
Bournemouth	1.477	1.456	1.471	1.331	1.434
Bradford	1.037	1.051	1.052	1.040	1.045
Brighton	1.487	1.428	1.509	1.345	1.442
Bristol	1.063	1.062	1.055	1.024	1.051
Brunel	1.017	1.021	1.021	1.023	1.021
Cambridge	1.022	1.017	1.019	1.023	1.020
Central England	1.275	1.333	1.409	1.370	1.347
Central Lancashire	1.752	1.896	1.641	1.714	1.751
City	1.024	1.031	1.028	1.107	1.048
Coventry	1.502	1.687	1.493	1.313	1.499
De Montfort	1.788	1.521	1.449	1.336	1.524
Derby	1.450	1.506	1.438	1.486	1.470
Durham	1.085	1.050	1.031	1.051	1.054
East Anglia	1.078	1.069	1.031	1.019	1.049
East London	1.323	1.389	1.389	1.273	1.343
Essex	1.037	1.030	1.021	1.019	1.027
Exeter	1.275	1.325	1.334	1.234	1.292
Glamorgan	1.316	1.332	1.222	1.220	1.273
Goldsmiths	1.344	1.258	1.251	1.367	1.305
Greenwich	1.464	1.455	1.444	1.364	1.432
Hertfordshire	1.537	1.528	1.532	1.520	1.529
Huddersfield	1.485	1.561	1.378	1.421	1.461
Hull	1.210	1.262	1.439	1.358	1.317
Imperial	1.007	1.008	1.014	1.017	1.012
Keele	1.033	1.022	1.017	1.018	1.022
Kent	1.049	1.071	1.037	1.025	1.045
King's College	1.026	1.034	1.038	1.034	1.033
Kingston	1.613	1.658	1.732	1.519	1.630
Lancaster	1.370	1.133	1.101	1.079	1.170
Leeds	1.118	1.086	1.064	1.037	1.076
Leeds Metropolitan	1.950	1.751	1.575	1.585	1.715
Leicester	1.035	1.028	1.025	1.014	1.026
Lincolnshire and Humberside	1.692	1.654	1.457	1.293	1.524
Liverpool	1.061	1.045	1.033	1.028	1.042
Liverpool John Moores	1.652	1.749	1.628	1.444	1.619
London Guildhall	1.647	1.407	1.198	1.319	1.393
Loughborough	1.045	1.074	1.061	1.038	1.054
LSE	1.194	1.037	1.028	1.073	1.083
Luton	1.349	1.286	1.176	1.480	1.323
Manchester	1.243	1.106	1.144	1.055	1.137
Manchester Metropolitan	1.578	1.501	1.440	1.444	1.491

Table 9 Inefficiency Scores, Model 3 (Continued)

	1995/6	1996/7	1997/8	1998/9	Average
Middlesex	1.542	1.618	1.681	1.522	1.591
Newcastle-upon-Tyne	1.060	1.046	1.028	1.029	1.041
Northumbria at Newcastle	1.641	1.709	1.640	1.472	1.615
Nottingham	1.117	1.157	1.124	1.101	1.125
Nottingham Trent	1.808	1.828	1.744	1.572	1.738
Oxford	1.017	1.020	1.017	1.016	1.017
Oxford Brookes	1.409	1.471	1.476	1.410	1.442
Plymouth	1.378	1.442	1.255	1.296	1.343
Portsmouth	1.471	1.443	1.326	1.207	1.362
QMW	1.019	1.034	1.023	1.045	1.030
Reading	1.062	1.046	1.056	1.062	1.057
Royal Holloway	1.198	1.274	1.370	1.345	1.297
Salford	1.074	1.484	1.391	1.295	1.311
Sheffield	1.024	1.026	1.023	1.012	1.021
Sheffield Hallam	1.439	1.314	1.311	1.272	1.334
South Bank	1.304	1.224	1.080	1.125	1.183
Southampton	1.021	1.023	1.021	1.014	1.020
Staffordshire	1.466	1.678	1.333	1.267	1.436
Sunderland	1.595	1.523	1.335	1.326	1.445
Surrey	1.032	1.049	1.034	1.034	1.037
Sussex	1.026	1.026	1.037	1.018	1.027
Teesside	1.516	1.513	1.308	1.350	1.422
Thames Valley	1.295	1.236	1.321	1.535	1.347
UCL	1.050	1.028	1.020	1.024	1.031
UMIST	1.036	1.018	1.016	1.026	1.024
UofW Aberystwyth	1.093	1.224	1.217	1.163	1.174
UofW Bangor	1.068	1.216	1.143	1.054	1.120
UofW Cardiff	1.072	1.107	1.050	1.038	1.067
UofW Lampeter	1.600	1.434	1.103	1.083	1.305
UofW Swansea	1.135	1.275	1.164	1.182	1.189
Warwick	1.042	1.108	1.116	1.019	1.071
West of England	1.488	1.389	1.375	1.508	1.440
Westminster	1.464	1.350	1.210	1.189	1.303
Wolverhampton	1.601	1.697	1.628	1.636	1.640
York	1.036	1.032	1.019	1.014	1.025
Mean	1.287	1.292	1.245	1.221	1.261
Median	1.259	1.260	1.187	1.185	1.282
Std. Dev	0.252	0.260	0.222	0.201	0.224
Min	1.007	1.008	1.014	1.012	1.012
Max	1.950	2.011	1.744	1.714	1.751